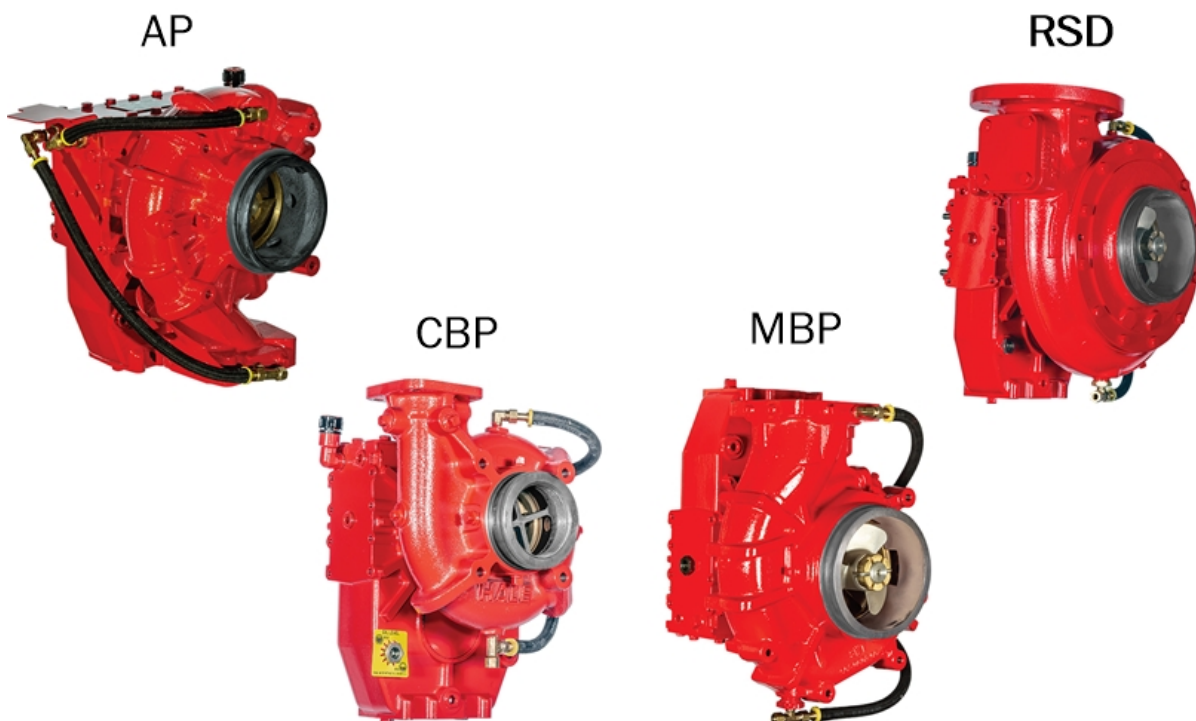




TECHNICAL MANUAL

FOR HALE

SINGLE STAGE BOOSTER PUMPS



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Revision A	8 May 2019	All – Initial Release
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Abbreviations And Acronyms

The abbreviations used in this manual are limited to standard (commonly used and accepted) scientific units of measure and therefore are NOT defined or listed. The acronyms used in this manual are defined in this listing (in numerical-alphabetical order) and are NOT defined within the text.

AKA	Also Known As
AP	Attack Pump
CBP	Centrifugal Booster Pump
CCW	Counter Clockwise
CW	Clockwise
ESP	Environmentally Safe Priming
EVT	Emergency Vehicle Technician
FAST	Factory Authorized Service Team
gpm	Gallons Per Minute
GR	Gear Ratio
ID	Inside Diameter
Lpm	Liters Per Minute
N/A	Not Applicable
NFPA	National Fire Protection Act
NFPA 1901	Standard For Automotive Fire Apparatus
NFPA 1911	Standard For The Inspection, Maintenance, Testing, And Retirement Of In-Service Automotive Fire Apparatus
NLGI	National Lubrication Grease Institute
NPT	Normal Pipe Thread
OEM	Original Equipment Manufacturer
OD	Outside Diameter
PM	Panel Mounted
PMD	Panel Mounted Display
PPE	Personal Protection Equipment
PTO	Power Take Off
R&R	Removal and Replacement (Installation)
RSD	Removable Side Drive
SAE	Society of Automotive Engineers
SCR	Symptom, Cause, Remedy (Troubleshooting Table)
SPV	Semi-automatic Priming Valve
SPVR	Suction Pressure Relief Valve
TRV	Thermal Relief Valve

1. SAFETY

This section provides definitions for DANGERS, WARNINGS, CAUTIONS, NOTICES, and NOTES contained herein, precautions to be taken for pump repair as well as an alphabetical summary listing of the DANGERS, WARNINGS, CAUTIONS, and NOTICES used in this manual.

DANGERS, WARNINGS, CAUTIONS, or NOTICES that immediately precede a step apply directly to that step and all sub steps. DANGERS, WARNINGS, CAUTIONS, or NOTICES that precede an entire procedure apply to the entire procedure. WARNINGS and CAUTIONS consist of two parts: a heading (that identifies possible result if disregarded) and a statement of the hazard (that provides the minimum precautions). The headings used and their definitions are.

ATTENTION ▲ DANGER

INDICATES A HAZARDOUS SITUATION, WHICH IF NOT AVOIDED WILL RESULT IN SERIOUS INJURY OR DEATH.

ATTENTION ▲ WARNING

INDICATES A HAZARDOUS SITUATION, WHICH IF NOT AVOIDED COULD RESULT IN SERIOUS INJURY OR DEATH.

ATTENTION ▲ CAUTION

INDICATES A POTENTIALLY HAZARDOUS SITUATION, WHICH IF NOT AVOIDED MAY RESULT IN MINOR OR MODERATE INJURY.

IMPORTANT ▲ NOTICE

ADDRESSES PRACTICES NOT RELATED TO PERSONAL INJURY.

NOTE

Highlights an essential aspect of an operating or maintenance procedure, condition, or statement and/or provides pertinent ancillary information.

NOTES may precede or follow the step or procedure, depending upon the information and how it pertains to the procedure/step. The headings used and their definitions are.

1.1. PPE

The following is the minimum PPE required when performing maintenance.

- Safety Glasses
- Safety Gloves
 - General Protection
 - Chemical Resistant
- Work Shoes (Steel Toe)
- Ear Protection
 - Single Use
 - Ear Muffs

1.2. Environmental Protection

Used oil from the gearbox must be disposed of in accordance with your local regulations. It is prohibited to pour oil and other contaminants onto the ground, down sewers, drains, or into water courses. Dispose of lubricants through authorized waste disposal contractors, licensed waste disposal sites, or to the waste reclamation trade. If in doubt, contact your Local Environmental Agency for advice regarding disposal policies.



1.3. Training

AP, CBP, MBP, and RSD pumps must only be operated and maintained by trained personnel. Training is available via the Hale Products Inc. website (www.haleproducts.com), Godiva Verified Training (godiva.co.uk), or through your local dealer or vehicle manufacturer. The Hale website provides a description of the course content and general information about the training, including an invitation to register with the EVT Certification Commission (www.evtcc.org) to take one EVT exam at the Hale facility.

NOTE

Be sure to record the contact phone number and contact person's information before completing the form.

Complete the SESSIONS, ORGANIZATION CONTACT INFORMATION, STUDENT CONTACT INFORMATION portions of the form. Check the Captcha (provides the proof of human input) and then click the SUBMIT button at the bottom of the page.

NOTE

Under the FAST buttons select No unless your facility is a FAST center. Do NOT click Yes unless you know for sure you are a FAST member requiring certification or recertification (a certification is valid for 4 years).

When the Thank you for Registering page appears record the halemarketing email address (Add this address to your email address book to prevent your response from being routed to the Junk folder.) and call the contact phone number (recorded earlier) to arrange payment.

NOTE

Due to demand, classes fill far in advance of the scheduled dates. The ONLY way to hold the selected dates is to pay at the time of enrollment submission.

1.4. Safety Summary

DO'S

- When installing or removing the pump, use ONLY appropriately rated lifting equipment that has been inspected and is in good condition.
- Use/wear all required PPE when operating the pump (including for maintenance purposes). See paragraph 1.1, PPE.

DON'TS

- Do NOT remove guards; rotating parts must be guarded against accidental contact.
- Do NOT insert items into the suction tube when pump is running.
- Do NOT disconnect discharge hoses while the unit is running.
- Do NOT loosen/unfasten/remove components while the unit is running.

The following warnings and cautions are used throughout this manual and are provided here as a safety summary. WARNINGS or CAUTIONS within a procedure (preceding an individual step), apply directly to that step, however WARNINGS or CAUTIONS that precede the entire procedure, apply to the ENTIRE procedure.

ATTENTION ⚠ WARNING

A PRESS PRESENTS A POTENTIAL CRUSH HAZARD (FROM MOVING PARTS) AND/OR STRIKE HAZARD (FROM EJECTED PARTS). WEAR APPROPRIATE PPE.

ATTENTION ⚠ WARNING

A PRESSURE HAZARD MAY EXIST EVEN WHEN THE PUMP IS NOT RUNNING. PRIOR TO REMOVING HOSES OR CAPS FROM PUMP CONNECTIONS, RELIEVE PRESSURE BY OPENING DRAINS. BLEEDER VALVES SHOULD ALSO BE USED WHEN CONNECTING TO AN INTAKE FROM A PRESSURIZED SOURCE.

ATTENTION ⚠ WARNING

ALWAYS FOLLOW LOCAL GUIDELINES FROM THE AHJ AND THE APPARATUS MANUFACTURER.

ATTENTION ⚠ WARNING

ALWAYS FOLLOW PROPER OPERATING PROCEDURES. THE PUMP OPERATOR MUST BE FAMILIAR WITH THE PUMP OPERATING INSTRUCTIONS AS WELL AS OTHER OPERATING GUIDELINES FOR THE APPARATUS AND ACCESSORIES.

ATTENTION ⚠ WARNING

DO NOT EXCEED OPERATING PRESSURE LIMITS OF PUMP, INSTALLED PLUMBING, HOSE(S), OR EQUIPMENT IN USE.

ATTENTION ⚠ WARNING

DO NOT LEAVE THE CAB OR ATTEMPT TO PUMP UNTIL ALL OK TO PUMP LIGHTS IN THE CAB ARE ILLUMINATED. SEE FIGURE 8.

ATTENTION ⚠ WARNING

OPERATORS, INSTALLERS, AND MAINTENANCE PERSONNEL MUST BE TRAINED AND QUALIFIED FOR ALL THE ACTIVITIES THEY PERFORM.

ATTENTION ⚠ CAUTION

ALWAYS USE PROPER PPE. OIL MAY BE TOXIC TO PEOPLE AND/OR THE ENVIRONMENT. CATCH AND DISPOSE OF OIL PROPERLY. IMPROPER OIL HANDLING MAY RESULT IN HEALTH RISKS AND/OR CRIMINAL PUNISHMENTS.

ATTENTION ⚠ CAUTION

FAILING TO REDUCE SYSTEM PRESSURE BEFORE SYSTEM SHUTDOWN OR FLUSHING COULD RESULT IN WATER HAMMERING.

ATTENTION ⚠ CAUTION

THE AP PUMP AND GEARBOX ASSEMBLIES WEIGH APPROXIMATELY 140 LBS (64 KG). USE PROPER LIFTING DEVICE WHEN REMOVING OR INSTALLING THE PUMP AND GEARBOX ASSEMBLY.

ATTENTION ⚠ CAUTION

THE CBP PUMP AND GEARBOX ASSEMBLIES WEIGH APPROXIMATELY 100 LBS (45 KG). USE PROPER LIFTING DEVICE WHEN REMOVING OR INSTALLING THE PUMP AND GEARBOX ASSEMBLY.

ATTENTION ⚠ CAUTION

THE MBP PUMP AND GEARBOX ASSEMBLIES WEIGH APPROXIMATELY 170 LBS (77 KG). USE PROPER LIFTING DEVICE WHEN REMOVING OR INSTALLING THE PUMP AND GEARBOX ASSEMBLY.

ATTENTION ▲ CAUTION

THE RSD PUMP AND GEARBOX ASSEMBLIES WEIGH APPROXIMATELY 225 LBS (102 KG). USE PROPER LIFTING DEVICE WHEN REMOVING OR INSTALLING THE PUMP AND GEARBOX ASSEMBLY.

ATTENTION ▲ CAUTION

USE PPE TO PROTECT HANDS AND FINGERS FROM SHARP EDGES. THE EDGES OF THE BLADES ON THE INDUCER MAY BE SHARP.

IMPORTANT ▲ NOTICE

A MECHANICAL SEAL IS A PRECISION ENGINEERED DEVICE. CARE MUST BE TAKEN NOT TO DAMAGE THE MATING FACES (SEAL FORMING PORTION) OF THE SEAL. ENSURE THE FACES REMAIN ABSOLUTELY CLEAN THROUGHOUT THE ENTIRE INSTALLATION. SEAL FACES MUST BE CLEANED WITH THE ALCOHOL WIPES PROVIDED WITH THE REPAIR KIT.

IMPORTANT ▲ NOTICE

ALWAYS INSTALL NEW BEARINGS WHEN INSTALLING THE PUMP GEAR OR PUMP SHAFT (ESPECIALLY IF METAL WAS FOUND IN THE GEAR OIL). FAILURE TO INSTALL NEW BEARINGS MAY RESULT IN PREMATURE PUMP FAILURE OR ADDITIONAL EQUIPMENT DAMAGE.

IMPORTANT ▲ NOTICE

ALWAYS USE AND ONLY USE PAC-EASE RUBBER LUBRICANT EMULSION (OR EQUIVALENT) WHEN INSTALLING THE MECHANICAL SEAL. USING ANY OTHER LUBRICANT OR NOT USING THE LUBRICANT MAY DAMAGE THE MECHANICAL SEAL AND SEAT.

IMPORTANT ▲ NOTICE

DO NOT ALLOW PUMP GEAR TO SLIDE THRU SUPPORTS. DO NOT ALLOW THE NEW OIL SEAL TO BE CUT ON THE KEYWAY OR PINCHED BETWEEN THE ADJACENT PUMP SHAFT COMPONENTS OR BE DAMAGED IN ANY OTHER WAY. DAMAGING THE OIL SEAL WILL RESULT IN AN OIL LEAK AND POSSIBLE EQUIPMENT DAMAGE AND/OR FAILURE.

IMPORTANT ▲ NOTICE

DO NOT ALLOW THE PRESSURE ON THE INTAKE GAUGE TO GO BELOW ZERO. PLACING A VACUUM ON THE WATER MAIN MAY RESULT IN SERIOUS DAMAGE TO OR FAILURE OF THE WATER MAIN.

IMPORTANT ▲ NOTICE

DO NOT APPLY LOCTITE TO A SELF-LOCKING NUT. DO NOT REUSE A SELF-LOCKING NUT. REUSING A SELF-LOCKING NUT OR ADDING LOCTITE MAY RESULT IN THE ITEM FAILING TO BE SECURED.

IMPORTANT ▲ NOTICE

DO NOT CUT THRU THE CLEARANCE RING. CUTTING THRU THE CLEARANCE RING WILL DAMAGE THE PUMP HEAD/SUCTION HEAD/VOLUTE AND MAY RESULT IN PUMP FAILURE.

IMPORTANT ▲ NOTICE

DO NOT DRIVE THE CLEARANCE RING INTO THE /SUCTION HEAD/VOLUTE AT AN ANGLE OR UNEVENLY (ALL THE WAY FROM ONE SIDE AT A TIME). BENDING, WARPING, OR CHIPPING THE CLEARANCE RING MAY RESULT IN POOR PERFORMANCE OR PUMP FAILURE.

IMPORTANT ▲ NOTICE

DO NOT INSTALL A USED COTTER PIN. A USED PIN MAY FAIL RESULTING IN DEBRIS GOING THRU THE PUMP AND/OR LOOSENING OF THE CASTLE NUT THAT SECURES THE IMPELLER.

IMPORTANT ▲ NOTICE

DO NOT LOOSEN THE CASTLE NUT TO INSTALL THE COTTER PIN. CONTINUE TO TIGHTEN THE CASTLE NUT UNTIL THE COTTER PIN CAN BE PUSHED THRU THE HOLE IN PUMP SHAFT.

IMPORTANT ▲ NOTICE

DO NOT LUBRICATE VANES OR VANE SLOTS. USING LUBRICANT ON THE VANES OR VANE SLOTS DURING DISASSEMBLY, CLEANING, OR ASSEMBLY EVENTUALLY CAUSES A GUMMY RESIDUE TO DEVELOP, RENDERING THE SYSTEM INOPERATIVE.

IMPORTANT ▲ NOTICE

DO NOT OPEN THE THROTTLE UNLESS THE OK TO PUMP (GREEN INDICATOR LIGHT) IS ON. SEE FIGURE 9. FAILURE TO WAIT FOR THE ILLUMINATED GREEN INDICATOR MAY RESULT IN EQUIPMENT DAMAGE OR FAILURE.

IMPORTANT ▲ NOTICE

DO NOT OVER FILL THE GEARBOX. EXCEEDING THE OIL LEVEL MAY RESULT IN EQUIPMENT DAMAGE.

IMPORTANT ▲ NOTICE

DO NOT RUN THE PRIMER FOR MORE THAN 45 SECONDS IF PRIME IS NOT ACHIEVED. IF PRIME IS NOT ACHIEVED IN 45 SECONDS, STOP AND LOOK FOR CAUSES (AIR LEAKS OR BLOCKED SUCTION HOSE). RUNNING THE PRIMER FOR LONGER PERIODS WITHOUT ACHIEVING PRIME MAY RESULT IN PRIMER AND/OR PUMP DAMAGE OR FAILURE.

IMPORTANT ▲ NOTICE

DO NOT STRIKE THE IMPELLER. STRIKING THE IMPELLER MAY RESULT IN IRREPAIRABLE DAMAGE.

IMPORTANT ▲ NOTICE

DO NOT STRIKE THE INDUCER OR IMPELLER. STRIKING THE INDUCER OR IMPELLER MAY RESULT IN IRREPAIRABLE DAMAGE.

IMPORTANT ▲ NOTICE

DO NOT USE GREASE DURING GEARBOX/PUMP SHAFT ASSEMBLY. IN ALL OTHER CASES IT IS ACCEPTED PRACTICE TO HOLD COMPONENTS IN PLACE OR LUBRICATE THEM FOR EASE OF ASSEMBLY USING GREASE, HOWEVER DURING GEARBOX/PUMP SHAFT ASSEMBLY USE ONLY GEAR OIL. GREASE IS NOT COMPATIBLE WITH THE SYNTHETIC GEAR OIL AND MAY CAUSE DRAIN HOLES TO CLOG PREVENTING CRITICAL LUBRICATION.

IMPORTANT ▲ NOTICE

IF A PUMP IS OPERATED WITHOUT WATER, OR WITHOUT DISCHARGING WATER, IT MAY OVERHEAT. FAILURE TO FLOW WATER MAY DAMAGE THE MECHANICAL SEAL OR THE DRIVE MECHANISM.

IMPORTANT ▲ NOTICE

IF IN 30 TO 45 SECONDS ONE OF THE FOLLOWING (BULLETS) DOES NOT OCCUR STOP THE PUMP AND CHECK FOR AIR LEAKS OR A POSSIBLE PUMP TROUBLE.

- THE DISCHARGE GAUGE READING INCREASES
- THE INTAKE GAUGE READING FALLS BELOW ZERO
- THE PRIMING PUMP DISCHARGES WATER TO THE GROUND

CONTINUING TO RUN THE PRIMING PUMP MAY RESULT IN PUMP FAILURE OR DAMAGE.

IMPORTANT ▲ NOTICE

OIL AND GREASE (INCLUDING SKIN OILS) WILL DAMAGE THE MECHANICAL SEAL FACE. NEVER TOUCH THE MATING FACES OF THE MECHANICAL SEAL. WEAR PROTECTIVE GLOVES TO PREVENT TOUCHING THE SEAL FACES WITH YOUR BARE HANDS. (USE RUBBER, ACRYLIC, LATEX, ETC. – DO NOT USE CLOTH OR LEATHER.)

IMPORTANT ▲ NOTICE

RUNNING THE ENGINE AT SPEEDS HIGHER THAN 1200 RPM DURING PRIMING IS NOT RECOMMENDED SINCE IT WILL NOT IMPROVE PRIMING OPERATION AND MAY CAUSE DAMAGE TO THE PUMP.

IMPORTANT ▲ NOTICE

USE ONLY PAC-EASE RUBBER LUBRICANT EMULSION (OR EQUIVALENT) ON THE RUBBER MECHANICAL SEAL PARTS TO EASE INSTALLATION. USING ANY OTHER LUBRICANT CAN DAMAGE THE SEAL AND SEAT.



2. INTRODUCTION

This section provides an overview of the Flex series pumps, drives, and their options. Additionally, the section provides how to use this manual and principles of operation (including an explanation of terms and standard components).

2.1. Overview

Hale Products currently produces four models of booster pumps:

- AP
- MBP
- CBP
- RSD

Unless otherwise indicated, these procedures will apply to all models of Hale booster pumps: Any variations in operation or maintenance for the different models will be addressed within the context of this manual. The AP, CBP, and MBP booster pump maintenance technics are similar and are therefore grouped in this manual. The RSD booster pump maintenance technics differ significantly and are presented separate from the AP, CBP, and MBP booster pumps.

Hale booster pumps are the favorite of fire fighters throughout the world. Booster pumps can be used as initial attack pumps or as auxiliary pumps in conjunction with the apparatus main pump. Covering a range of capacities from 20 gpm (75 Lpm) to 1500 gpm (5,678 Lpm), Hale booster pumps offer the versatility, dependability, reliability, small size, and ease of operation so necessary for effective firefighting.

Hale booster pumps are of a compact size and lightweight design for easy mounting on the apparatus chassis. The pump coupled with the new aluminum gearbox allows the apparatus builder to only supply the PTO and connecting shaft or direct engine mount a Flex series single stage booster pump.

2.2. How To Use This Manual

This manual was developed for the purposes of FAST team and OEM support. This manual provides information and procedures to perform three levels of pump maintenance and impeller renewal. The manual also provides information to be used to troubleshoot and R&R failed components based on the three levels of repair and impeller renew kits available from Hale Products Inc. The repair/impeller renew kits support pump maintenance, repair, and rebuild.

This manual requires the use of the both the Hale Assembly drawings and the Parts Manual For Hale Single Stage Booster Pumps (FSG-MNL-00185) for parts identification. Use the Parts Manual to determine the drawing sheet (or sheets) required for reference. Then use the drawing(s) to locate the part and the item number associated with that part. The item number also appears listed (in numerical order) in the parts table along with the part number, description, and quantity for that item number.

The Introduction section is of interest to management for pump familiarization, visual recognition, pump identification documentation, and risk assessment information.

The Safety section is of interest to both management and maintainers as it provides precautions for maintenance (including operation for maintenance purposes) and definitions of warnings, cautions, and notes. This section also provides a summary of both PPE and a DANGER/ WARNING/CAUTION/NOTICE summary. The section provides a single point view of compiled hazards and PPE in a condensed format. The appropriate DANGER, WARNING, CAUTION, or NOTICE and PPE list also appears at each point of use throughout the manual.

The two Maintenance sections provide all aspects of maintaining the AP, CBP, MBP, and RSD pumps, including sparing, preventive and corrective maintenance (which includes troubleshooting and remove and replace instructions). Notice that the use of this manual also requires maintenance personnel to have received Hale training prior to using it. Use Hale Training Academy (Pumping And Maintenance) training (see paragraph 1.3, Training) and the two Maintenance sections for all aspects of maintaining the pumps.

Within the two Maintenance sections, the troubleshooting provided utilizes SCR tables which provide the list of known symptoms associated with a pump trouble/problem/failure. To use a SCR table, locate the indicated SYMPTOM, verify the associated CAUSE (the maintainer must verify ALL the associated causes if multiple causes are listed) and then perform the associated REMEDY (or remedies). The R&R procedures provide pump removal from the apparatus via two separate methods: removing a pump as a complete assembly or removing only the pump portion leaving the gearbox in the apparatus. Once removed the subsequent pump or gearbox repairs are treated as bench procedures each covering a specific level (1, 2, 3, or renewal) of maintenance. Each level of maintenance requires the associated repair kit be utilized. Utilizing the associated repair kit ensures all the required components are available for replacement. Utilizing the repair kits as intended prolongs pump performance and supports the manufacturer's warranty.

Performing a procedure is NOT the ONLY key action in maintaining a pump, documentation of the pumps Preventive Maintenance, R&R, and SYMPTOM/REMEDY history (including meaningful tracking of when each issue occurred) is also key to maintaining each pump. A maintenance log with meaningful entries will provide invaluable insight, time/money savings (in reduced down time and shorted troubleshooting time), and cost savings over the life cycle of each pump.

2.3. Pump Specifications And Numbering

Hales policy is one of continuous development. Hale therefore reserves the right to amend specifications without notice or obligation. Refer to Section 2.2, Pump Specifications And Numbering, in the Hale OIM manual (FSG-MNL-00183) for serial number locations, model number definitions, and major pump features. Refer to the Hale Products website (www.haleproducts.com) for detailed booster pump specifications. NOTE: Using your pumps serial number and the Hale website (or Customer Service) is the best way to ensure you receive/utilize the correct replacement parts for your pump.

2.4. Principles Of Operation

Hale booster pumps are centrifugal pumps that operate on the principle that centrifugal force is created by a rapidly spinning disk. Figure 1 shows an amount of water has been placed at the center of a disk. The disk is rotated and the water is thrown outward from the center to the edge of the disk. The velocity at which the water travels from the center directly relates to the diameter of the disk and the speed of rotation. When water is confined in a closed container (such as the volute), the velocity is converted to pressure; pressure is therefore, dependent on the speed of rotation.

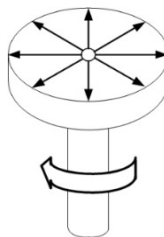


Figure 1. Centrifugal Force From A Rotating Disk

There are three interrelated factors that regulate the performance of a centrifugal pump:

Speed (RPM):

If the speed of rotation increases with the flow held constant, the water pressure increases.

Pressure:

Pressure is usually expressed in psi or bar. If pressure changes and speed is constant, the flow will change inversely (if pressure increases, flow decreases).

Flow:

Flow is usually expressed in gpm or Lpm that a pump can deliver when supplied from draft. If the pressure is held constant, the flow will increase with an increase in the speed of rotation.

The centrifugal pump is preferred by the fire protection service due to its ability to fully utilize any positive inlet pressure, reducing the strain on the pump.

For example, if the required discharge pressure is 120 psi (8 bar), and the inlet pressure is 45 psi (3 bar), the pump must only produce the difference in pressure of 75 psi (5 bar). This contributes to low engine and pump speeds which reduces wear on the pump. Another important benefit is the centrifugal pump has basically only two moving parts; the impeller and the shaft.

As shown on Figure 2, during operation water enters the suction eye of the impeller (intake). The rotating impeller vanes develop discharge pressure and direct the water to the discharge opening. The cutwater is a wedge that divides the water between the volute (a single chamber diffuser) and the pump discharge.

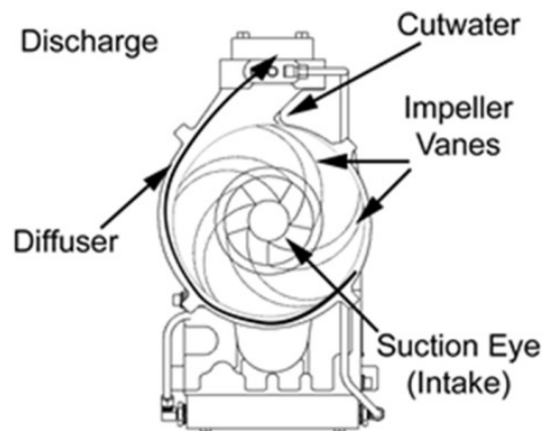


Figure 2. Single Stage Water Flow

2.4.1 Explanation Of Terms

The following major terms are explained in sufficient detail to allow a maintainer to communicate pumping issues or troubles with Hale Customer Service personnel. As a basic understanding of the terms (and the principles associated with them) will assist operators (for both operations and maintenance purposes) utilize common terminology and understand accepted principles when communicating among each other.

2.4.1.1 Atmospheric Pressure (Static Air Pressure)

Air pressure is 14 pounds (AKA psi) at sea level. Pressure increases below sea level and decreases above sea level due to the increased or decreased volume of air pushing down at that height. In addition to the amount of air, weather also effects air pressure. Air in a high pressure

area compresses and warms as it descends. The warming inhibits the formation of clouds, meaning the sky is normally sunny in high pressure areas. But haze and fog still might form. Just the opposite occurs within an area of low atmospheric pressure. Atmospheric pressure affects a pumps ability to pump from draft. Higher pressures will increase a pumps performance, while lower pressures can cause a noticeable decrease in lift.

2.4.1.2 Cavitation

The definition of cavitation is the formation of empty cavities (low-pressure bubbles) in a liquid being moved by means of mechanical force (such as the rotation of an impeller) which is then followed by their immediate and sudden implosion. The resulting forces can be as damaging as striking the metal with a hammer. Cavitation within a pump may sound as if the pump were filled with gravel or being struck with a hammer. See Section 3.5, Cavitation (Details), for more details.

2.4.1.3 Dead Heading

Operating a pump without any discharge is known as dead heading. Lack of flow causes temperatures to rise inside the pump.

2.4.1.4 Impeller And Clearance Rings

The impeller is the primary working part of a centrifugal pump. The impeller moves the water. An impeller consists of two discs surrounding curved vanes. The vanes force water to rotate within the discs resulting in the water being thrown outward at high velocity. The water from the impeller discharges into the volute, converting the high velocity energy into pressure.

The clearance rings minimizes the amount of water that bypasses the discharge and returns to the suction side of the impeller reducing pump performance (gpm). The wrap around clearance ring reduces the bypass even more than the typical style ring (see Figure 3). Clearance rings are wear items that protect the volute from experiencing the wear generated by the moving water and especially the debris (sand, salt, etc.) when present.

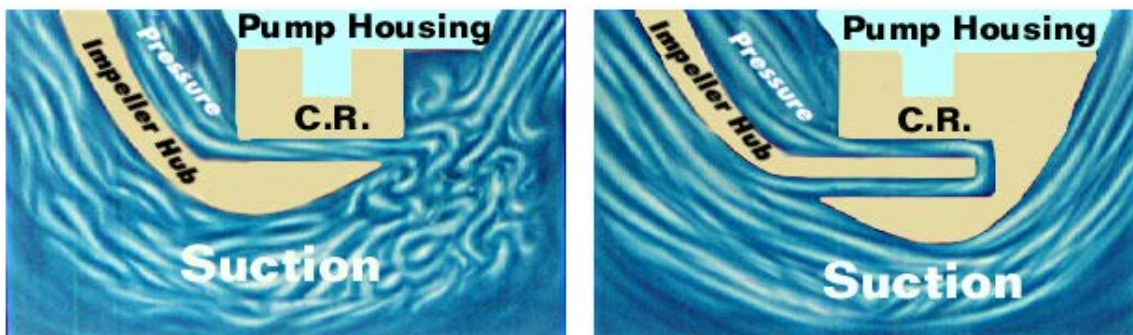


Figure 3. Clearance Ring Water Flow

2.4.1.5 Priming Pump

An auxiliary pump attached to provide positive displacement of air out of the booster pump creating a vacuum which initially draws water into the pump. The type of priming pump used (by Hale) for the AP, CBP, MBP, and RSD pumps is an electric motor driven rotary vane pump. Once the main pump is primed and pumping, the priming pump is turned off.

2.4.1.6 Relief Valve

An automated valve with a control mechanism that maintains the pump pressure within 30 psi when the pump discharge is gated (reduced) or closed (off). The valve maintains a set pressure by diverting a portion of the pump discharge flow into the pump suction.

2.4.1.7 PM Relief Valve Control

The PM indicates a panel mounted hand-adjustable valve. When set to the desired pressure, the relief valve will maintain the desired pump discharge pressure and limit a pressure increase to no more than 30 psi (2 bar).

2.4.1.8 Volute

The increasing discharge path of the pump, its function is to collect the water from the impeller and depending on its design can either increase pressure and decrease velocity or increase velocity and decrease pressure.

2.4.2 Standard Booster Pump Components

All Hale Flex Series single stage booster pumps (AKA the standard pump) consist of the following:

- Volute
- Impeller
- Mechanical Seal
- Gearbox
- Gears (Drive, Mating/Pump)
- Shaft Assemblies (Input, Pump)

Figure 4 shows these standard parts of a Hale booster pump. These parts are briefly described in the following paragraphs.

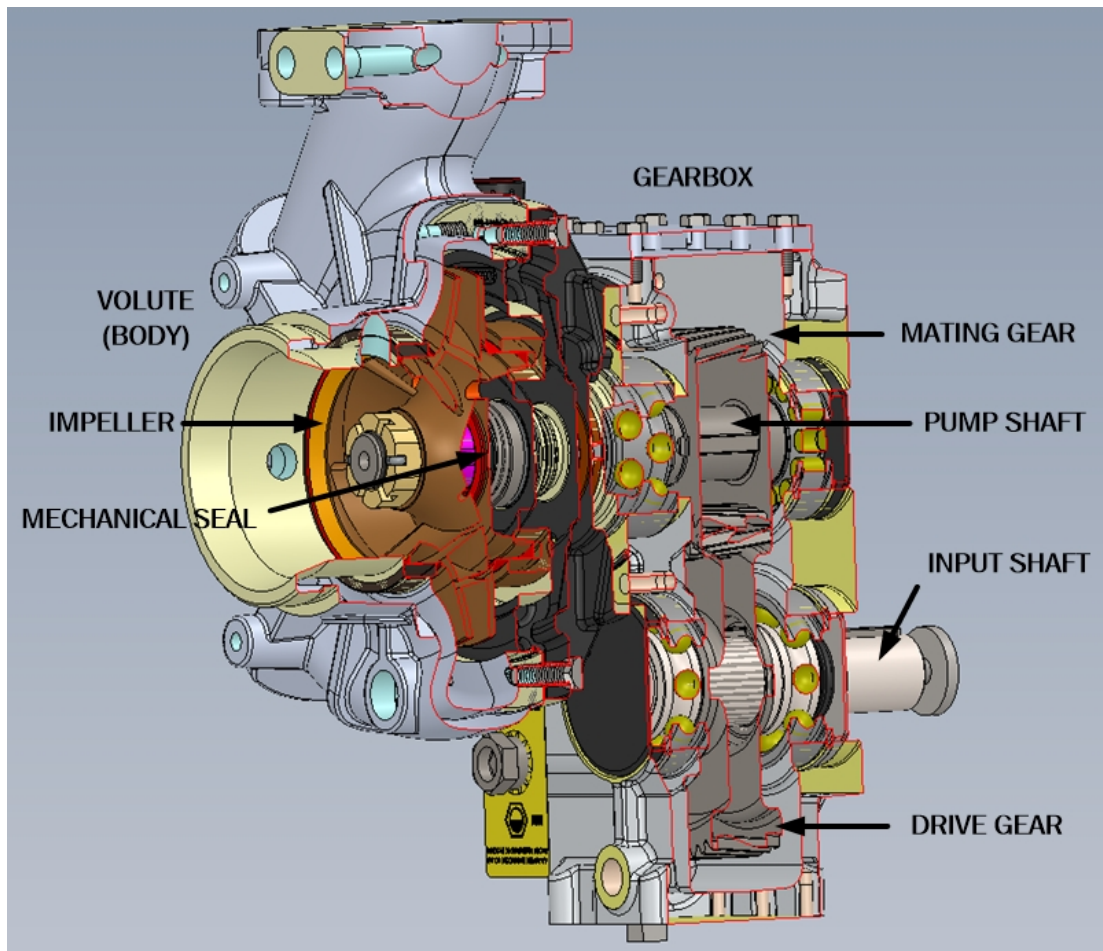


Figure 4. Parts Of The Hale Booster Pump

2.4.2.1 Volute

The Hale AP, CBP, and MBP single stage booster volutes (body) are a single-piece casting. Service of the impeller, clearance rings, and mechanical seal is accomplished by removing the volute from the assembled pump head and gearbox. The Hale RSD single stage booster volute is a three-piece casting, with service of the impeller, clearance rings, and mechanical seal accomplished by removing ONLY the appropriate piece of the volute required to access the component requiring service.

All volutes are constructed from fine grain cast iron. For areas where salt water is commonly used, a bronze version of each booster pump is available.

The Hale Flex Series single stage booster pumps support multiple discharge port configurations. Depending on the model, the pumps provide between 12 and 24 different configurations (including both rotations – ER or OER). Refer to the Parts Manual For Hale Single Stage Booster Pumps (FSG-MNL-00185), Section 2, Hale Booster Pump Illustrated Breakdowns, (Gearbox And Discharge Positions paragraphs) for a reference to the appropriate drawing and sheet number(s) providing the views of the volute positions.

2.4.2.2 Impeller And Shaft Assembly

The impeller provides velocity to the water. The impeller is made of high quality bronze and is mounted on a stainless steel shaft that is rotated by the gearbox. Water enters the rotating impeller at the intake (or eye). The vanes guide water from the intake to the discharge. Vanes curve away from the direction of rotation so water moves toward the outer edge (see Figure 2). The shrouds (discs) form the sides of the impeller and keep the water confined to increase acceleration and pressure. The back of the impeller houses the rotating portion of the mechanical seal.

2.4.2.3 Mechanical Seal

The mechanical seal is common to all Hale booster pumps. Figure 5 shows a stationary seat is in constant contact with a rotating seal ring to prevent leakage. The seal ring/diaphragm is specifically designed for high-temperature, low friction, self-adjusting, dependable operations.

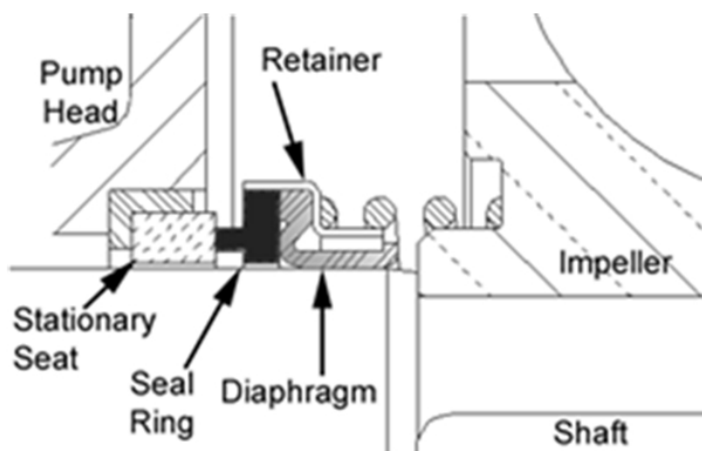


Figure 5. Mechanical Seal

IMPORTANT ⚠ NOTICE

IF A PUMP IS OPERATED WITHOUT WATER, OR WITHOUT DISCHARGING WATER, IT MAY OVERHEAT. FAILURE TO FLOW WATER MAY DAMAGE THE MECHANICAL SEAL OR THE DRIVE MECHANISM.

2.4.2.4 Gearbox

The gearbox is cast aluminum and machine finished. The gearbox can be mounted in any one of six positions. Refer to FSG-MNL-00185 (Parts Manual For Hale Single Stage Booster Pumps), paragraph 2.1, (Gearbox Illustrated Breakdowns) for a reference to the appropriate drawing and sheet number providing the views of the gearbox positions available.

Inside the gearbox a gear set transfers power from the input shaft, made of heat treated nickel steel, to the pump shaft to turn the impeller at the appropriated speeds, which are determined by the gear ratio of the gear set selected. Hale offers a variety of pump gear ratios to accommodate a wide range of end-user and apparatus manufacturer requirements based on the pump's intended use, horsepower and speed rating of the engine, or the torque rating of the transmission PTO or hydraulic drive. Refer to FSG-MNL-00185 (Parts Manual For Hale Single Stage Booster Pumps), paragraph 2.1, (Gearbox Illustrated Breakdowns) for a reference to the appropriate drawing and sheet number providing the gear ratio listings available.

2.5. Pump Drives

The Hale Flex Series pumps support the common types of booster pump drives used on fire-fighting apparatus:

- The most common drive is the PTO mounted on the truck transmission or four-wheel drive transfer case, which allows for pump and roll operation.
- Hydraulic motor mounting via SAE J744 "C" adapter.
- Direct engine mounting via SAE #3 (or #4) flywheel housing.

Hale booster pumps are built to produce the volumes and pressures shown on their respective performance curves and specifications (see paragraph 2.3, Pump Specifications And Numbering). However, the maximum pump performance safely obtainable is dependent on the torque rating of the PTO system or hydraulic system.

The apparatus builder can provide various pump performance spots that will define the torque limit of the PTO in terms of gpm and psi. When pumping continuously, care should be taken not to overheat the PTO, transmission or transfer case.

Hale booster pumps are available for either engine rotation or opposite engine rotation PTO operation. Since some PTOs match engine rotation and some turn opposite of the engine rotation, each pump model can be built to match the rotation of the PTO.

NOTE

Please refer to Hale Bulletin #886 and F-72 (Hale Torque Limit Chart) for further assistance in selecting the correct Flex series booster pump PTO.

Hale booster pumps are also available with an adapter that allows direct engine mount. Figure 6 shows the available flywheel housing (SAE #3 or #4) with the gearbox in the inverted configuration and the volute in the up configuration.

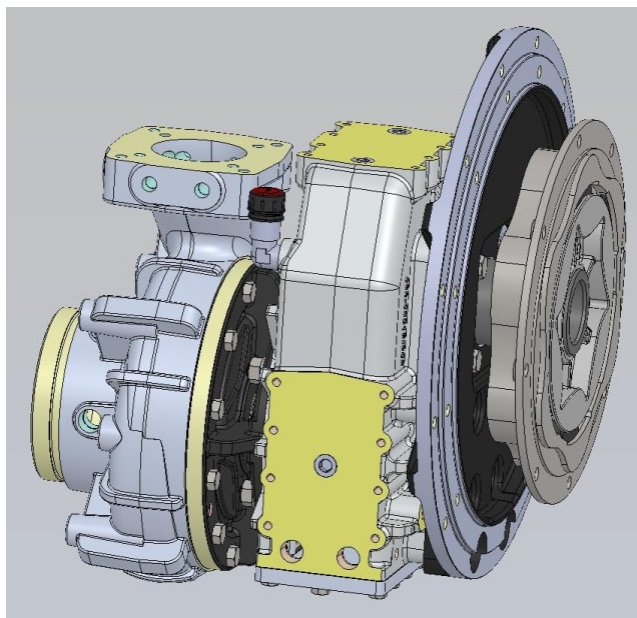


Figure 6. Direct Engine Mount

2.6. Optional Pump Components

In addition to the basic parts of Hale booster pumps described above, the following items are available to enhance pump operation:

- Anodes
- TRVs

2.6.1 Anodes

The Hale anode system (Figure 7) helps prevent pump damage caused by galvanic corrosion.



Figure 7. Hale Anode

Galvanic action pits the pump and pump shaft material. The popularity of non-corrosive water tanks and piping has increased this type of corrosion in today's fire pumps. The Hale anode system is a sacrificial metal, which helps prevent corrosion. A Hale makes an anode that will fit on any Hale truck mounted pump, regardless of age or model. The RSD uses Hale anodes designed to be easily installed **ONLY** requiring four bolts and a gasket. Total time to install is just fifteen minutes or less, yet it will provide years of protection for the pump. The anode kit is designed for installation in the standard Hale 115 series flange opening located on the side of the RSD volute (K port). On fabricated manifolds and similar applications, the installer is to provide 1-1/4-in NPT openings and install anodes directly. It is recommended that one anode be installed on the suction side and one on the discharge side.



2.6.2 TRVs

Hale optional offers a thermal relief valve in two temperature ranges and with remote indication.

- TRV-120
- TRV-170
- TRV-L

The TRV is a thermal relief valve that acts as a thermostat and opens when the temperature of the water in the pump exceeds 120 °F (TRV-120) or 170 °F (TRV-170) and resets (closes) when the water cools. The RSD utilizes the standard Hale 115 series flange opening located on the side of the volute (K port) and a flange adapter to house the TRV. For all other Flex series booster pumps the TRV must be installed on a fabricated manifold and similar application and the installer is to provide 1-1/4-in NPT opening and install the TRV close to the volute discharge port. The TRV discharge water should be directed to the ground or back to the booster tank, helping to keep the pump cool and avoiding premature wear and damage.

The TRV-L is a TRV (120 °F or 170 °F) with the added feature of a remoted indicator (audible and visual) panel to show when the TRV is open and flowing water. The indicator panel also has an integral test switch.



3. MAINTENANCE OPERATING PROCEDURES

This section provides information and procedures for the operation of Hale booster pumps for the purpose of performing maintenance. Maintenance operating procedures differ greatly from typical operations. Typical operations are based on the pump being installed in a firefighting apparatus and include pumping from: an onboard tank, or a hydrant, or from draft. Operating procedures for maintenance purposes include pump performance verification, repair verification, and troubleshooting and unless otherwise indicated, these instructions apply to all Hale booster pumps.

ATTENTION ⚠ WARNING

THE PROCEDURES IN THIS SECTION PROVIDE ONLY GENERAL/MINIMAL INSTRUCTION. DO NOT REPLACE LOCAL PROCEDURES OR POLICIES OR RECOMMENDATIONS AND PROCEDURES PROVIDED IN THE APPARATUS/TRUCK/UNIT MANUAL WITH THESE PROCEDURES.

ALWAYS FOLLOW LOCAL GUIDELINES FROM THE AHJ AND THE APPARATUS MANUFACTURER.

ALWAYS FOLLOW PROPER OPERATING PROCEDURES. THE PUMP OPERATOR MUST BE FAMILIAR WITH THE PUMP OPERATING INSTRUCTIONS AS WELL AS OTHER OPERATING GUIDELINES FOR THE APPARATUS AND ACCESSORIES.

A PRESSURE HAZARD MAY EXIST EVEN WHEN THE PUMP IS NOT RUNNING. PRIOR TO REMOVING HOSES OR CAPS FROM PUMP CONNECTIONS, RELIEVE PRESSURE BY OPENING DRAINS. BLEEDER VALVES SHOULD ALSO BE USED WHEN CONNECTING TO AN INTAKE FROM A PRESSURIZED SOURCE.

DO NOT EXCEED OPERATING PRESSURE LIMITS OF PUMP, INSTALLED PLUMBING, HOSE(S), OR EQUIPMENT IN USE.

OPERATORS, INSTALLERS, AND MAINTENANCE PERSONNEL MUST BE TRAINED AND QUALIFIED FOR ALL THE ACTIVITIES THEY PERFORM.

ATTENTION ⚠ CAUTION

FAILING TO REDUCE SYSTEM PRESSURE BEFORE SYSTEM SHUTDOWN OR FLUSHING COULD RESULT IN WATER HAMMERING.

IMPORTANT ⚠ NOTICE

IF IN 30 TO 45 SECONDS ONE OF THE FOLLOWING (BULLETS) DOES NOT OCCUR STOP THE PUMP AND CHECK FOR AIR LEAKS OR A POSSIBLE PUMP TROUBLE.

- THE DISCHARGE GAUGE READING INCREASES
- THE INTAKE GAUGE READING FALLS BELOW ZERO
- THE PRIMING PUMP DISCHARGES WATER TO THE GROUND

CONTINUING TO RUN THE PRIMING PUMP MAY RESULT IN PUMP FAILURE OR DAMAGE.

Utilize the testing provided herein ONLY for the intended purpose. The Repair Verification Operations procedure (paragraph 3.1) is intended as the initial post repair test for a repaired booster pump and the paragraphs description explains why. If the pump passes the Repair Verification Operations procedure proceed with the Pumping From Draft Verification Operations procedure (paragraph 3.4 on page 23). ALWAYS verify a repaired pumps drafting ability before returning the pump to service.

The Vacuum Test (paragraph 3.2 on page 20) is intended as the initial check to determine if a pump leaks. This test quickly and safely indicates if a leak exists however it typically **ONLY** indicates a leak is present and usually does **NOT** locate the leak (or leaks). If a pump fails the Vacuum Test utilize the Pressure Test (paragraph 3.3 on page 22) to locate the leak (or leaks).

3.1. Repair Verification Operations

Perform the following steps when a repair is completed to verify the pump is functional. This procedure is performed by pumping from a hydrant to ensure a clean, high quality water source and to eliminate the risk of pump damage that could occur from an extended priming period which could result from attempting to draft with an unverified pump.

NOTES

Refer to department procedures for setting wheel chocks and laying out suction and discharge hoses.

All valves, drain cocks, and caps should be closed.

A. Prepare truck to pump.

1. Position truck for best hydrant hookup and discharge hose layout.
2. Bring truck to a complete stop and come to an idle. (Never attempt to shift a moving truck from **ROAD** to **PUMP**.)
3. Apply truck parking brake.
4. Shift truck transmission into **NEUTRAL**.
5. Engage pump PTO switch.
6. Shift road transmission into proper gear (usually **DRIVE**).
7. Check the indicator lights to see if pump is in gear, check speedometer, and listen as pump goes in gear.
8. Momentarily press accelerator to ensure shift is complete.

ATTENTION ⚠ WARNING

DO NOT LEAVE THE CAB OR ATTEMPT TO PUMP UNTIL ALL OK TO PUMP INDICATORS IN THE CAB ARE ILLUMINATED. SEE FIGURE 8.

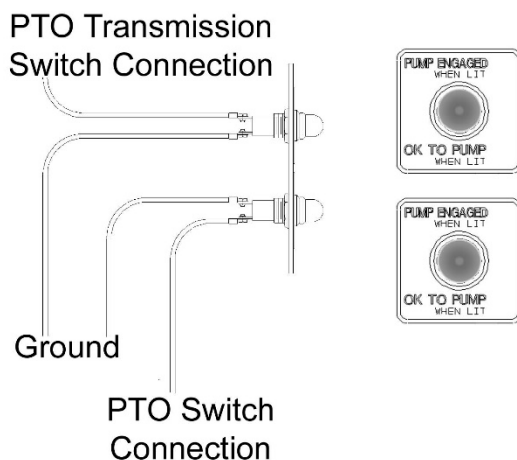


Figure 8. Driver Compartment Indicator Lights

9. ONLY after completing ALL previous steps, exit driving compartment.

IMPORTANT ▲ NOTICE

DO NOT OPEN THE THROTTLE UNLESS THE GREEN INDICATOR LIGHT IS ON. SEE FIGURE 9.

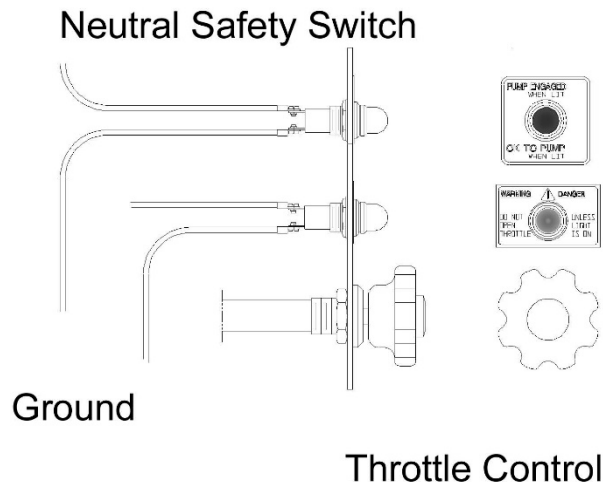


Figure 9. Pump Operator Panel

10. Verify pump panel shift indicator light is on.
 11. Set wheel chocks.
 12. Complete all hose connections.
- B. Prepare pump to pump.
1. Open hydrant and bleeder valves (to bleed off air in suction hose).
 2. Open suction valve.
 3. If necessary to eliminate air pockets, prime pump.
(For instructions, see paragraph 3.2, Pumping From Draft, on page 20.)
 4. Slowly open appropriate discharge(s).
 5. Advance engine throttle gradually until master discharge gauge indicates desired pressure.

IMPORTANT ▲ NOTICE

DO NOT ALLOW THE PRESSURE ON THE INTAKE GAUGE TO GO BELOW ZERO. PLACING A VACUUM ON THE WATER MAIN MAY RESULT IN SERIOUS DAMAGE TO OR FAILURE OF THE WATER MAIN.

NOTES

The master intake gauge reading must be maintained at 5 psi (0.3 bar), minimum. If the gauge shows a vacuum the pump is attempting to draw more water than the hydrant can supply. When this occurs, reduce the pump flow to increase the pressure.

As the throttle is opened, the pressure gauge reading should increase with the engine speed. If the engine speed increases without an increase in pressure, the pump is beginning to cavitate. Close the throttle slowly until the pressure begins to drop and the engine returns to an idle.

6. If pump overheats, perform appropriate following step.
 - a) If pump is NOT equipped with a Hale TRV valve, open appropriate valve(s) (usually tank fill or gutter line) to provide a bypass line.
 - b) If pump is furnished with a Hale TRV valve, open valve to booster tank (both suction and discharge sides) to circulate water (and/or fill water tank).
- C. Verify pump is operating correctly by checking ALL gauge readings.
- D. Begin shutdown.
 1. Gradually reduce throttle and pump pressure until engine is at idle speed.
 2. Close discharge(s).
 3. Ensure tank is full of water.
 4. If opened, close bypass line valve(s) or TRV.
 5. Close suction valve.
 6. Place transmission in NEUTRAL.
 7. Disengage PTO.
 8. Close hydrant.
- E. Disconnect all hose connections and stow hoses.
- F. Make all appropriate Maintenance Log entries.
- G. Perform Pumping From Draft Verification Operations procedure (see paragraph 3.4 on page 23).

3.2. Vacuum Test

Refer to Table 1 for a list of tools and/or consumables required for this procedure.

Table 1. Vacuum Test Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye, Hand, and Ear Protection)	30 inHg Vacuum Gauge (or Manometer) (Use ONLY a High Quality Calibrated Gauge/Manometer)	Shop Rag(s) (As Required)
		Blanking Cap(s) (As Required)
		Tachometer

This test is intended to ONLY test the booster pump for leaks. A known good vacuum pump is preferred for this test. However, if the apparatus has a primer pump, that primer can be used for this test to verify both are leak free and the primer does NOT exhibit excessive wear or damage. If the apparatus associated primer does NOT reach a vacuum of 22 (\pm 2) inHg (0.745 bar) but holds a lower vacuum, a fault in the primer is indicated. Perform the following steps to Vacuum Test a pump.

- A. Place blanking cap(s) on pump inlet(s).
- B. If no apparatus primer is present, connect a known good primer or vacuum pump (along with a vacuum/compound gauge) to highest discharge port.
- C. Close discharge valve(s) or place blanking cap(s) on pump outlet(s).

IMPORTANT ▲ NOTICE

DO NOT RUN THE PRIMER FOR MORE THAN 45 SECONDS IF PRIME IS NOT ACHIEVED. IF PRIME IS NOT ACHIEVED IN 45 SECONDS, STOP AND LOOK FOR CAUSES (AIR LEAKS OR BLOCKED SUCTION HOSE). RUNNING THE PRIMER FOR LONGER PERIODS WITHOUT ACHIEVING PRIME MAY RESULT IN PRIMER AND/OR PUMP DAMAGE OR FAILURE.

NOTE

NFPA 1901 recommends: The time required to prime the pump if the rated capacity is 1250 gpm or less shall not exceed 30 seconds. If the rated capacity is 1500 gpm or more, the time to prime the pump shall not exceed 45 seconds.

- D. Run primer pump and observe vacuum/compound needle as follows.
 - 1. When 22 (\pm 2) inHg (-0.745 bar) of vacuum is obtained, stop primer/vacuum pump.
 - 2. Pump under test shall maintain this vacuum.
 - a) For at least 15 seconds.
 - b) And NOT drop more than 2 inHg (0.07 bar) in 1 minute.
 - c) And NOT drop more than 10 inHg (0.33 bar) in 5 minutes.

NOTES

If pump does NOT hold at least 22 (\pm 2) inHg (0.745 bar) of vacuum with the blanking caps in position, a leak is present in the apparatus/pump, and a pressure test must be performed to trace the leak.

If the apparatus/pump can NOT reach a vacuum of 22 (\pm 2) inHg (0.745 bar) but holds a lower vacuum, a fault in the primer pump is indicated. NOT reaching an acceptable vacuum AND NOT being able to locate a leak may indicate excessive wear in the primer.

Even though the apparatus meets the NFPA minimum leakage requirement, a small air leak in the wrong spot will reduce pump performance. Preferably, your performance should exceed the minimum set by NFPA. In reality, the 10 inHg. in 5 minutes was allotted for pump shaft packing adjustment and not for plumbing or valve leaks. Since all Hale two stage booster pumps utilize a mechanical seal, the vacuum drop over a 5-minute period should be insignificant.

- E. If pump passes Vacuum Test.
 - 1. Remove all test plates and primer.
 - 2. Complete maintenance log entry(ies).
 - 3. Return booster pump to service.
- F. If pump fails Vacuum Test perform Pressure Test.
(See paragraph 3.3, on page 22.)

3.3. Pressure Test

This test is to be carried out ONLY if the pump will not hold a vacuum with blanking cap(s) in position, and is intended to trace the leak(s) responsible for the loss of vacuum. This test is conducted without the pump running. Refer to Table 2 for a list of tools and/or consumables required for this procedure.

Table 2. Pressure Test Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
		Pressurized Water Source (50 to 100 psi)

Perform the following steps to pressure test a pump.

- A. Place blanking cap(s) on pump inlet(s) and outlet(s).
- B. Attach pressurized water source. (Can be attached via a blanking plate or pump plug.)
- C. Apply a water pressure of 50 – 100 psi (3.5 – 7.0 bar or 350 – 700 kPa) to pump.
- D. Check for leaks.
 1. Visually inspect all drain/relief valves for water leakage.
 2. Visually inspect all external fittings/hoses on pump for water leakage.
 3. Visually inspect all external areas/surfaces of pump for water leakage.
 4. Visually inspect all external areas/surfaces of primer assembly for water leakage.
 - a) If leakage is found, replace the primer seals and O-rings. Refer to paragraph C.3.3.3, ESP Primer Maintenance, in APPENDIX C.
 - b) If leakage persists, replace primer assembly.

If the pump will not achieve 22 (\pm 2) inHg (-0.745 bar or -74.5 kPa) of vacuum, and will not hold what it does achieve, there is a leak. It may possibly be a fault in the primer (if apparatus is so equipped) or the pump shaft seals.

If the apparatus priming pump was used for the Vacuum Test (or was attached to the pump during pressure testing) and no external leaks are apparent, first check the primer (ONLY if the apparatus is so equipped and the primer was attached during testing). Primer points to check are:

- Low charge on or batteries not of sufficient size.
- Electrical connectors on cable dirty or bad ground.
- Primer vanes worn.
- Priming valve not fully opening (operator error).

If a fault in the primer is NOT indicated check the pump shaft seals and the gearbox cooling tube. Pump shaft seal and cooling tube points to check are:

- Water in the gear oil.
- Gear oil in the discharge or drain ports.

Complete all associated maintenance log entries.

3.4. Pumping From Draft Verification Operations

This test is ONLY conducted to verify a pump can now pump from draft when the fault repaired prevented the failed pump from pumping from draft. Perform the following test ONLY when required to verify a pump repair has corrected a failure to pump from draft (lakes, ponds, streams and other non-pressurized water supplies). This test is intended to be conducted under controlled conditions and NOT from a randomly available/selected water source.

NOTE

This test is intended to be conducted using a known lift under controlled conditions. The pump can ONLY draw 100% of its rated capacity with less than a 10 ft vertical lift. As the lift increases to above 10 ft, the pump capacity will be reduced and a conclusive test can NOT be conducted.

- A. Prepare truck to pump from draft.
 1. Position apparatus at test pit or other predetermined testing water source.
 2. Bring truck to a complete stop.
 3. Apply truck parking brake.
 4. Shift truck transmission into NEUTRAL.
 5. Engage pump PTO.
 6. Shift road transmission into proper gear (usually DRIVE).
 7. Check indicator lights to see if pump is in gear, check speedometer, and listen as pump goes in gear.
 8. Momentarily press accelerator to ensure shift is complete.

ATTENTION ⚠ WARNING

DO NOT LEAVE THE CAB OR ATTEMPT TO PUMP UNTIL ALL OK TO PUMP LIGHTS IN THE CAB ARE ILLUMINATED. SEE FIGURE 8.

9. ONLY after completing ALL previous steps, exit driving compartment.

IMPORTANT ⚠ NOTICE

DO NOT OPEN THE THROTTLE UNLESS THE GREEN INDICATOR LIGHT IS ON. SEE FIGURE 9. FAILURE TO WAIT FOR THE ILLUMINATED GREEN INDICATOR MAY RESULT IN EQUIPMENT DAMAGE OR FAILURE.

10. Verify pump panel shift indicator light is on.
11. Open Tank-to-Pump valve. (Prevent pump from running dry as quickly as possible.)
12. Set wheel chocks.
13. Complete all hose connections and close all discharges.
 - a) Ensure intake hose is free of humps and sharp bends and no part of hose is higher than pump intake inlet. (Air pockets in the intake hose may cause loss of prime or erratic pump action, and may reduce pump capacity.)
 - b) Ensure all intake connections are tight and all discharge valves are closed.



B. Prime pump.

IMPORTANT ▲ NOTICE

RUNNING THE ENGINE AT SPEEDS HIGHER THAN 1200 RPM DURING PRIMING IS NOT RECOMMENDED SINCE IT WILL NOT IMPROVE PRIMING OPERATION AND MAY CAUSE DAMAGE TO THE PUMP.

IMPORTANT ▲ NOTICE

IF IN 30 TO 45 SECONDS ONE OF THE FOLLOWING (BULLETS) DOES NOT OCCUR STOP THE PUMP AND CHECK FOR AIR LEAKS OR A POSSIBLE PUMP TROUBLE.

- **THE DISCHARGE GAUGE READING INCREASES**
- **THE INTAKE GAUGE READING FALLS BELOW ZERO**
- **THE PRIMING PUMP DISCHARGES WATER TO THE GROUND**

CONTINUING TO RUN THE PRIMING PUMP MAY RESULT IN PUMP FAILURE OR DAMAGE.

1. Immerse intake strainer at least two feet below water surface to prevent pump from drawing air. (If whirlpools form above intake strainer the strainer is too close to the surface of the water.)
2. Make sure intake strainer is far enough from the bottom to prevent sand, gravel and other foreign matter from being drawn into the pump.

NOTE

The pump is primed when the intake indication reading falls below zero, and the discharge pressure starts to increase. Water may also be heard discharging to the ground.

3. If apparatus is equipped with a priming pump, activate priming pump. (Pull control handle located on pump panel.) Otherwise, slowly open appropriate discharge(s) and advance engine throttle gradually until master discharge gauge indicates desired pressure.
4. Monitor intake and discharge master gauges.

NOTE

As the throttle is opened, increase the pressure gauge reading with engine speed. If the engine speed increases without an increase in pressure, the pump is nearing cavitation.

C. Verify pump performance.

1. Set automatic control/relief valve per department policy. If no department policy exists, refer to paragraph 3.6, Relief Valve Procedures, on page 30.
2. If pump overheats, perform appropriate following step.
 - a) If pump is NOT equipped with a Hale TRV valve, open appropriate valve(s) (usually tank fill or gutter line) to provide bypass line.
 - b) If pump is furnished with a Hale TRV valve, open valve to booster tank (both suction and discharge sides) to circulate water (and/or fill water tank).
 - c) Verify pump is operating correctly by checking ALL gauge readings.

- D. Begin shutdown.
 1. Reduce engine speed to idle.
 2. Close discharge valves.
 3. If opened, close bypass line valve(s) or TRV.
 4. Close suction valve.
 5. Place transmission in NEUTRAL.
 6. Disengage PTO.
- E. Disconnect all hose connections and stow hoses and strainers.
- F. Make all appropriate Maintenance Log entries.
- G. Return pump/apparatus to service.

3.4.1 Draft Limiting Factors

The effect of raised water temperatures when pumping from a positive pressure source (hydrant) is negligible on fire pump performance. But when pumping from draft, elevated water temperature does have a limiting effect. Water temperatures above 90° F (32° C) will cause a noticeable decrease in lift when drafting. (See Table 3 for additional losses beyond NFPA rating baseline.) Another factor that can limit lift is barometric pressures below 29 inHg. It is important to be aware of environmental conditions when drafting.

Table 3. Additional Losses Beyond NFPA Rating Baseline

Water Temp ° F (° C)	Lift Loss In Hd Ft (Hd M)	Water Temp ° F (° C)	Lift Loss In Hd Ft (Hd M)	Water Temp ° F (° C)	Lift Loss In Hd Ft (Head M)
60 (16)	NFPA Baseline	80 (27)	0.6 (0.18)	100 (38)	1.7 (0.52)
70 (21)	0.3 (0.09)	90 (32)	1.1 (0.34)	110 (43)	2.5 (0.76)

3.5. Cavitation (Details)

Cavitation (see definition – paragraph 2.4.1.2 on page 10) can occur while pumping from draft, in relay, or from a hydrant. The operator must be aware of the warning signs and correct the situation, or serious damage to the pump and impeller will occur. Figure 10 shows the results of cavitation.

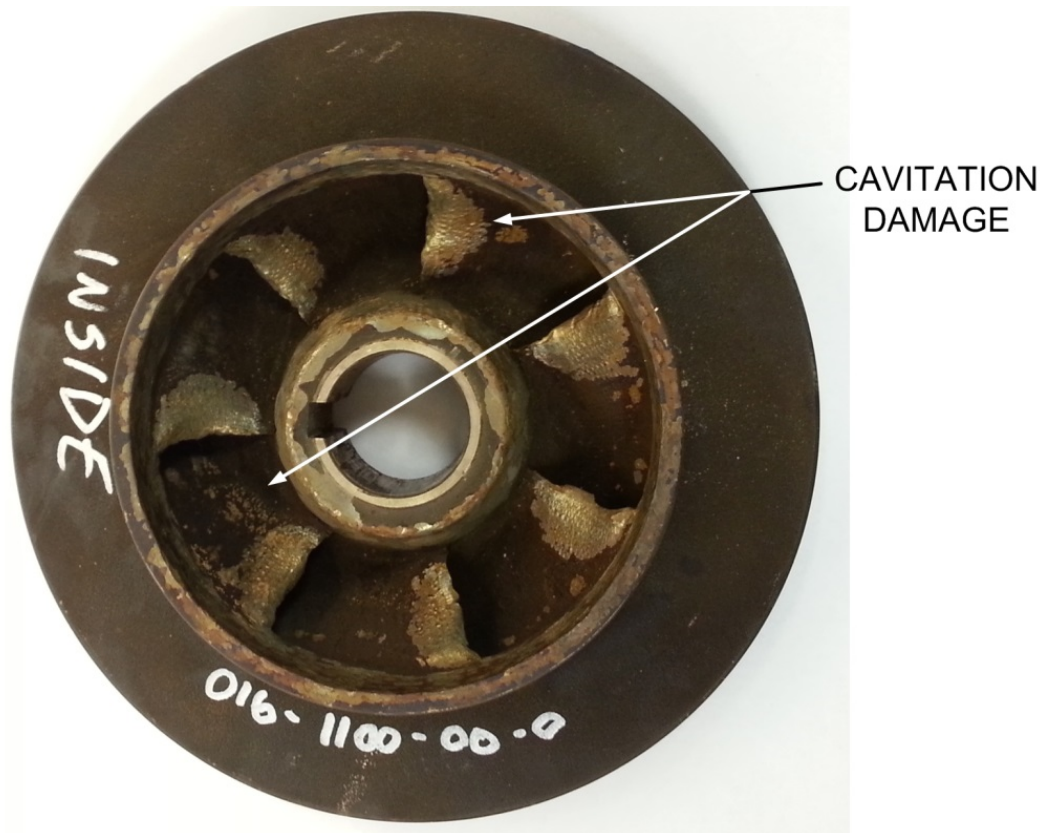


Figure 10. Results Of Cavitation

Cavitation can damage the impeller and other sensitive components, impair pump performance, and reduce flow capacity. The damage done during any one period of cavitation is not great, but the effects are cumulative. Implosions occurring during cavitation break away or erode tiny pieces of metal from the internal parts and the pump casing. When enough metal has been chipped away, the impeller becomes unbalanced causing a strain and vibration on bearings, bushings and shafts.

The way to eliminate cavitation is to increase the flow to the pump, decrease the amount of water being discharged from the pump, or reduce the pressure in the pump by decreasing engine speed.

3.5.1 Process Of Cavitation

Cavitation occurs when a centrifugal pump is attempting to discharge more water than it is receiving. It is often referred to as the pump running away from the supply.

- A. When increased discharge demand exceeds the intake, bubbles form in the low pressure region (eye) of the impeller. See Figure 11.

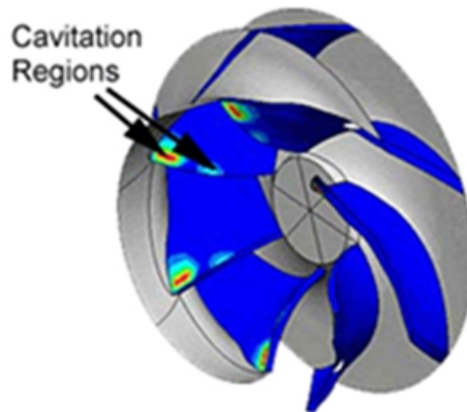


Figure 11. Low Pressure Regions

- B. The pressure of the water in the pump drops as it flows from the suction flange through the suction nozzle and into the impeller.
- C. As flow from the pump increases, the vacuum at the impeller increases. As the vacuum increases, the boiling point of water in that vacuum decreases until it reaches a point near the impeller eye where it boils and vaporizes.
- D. Once the vapor pockets, or bubbles, enter the impeller, the process begins to reverse itself. As the vapor reaches the discharge side of the pump, it is subjected to a high positive pressure and condenses back to a liquid.
- E. The sudden change from vapor to liquid generates a shock effect that damages the impeller and pump housing. Usually there are thousands of tiny vapor pockets (bubbles) rather than a few large ones. It is the collapsing (or implosion) of these bubbles that causes the characteristic sound of cavitation that has been described as rocks tumbling in the pump.

3.5.2 Warning Signs Of Cavitation

As a pump approaches cavitation, certain warning signs appear on the gauges that monitor the suction and discharge pressures. These signs are discussed in the following subparagraphs.

3.5.2.1 Discharge Pressure

In a properly functioning pump, an increase in RPM will increase the discharge pressure and volume. An increase in engine RPM that does not cause an increase in the pump discharge pressure, is the most reliable indication that a pump is approaching cavitation.

3.5.2.2 Vacuum Compound Gauge

The operator should not depend entirely on the vacuum (compound) gauge to indicate when a pump is nearing cavitation: The vacuum gauge is usually tapped into the intake chamber several inches away from the leading edge of the impeller eye where the greatest amount of vacuum occurs. The vacuum gauge does not take into account ambient temperature nor atmospheric pressure and is not accurate near zero on the vacuum scale.

3.5.3 How To Prevent Cavitation

Monitoring current operating conditions, knowing the capabilities of the equipment, and regular inspection are the best protection against cavitation.

When pumping from a hydrant, a soft sleeve has an advantage over a hard sleeve because it will partially collapse providing an immediate indication to the operator that cavitation is imminent. A hard sleeve indicates problems only at the intake gauge which is not the best or most reliable indicator.

3.5.3.1 General Considerations

Consider the following to generally avoid conditions that lend themselves to cavitation.

- Regularly inspect discharge and suction hoses to check for air leaks as these can also cause cavitation.
- Consider the size of the suction hose: Table 4 shows the NFPA pre-selected hose sizes for each pump rating capacity. Using the appropriate-sized hose will minimize the occurrence of cavitation.

Table 4. Hose Sizes For Pump Rating Capacity

Hose Diameter In (mm)	3 (76)	4 (102)	4.5 (114)	5 (127)	6 (152)	Dual 6 (Dual 152)
Flow gpm (Lpm)	Lift Loss In Head Ft (Head M)					
250 (946)	5.2 (19.7)					
350 (1325)		2.5 (9.5)				
500 (1893)		5.0 (19.0)	3.6(51.5)			
750 (2839)		11.4(43.0)	8.0 (30.0)	4.7 (17.8)	1.9 (7.2)	
1000 (3785)			14.5 (55.0)	8.5 (32.0)	3.4 (12.9)	
1250 (4732)				13.0 (49.0)	5.2 (19.6)	
1500 (5678)					7.6 (28.7)	1.9 (7.2)
1750 (6625)					10.4 (39.4)	2.6 (9.8)
2000 (7571)						3.4 (12.9)
2500 (9464)						5.2 (19.6)

- Consider the piping within the truck: Further suction losses may result from additional suction piping added to the fire pump during assembly by the manufacturer.
- Follow the maintenance and inspection procedures.
- Cavitation can occur with large nozzle tips. Solve this problem by reducing flow.
- Cavitation can also occur when air enters the pump. The pump may be primed, however, air leaks can cause rough operation and an increase of engine speed without an increase in pressure or flow. If an air leak is suspected, discontinue pumping and refer to Section IV.

3.5.3.2 During Operations

During operations, additionally consider the following to further avoid conditions that lend themselves to cavitation. Being aware of the pumping environment can contribute greatly to avoiding cavitation. Use Table 5 and Table 6 to help predict lift losses when operations dictate pumping from draft.

- Do not increase the pump speed beyond the speed at which the pressure ceases to rise.
- Monitor the water temperature. NFPA standards set a baseline of 60° F (16° C). Table 3 illustrates the amount of lift loss as temperatures rise. If there is a marked loss of suction capacity, the pump may be near cavitation.

NOTE

When water reaches 90° F (32° C), the operator is likely to notice a marked decrease in lift.

- Monitor barometric pressure. NFPA standards set a baseline of 29.9 inHg. See Table 5.

Table 5. Lift Loss From Barometric Pressure

Barometric Reading inHg (mb)	Lift Loss In Head Ft (Head M)
29.9 (1012.53)	NFPA Baselines
29.7 (1005.76)	0.2 (0.06)
29.5 (999.00)	0.5 (0.15)
29.3 (992.21)	0.7 (0.21)
29.1 (985.44)	0.9 (0.27)
28.9 (978.67)	1.1 (0.33)
28.7 (971.89)	1.4 (0.43)

- Know your elevation (especially in mountainous regions). NFPA standards set a baseline of 2,000 feet MSL. See Table 6.

NOTE

Location: The higher the elevation (height above sea level), the lower the atmospheric pressure and less lift. See Table 6.

Table 6. Lift Loss From Elevation

Elevation Ft (M)	Lift Loss In Head Ft (Head M)
2,000 (609)	NFPA Baseline
3,000 (914)	1.1 (0.33)
4,000 (1219)	2.2 (0.67)
5,000 (1524)	3.3 (1.00)



Table 6. Lift Loss From Elevation – CONTINUED

Elevation Ft (M)	Lift Loss In Head Ft (Head M)
6,000 (1828)	4.4 (1.34)
7,000 (2133)	5.5 (1.67)
8,000 (2438)	6.6 (2.01)
9,000 (2743)	7.7 (2.35)
10,000 (3048)	8.8 (2.68)

- Open the throttle gradually and, if equipped, watch the pressure gauge and the tachometer. An increase in engine RPM without a corresponding increase in pressure indicates cavitation.
- Use a hard suction hose when pumping from draft and soft suction hose when pumping from hydrant.

3.6. Post Operation Procedure

Perform the following steps at the end of all operations.

- A. Return engine to idle.
- B. Slowly close all valves.
- C. Place transmission into neutral or park.
- D. Drain pump (especially important in freezing weather):
 1. Open discharge valves, remove suction tube caps, and discharge valve caps.
 2. Open volute drain cocks or Hale multiple drain valve. If a multiple drain valve is used, all pump drain lines should be connected to this valve.
 3. After pump is completely drained, replace all caps and close all valves.
- E. If any of the following was used, sea water, dirty water, alkaline water or foam solution; flush pump with clean water.
- F. Remove wheel chocks only when preparing to leave scene.
- G. Fill out pump run log, indicating total pumping time and total out-of-station time.
- H. Report all pump, vehicle, and equipment malfunctions and irregularities to proper authority.
- I. Know and follow all local procedures.

4. PREVENTIVE MAINTENANCE

Regular preventive maintenance assures continued dependable operation. This section provides recommended actions to be completed for both the booster pump and the ancillary equipment. The pump preventive maintenance actions listed are scheduled to be completed after each use and on a weekly, quarterly and annually basis.

4.1. Preventive Maintenance Plan And Schedule

Hale Products recommends the preventive maintenance and inspections listed in Table 7 be performed as scheduled. The booster pump requires very little care and maintenance, however, the preventive maintenance and inspections required are important. The booster pumps do NOT require any daily, weekly, or monthly preventive maintenance. The listed preventive maintenance, inspections and checks are required to ensure proper and economical operation and to minimize corrective maintenance. Table 7 lists the projected preventive maintenance on a per use, quarterly, annual, and triennium basis.

Table 7. Recommended Preventive Maintenance – Pump

Interval	Check/Test	Action Required	Item(s) Required
After Each Use			
	Flush if Contaminated	Flush pump thoroughly with clean water (See paragraph 4.4.1, Flush After Each Use)	Supply of clean water
	Leakage Checks	Check for water or oil leaks (wipe off road dirt and debris) (See paragraph 4.4.2, Leakage Checks)	Shop Rags
Quarterly (Every 3 Months)			
	Oil Level Check	Check gearbox oil level using sight glass (See paragraph 4.4.3.1, Check Gearbox Oil Level)	None
	Perform Vacuum Check	Use installed primer to pull vacuum on pump and valves (See 4.4.3.2, Perform Vacuum Test)	None
Annually (Every 12 Months)			
	Perform NFPA 1911 Performance Level Test	Check the pump (according to the rating in Table 9 at each capacity and compare the results to when the pump was first placed in service.	Supply of clean water
Triennium (Every 36 Months)			
	Oil Change	Drain oil from gearbox and refill with new oil (See paragraph 4.4.6.1, Gearbox Fluid Change)	1.25 qt Full Synthetic

Additionally, Hale Products recommends the preventive maintenance and inspections listed in Table 8 also be performed as scheduled. Hale and OEM ancillary equipment preventive maintenance tasks take little time to accomplish and consist of leak testing, operational checks, lubrication and cleaning. The listed preventive maintenance, inspections and operational checks are required to ensure proper and economical operation and to minimize corrective maintenance.

Table 8 lists the projected preventive maintenance on a weekly, monthly, quarterly, and annual basis.

Table 8. Recommended Preventive Maintenance – Ancillary Equipment

Interval	Check/Test	Action Required	Item(s) Required
Weekly			
	Test Relief Valve System	Operate the relief valve system to verify it is functioning properly.	PM valve control & onboard water
	Test Pump Shift Warning Indicator	Engage the pump and verify the indicator lights on the control panel function properly and agree with the indicators in the cab.	Wheel chocks
	Check Valves	Verify each valve operates easily and closes completely. Inspect all valve linkages for lubricant and function.	None
	Check And Clean Intake Strainers	Remove strainers. Clean strainers. Inspect strainers for any damage.	Supply of clean water
	Check Hydraulic Motor	If the pump is powered by a hydraulic motor, check the motor for function, filters, and fluid level. Inspect drive for wear. Check drive for proper operation.	Shop rags
	Check All Gauges	Check that gauges that are repeated (in the cab or another panel), agree with the gauge on the operator's panel. Check that all gauges read within 10% of a calibrated test gauge.	Calibrated test gauges
	Check Pump Controls	Check the pump drive controls to verify the pump can be engaged. Verify all indicator lights work properly.	Onboard water
	Inspect Water And Foam Tanks	Visually inspect water and foam tanks for proper level, gauge readings, and debris. If debris is present, flush tank to protect the pump from dirty water or foam concentrate contamination.	Supply of clean water
	Check Roof And Bumper Turrets	Verify all turrets function properly, and no leaks are present.	Supply of clean water
	Check Auxiliary Fire Suppression Equipment	Visually inspect all piping and valves on the pump and auxiliary equipment for corrosion or damage.	None



Table 8 Recommended Preventive Maintenance – CONTINUED

Interval	Check/Test	Action Required	Item(s) Required
Monthly			
	Test Priming System	Dry Vacuum Test per NFPA 1901 or NFPA 1911	Inlet and outlet caps Vacuum gauge (or manometer) 5 min timer
	Check Drive Line Bolts	Inspect for missing bolts. Torque all drive line bolts. Inspect all drive line bolts are Grade 8 or stronger.	Torque wrench
Quarterly (Every 3 Months)			
	Lubricate Relief Valve	Inspect and lubricate all relief valve operators.	Brush Grease
Annually (Every 12 Months)			
	Check Drain Lines	Check individual drain lines going to the multi-drain to ensure drains empty (providing protection from freezing).	None
	Test Tank To Pump Flow Rate	Compare flow rate measured to NFPA minimum (or designed rate of pump). If flow rate is lower, a problem exists in the tank to pump line. The minimum flow rate should be continuously discharged until 80% of the tank is discharged.	Supply of clean water
	Clean ESP Primer	Disassemble ESP primer and clean mineral deposits. See paragraph C.3.3.3, Clean ESP Primer.	Lime Scale Remover & Soft Bristle Brush

4.2. Maintenance Log

As a minimum, use this form to record all maintenance actions: cleanings, checks, faults, tests, parts replaced, and tear downs/major overhauls. An accurate maintenance log can provide key insights when pump problems arise; preventing extended down times, and shorten troubleshooting.

Full page Log sheets are provided in APPENDIX D, Operator Maintenance Log, for your convenience. Always keep at least one original (unused) sheet in this manual for copying purposes. The remaining pages may be used to start the LOG.

A sample of the Log (with only a single row of data/entry cells) is provided below. The recommended data/entries are explained in detail in the text that follows the sample.

PUMP SERIAL NUMBER: _____



Use this Log to record all maintenance actions and problems (faults, part replacements, tear downs, and major overhauls – as a minimum). Please contact Customer Services at Hale Products Inc. prior to any proposed return of either a single part, or a complete assembly.

DATE	HOURS RUN	MAINTENANCE/ PROBLEM	PART(S) USED	REASON REPLACED	INITIALS

To make the most effective Log always fill in every Log cell for each entry as follows as a minimum.

Enter the **DATE**: chronology, this is important as loose pages may get out-of-order.

Enter the **HOURS RUN**: the accumulated hour of run time is important for adjusting the recommended maintenance intervals. These intervals should be adjusted (especially if a shorter interval is suggested by the data) since an individual pumps operating environment can vary widely. Clean verses dirty water sources, ambient operating temperature for the geographical location or mounting location, and other key factors should be considered for planned/scheduled maintenance purposes.

Enter the **MAINTENANCE/PROBLEM**: enter ALL maintenance actions (especially those listed in Table 7 although items listed in Table 8 should NOT be ignored or excluded) and problems the pump encounters. The more complete the Log, the more time saved if/when troubleshooting is required and good (or bad) maintenance practices become highly visible. A PUMPS HISTORY CAN BE INVALUABLE TO A TRAINED TECHNICIAN.

Enter the **PART(S) USED**: enter ALL parts replaced. It is important to list not only the assemblies and components replaced but always include the little things: hoses, connectors, fasteners, seals, thread lock, etc. The replacement of the little things can be just as critical (or even more critical) as the big items when it comes to maintaining a pump.

Enter the **REASON REPLACED**: be as specific as possible (use a cross referenced add-in page(s) if necessary) when recording a failure, entering a % of wear for a scheduled replacement part is recommended if attempting to adjust the scheduled interval.

Enter the **INITIALS**: of the person (or persons) performing/witnessing/recording the maintenance action or problem for the associated pump.

4.3. Extreme Conditions Maintenance Guidelines

Extreme conditions occur when the pump has been operated during freezing weather or when pumping from a water source that contains material that is harmful to the pump if not purged as soon as possible. Extreme conditions indicate a need for increased maintenance. The procedures in this section identifies only two extreme conditions however many others exist (too numerous to list). The time and cost of the additional measures needed to ensure continued pump life and dependability are always far exceeded by the cost savings achieved from their performance. The following procedures are general in nature, always follow local maintenance and test procedures when they exist.

4.3.1 Freezing Weather

Drain the volute and discharge valves. If the gearbox is equipped with a water cooling line, drain this line also. There should be drains for the gauge lines, the cooling line to the engine, and to the relief valve (if equipped). All of these should be opened until all water is drained out, then close the drain valves.



In freezing weather, drain the pump as follows.

- A. Open discharge and suction valves, remove suction tube caps and discharge valve caps.
- B. Open volute drain cocks and drain valves.
- C. After pump is completely drained, replace all caps and close all valves.

4.3.2 Contaminated Water

After pumping salt water, contaminated water or foam solution, or if water containing sand or other foreign matter has been used, connect the pump to a fresh water hydrant or other source of fresh clean fresh water and flush the contaminants out of the pump.

4.4. Booster Pump Preventive Maintenance Procedures

Perform the procedures provided in the following subparagraphs on the schedule indicated by each subparagraph title. An additional level of subparagraphs provides separation when multiple procedures apply to the same periodicity.

4.4.1 After Each Use (Flush Pump)

- A. Connect apparatus to a fresh, clean, high quality water source.

NOTE

Do NOT perform Step G (on page 20) of the Repair Verification Operations.

- B. Perform Repair Verification Operations (see paragraph 3.1 on page 18) and flush pump for a minimum of five (5) minutes.
- C. Inspect suction hose and rubber washers as well as washers in suction tube caps.
 - 1. Remove any foreign matter from hose(s) and coupling(s).
 - 2. Replace all worn, damaged, or dry rotted washer(s).
- D. Verify all discharge valves, drain valves and drain cocks are closed.
- E. Tighten suction caps.

4.4.2 Leakage Checks

- A. Inspect the following:
 - 1. Suction hose
 - 2. Rubber washers
 - 3. Suction tube cap washers
 - 4. Suction hose adapters
 - 5. Suction strainer(s)
- B. Remove any foreign matter from hose(s) and coupling(s).
- C. Replace all worn or damaged washer(s) and lubricate as required.
- D. Verify all discharge and drain valves are closed.
- E. Tighten suction caps.

F. If procedures call for a wet pump, open tank fill valve (removes trapped air).

1. Close valve after several minutes.
2. Check apparatus for signs of leaks.

4.4.3 Quarterly Maintenance

Perform the following procedure every three months.

4.4.3.1 Check Gearbox Oil Level

The gearbox is drained of oil at the factory prior to shipment. Check the gearbox oil level upon receipt of the pump and then at least every three months. The gearbox needs to be filled with 1 to 1-1/2 qt (1.1 liter) of the gear oil listed in 5.7.2, Recommended Lubricants. (The amount depends on gearbox position.) Figure 12 shows the typical gearbox oil fill, and level component locations as the gearbox is rotated through the available positions. Check the gearbox oil level via the plug style sight glass.

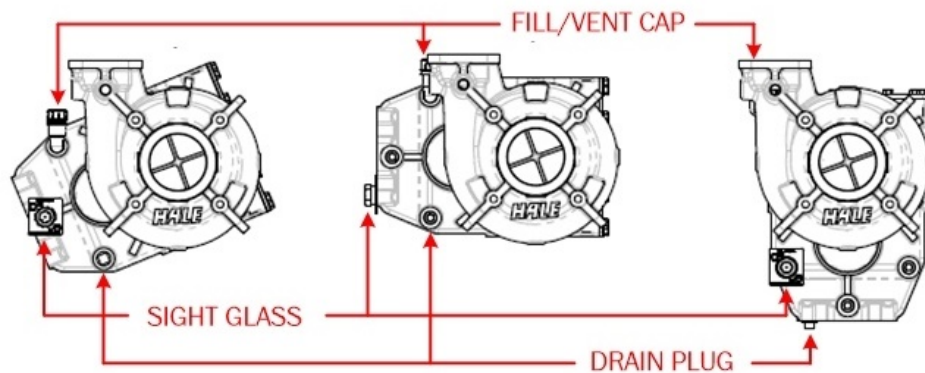
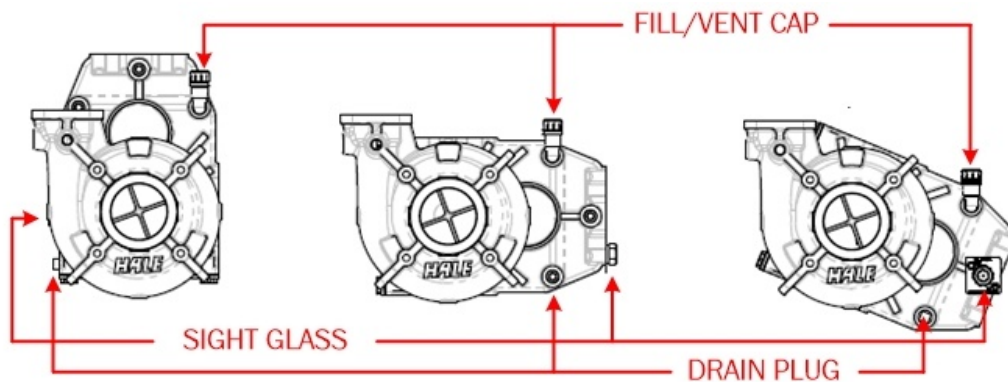


Figure 12. Typical Gearbox Oil Fill/Level Component Locations



Perform the following procedure to check the oil level in the gearbox.

- A. Visually check gearbox oil level sight glass (Figure 12).

NOTE

The oil level should be the center of the sight glass.

- B. If oil is NOT visible in sight glass, or if oil is below midpoint of sight glass, add oil as follows.

1. Remove fill/vent cap (Figure 12).

ATTENTION ⚠ CAUTION

ALWAYS USE PROPER PPE. OIL MAY BE TOXIC TO PEOPLE AND/OR THE ENVIRONMENT. CATCH AND DISPOSE OF OIL PROPERLY. IMPROPER OIL HANDLING MAY RESULT IN HEALTH RISKS AND/OR CRIMINAL PUNISHMENTS.

IMPORTANT ⚠ NOTICE

DO NOT OVER FILL THE GEARBOX. EXCEEDING THE OIL LEVEL MAY RESULT IN OVER HEATING.

2. Add oil (see paragraph 5.7.2), until oil is at midpoint of sight glass (See Figure 12).

NOTE

A funnel may make adding oil easier and safer.

3. Install fill/vent cap.
- C. If oil completely covers sight glass, drain excess oil as follows.
 1. Position appropriate catch pan.
 2. Remove magnetic drain plug from gearbox. (See Figure 12)
 3. Restrict oil flow to slowly drain oil from gearbox.
 4. Simultaneously examine magnetic drain plug for the following.
 - a) Metal fragments, if metal fragments are present on drain plug continue, otherwise go to Step 5.
 - b) Remove cover plate and cooler.
 - c) Visually inspect for large quantities of fragments present in gearbox.
 - d) If large quantities of fragments are present in gearbox, remove all fragments from gearbox and on internal components.
 - e) Repair or replace internal components as necessary.
 - f) Replace cooler and cover.
 - g) Remove oil fill plug, and install magnetic drain plug.
 - h) Fill gearbox with approved gearoil until oil level is centered in the sight glass.
 - i) Replace fill plug.
 - j) Procedure is complete; do NOT perform Step 5 or Step 6.
 5. Slowly drain oil until oil level is centered in sight glass.
 6. Replace magnetic drain plug.

4.4.3.2 Perform Vacuum Test

Verify pump maintains a vacuum as follows.

- A. Close all valves.
- B. Ensure all caps are in place and tightened.
- C. Use primer to pull vacuum of at least 22 (±2) inHg.



- D. Verify apparatus maintains vacuum for 5 minutes.

NOTES

A vacuum loss of up to 2 inches per minute is the maximum loss permitted.

The above stated loss should only occur when a packing type pump seal is utilized and all Flex Series Booster pumps utilize a mechanical type pump seal that, if operating properly, produces little or no loss.

4.4.4 Annual Pump Maintenance

Perform the following as a minimum to maintain pump dependability and optimum performance.

- Perform the yearly pump test to check performance levels. (See NFPA Standard 1911 for more details.)

4.4.4.1 Performance Testing

The yearly standard performance test consists of checking the pump (according to the rating) at three capacities and comparing the results to when the pump first placed in service.

4.4.4.1.1 Testing Overview

The performance test provides some measure of any performance deterioration. A pump must be able to pump full capacity at 150 psi, 70% capacity at 200 psi and 50% capacity at 250 psi. See Table 9.

Table 9. Example Performance Test

Example Performance		Pump Rating gpm (Lpm)					
CAPACITY	PRESSURE psi (bar)	250 (946)	350 (1325)	450 (1703)	500 (1893)	750 (2839)	1000 (3785)
FULL	150 (10)	250 (946)	350 (1325)	450 (1703)	500 (1893)	750 (2839)	1000 (3785)
70%	200 (13)	175 (662)	245 (927)	315 (1192)	350 (1325)	525 (1987)	700 (2650)
50%	250 (17)	125 (473)	175 (662)	225 (852)	250 (946)	375 (1419)	500 (1893)

4.4.4.1.2 Testing Equipment And Materials

Testing is appropriately accomplished with a dead weight gauge tester, which is usually available at the local water works, otherwise accurately testing pumper performance requires: a pitot gauge, a calibrated 0 – 400 psi pressure gauge (with 5 psi graduations), a calibrated 0 – 200 psi pressure gauge (with 1 psi graduations marked in 5-10 psi increments), and a vacuum gauge or manometer. Additionally, required is a revolution counter (RPM contact or non-contact type), an accurate timer, thermometer, and a tape measure.

Use a straight stream (smooth bore) test nozzles of accurate size and capable of the pumps gpm with the pitot gauge. The volume pumped is then determined by referring to the discharge tables for smooth nozzles. Preferably, nozzles will be used on a Siamese deluge gun for greatest accuracy. A stream straightener, just upstream of the nozzle is advisable.

NOTES

Refer to local procedures for pump testing procedures and practices.



Use a fog nozzle **ONLY** in conjunction with flow meters, Use **ONLY** a nozzle rated for the required flows.

Conduct testing between 60 and 70 psi for most accurate results.

For pitot gauge accuracy, the pressures should be between 30 and 120 psi. Table 10 provides nozzle flow (in gpm) and pressures (in psi) for various nozzle sizes (in inches).

Table 10. Pressure And Flow For Various Size Nozzles

Nozzle Size	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8
Pitot Pressure	Flow (gpm)							
30	41	64	92	125	163	206	254	308
35	44	69	99	135	176	222	275	332
40	47	73	106	144	188	238	294	355
45	50	78	112	153	199	252	311	377
50	53	82	118	161	210	266	328	397
55	55	86	124	169	220	279	344	417
60	58	90	130	176	230	291	360	435
62	58	91	132	179	234	296	366	442
64	59	93	134	182	238	301	371	449
66	60	94	136	185	241	305	377	456
68	61	96	138	188	245	310	383	463
70	62	97	140	190	248	315	388	470
72	63	99	142	193	252	319	394	477
74	64	100	144	196	255	323	399	483
76	65	101	146	198	259	328	405	490
78	66	103	148	201	262	332	410	496
80	66	104	150	203	266	36	415	502
85	68	107	154	210	274	347	428	518
90	70	110	159	216	282	357	440	533
95	72	113	163	222	289	366	452	547
100	74	116	167	228	297	376	464	562
105	76	119	171	233	304	385	476	575
110	78	122	175	239	311	394	487	589
115	80	125	179	244	319	403	498	602
120	81	127	183	249	325	412	509	615

Table 10. Pressure And Flow For Various Size Nozzles – CONTINUED

Nozzle Size	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/4	2 1/2	3
Pitot Pressure	Flow (gpm)							
30	366	430	498	572	651	824	1017	1464
35	395	464	538	618	703	890	1098	1581
40	423	496	575	660	751	951	1174	1691
45	448	525	610	700	797	1009	1245	1793
50	473	555	643	738	840	1063	1313	1890
55	496	582	675	774	881	1115	1377	1982
60	518	608	705	809	920	1165	1438	2071
62	526	618	716	822	935	1184	1462	2105
64	535	628	728	835	950	1203	1485	2138
66	543	637	739	848	965	1222	1508	2172
68	551	647	750	861	980	1240	1531	2204
70	559	656	761	874	994	1258	1553	2236
72	567	666	772	886	1008	1276	1575	2268
74	575	675	783	898	1022	1293	1597	2299
76	583	684	793	910	1036	1311	1618	2330
78	590	693	803	922	1049	1328	1639	2361
80	598	702	814	934	1063	1345	1660	2391
85	616	723	839	963	1095	1386	1711	2465
90	634	744	863	991	1127	1427	1761	2536
95	651	765	887	1018	1158	1466	1809	2605
100	668	784	910	1044	1188	1504	1856	2673
105	685	804	932	1070	1217	1541	1902	2739
110	701	823	954	1095	1246	1577	1947	2803
115	717	841	976	1120	1274	1613	1991	2867
120	732	859	997	1144	1301	1647	2034	2928

Because NFPA standards specify both flow and pressure, it is usually necessary to restrict the flow somewhat to build up the pump pressure. In normal pumping, this restriction would be caused by the friction loss in the lines. However, depending on line loss alone would require a large amount of hose for some tests. It is common practice to use 50 to 100 ft of hose and gate the discharge valves as required to maintain pressure.



4.4.4.1.3 Performance Testing Test Procedure

The NFPA standards require a 10% reserve in pressure at the capacity being run when the apparatus is delivered.

- A. Check engine speed (No load maximum). Use RPM counter. If more than 50 RPM off from original recorded RPM correct problem/RPM before testing.)

NOTE

The loss is specified to account for packing seals (the Hale Flex Series pumps use mechanical seals) therefore the loss should NOT occur.

- B. Check dry vacuum. (Check with two 10 ft lengths of correct sized suction hose attached and using suction tube cap[s].) Use vacuum gauge. If 22(± 2) inHG is NOT obtained (or maintained with less than 10 inHG loss in five minutes) correct all leaks before testing.
- C. Warm up apparatus prior to start of test. Run pump for 10-15 minutes at 70-80 psi before beginning performance test. (Turned on engine driven loads including 50% loading of PTO generators.)
- D. Run standard pump test in accordance with NFPA standards to check pump performance.

NOTES

Utilize Table 3 for draft limiting factors (Lift Loss), Table 4 to determine hose sizes for pump rating capacity, Table 5 for lift loss from barometric pressure, Table 6 for lift loss from elevation, and Table 10 pressure and flow for various size nozzles.

Select a properly sized nozzle. Choose a nozzle, which allows a minimum flow of the gpm being tested while maintaining a pitot reading close to 60–70 psi.

Pumps rated below 750 gpm are NOT overload tested per NFPA.

1. Run pump for 20 minutes at capacity.
2. Run pump for 10 minutes at 70% capacity.
3. Run pump for 10 minutes at 50% capacity.

NOTE

If the apparatus does not reach performance levels, refer to Section 4.4.4.

- E. Compare results of this test to test results for apparatus when it was delivered.

NOTE

It may be that the apparatus did not show the 10% reserve at delivery.

If the apparatus performance has dropped appreciably compared to its original performance, it needs to be serviced. (Apparatus test results should be on file with the delivery documents. If not, they may be obtained from the apparatus manufacturer or from the original certifying authority.)

4.4.5 Annual Pump Maintenance

Perform the following as a minimum to maintain pump dependability and optimum performance.

- Perform the yearly pump test to check performance levels. (See NFPA Standard 1911 for more details.)

4.4.6 Triennium Pump Maintenance

Perform the following as a minimum to maintain pump dependability and optimum performance.

- Perform the gearbox fluid change at a minimum of every three years (36 months) or more often if conditions indicate.

4.4.6.1 Gearbox Fluid Change

Use the lubricant listed in the paragraph 7.4.4.1.1, Recommended Gearbox Lubricants, in the Flex Series Single Stage Booster Pump OIM (FSG-MNL-00183), when lubricating the gearbox.

Lubricate the gearbox as instructed in paragraph 7.4.4.1 Fluid Change Procedure, in the Flex Series Single Stage Booster Pump OIM (FSG-MNL-00183), according to the schedule in Table 7, Recommended Preventive Maintenance.

5. CORRECTIVE MAINTENANCE (REPAIR)

This section describes the removal and replacement (as required for maintenance and repair) of all booster pump components. To completely disassemble the pump and gearbox, follow the disassembly instructions in the order which they appear in the text. At any point in the disassembly process, the pump may be reassembled by following the appropriate portion of the installation instructions.

Disassembly of the pump and/or gearbox is a major undertaking that can remove a pump from service for a considerable period of time. Gaskets must be replaced to ensure the pump is fully operational when returned to service. It is never permissible to reassemble the pump without installing new gaskets. Hale Products supplies repair kits designed specifically for each pump and the gearbox. Other parts can be ordered by calling 800-533-3569 (Hale Products Customer Service). NOTE: Using your pumps serial number and the Hale website (or Customer Service) is the best way to ensure you receive/utilize the correct replacement parts for your pump. The descriptions of the maintenance levels and how each kit supports the maintenance along with the general contents of that kit are provided in paragraphs 5.2, Maintenance Level 1 (see page 48) thru paragraph 5.6, Miscellaneous Maintenance (see page 49).

5.1. Troubleshooting

To troubleshoot the system, locate the SCR table listing the indicated SYMPTOM, verify the associated CAUSE (verify ALL if multiple are listed) and perform the associated REMEDY (or remedies).

The SCR tables assume a single fault and the SYMPTOM, CAUSE, and REMEDY columns have been listed in a hierarchy order. If multiple faults exist, repeat following the table using multiple passes unless the REMEDY is always the same and does NOT remedy the symptom. When this occurs contact Hale Customer Service Technician Department for further assistance by calling the Customer Service Number: 800-533-3569 with the following information.

- Pump and Gearbox ID plate (MODEL NUMBER and SERIAL NUMBER) (Refer to Section 2.2, Pump Specifications And Numbering, in the Hale OIM manual (FSG-MNL-00183) for serial number locations, model number definitions, and major pump features.)
- Observed symptoms and conditions under which the symptoms occur.

Therefore, treat each SYMPTOM as the result of a single CAUSE, trace through the SCR table until a single REMEDY is indicated. Perform the REMEDY, and then check the system again. Determine if the same SYMPTOM exists, a different SYMPTOM is now indicated, or no symptoms exist. If the original symptom persists and no other symptoms are indicated, contact Hale Products at 800-533-3569 for assistance.

5.1.1 PTO Or Pump Engagement Problems

Table 11 lists the symptoms of some common problems and possible corrective measures. Before calling Hale or a Hale authorized parts service center for assistance, eliminate problem causes using this guide.

Table 11. Engagement SCR Table

SYMPTOM	CAUSE	REMEDY
PTO Will NOT Engage Pump Will NOT Engage	PTO Problem(s)	Consult PTO Manufacturer's Instructions
	Faulty Wiring	Verify the indicators are functioning properly

SYMPTOM	CAUSE	REMEDY
Hydraulic Motor Will NOT Engage	Hydraulic System Problem	Review hydraulic components and system controls and troubleshoot.
	Hydraulic Motor Coupling Problem	Verify hydraulic motor gearbox coupling components are intact and engaged.

5.1.2 Pump Priming Problems

Table 12. Pump Priming SCR Table

SYMPTOM	CAUSE	REMEDY
Pump Loses Prime Or Will NOT Prime	Electric Priming System	No recommended engine speed is required to operate the electric primer. However, an engine RPM of 1,000 will maintain the electrical system while providing enough speed for initial pumping operation.
	Defective Priming System	Check the priming system by performing a “Dry Vacuum Test” per NFPA standards. If the pump holds vacuum, but primer pulls less than 22 (\pm 2) inHg of vacuum, it could indicate excessive wear in the primer.
	Suction Lift Too High	Do NOT attempt lifts exceeding 22 ft.
	Restricted Suction Strainer	Remove obstruction from suction hose strainer.
	Suction Connections Loose Or Dirty	Clean and tighten all suction connections. Check suction hose and hose gaskets for possible defects.
	Primer NOT Operated Long Enough	Proper priming procedures should be followed. Do not release the primer control before assuring a complete prime.
	Air Leaks	Attempt to locate and correct air leaks using the following procedure.
		1. Perform dry Vacuum Test on pump per NFPA standards with 22 (\pm 2) inches minimum vacuum required with loss not to exceed 10 inches of vacuum in 5 minutes.
		2. If a minimum of 22 (\pm 2) inches of vacuum cannot be achieved, the priming device or system may be defective, or the leak is too big for the primer to overcome (such as an open valve).
		3. After priming, shut off the engine. Audible detection of a leak is often possible.
		4. Connect the suction hose from the hydrant or the discharge of another pumper to pressurize the pump with water, and look for visible leakage and correct. A pressure of 100 psi (6.9 bar) should be sufficient. Do not exceed pressure limitations of pump, accessories, or piping connections.
		5. The suction side relief valve can leak. Plug the valve outlet connection and retest.

5.1.3 Insufficient Pump Capacity

Table 13. Insufficient Pump Capacity SCR Table

SYMPTOM	CAUSE	REMEDY
Insufficient Pump Capacity	Insufficient Engine Power	Engine power check or tune up may be required for peak engine and pump performance.
		Refer to rotation symptoms later in this section.
	Suction Hose Diameter Is Too Small For The Volume Being Discharged	Use a larger suction hose.
		Shorten total length by removal of one length.
		Reduce volume of discharge.
	Restriction In The Suction Line At The Strainer	Remove any debris restricting entrance of water at the strainer.
	Partial Collapse Of The Lining In The Suction Hose	Damage to the outer lining may allow air in between the outer and inner linings causing a partial collapse. Replace the hose and retest.
	Relief Valve Improperly Set	If the relief valve control is set too low the relief valve will open and bypass water. Reset the relief valve control per the procedures in Section III. Other bypass lines (such as foam system or in line valves) may reduce pump capacity or pressure.

5.1.4 Engine Speed Problems

Table 14. Engine Speed SCR Table

SYMPTOM	CAUSE	REMEDY
Engine Speeds Too High For Required Capacity Or Pressure	Truck Transmission In Wrong Range Or Gear	Verify the transmission is in the correct range and/or gear. Change range or gear if required.
	Lift Too High, Suction Hose Too Small	Higher than normal lift (10 ft) will cause higher engine speeds, high vacuum and rough operation. Use larger suction hose. Bring the pump closer to the water source.
	Defective Suction Hose	Inner line of suction hose may collapse when drafting and is usually undetectable. Change the suction hose on the pump; test for comparison against original hose.
	Blockage Of Suction Hose Strainer	Clean suction hose strainer of obstruction and follow recommended practices for laying suction hose.
	Pump Is Approaching Cavitation	Gate the discharge valves to allow pressure to increase. This will reduce flow.
		Reduce the throttle opening to the original pressure setting.

Table 14. Engine Speed SCR Table – CONTINUED

SYMPTOM	CAUSE	REMEDY
Engine Speeds Too High – CONTINUED	Worn Pump Impeller(s) And/or Clearance Rings	Installation of new parts required.
	Impeller Blockage	Blockage in the impeller can prevent loss of both capacity and pressure. Back flushing the pump from discharge to suction may free blockage. Removal of the pump head may be required (this is considered a major repair).

5.1.5 Relief Valve Problems

Table 15. Relief Valve SCR Table

SYMPTOM	CAUSE	REMEDY
Relief Valve Does Not Relieve Pressure When Valves Are Closed	Incorrect Setting Of Control Valve (PMD)	Check and repeat proper procedures for setting relief valve system. (See www.Haleproducts.com and search for your relief valve for setup instructions.)
	Relief Valve Inoperative	Refer to the relief valve manual.
Relief Valve Does Not Recover And Return To Original Pressure Setting After Opening Valves	Dirt In System Causing Sticky Or Slow Reaction	Refer to the relief valve manual.
	Relief Valve Blocked	Clean the valve with a small wire or straighten of a paper clip. Refer to the relief valve manual.

5.1.6 Gearbox Problems

Table 16. Gearbox SCR Table

SYMPTOM	CAUSE	REMEDY
Water In Pump Gearbox	Leak Coming From Above Pump	Check all piping connections and tank overflow for possible spillage falling directly on to the pump gearbox.
	Leaking Mechanical Seal	If mechanical seal is installed, there should be no leaks. Inspect the oil seal and replace if necessary.

5.1.7 Discharge Valve Problems

Table 17. Discharge Valve(s) SCR Table

SYMPTOM	CAUSE	REMEDY
Discharge Valves Difficult To Operate	Lack Of Lubrication	Recommended weekly lubrication of discharge and suction valve, use an approved lubricant. Refer to the valve manual for more information.

5.1.8 Cavitation

Table 18. Cavitation SCR Table

SYMPTOM	CAUSE	REMEDY
Pump Is Cavitating	Discharging More Water Than The Pump Is Taking In	Increase the flow into the pump with more and/or larger intake lines.
		Gate the discharge valves to reduce flow and maintain pressure.
	Air Leak	Verify air bleeder on the suction tube is not open.
		Locate and eliminate all air leaks during maintenance.
	Drafting Too High	Verify lift loss, hose friction, water temperature and other lift limiting factors are reduced or eliminated.
		Locate the pump closer to the water source.
	Water Temperature Too High	Reduce volume discharged by lowering RPM or gating the discharge valves.
		Locate a source of cooler water.

Table 19. Rotation SCR Table

SYMPTOM	CAUSE	REMEDY
Reduced Pressure To 60–100 psi And Reduced Flow	Wrong Impeller Installed See Figure 13	Verify the new impeller vanes are oriented the same as the old impeller before installation. See Figure 13.
	Wrong Application	The pump was installed on an application for which it was not intended i.e. front mount vs. rear mount.

It is possible to reassemble the pump incorrectly or with the wrong parts. Always compare the replacement parts with the original hardware. (See Figure 13.)

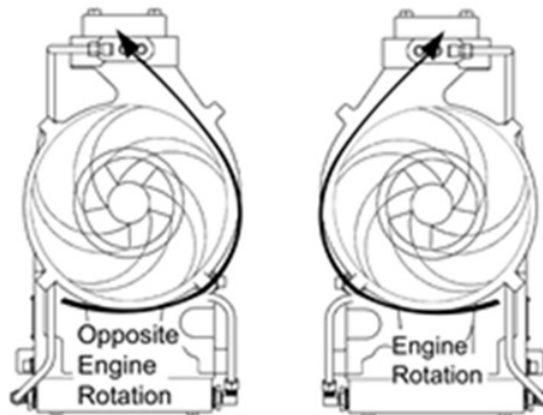


Figure 13. Engine Or Opposite Engine Rotation



Contact Hale Customer Service for further assistance by calling the Customer Service Number: 800-533-3569 with the following information.

Pump MODEL NUMBER and SERIAL NUMBER (Refer to Section 2.2, Pump Specifications And Numbering, in the Hale OIM manual [FSG-MNL-00183] for serial number locations, model number definitions, and major pump features.)

Observed symptoms and conditions under which the symptoms occur.

5.2. Maintenance Level 1

Maintenance Level 1 consists of basic repair. This includes support of all preventive maintenance and the most common or basic pump/gearbox repairs. This maintenance would include preventive maintenance inspections, disassembly for cleaning or troubleshooting purposes, and additionally repair an air/water leak resulting from gasket or seal damage. The Level 1 repair kit ONLY supports Level 1 maintenance and contains O-rings, oil seals, gaskets, mechanical seal, and cotter pin for basic reassembly of the pump/gearbox after replacing a failed pump seal or gearbox oil seal. The kit contents are the recommended spare parts for the first three years (multiple kits may be required during that period) and is intended to be used whenever a Level 1 basic repair is required (repairing a water leak, minor water/oil intrusions, or a failed pump seal).

5.3. Maintenance Level 2

Maintenance Level 2 consists of intermediate maintenance or basic repairs plus wear items (such as bearings and selected fasteners) and performance testing (typically testing beyond the first three years). This maintenance level includes support for preventive maintenance performance testing failure and the most common or basic pump/gearbox wear items replacement. This maintenance would include preventive maintenance performance test failures (flow rate issues), troubleshooting, and restoration of pump performance resulting from typical wear items (bearings, seals, gaskets/O-rings, and select fasteners). The Level 2 repair kit supports Level 1 and Level 2 maintenance and provides the contents of the Level 1 kit and the added Level 2 items. A Level 2 kit is recommended as the minimum spare parts for each five year interval of pump life expectancy.

5.4. Maintenance Level 3

Maintenance level 3 consists of replacement gear set and shaft keys. Before attempting a level 3 repair contact with Hale Customer Service (see Section 5.1, Troubleshooting) is recommended. The Customer would need to be prepared to provide ID plate information (COMPLETE INFORMATION FROM ALL ID PLATES) for the affected pump and gearbox.

5.5. Maintenance Impeller Renew

The combined use of a level 3 and an impeller renew kit constitutes a complete overhaul of the pump. This maintenance level is typically considered shop maintenance, in which a complete tear down and removal and replacement of major parts is required.

The level 3/renew kits are purposed for a complete overhaul of the pump. In addition to the entire contents of the level 2 kit, they supply bearings, retaining rings, select hardware, gaskets (and/or O-rings), impeller(s), clearance rings, a set of drive gears, and shaft keys. Before attempting a level 3 repair contact with Hale Customer Service (see Section 5.1, TROUBLESHOOTING) is recommended. The Customer would need to be prepared to provide ID plate information (COMPLETE INFORMATION FROM ALL ID PLATES) for the affected pump and gearbox. Be aware customer service will determine affordability/feasibility of the level 3/renew of a pump before authorizing the parts sale. Remember the combined down time, cost of parts, cost of installation and testing may make a new pump the more cost effective solution (and includes a new warranty).



5.6. Miscellaneous Maintenance

Miscellaneous maintenance consists of procedures to replace pump and/or gearbox components that typically do NOT fail under normal operating conditions. The procedures cover all major components that typically constitute a complete overhaul of the pump.

Before attempting a miscellaneous maintenance repair contact with Hale Customer Service (see Section 5.1, TROUBLESHOOTING) is recommended for FAST Centers and required for an end-user. (Hale pumps require ONLY trained maintainers perform miscellaneous maintenance.) This level of maintenance is typically considered shop maintenance, in which a complete tear down and removal and replacement of select major parts is required. Especially when this level of maintenance is required the repair must be conducted by a FAST Center or an OEM (supported but NOT typical). The Customer would need to be prepared to provide ID plate information (COMPLETE INFORMATION FROM ALL ID PLATES) for the affected pump and gearbox.

Unlike level 1 or level 2 maintenance there is no kit to support a complete overhaul of the pump. With this type of maintenance individual failed components must be ordered. The cost of individual major components and the associated labor for replacing them added to the subsequent required pump testing may be prohibitive. Miscellaneous maintenance procedures are included to replace all major components (cooler parts, shafts, inducers, impellers, clearance rings, gears, etc.) however when Hale Customer Service (see Section 5.1, TROUBLESHOOTING) is contacted it will evaluate the cost associated with the requested components and advise if a replacement pump (including a new warranty) would be more cost effective.

5.7. General Repair Guidelines

The following subparagraphs provide general guidelines to be utilized and/or followed whenever the maintenance procedure being performed is associated with the type of information/ instructions provided in these subparagraphs.

5.7.1 Match Mark Or Note Component Orientation

As a general maintenance practice, match mark and/or note (document/record) the orientation of a component before disconnecting or removing it.

5.7.2 Recommended Lubricants

Where grease is called for, use lithium based grease with 1 to 3% Molybdenum Disulfate. The following lists examples of approved greases.

- Dow Corning BR2-PLUS
- Lubriplate Fiske #3000
- Shell Super Duty Grease
- Imperial #777
- Mobil Grease Special
- Sunoco Moly #2EP

The lubricant listed in Table 20 is recommended to protect the O-ring from damage, speeds up assembly, and to ensure continued service and operation.

Table 20. Recommended O-ring Lubricant

Application	Lubricant <u>1</u> /
O-ring	Synthetic Multi-Purpose Clear O-ring Lubricant (Synthetic NLGI Grade 2 Heavy Duty, Multi-Purpose)

Note 1/: Or equivalent lubricant.



Use the lubricant listed in Table 21 to protect the mechanical seals from damage, speeds up assembly, and to ensure continued service and operation.

Table 21. Recommended Mechanical Seal Lubricant

Application	Lubricant <u>1</u> /
Mechanical Seal	P-80 THIX Lubricant Gel (Blend of synthetic esters and water in a thixotropic formula with a viscosity of about 10,000 cps)

Note 1: Or equivalent lubricant.

The gearbox lubricants listed in paragraph 7.4.4.1.1, Recommended Gearbox Lubricants, in the Flex Series Single Stage Booster Pump OIM (FSG-MNL-00183) are required to maintain the change interval listed in Table 7, Recommended Preventive Maintenance, and to ensure continued service and operation across the required ambient temperature range of - 20 ° to +50 °C (0 to +120 °F).

5.7.3 Cleaning And Lubrication Required For Mechanical Seal Installation

Before installing the mechanical seal, use the alcohol swabs provided by Hale Products Inc. to clean all grease or oil from the pump shaft and pump head.

IMPORTANT ▲ NOTICE

ALWAYS USE AND ONLY USE PAC-EASE RUBBER LUBRICANT EMULSION (OR EQUIVALENT) WHEN INSTALLING THE MECHANICAL SEAL. USING ANY OTHER LUBRICANT OR NOT USING THE LUBRICANT MAY DAMAGE THE MECHANICAL SEAL AND SEAT.

5.7.4 Replacement Fasteners

Replacement studs must be metric class 8.8 (or better). Apply Loctite™ 680 (or equivalent) to the housing side threads at the time of install (locker dries to fast to pre-apply).

Replacement screws and steel nuts must be grade 5 (or better) and grade 8 (or better) for drive line fasteners. Apply Loctite™ 243 (or equivalent) to all threads where lock/spring washers are NOT used.

Self-locking nuts must be grade 5 (or better), 3600 nylon patch lock fasteners. Do NOT reuse self-locking nuts. Do NOT apply Loctite.

Always remove old thread locker from used fastener threads before installation and torque as specified in Table 22.

Table 22. Maximum Torque Values

Fastener Size	Fastener Material	Torque ft-lb (Nm)
3/8–16	Zinc-Plated Steel	50(68)
3/8–16	Stainless Steel	28(39)
7/16–14	Zinc-Plated Steel	70(95)
7/16–14	Stainless Steel	28(39)
M8 x 1.25	Zinc-Plated Steel (Into Aluminum)	12(16)
M10 x 1.5	Unplated Steel Nut	17(23)
M10 x 1.5	Unplated Steel Stud (Into Aluminum)	24(32)
M12 x 1.75	Unplated Steel Stud (Into Aluminum)	40(54)
M12 x 1.75	Unplated Steel Nut (Grade 8)	29(39)

As previously stated, Loctite™ or sealant was used during factory assembly for all fasteners/hardware requiring the use of a thread lock or sealant compound, remnant compound ALWAYS causes false torque reading when installing old and/or new fasteners/hardware. Therefore ALWAYS clean both sets of threads when installation instructions specify a torque requirement. Use a cleanout tap (followed by a compressed air/water wash out) for female threads. Use a wire brush (or die) for male threads (followed by a compressed air/water wash off). Use of a torque lubricant is NOT required and is allowable ONLY for fasteners/hardware that do NOT require thread lock or sealant compound. Specific torque requirements are provided within a procedure when required. General torque values are provided in Table 22.

5.7.5 Circlip/Snap Ring Installation

All circlips (also called snap rings) should be installed with the sharp edge in the direction of thrust support. If you examine the circlip closely you can determine which side has the sharp edge by rubbing the edges with your finger. The edge of one side will feel sharp and the other side will be rounded. The different edges are caused by the punch press stamping the circlips out of a sheet of steel. Additionally the shape of the circlip is critical and for this reason they should never be reused once removed. The pumps utilize three types of circlips: internal, external, and general retaining as shown on Figure 14.



Figure 14. Circlips (How To Recognize And Remove Them)

5.7.6 Thread Lock Or Sealant Compound

Loctite™ (or suitable equivalent/substitute thread locker) or sealant shall be used when directed. Reference the procedures associated list of tools and/or consumables for the specific thread locker or sealant required. Loctite™ (243, 680) or sealant (580) was used during factory assembly for all fasteners/hardware requiring the use of a thread lock or sealant compound, remnant compound ALWAYS causes false torque reading when installing old and/or new fasteners/hardware. See paragraph 5.7.4, Replacement Fasteners, for thread lock or sealant compound cleaning information.

The following Loctite™ compounds were used for thread lock or sealant during factory assembly.

- Thread Lock Compounds
 - 243
 - 680
- Sealant
 - 580

5.7.7 Cleaning And Inspection Guidelines

Wherever a procedure calls for cleaning and inspection, these guidelines should be followed.

- A. Inspect all components for excessive or abnormal wear.
- B. Wherever a requirement for new parts is indicated, obtain new components from Hale Products Inc.



- C. Wherever procedures call for removal of gaskets, gasket should be replaced. Clean all gasket mating surfaces before installing new gaskets.
- D. Bearings and other components should be cleaned using only recommended solvents.
- E. Bearings and seals should be inspected whenever parts are disassembled. Look for signs of excessive and irregular wear. Replace seals with tears, that are out-of-round, hardened, cracked, rusted, impact damaged (dents), etc.
- F. Replace any hardware (including pump and input shaft keys) that shows signs of excessive wear.
- G. When inspecting impellers and clearance rings for wear, measure impeller hub diameter and inner diameter of clearance ring. Compare these measurements to data in Table 23. If measurements indicate, obtain replacement clearance rings and impeller.

NOTE

If either the impeller hub or clearance rings are out-of-tolerance, both rings and the impeller must be replaced as well as the mechanical seal.

5.7.7.1 Recommended Cleaners

Hale recommends the following:

- Safety Kleen
- Stoddard Solvent
- Loctite Clean-Up Solvent (thread locker removal for hardware and clearance rings)

5.7.8 Repair Kits

Reference the applicable pump drawing REPAIR PART KITS IDENTIFICATION sheet (typically sheet 3 of 6) for the available level 1, 2, or 3 repair kit part numbers.

5.7.9 Impeller Renew Kits

Reference the applicable pump drawing REPAIR PART KITS IDENTIFICATION sheet (typically sheet 3 of 6) for the available impeller renew kit part number (or numbers). Refer to the following paragraph for additional information about the need for installing an impeller renew kit.

5.7.9.1 Worn Clearance Rings And Impeller Hubs

Because clearance ring replacement requires pump disassembly, it is advisable to thoroughly check other possible causes of low performance before assuming that clearance ring wear is at fault.

Clearance rings limit the internal bypass of water from the discharge side of the pump back to the suction side. The radial clearance between the impeller hub and the clearance rings is only a few thousandths of an inch when new. In clear water, the clearance rings continue to effectively seal for hundreds of hours of pumping. In dirty or sandy water, the impeller hub and clearance rings will wear faster. The more wear, the greater the bypass and the lower the pump performance. Refer to Table 23.

Table 23. Impeller And Clearance Ring Diameters And Clearance Values

Booster Pump Model	Maximum Clearance Ring Inner Diameter in (mm)	Minimum Impeller Hub Outer Diameter in (mm)	Maximum Acceptable Radial Clearance in (mm)
AP	4.777 (121.336)	4.760 (120.904)	0.006 – 0.0085 (0.153 – 0.216)
CBP	3.6326 (92.268)	3.620 (91.948)	0.0045 – 0.0065 (0.114 – 0.165)
MBP	5.638 (143.205)	5.620 (142.748)	0.0075 – 0.01 (0.1905 – 0.254)
RSD (750-1250 gpm)	6.022 (152.959)	5.987 (152.070)	0.0075 – 0.01 (0.1905 – 0.254)
RSD (1500 gpm)	6.492 (164.897)	6.419 (163.043)	0.0075 – 0.01 (0.1905 – 0.254)

Often, replacement of the clearance rings will reduce the bypass and restore the pump to near original performance. A complete restoration requires that the impeller also be replaced. Inspect the front and back of both clearance ring IDs in several places for signs of wear. Measure the diameter of each ring in several places. Using a caliper as shown on Figure 15, measure the ID of each clearance ring and the OD of the impeller.

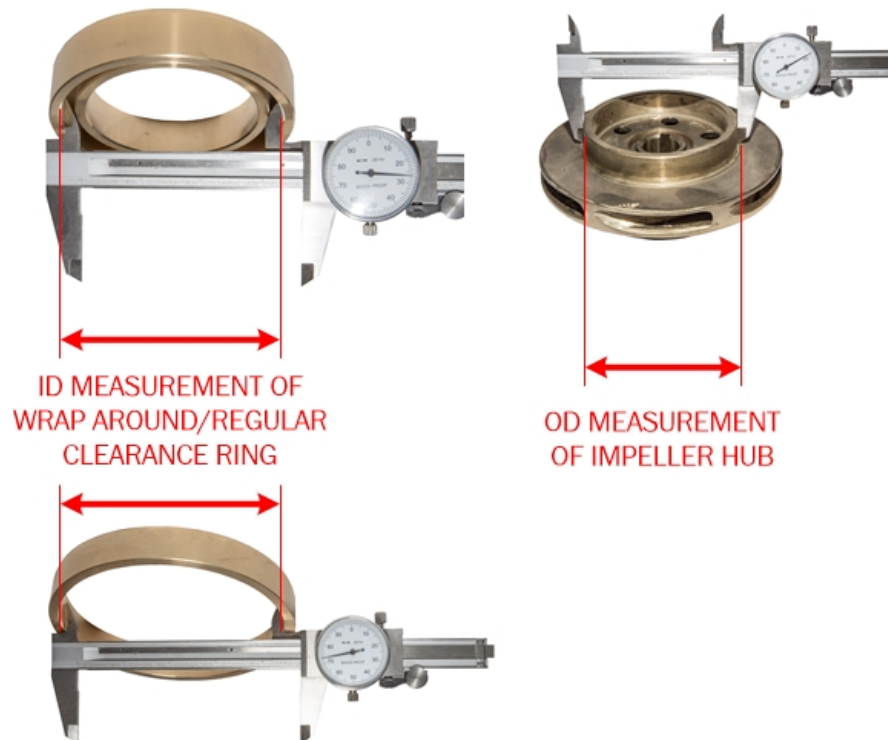


Figure 15. Measuring For Worn Clearance Rings And Impeller Hubs

NOTES

Do NOT measure clearance rings prior to installation, installing the ring compresses the ring which changes the measurement.

Do NOT measure a clearance rings after removing the ring, removing the ring distorts the ring which changes the measurement.

5.8. Removal And Replacement Instruction Guidelines

Removal and replacement instructions are provided for select components. The instructions provided describe a complete tear down of a booster pump. The tear down instructions are ordered by the sequence required to remove and replace the target assembly/part. To reduce unnecessary work and to avoid the introduction of additional/new issues, only dismantle the parts as instructed and necessary to accomplish the target inspection and or removal and replacement.

The R&R procedures are written to provide three layers of detail. The "A" steps provide an experienced technician (who is very familiar with a Hale booster pump) a Top Level View of the steps required to R&R the titled component. The "A" steps along with the "1" steps provide an experienced technician (who is NOT familiar with a Hale booster pump but is familiar with pumps in general) a more detailed set of steps to R&R the titled component. Using all three levels of the steps provides an inexperienced technician (training is require for all who work on the pumps) very detailed steps to perform the task.

5.8.1 Tools Required/Suggested

Individual tool and consumable lists are provided for each procedure. The following tools are the minimum required to perform maintenance/repairs on the pumps contained in this manual.

- Allen Wrenches (or Hex Socket Set)
- Ball Peen Hammer
- Bearing/Seal Driver Kit (See Figure 16.)
- By hand Push Tube
(a small section of PVC tubing to fit over/around shafts used as a special tool)
- Caliper (12 in) (See Figure 17.)
- Catch Pan (To Catch Oil)
- Center Punch
- Cutting Wheel/Grinder (Electric or Pneumatic)
- Dental Pick Set
- Drift Punch
- Funnel
- Hacksaw
- Hose Removal Tool
- Hydraulic Press
- Impact Driver
- Infrared Thermometer (Precise Non-Contact IR)
(See APPENDIX B, Test Equipment And Special Tool Information)
- Lift and Rigging Devices (Lever Hoist or Chain Hoist) and (Short Strap Or Choker)
- Non-marring Hammer
- Non-marring Pliers
- Oil Dry
- Pin Punch
- Pry Bar (2)
- Puller (Bearing/Impeller) (See APPENDIX B, Test Equipment And Special Tool Information)

- Pump Shaft Hydraulic Press Adapter
(a piece of 3-inch diameter, schedule 40, steel pipe, 10-inches long used as a special tool)
- Ratchet(s), Sockets, and Wrenches
- Screwdriver Set
- Seal Removal Tool (See Figure 16.)
- Shop Rags
- Snap Ring Pliers
- Torque Wrench(s) Or Torque Limiting Socket(s)
(Capable of 10, 17, 18, 19, 29, 30, 33, 40, 45, 50, 53, 59, 65, and 135 ft-lb [14, 23, 24, 26, 39, 41, 45, 54, 60, 68, 72, 79, 88, and 183 Nm])
(See APPENDIX B, Test Equipment And Special Tool Information)
- Wheel Chocks
- Wire Cutter
- Wire Tags
- Wooden Wedges



Figure 16. Seal Removal Tool And Seal Driver Kit



Figure 17. Caliper (Depth Rod Extended)

5.8.2 General Pump Disassembly For Access Guidelines

Before working on the pump, disconnect the suction and discharge piping and drain the volute. Disconnect cooling tubes from the pump as required.

Label/tag and then disconnect all wiring leaving the sensor/switch/valve on the pump.

The Hale booster pump design allows two methods of pump maintenance. If only pump components require removal and replacement the maintainer may be able to repair the pump without pump removal from apparatus depending on the apparatus configuration (pump access). See the appropriately titled subparagraph under section 5.8.3, AP Pump Disassembly, to R&R pump components without removing the pump from the apparatus.

If the gearbox requires internal component replacement or the apparatus configuration does NOT allow pump access the maintenance method requires both pump and gearbox be removed as an assembly from the apparatus. (See paragraph 5.8.2.1, AP Removal From The Apparatus.)

When AP gearbox and/or pump maintenance or repairs (which required method two, which supports gearbox component repairs or pump repairs when pump access is NOT possible) are completed, the AP pump/gearbox installation back onto the apparatus is accomplished by following the instructions in paragraph 5.8.8, AP Install On The Apparatus.

Read and understand all the instructions before beginning any pump removal or replacement.

5.8.2.1 General Pump Removal From The Apparatus

Refer to Table 24 for a list of tools and/or consumables required for this procedure.

Table 24. Pump R&R From The Apparatus Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None **	Shop Rag(s) (As Required)
PPE (For Handling Oil)		Tags (Wire, Etc.)
Catch Pan (For Gear Oil)		
Wheel Chocks		
Lifting Device And Rigging (Or Jack)		
9/16-in Socket (8 Pt.) And Ratchet (Or Wrench Or Adjustable Wrench)		

** None for pump – see OEM/Apparatus documentation for a complete list.

ATTENTION ⚠ CAUTION

THE AP PUMP AND GEARBOX ASSEMBLIES WEIGH APPROXIMATELY 140 LBS (64 KG). USE PROPER LIFTING DEVICE WHEN REMOVING OR INSTALLING THE PUMP AND GEARBOX ASSEMBLY.

ATTENTION ⚠ CAUTION

THE CBP PUMP AND GEARBOX ASSEMBLIES WEIGH APPROXIMATELY 100 LBS (45 KG). USE PROPER LIFTING DEVICE WHEN REMOVING OR INSTALLING THE PUMP AND GEARBOX ASSEMBLY.

ATTENTION ⚠ CAUTION

THE MBP PUMP AND GEARBOX ASSEMBLIES WEIGH APPROXIMATELY 170 LBS (77 KG). USE PROPER LIFTING DEVICE WHEN REMOVING OR INSTALLING THE PUMP AND GEARBOX ASSEMBLY.

ATTENTION ⚠ CAUTION

THE RSD PUMP AND GEARBOX ASSEMBLIES WEIGH APPROXIMATELY 225 LBS (102 KG). USE PROPER LIFTING DEVICE WHEN REMOVING OR INSTALLING THE PUMP AND GEARBOX ASSEMBLY.

- A. Prepare apparatus/vehicle for pump removal.
 1. Place apparatus out of service in accordance with departmental procedures.
 2. Park vehicle on level surface.

3. Set parking brake and chock front and rear wheels.
- B. Disassemble/remove all items required to access pump and gearbox. See Figure 19.
1. Support pump and gearbox using appropriately sized lifting device and rigging or jack.
 2. Match mark and tag all items/connections before removal.
 3. Remove ONLY items/connections required to access pump and gearbox.
 4. Follow all OEM provided instructions to disassemble/remove items when required to access pump and gearbox.
- C. Prepare pump for removal.
1. Remove drain plugs (water ONLY – do NOT drain oil until instructed) and drain pump.
 2. Place catch pan under magnetic oil drain plug.

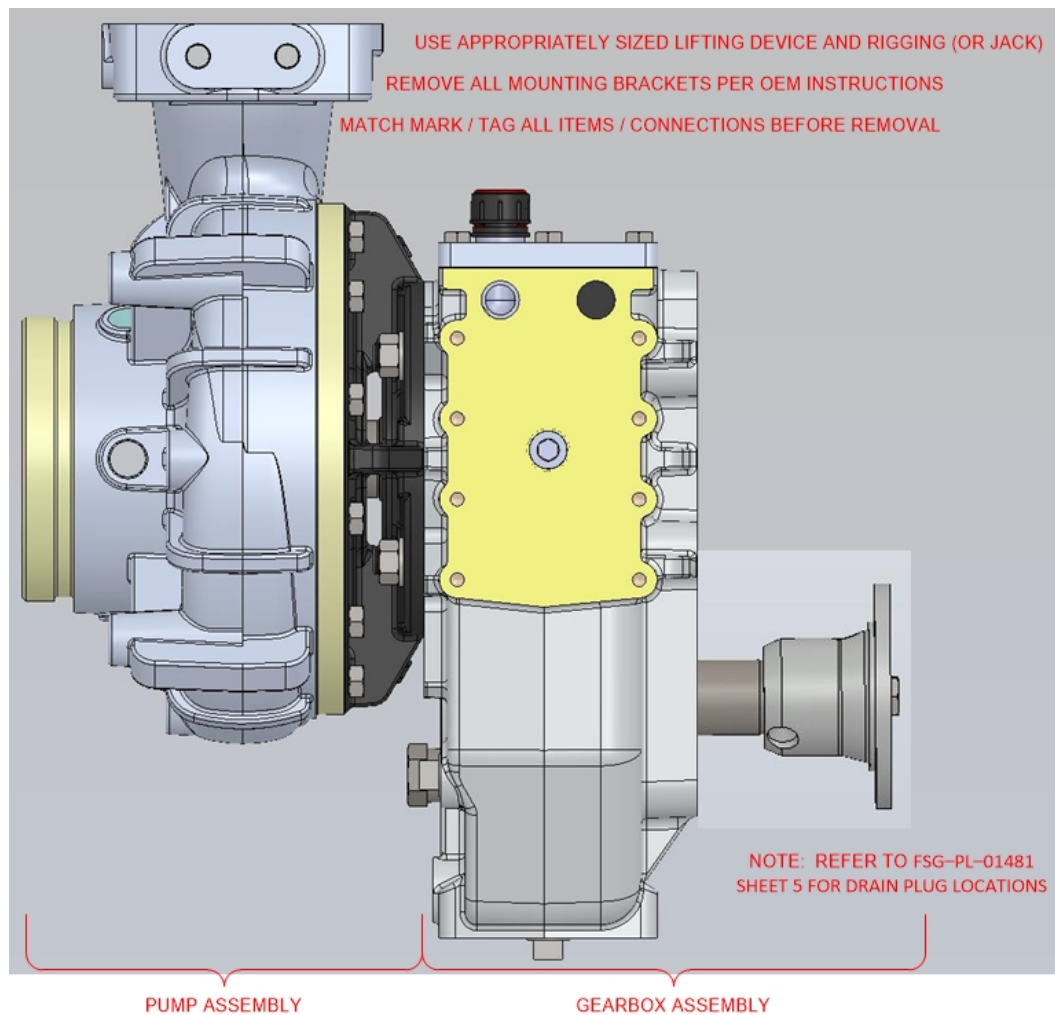


Figure 18. Pump And Gearbox Assembly R&R

3. Remove magnetic oil drain plug. (See Figure 18.)

- a) Using 9/16-in socket (8 point) and ratchet (set for CCW), loosen drain plug.
- b) Remove drain plug.
4. Wait for oil flow to stop.

NOTE

Check for metal accumulation on drain plug. Metal accumulation provides clues and insight as to gearbox component health.

5. Clean drain plug.
6. Install drain plug.
 - a) Hand start drain plug.
 - b) Using 9/16-in socket (8 point) and ratchet (set for CW), tighten drain plug.
 - c) Using shop rag(s), clean drain plug area.
7. Examine oil for water.

NOTE

Water turns the oil a milky color or settles in the bottom of the catch pan.

8. Dispose of oil properly.
9. Disconnect drive shaft from drive flange.
10. Tag and disconnect airlines, electronics, and tachometer cable as required.

ATTENTION ▲ CAUTION

THE AP PUMP AND GEARBOX ASSEMBLIES WEIGH APPROXIMATELY 140 LBS (64 KG). USE PROPER LIFTING DEVICE WHEN REMOVING OR INSTALLING THE PUMP AND GEARBOX ASSEMBLY.

11. Disconnect mounting brackets at pump and gearbox assembly.
- D. Remove pump and gearbox from apparatus. See Figure 18.
 1. Using lifting device (or jack), lift (or lower) pump and gearbox free from apparatus.
 2. Place pump and gearbox assembly on stable work stand so that breather and gearbox cover are exposed.

NOTE

This positioning will provide easy and safe access to the internal components.

5.8.3 General Pump Disassembly Methodology

Please review the general repair (section 5.7) and cleaning and inspection guidelines (section 5.7.7) before beginning these procedures.

The Hale Flex Series single stage booster pumps design separates the four pumps into two groups based on the volute. The first group (the AP, CBP, and MBP) utilizes a one-piece volute (see Figure 19) while the second (the RSD) utilizes a three-piece volute (see Figure 20). This makes the RSD pump disassembly unique among the Hale booster pumps. The RSD three-piece volute consists of the suction head, the body (volute), and the pump head. Additionally, the pump is unique in that the volute provides a side discharge flange to support ancillary equipment (typically a TRV).

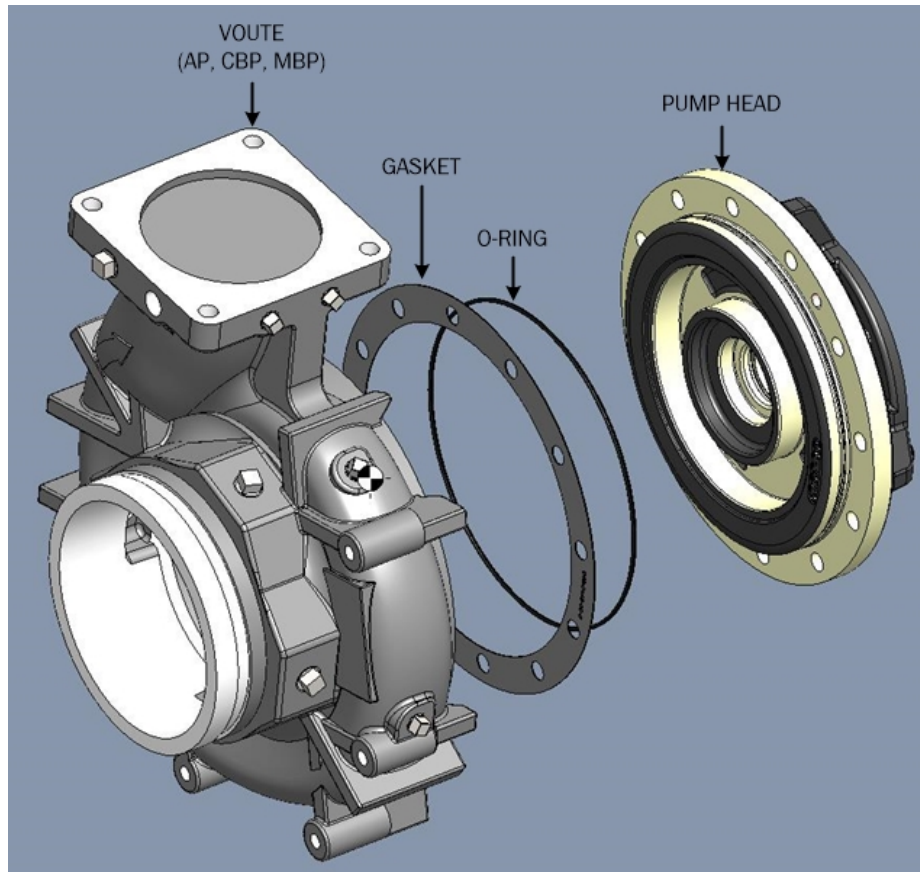


Figure 19. One-Piece Volute (AP, CBP, MBP)

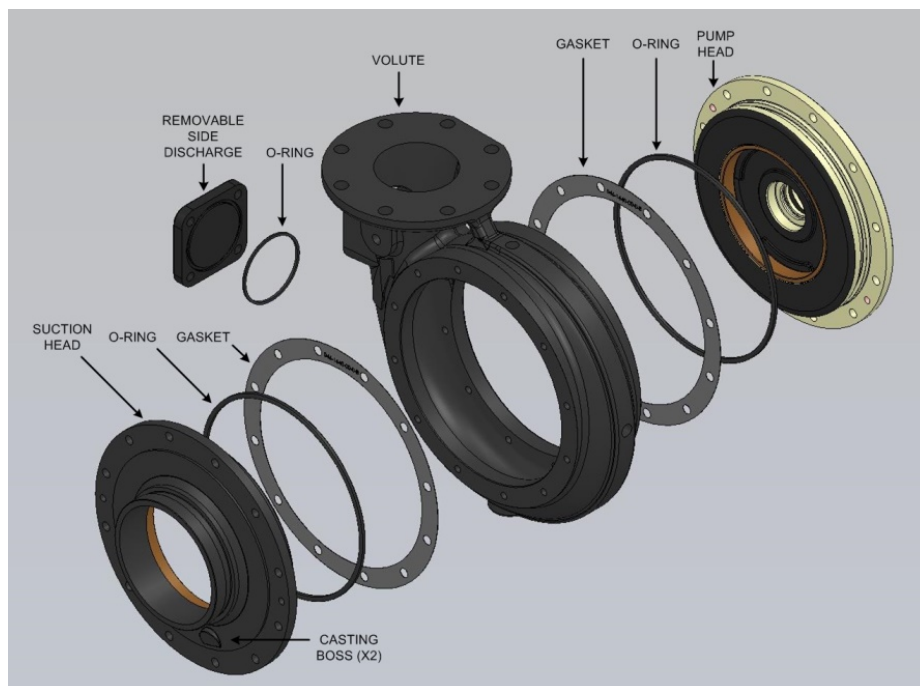


Figure 20. Three-Piece Volute (RSD)



No matter which group requires maintenance, the Hale Flex Series single stage booster pump design allows two methods of pump maintenance. In the first method (and the preferred method when only pump components require removal and replacement) the maintainer may be able to repair the pump without removing the pump and gearbox from the apparatus. Even though the Hale pump design allows the pump component to be removed without removing the pump and gearbox, the apparatus installation may prevent pump component removal without first removing the pump and gearbox. This is due to limited pump access when the pump is installed on the apparatus (as the pump is typically located between the frame rails and under other apparatus components). Therefore use of this method depends on the apparatus configuration (pump access). If the apparatus configuration allows pump component ONLY removal, see the appropriately titled subparagraph for the pump component that requires R&R.

If the gearbox requires internal component replacement or the apparatus configuration does NOT allow pump access the maintenance method requires the pump and gearbox be removed from apparatus as one assembly. If the apparatus configuration does NOT allow pump component ONLY removal or if the gearbox requires repair, see paragraph 5.8.2.1, General Pump Removal From The Apparatus for generalized removal instructions.

No matter which method of removal is utilized; Figure 21 provides an exploded view of the AP pump, Figure 22 provides an exploded view of the CBP pump, and Figure 23 provides an exploded view of the MBP pump, and Figure 24 provides an exploded view of the RSD pump to support Level 1 maintenance procedures. Figure 25 and Figure 26 provide exploded views of the gearbox (based on gear ratio) for support of Level 2 and/or 3 maintenance procedures. Impeller renew and miscellaneous maintenance procedures require the combination of both the applicable pump and applicable gearbox figures to provide adequate support. Note: Figure 26 additionally shows the optional gearbox cooling components, which (in addition to the gearbox cover) must be removed to replace the drive gear. The gearbox cover and the optional cooling tube must also be removed to replace some, pump gears. Removal is required for pumps with 1.14, 1.31, 1.64, and 1.90:1 gear ratios as the pump gear is too large to exit via the gearbox bearing bores.

Under any circumstances, do NOT remove a pump as an assembly (the entire unassembled pump) from the gearbox. Doing so leaves the pump shaft unsupported and allows significant damage to the internal pump components. Removing the pump as an entire assembly may result in catastrophic damage to the clearance rings, impeller, and the mechanical seal.

Regardless of the maintenance level, read and understand all the instructions before beginning any pump and especially a gearbox repair.

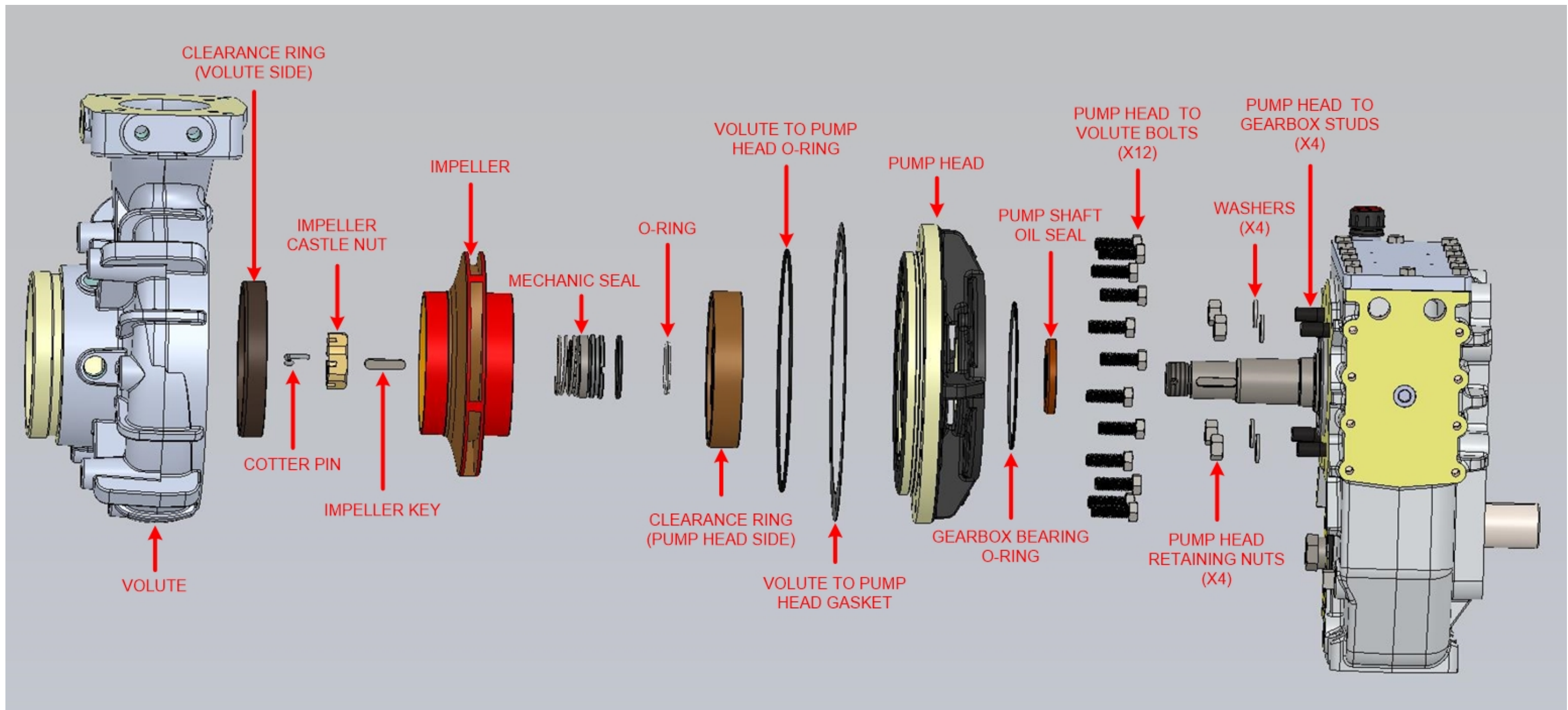


Figure 21. AP Pump Exploded View

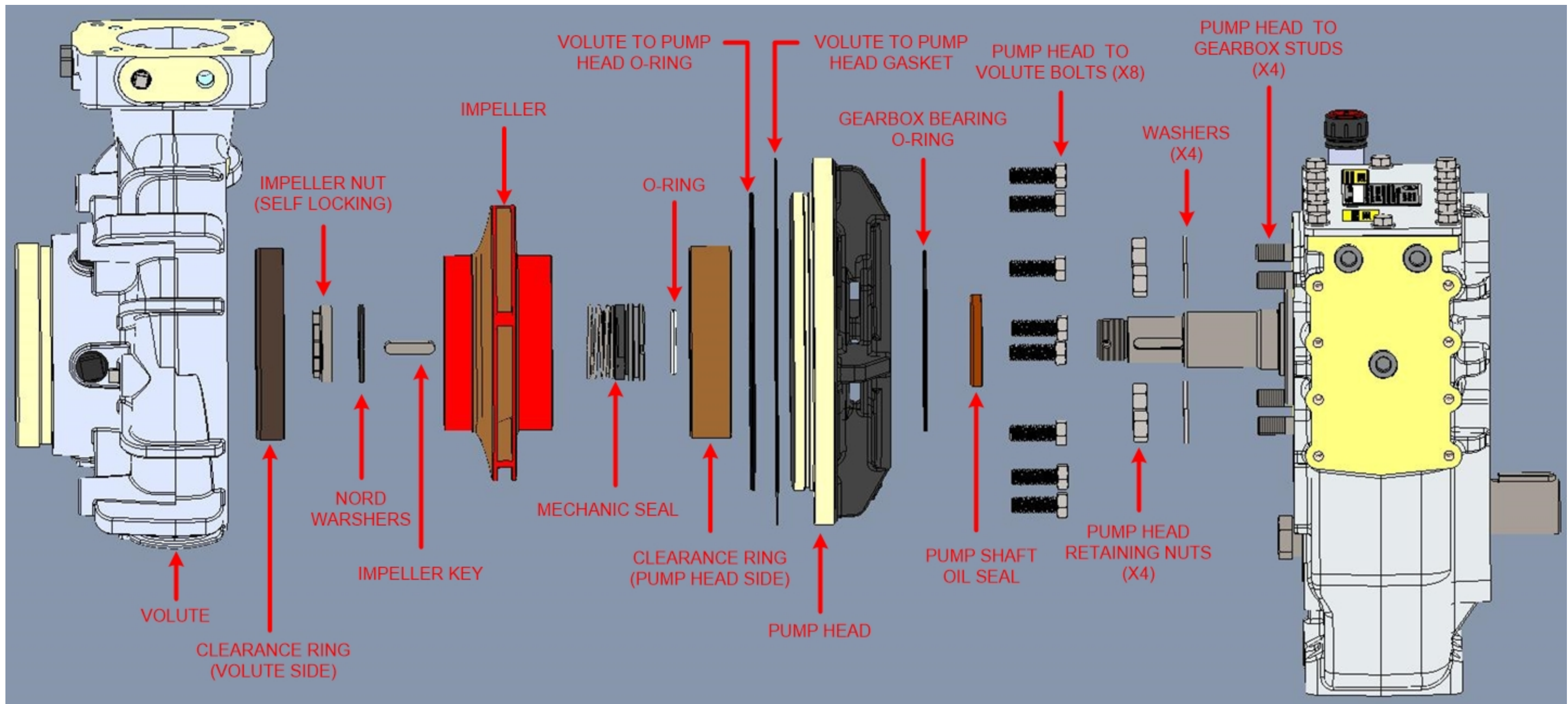


Figure 22. CBP Pump Exploded View

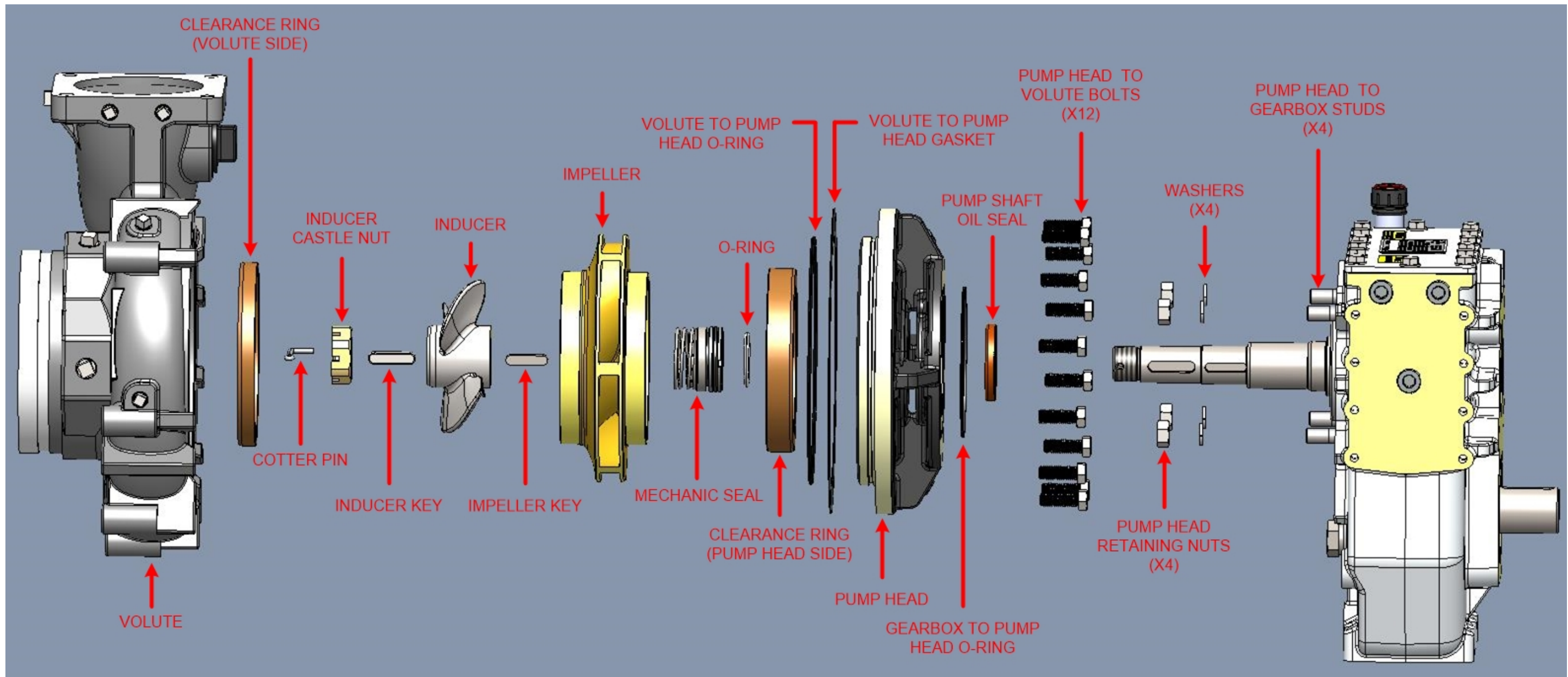


Figure 23. MBP Pump Exploded View

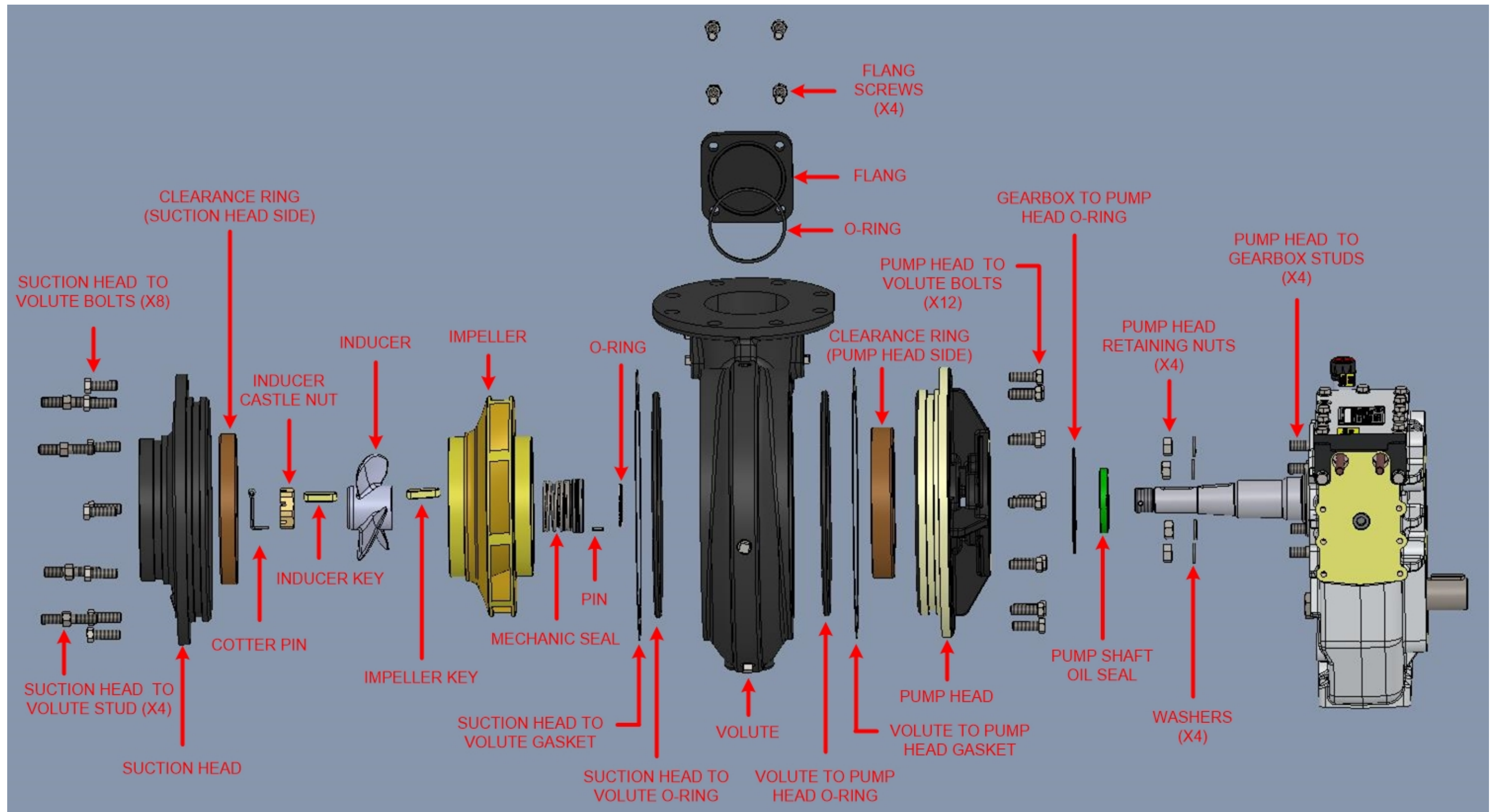


Figure 24. RSD Pump Exploded View

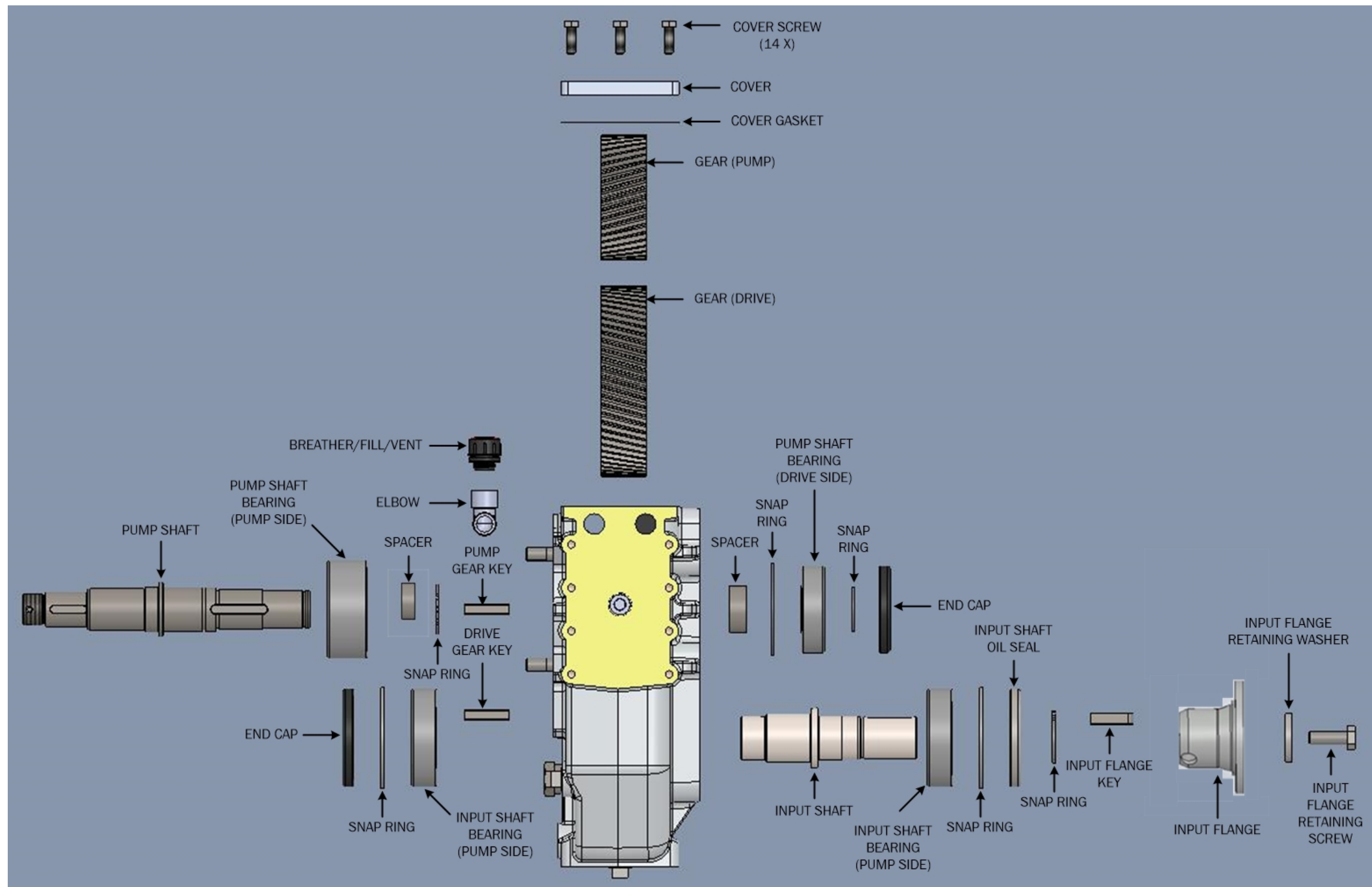


Figure 25. Gearbox Exploded View (All Except 3.74:1 GR)

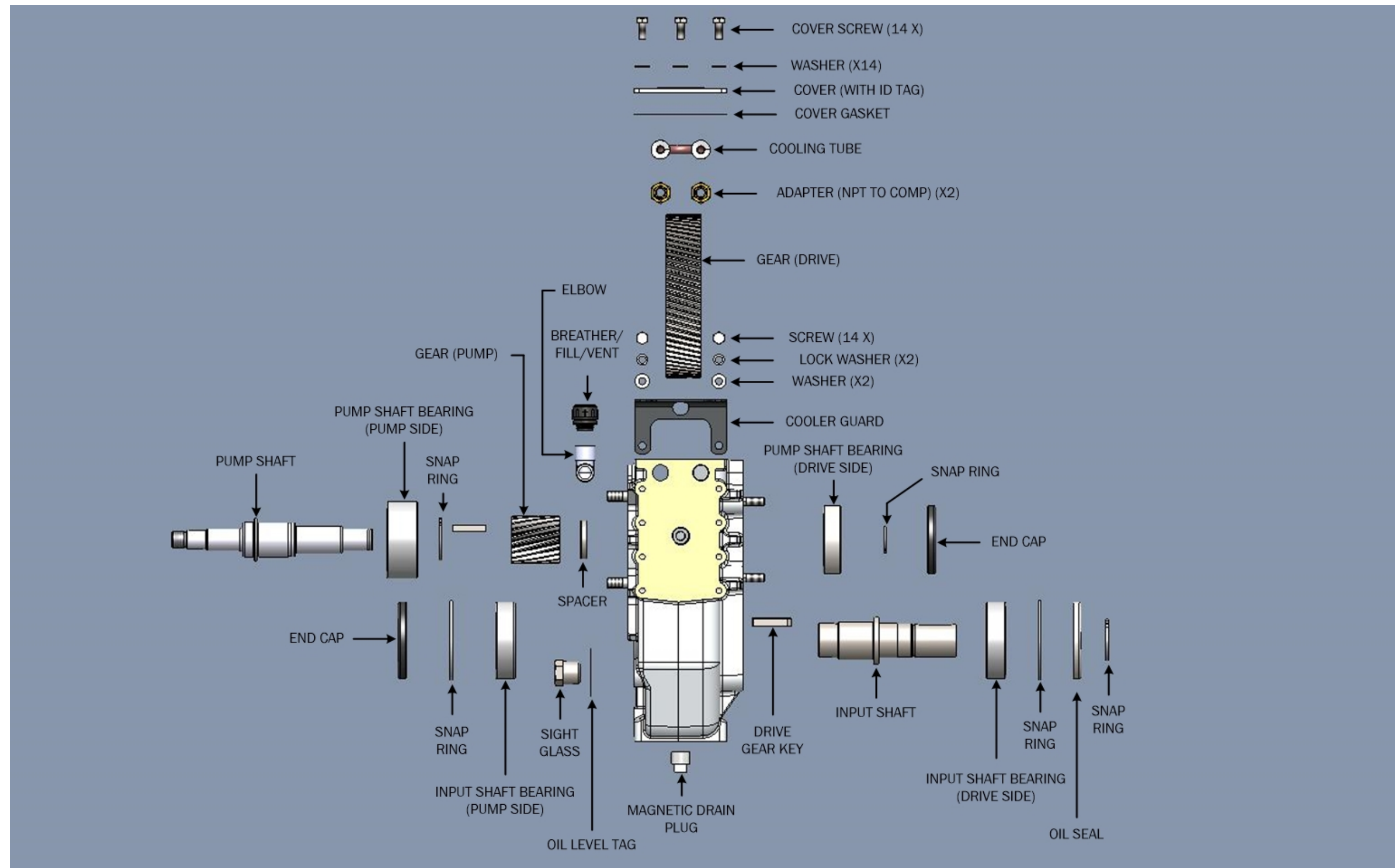


Figure 26. Gearbox Exploded View (3.74:1 GR)

5.8.4 Level 1 Procedures

If pump access permits, selected pump components (see Figure 21, Figure 22, or Figure 23) can be removed and replaced without removing the pump and gearbox assembly from the apparatus. Discharge and suction port hoses/plumbing may require removal before the selected pump component R&R procedure can be performed. Follow OEM instructions/procedures to remove and install discharge and/or suction port hoses/plumbing when required for pump component access. The following pump components can be removed and replaced without removing the pump and gearbox assembly from the apparatus.

- Gaskets and O-rings
- Pump Shaft Oil Seal
- Mechanical Seal
- Input Shaft Oil Seal

Air and/or water leaks may occur at the volute joints as a result of gasket or O-ring damage or wear. This may be indicated by symptoms of cavitation or poor performance (see section 5.1, Troubleshooting) or be visually noticeable as water stains or mineral deposits appearing from the volute to pump head joint.

5.8.4.1 RSD Suction Head R&R

In addition to gasket/O-ring failure the suction head requires removal to examine or access internal pump components (suction side clearance ring, inducer, or impeller). Typically the suction head would not require replacement unless it has been damaged by allowing the pump to freeze with water in it or a large piece of debris was allowed into the pump by not using or maintaining strainers.

NOTE

If the joint between the suction head and the volute appears to be leaking water or the suction head is damaged, suction head removal is required. If a leak is indicated, water staining will appear on the paint between the assemblies. Additionally mineral deposits may also indicate a leak at the joint.

Refer to Table 26 for a list of tools and/or consumables required for this procedure.

Table 25. RDS Suction Head R&R Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
5/8-in Wrench (Or Ratchet And Socket) (Or Pass Thru Ratchet)		O-ring Lubricant (See Table 20)
Hooked-end Dental Pick (or Hose Removal Tool)		O-RING <See FSG-PL-01487, Sheet 4, Item 30> (Suction Head To Volute)
Gasket Scraper		Gasket <See FSG-PL-01487, Sheet 4, Item 3> (Suction Head To Volute)
Non-marring Hammer		Suction Head: (ONLY ONE REQUIRED – SELECT FROM:) <See FSG-PL-01487, Sheet 4, Table B>
		Loctite™ Clean-Up Solvent
		Loctite™ 243 (Or Equivalent)



Perform the following to remove and replace the suction head.

NOTES

Remove any suction tube and/or piping blocking access to the pump per OEM/equipment manufacturer instructions.

Remove any discharge piping blocking access to the pump per OEM/equipment manufacturer instructions.

RSD Suction Head Removal

- A. If pump is still in apparatus, match mark/note/tag and then disconnect suction, discharge, and cooling lines.
- B. If pump is still in apparatus, tag and disconnect any electrical wiring.
- C. Match mark suction head to volute to ensure proper alignment during reassembly (volute position may vary).
- D. If pump is still in apparatus, disconnect ONLY mounting bracket(s) required for suction head removal.
- E. Remove eight (8) 7/16 – 14 X 1.25–in screws that hold suction head to volute.

NOTE

Do NOT damage clearance ring or inducer during suction head removal.

- F. Remove four (4) 7/16 – 14 X 2.63–in studs that hold suction head to volute.
- G. Remove suction head from volute.

NOTE

Gentle tapping with a non-marring hammer may be required to loosen the suction head from the volute.

- H. Remove O-ring from suction head.
- I. Remove all remaining gasket material from mating surfaces of volute and suction head.

Measure suction side clearance ring (see Table 23.), replace if out-of-tolerance. If the clearance rings have failed, perform RSD Clearance Ring R&R (see paragraph 5.8.7.2 on page 110). If the impeller has failed, perform Impeller R&R (see paragraph 5.8.4.6 on page 81). If the mechanical seal has failed, perform RSD Mechanical Seal R&R (see paragraph 5.8.4.10 on page 93).

RSD Suction Head Installation

- A. Apply a small amount of grease to a new gasket and align gasket on suction head.
- B. Apply O-ring lubricant to a new suction head O-ring.
- C. Using care NOT to damage O-ring, install O-ring on suction head.
- D. Align bolt holes and match mark(s) then push suction head into volute.

NOTES

Unless match marking differs, place the two (2) casting bosses at the 6 o'clock position on the volute (see Figure 20) regardless of volute orientation.

Gentle tapping with a non-marring hammer may be required to seat the suction head on the volute.

Use care NOT to damage (pinch) the O-ring if using the bolts to pull the suction head onto the volute (especially if the suction head is angled). Additional O-ring lubricant may be required.

- E. Install fasteners.
 - 1. Clean original fastener threads (or replace with the correct new fasteners).
 - 2. Apply Loctite™ 243 (or equivalent) to threads of fasteners.
 - 3. Install four (4) 7/16 – 14 X 2.63-in studs that hold suction head to volute.
 - 4. Install eight (8) 7/16 – 14 X 1.25-in screws that hold suction head to volute.
 - 5. Refer to Table 22 for recommended torque values for fastener size and material.
- F. Connect mounting bracket(s) as noted/match marked.
- G. Connect any electrical wiring according to tags.
- H. Connect all suction, discharge, and cooling tubing and piping as noted/match marked.
- I. Perform paragraph 4.4.4.1.3, Performance Testing Test Procedure, to verify repair complete and pump in working condition. Repair any leaks or problems. (See page 41.)
- J. Update maintenance log entries.
- K. Place apparatus in service in accordance with departmental procedures.

5.8.4.2 RSD Volute R&R

In addition to gasket/O-ring failure the pump body components require removal to examine or access internal pump components (clearance rings, inducer, impeller, or mechanical seal). Typically, the volute would not require replacement unless it has been damaged by allowing the pump to freeze with water in it or a large piece of debris was allowed into the pump by not using or maintaining strainers.

The RSD volute removal does NOT require suction head removal unless required for access purposes.

NOTE

If the joint between the volute and the pump head appears to be leaking water or the volute is damaged, volute removal is required. If a leak is indicated, water staining will appear on the paint between the assemblies. Additionally mineral deposits may also indicate a leak at the joint.

Refer to Table 26 for a list of tools and/or consumables required for this procedure.

Table 26. RSD Volute R&R Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
5/8-in Wrench (Or Ratchet Wrench) (Or Pass Thru Ratchet)		O-ring Lubricant (See Table 20.)
Hooked-end Dental Pick (or Hose Removal Tool)		O-RING <See FSG-PL-01487, Sheet 4, Item 30> (Two Required) (Suction Head To Volute) (Volute To Pump Head)
Adjustable Wrench (For cooling tubing removal)		Grease (See paragraph 5.7.2, Recommended Lubri- cants.)
Gasket Scraper		Gasket <See FSG-PL-01487, Sheet 4, Item 3> (Two Required) (Suction Head To Volute) (Volute To Pump Head)
Non-marring Hammer		Volute: (ONLY ONE REQUIRED – SELECT FROM:) <See FSG-PL-01487, Sheet 4, Item 29>
		Loctite™ Clean-Up Solvent
		Loctite™ 243 (Or Equivalent)

Perform the following to remove and replace the volute.

NOTES

Remove any suction tube and/or piping blocking access to the pump per OEM/equipment manufacturer instructions.

Remove any discharge piping blocking access to the pump per OEM/equipment manufacturer instructions.

RSD Volute Removal

- If pump is still in apparatus, match mark/note/tag and then disconnect suction, discharge, and cooling lines.
- If pump is still in apparatus, tag and disconnect any electrical wiring.
- Match mark volute and pump head to ensure proper alignment during reassembly.
- If pump is still in apparatus, disconnect ONLY mounting bracket(s) required for volute removal.
- Using 5/8-in ratchet wrench (or pass thru ratchet set CCW), remove twelve (12) 7/16 – 14 X 1.25-in screws that hold volute to pump head.

NOTE

Do NOT damage brass clearance rings, inducer, or impeller during volute removal.

- F. Remove volute from pump head.

NOTE

Gentle tapping with a non-marring hammer may be required to loosen the volute from the pump head.

- G. Remove all remaining gasket material from mating surfaces of volute and pump head.

Measure clearance rings and impeller hub (see Table 23.), replace if out-of-tolerance. If the clearance rings have failed, perform RSD Clearance Ring R&R (see paragraph 5.8.7.2 on page 110). If the impeller has failed, perform Impeller R&R (see paragraph 5.8.4.6 on page 81). If the mechanical seal has failed, perform RSD Mechanical Seal R&R (see paragraph 5.8.4.10 on page 93).

RSD Volute Installation

- A. Apply a small amount of grease to a new gasket and align gasket on pump head.
- B. Apply O-ring lubricant to a new pump head O-ring.
- C. Using care NOT to damage O-ring, install O-ring on pump head.
- D. Using care NOT to damage clearance rings or impeller, install volute onto pump head.

NOTE

Gentle tapping with a non-marring hammer may be required to seat the volute onto the pump head. Using the bolts to pull the volute (especially if the volute is angled) into the pump head may damage the O-ring.

- E. Install volute fasteners.
 - 1. Clean original fastener threads (or replace with the correct new fasteners).
 - 2. Apply Loctite™ 243 (or equivalent) to threads of fasteners.
 - 3. Install twelve (12) 7/16 – 14 UNC x 1.25-in screws that hold volute to pump head.
 - 4. Refer to Table 22 for recommended torque values for fastener size and material.
- F. Connect mounting bracket(s) as noted/match marked.
- G. Connect any electrical wiring according to tags.
- H. Connect all suction, discharge, and cooling tubing and piping as noted/match marked.
- I. Perform paragraph 4.4.4.1.3, Performance Testing Test Procedure, to verify repair complete and pump in working condition. Repair any leaks or problems. (See page 41.)
- J. Update maintenance log entries.
- K. Place apparatus in service in accordance with departmental procedures.

5.8.4.3 AP/MBP Volute R&R

In addition to gasket/O-ring failure the volute requires removal to examine or access internal pump components (clearance rings, impeller, mechanical seal, etc.). See Figure 27 for AP volute removal. Typically the volute would not require replacement unless it has been damaged by allowing the pump to freeze with water in it or a large piece of debris was allowed into the pump by not using or maintaining strainers.

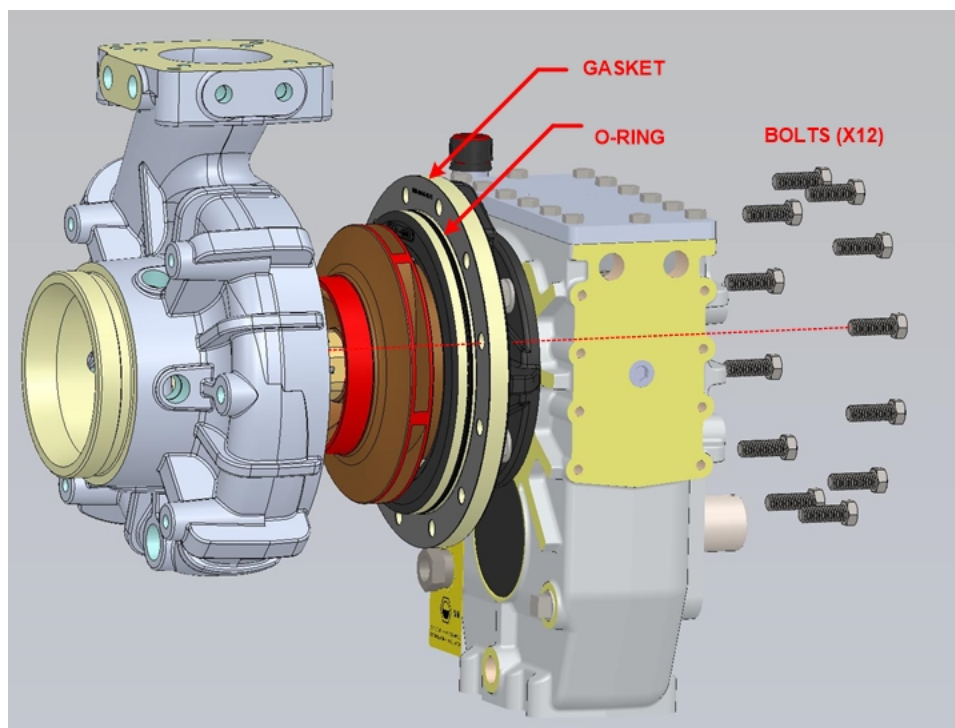


Figure 27. AP/MBP Volute R&R

Refer to Table 27 for a list of tools and/or consumables required for this procedure.

Table 27. AP Volute R&R Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
Gasket Scraper		O-ring Lubricant (See Table 20)
Hooked-end Dental Pick (or Hose Removal Tool)		O-RING, <See FSG-PL-01483 Sheet 4 Item 7> (Volute to Pump Head)
5/8-in Wrench (Or Ratchet Wrench) (Or Pass Thru Ratchet)		Gasket <See FSG-PL-01483 Sheet 4 Item 6> (Volute to Pump Head)
5/8-in Torque Wrench		Volute: (ONLY ONE REQUIRED – SELECT FROM:) <See FSG-PL-01483 Sheet 4 Item 1>
		Loctite™ Clean-Up Solvent
		Loctite™ 243 (Or Equivalent)



Perform the following to remove and replace the volute.

NOTES

Remove any suction tube and/or piping blocking access to the pump per OEM/equipment manufacturer instructions.

Remove any discharge piping blocking access to the pump per OEM/equipment manufacturer instructions.

AP/MBP Volute Removal

- A. If pump is still in apparatus, match mark/note/tag and then disconnect suction, discharge, and cooling lines.
- B. If pump is still in apparatus, tag and disconnect any electrical wiring.
- C. Match mark volute and pump head to ensure proper alignment during reassembly.
- D. If pump is still in apparatus, disconnect ONLY mounting bracket(s) required for volute removal.
- E. Remove twelve (12) 7/16 – 14 X 1.25-in bolts that hold volute to pump head.
 - 1. Using 5/8-in wrench (or ratchet wrench or pass thru ratchet [set CCW]), loosen twelve (12) 7/16 – 14 X 1.25-in bolts.
 - 2. Remove twelve (12) 7/16 – 14 X 1.25-in bolts.

NOTE

Do NOT damage brass clearance rings or impeller during volute removal.

- F. Remove volute from pump head.
- G. Remove O-ring from pump head.
- H. Remove all remaining gasket material from mating surfaces of volute and pump head.

Measure clearance rings and impeller hub, replace if out-of-tolerance (see Table 23). If the clearance rings have failed, perform Clearance Ring R&R (see paragraph 5.8.7.2 on page 110). If the impeller has failed, perform Impeller R&R (see paragraph 5.8.4.7 on page 83). If the mechanical seal has failed, perform Mechanical Seal R&R (see paragraph 5.8.4.9 on page 90).

AP/MBP Volute Installation

- A. Prepare volute for installation.
 - 1. Install new O-ring.
 - a) Lubricate O-ring. Refer to Table 20.
 - b) Install new O-ring on pump head into O-ring groove on pump side.
 - 2. Install new gasket. (Align new gasket with pump head screw holes.)
- B. Using care NOT to damage clearance rings or impeller, install volute onto pump head.
- C. Install volute fasteners.

1. Clean original fastener threads (or replace with the correct new fasteners) and volute screw hole threads. (Loctite Clean-up Solvent)
 2. Apply Loctite™ 243 (or equivalent) to threads of fasteners.
 3. Hand start twelve (12) 7/16 – 14 UNC x 1.25-in bolts that hold volute to pump head.
 4. Using a 5/8-in wrench (or ratchet wrench or pass thru ratchet) tighten (CW) twelve (12) 7/16 – 14 UNC x 1.25-in bolts.
 5. Using circular pattern, torque twelve (12) 7/16 – 14 UNC x 1.25-in bolts. Refer to Table 22 for recommended torque values for fastener size and material.
- D. Connect mounting bracket(s) as noted/match marked.
- E. Connect any electrical wiring according to tags.
- F. Connect all suction, discharge, and cooling tubing and piping as noted/match marked.
- G. Perform paragraph 4.4.4.1.3, Performance Testing Test Procedure, to verify repair complete and pump in working condition. Repair any leaks or problems.
- H. Update maintenance log entries.
- I. Place apparatus in service in accordance with departmental procedures.

5.8.4.4 CBP Volute R&R

The primary difference between the CBP and the AP/MBP volute removal is the number of screws that hold the volute to the pump head, the CBP uses only eight (8) 3/8-in-16 by 0.88 in long screws instead of the twelve (12) larger screws.

NOTE

If the joint between the volute and the pump head appears to be leaking water or the volute is damaged, volute removal is required. If a leak is indicated, water staining will appear on the paint between the assemblies. Additionally mineral deposits may also indicate a leak at the joint.

Refer to Table 28 for a list of tools and/or consumables required for this procedure.

Table 28. CBP Volute R&R Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
Gasket Scraper		Loctite™ 243 (Or Equivalent)
9/16-in Wrench (Or Ratchet Wrench) (Or Pass Thru Ratchet)		Volute: (ONLY ONE REQUIRED – SELECT FROM:) < See FSG-PL-01482 Sheet 4 Item 1>
9/16-in Torque Wrench		O-ring Lubricant (See Table 20)

Table 28. CBP Volute R&R Tools And Consumables List – CONTINUED

Standard Tools	Special Tools	Consumables
Hooked-end Dental Pick (or Hose Removal Tool)		O-RING, <See FSG-PL-01482 Sheet 4 Item 9> (Volute to Pump Head)
		Gasket <See FSG-PL-01482 Sheet 4 Item 10> (Volute to Pump Head)
		Loctite Clean-Up Solvent

Perform the following to remove and replace the volute.

NOTES

Remove any suction tube and/or piping blocking access to the pump per OEM/equipment manufacturer instructions.

Remove any discharge piping blocking access to the pump per OEM/equipment manufacturer instructions.

CBP Volute Removal

- A. If pump is still in apparatus, match mark/note/tag and then disconnect suction, discharge, and cooling lines.
- B. If pump is still in apparatus, tag and disconnect any electrical wiring.
- C. Match mark volute and pump head to ensure proper alignment during reassembly.
- D. If pump is still in apparatus, disconnect ONLY mounting bracket(s) required for volute removal.
- E. Remove eight (8) 3/8 – 16 X 7/8-in bolts that hold volute to pump head.
 1. Using 9/16-in wrench (or socket and ratchet [set CCW]), loosen eight (8) 3/8 – 16 X 7/8-in bolts.
 2. Remove eight (8) 3/8 – 16 X 7/8-in bolts.

NOTE

Do NOT damage brass clearance rings or impeller during volute removal.

- F. Remove volute from pump head.
- G. Remove all remaining gasket material from mating surfaces of volute and pump head.

Measure clearance rings and impeller hub, replace if out-of-tolerance (see Table 23). If the clearance rings have failed, perform Clearance Ring R&R (see paragraph 5.8.7.2 on page 110). If the impeller has failed, perform Impeller R&R (see paragraph 5.8.4.7 on page 83). If the mechanical seal has failed, perform Mechanical Seal R&R (see paragraph 5.8.4.9 on page 90).

CBP Volute Installation

- A. Prepare volute for installation.
 1. Install a new gasket.
 2. Align gasket with screw holes in pump head.

- B. Using care NOT to damage clearance rings or impeller, install volute onto pump head.
- C. Install volute fasteners.
 - 1. Clean original fastener threads (or replace with the correct new fasteners) and volute screw hole threads. (Loctite Clean-Up Solvent)
 - 2. Apply Loctite™ 243 (or equivalent) to threads of fasteners.
 - 3. Hand start eight (8) 3/8 – 16 X 7/8-in bolts (with washers) that hold volute to pump head.
 - 4. Using a 9/16-in wrench (or ratchet wrench or pass thru ratchet) tighten (CW) eight (8) 3/8 – 16 X 7/8-in bolts.
 - 5. Using circular pattern, torque eight (8) 3/8 – 16 X 7/8-in bolts. Refer to Table 22 for recommended torque values for fastener size and material.
- D. Connect mounting bracket(s) as noted/match marked.
- E. Connect any electrical wiring according to tags.
- F. Connect all suction and discharge tubing/piping as noted/match marked.
- G. Perform paragraph 4.4.4.1.3, Performance Testing Test Procedure, to verify repair complete and pump in working condition. Repair any leaks or problems. (See page 41.)
- H. Update maintenance log entries.
- I. Place apparatus in service in accordance with departmental procedures.

5.8.4.5 MBP/RSD Inducer R&R

Typically, the inducer would not require replacement unless it has been damaged by allowing a large piece of debris into the pump by not using or maintaining strainers. Long term wear can damage an inducer to the point it must be replaced to maintain pump performance specifications.

When the MBP inducer R&R is performed without removing the volute, installing the cotter pin may be difficult with the volute in place. The preferred method would be prior to performing this procedure, remove the MBP volute as described in paragraph 5.8.4.3, Volute R&R (page 72).

For either pump, if the volute is removed when the inducer requires replacement, always inspect (measure) the clearance rings and the impeller before installing the new inducer. Refer to Table 23 for the impeller wear specifications. If the clearance rings are out-of-tolerance they require replacement, see Pump Clearance Ring R&R (paragraph 5.8.7.2 on page 110) for an MBP or RSD. If the impeller is out-of-tolerance it requires replacement, see paragraph 5.8.4.6 (page 81), Impeller R&R for either pump. Figure 28 shows the MBP pump with the volute removed and depicts the inducer removal.

NOTE

For the RSD pump, if pump performance is an issue and the clearance rings/impeller are suspect, remove the volute instead of the suction head to provide access to the impeller and rear clearance ring. See paragraph 5.8.4.2 (on page 69).

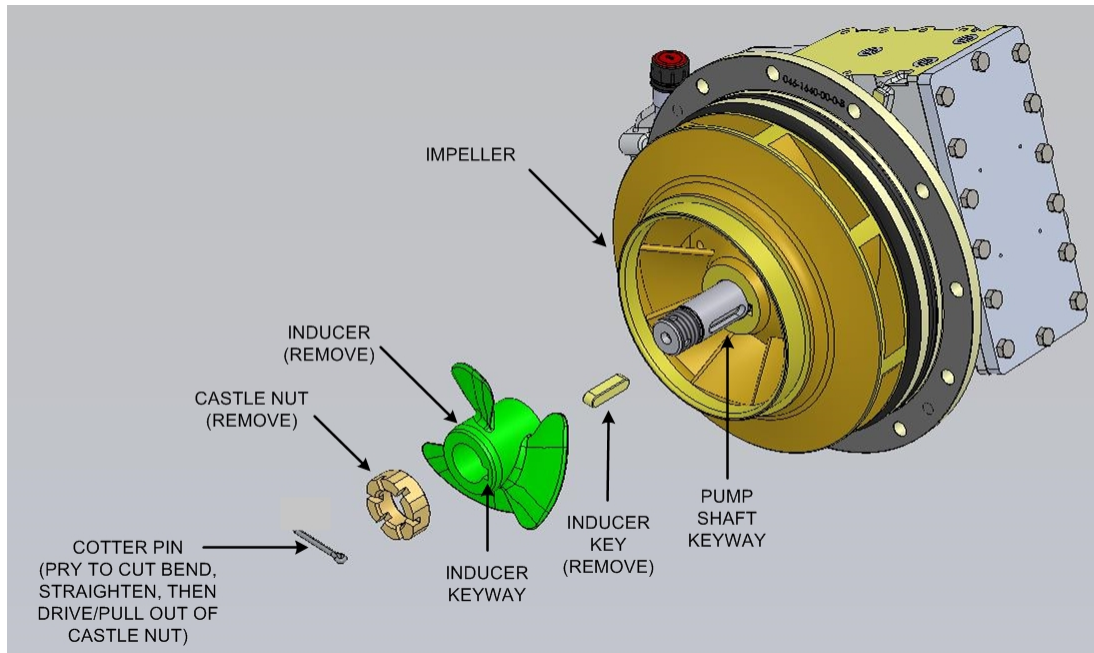


Figure 28. MBP Inducer R&R

If the pump is a RSD, prior to performing this procedure, remove the suction head as described in paragraph 5.8.4.1, RSD Suction Head R&R (on page 67). Figure 29 shows the RSD pump with the suction head removed and depicts the inducer removal.

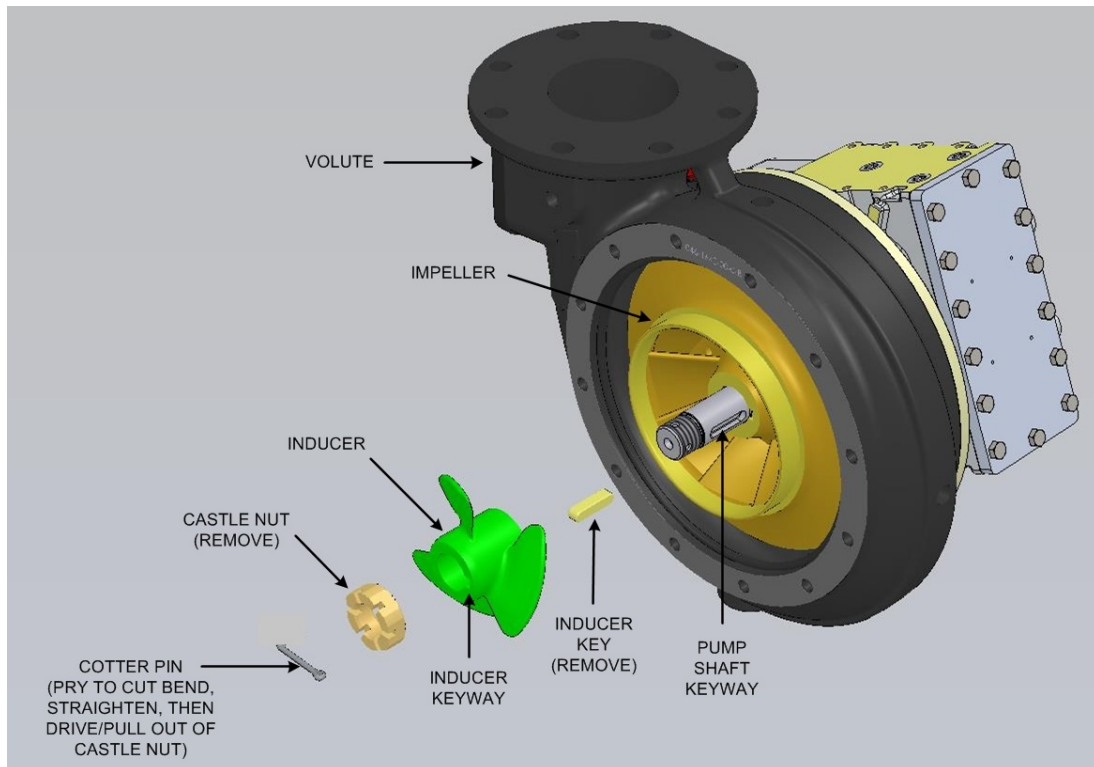


Figure 29. RSD Inducer R&R

Refer to Table 29 for a list of tools and/or consumables required for this procedure.

Table 29. MBP/RSD Inducer R&R Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	Torque Limiting Extension 210 ft-lb (285 Nm)	Shop Rag(s) (As Required)
2-1/2-in Socket and Ratchet (RSD)	Torque Limiting Extension (110 ft-lb [149 Nm])	Grease (See paragraph 5.7.2 on page 49.)
1 3/4-in Socket and Ratchet (MBP)	Puller Set (See APPENDIX B)	O-ring Lubricant (See Table 20, page 49.)
Torque Wrench (MBP) 110 ft-lb (149 Nm)		Key (Inducer To Pump Shaft) <See FSG-PL-01486 or -01487 Sheet 5 Item 2>
Torque Wrench (RSD) 210 ft-lb (285 Nm)		Inducer <See FSG-PL-01486, Sheet 4, Item 6> (MBP) <See FSG-PL-01487, Sheet 4, Item 22>(RSD)
Cold Cut Chisel		Cotter pin (Inducer Nut To Pump Shaft) <See FSG-PL-01486, Sheet 4, Item 5> (MBP) <See FSG-PL-01487, Sheet 4, Item 9> (RSD)
Flat Blade Screwdriver		Gasket MBP (Volute to Pump Head) <See FSG-PL-01486, Sheet 4, Item 9> RSD (Suction Head To Volute) <See FSG-PL-01487, Sheet 4, Item 3>
Hammer		O-RING MBP (Volute to Pump Head) <See FSG-PL-01486 Sheet 4 Item 10> RSD (Suction Head To Volute) <See FSG-PL-01487, Sheet 4, Item 30>
Heavy Wire Cutters		
Impact Driver		
Pin (or Drift) Punch		
Pliers		

Perform the following to remove and replace the inducer.

ATTENTION ⚠ CAUTION

USE PPE TO PROTECT HANDS AND FINGERS FROM SHARP EDGES. THE EDGES OF THE BLADES ON THE INDUCER MAY BE SHARP.

Inducer Removal

- A. Remove cotter pin that secures inducer nut.
 1. Using flat blade screwdriver, pry bent portion of cotter pin so bend can be cut off or driven out of pump shaft.
 2. Using heavy wire cutters, cut off bent portion of cotter pin. (Or using pliers, bend cotter pin straight.)

3. Using pliers (or hammer and pin punch), pull (or drive) cotter pin out of castle nut.
- B. Remove inducer nut.
 1. If pump is a RSD.
 - a) If using a 2-1/2-in socket and impact driver (set CCW).
 - i. Hold inducer (or input shaft) by hand. (Use proper PPE.)
 - ii. Using 2-1/2-in n socket and impact driver (set CCW), loosen castle nut.
 - b) If using a 2-1/2-in (or adjustable) wrench and strap wrench:
 - i. Hold impeller (or input shaft) with a strap wrench.
 - ii. Using 2-1/2-in (or adjustable) wrench, loosen (turn CCW) castle nut.
 2. If pump is an MBP.
 - a) If using a 1 3/4-in socket and impact driver (set CCW):
 - i. Hold inducer by hand. (Use proper PPE.)
 - ii. Using 1 3/4-in socket and impact driver (set CCW), loosen castle nut.
 - b) If using a 1 3/4-in (or adjustable) wrench and strap wrench:
 - i. Hold impeller with a strap wrench.
 - ii. Using 1 3/4-in (or adjustable) wrench, loosen (turn CCW) castle nut.
 3. Remove castle nut.

IMPORTANT ▲ NOTICE

DO NOT STRIKE THE INDUCER OR IMPELLER. STRIKING THE INDUCER OR IMPELLER MAY RESULT IN IRREPARABLE DAMAGE.

- C. Remove inducer.
 1. Pull inducer off pump shaft by hand if possible.
 2. If inducer can NOT be removed by hand, use wedges and puller to pull inducer. Loosen inducer as follows:
 - a) Install puller (See APPENDIX B, Test Equipment And Special Tool Information) on inducer. (See page B-1.)
 - b) Place 1/2-in (M12) flanged nut (flange toward pump shaft) between pump shaft and puller drive screw (protects shaft threads).
 - c) Using a wrench (or socket and ratchet), tighten puller drive screw until inducer comes loose.
 - d) Remove 1/2-in (M12) flanged nut and puller.
 3. Then pull inducer off pump shaft by hand.
 4. Remove inducer/pump shaft key.



Inspect and clean all components. See paragraph 5.7.7, Cleaning And Inspection Guidelines, on page 51.

If volute is removed and inspection indicates any of the following require replacement.

- Clearance rings require replacement see paragraph 5.8.7.2 (page 110), Pump Clearance Ring R&R.
- Impeller requires replacement see paragraph 5.8.4.6 (page 110), Impeller R&R.
- Mechanical seal requires replacement see paragraph 5.8.4.10 (page 93), RSD Mechanical Seal R&R mechanical seal requires replacement see paragraph 5.8.4.9 (page 90), Mechanical Seal R&R.
- Pump shaft oil seal requires replacement see paragraph 5.8.4.13.1 (page 102), Pump Shaft Oil Seal And O-ring.

Inducer Installation

- A. Install inducer key in pump shaft keyway. (Use small amount of grease to hold key in place.)
- B. Carefully slide inducer over pump shaft, aligning inducer keyway with key.
- C. Install inducer nut.
 1. If pump is a RSD.
 - a) If using a 2-1/2-in socket, torque limiting extension, and impact driver (set CW).
 - i. Hold inducer (or input shaft) by hand. (Use proper PPE.)
 - ii. Using 2-1/2-in n socket, torque limiting extension, and impact driver torque castle nut.
 - b) If using a 2-1/2-in (or adjustable) wrench and strap wrench:
 - i. Hold impeller (or input shaft) with a strap wrench.
 - ii. Using 2-1/2-in torque wrench, torque castle nut to 210 ft-lb (285 Nm).
 2. If pump is an MBP.
 - a) If using a 1 3/4-in socket, torque limiting extension, and impact driver (set CW):
 - i. Hold inducer by hand. (Use proper PPE.)
 - ii. Using 1 3/4-in socket, torque limiting extension, and impact driver, torque castle nut.
 - b) If using a 1 3/4-in torque wrench and strap wrench:
 - i. Hold impeller with a strap wrench.
 - ii. Using 1 3/4-in torque wrench, torque castle nut to 110 ft-lb (149 Nm).

IMPORTANT ▲ NOTICE

DO NOT INSTALL A USED COTTER PIN. A USED PIN MAY FAIL RESULTING IN DEBRIS GOING THRU THE PUMP AND/OR LOOSENING OF THE CASTLE NUT THAT SECURES THE IMPELLER.

IMPORTANT ▲ NOTICE

DO NOT LOOSEN THE CASTLE NUT TO INSTALL THE COTTER PIN. CONTINUE TO TIGHTEN THE CASTLE NUT UNTIL THE COTTER PIN CAN BE PUSHED THRU THE HOLE IN PUMP SHAFT.

- D. Install new cotter pin to lock inducer nut in place.
1. Insert new cotter pin until head of pin seats inside castle nut groove.
 2. Bend cotter pin 90° toward pump shaft. (Bend both halves toward shaft.)
 3. Using a cold cut chisel and hammer, cut cotter pin flush at mating point of castle nut and pump shaft.
 4. Ensure cut away excess cotter pin is removed from the pump.

If the pump is a RSD, after performing this procedure, install the RSD suction head (see paragraph 5.8.4.1, RSD Suction Head R&R) or the RSD volute (see paragraph 5.8.4.2 on page 69).

If the pump is an MBP, after performing this procedure, install the volute as described in paragraph 5.8.4.3, AP/MBP Volute R&R.

5.8.4.6 MBP/RSD Impeller R&R

Prior to performing this procedure, remove the volute as described in paragraph 5.8.4.3, Volute R&R for an MBP pump or paragraph 5.8.4.2, RSD Volute R&R, for a RSD pump. Then remove the inducer as described in paragraph 5.8.4.6, Inducer R&R. Figure 30 shows the pump with the volute and inducer removed and depicts the impeller removal.

Typically the impeller would not require replacement for many years unless it has been damaged by allowing the pump to freeze with water in it or a large piece of debris was allowed into the pump by not using or maintaining strainers. Long term wear can damage an impeller to the point it (and the clearance rings) must be replaced to maintain pump performance specifications. Refer to Table 23 for the MBP/RSD impeller wear specifications. If the impeller requires replacement always inspect (measure) the clearance rings before installing the new impeller. If the clearance rings are out-of-tolerance they require replacement, see paragraph 5.8.7.2 (page 110) for the MBP or RSD.

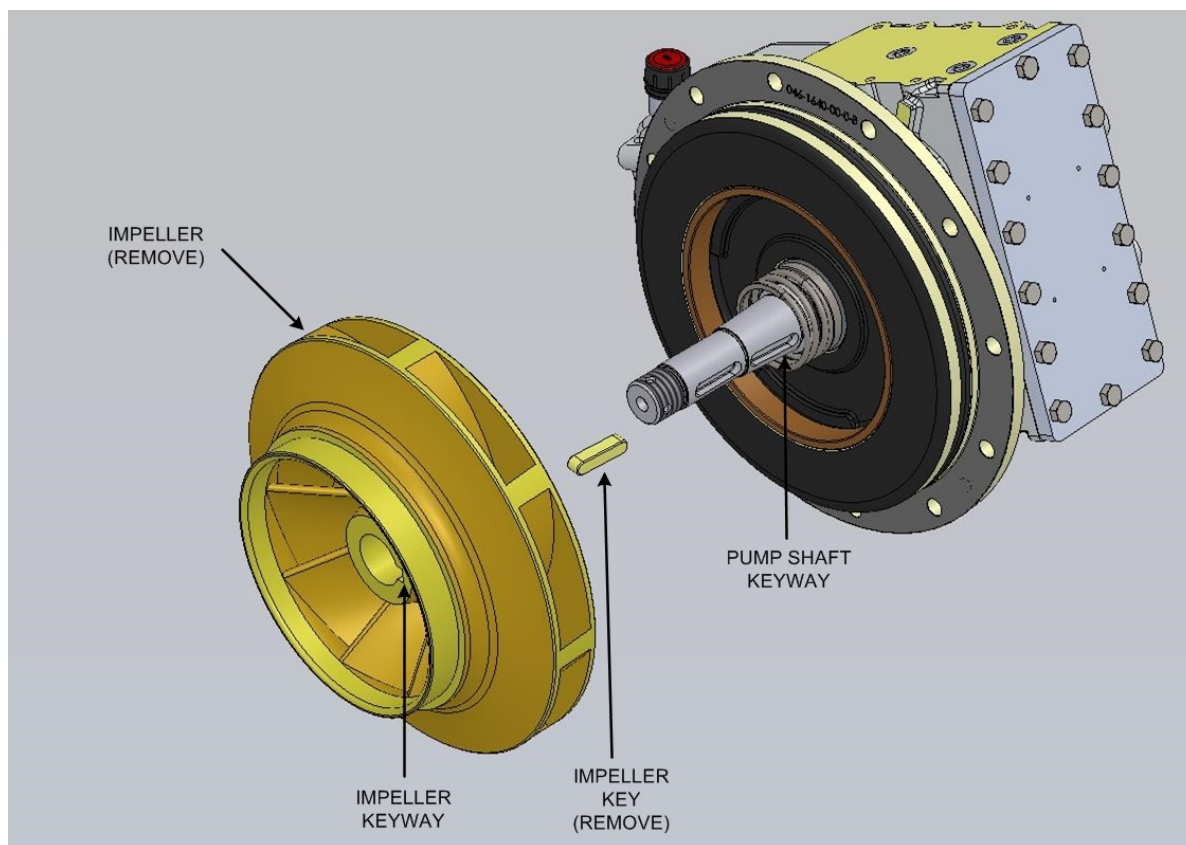


Figure 30. MBP Impeller R&R

Refer to Table 30 for a list of tools and/or consumables required for this procedure.

Table 30. MBP/RSD Impeller R&R Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	Puller Set (See APPENDIX B)	Shop Rag(s) (As Required)
Brush (For Grease)		Grease (See paragraph 5.7.2, page 49)
		IMPELLER <See FSG-PL-01486, Sheet 4, Item 7> (MBP) <See FSG-PL-01487, Sheet 4, Item 21> (RSD)
		Key (Impeller To Pump Shaft) <See FSG-PL-01486 or -01487 Sheet 5 Item 3>

Perform the following to remove and replace the impeller.

MBP/RSD Impeller Removal

IMPORTANT ▲ NOTICE

DO NOT STRIKE THE IMPELLER. STRIKING THE IMPELLER MAY RESULT IN IRREPAIRABLE DAMAGE.

- A. Pull impeller off pump shaft by hand if possible.

- B. If impeller can NOT be removed by hand, use wedges and puller to pull impeller. Loosen impeller as follows:
 - 1. Install puller (See APPENDIX B, Test Equipment And Special Tool Information) on impeller.
 - 2. Place 1/2-in (M12) flanged nut (flange toward pump shaft) between pump shaft and puller drive screw (protects shaft threads).
 - 3. Using a wrench (or socket and ratchet), tighten puller drive screw until impeller comes loose.
 - 4. Remove 1/2-in (M12) flanged nut and puller.
 - 5. Then pull impeller off pump shaft by hand.
- C. Remove impeller/pump shaft key.

The pump shaft keyways and the impeller and inducer keys should be inspected whenever parts are disassembled. Look for signs of excessive and irregular wear. Replace the shaft and/or key if inspection indicates rounding, excessive wear, or damage.

MBP/RSD Impeller Installation

- A. Remove mechanical seal spring.
- A. Install impeller key in pump shaft keyway. (Use small amount of grease to hold key in place.)
- B. Install mechanical seal spring.
- C. Apply a heavy coating of grease to impeller ends.

NOTE

The grease protects the clearance ring during the initial pump priming to prevent the ring from contacting the impeller.

- D. Carefully slide impeller over pump shaft, aligning key with impeller keyway.

After performing this procedure, install the inducer by performing the Inducer Installation portion of Inducer R&R procedure (see paragraph 5.8.4.5 on page 76). Then install the volute as described in Volute R&R (see paragraph 5.8.4.3 on page 72) or suction head R&R (see paragraph 5.8.4.1 on page 67). If the RSD volute was removed, perform the Installation portion of the Volute R&R procedure. (See paragraph 5.8.4.2 on page 69.)

5.8.4.7 AP Impeller R&R

Prior to performing this procedure, remove the volute as described in paragraph 5.8.4.3, Volute R&R. (See page 72.)

Typically the impeller would not require replacement for many years unless it has been damaged by allowing the pump to freeze with water in it or a large piece of debris was allowed into the pump by not using or maintaining strainers. Long term wear can damage an impeller to the point it (and the clearance rings) must be replaced to maintain pump performance specifications. Refer to Table 23 for the AP impeller wear specifications. If the impeller requires replacement always inspect (measure) the clearance rings before installing the new impeller. If the clearance rings are out-of-tolerance they require replacement, see paragraph 5.8.7.2 on page 110. Figure 31 shows the pump with the volute removed and depicts the impeller removal.

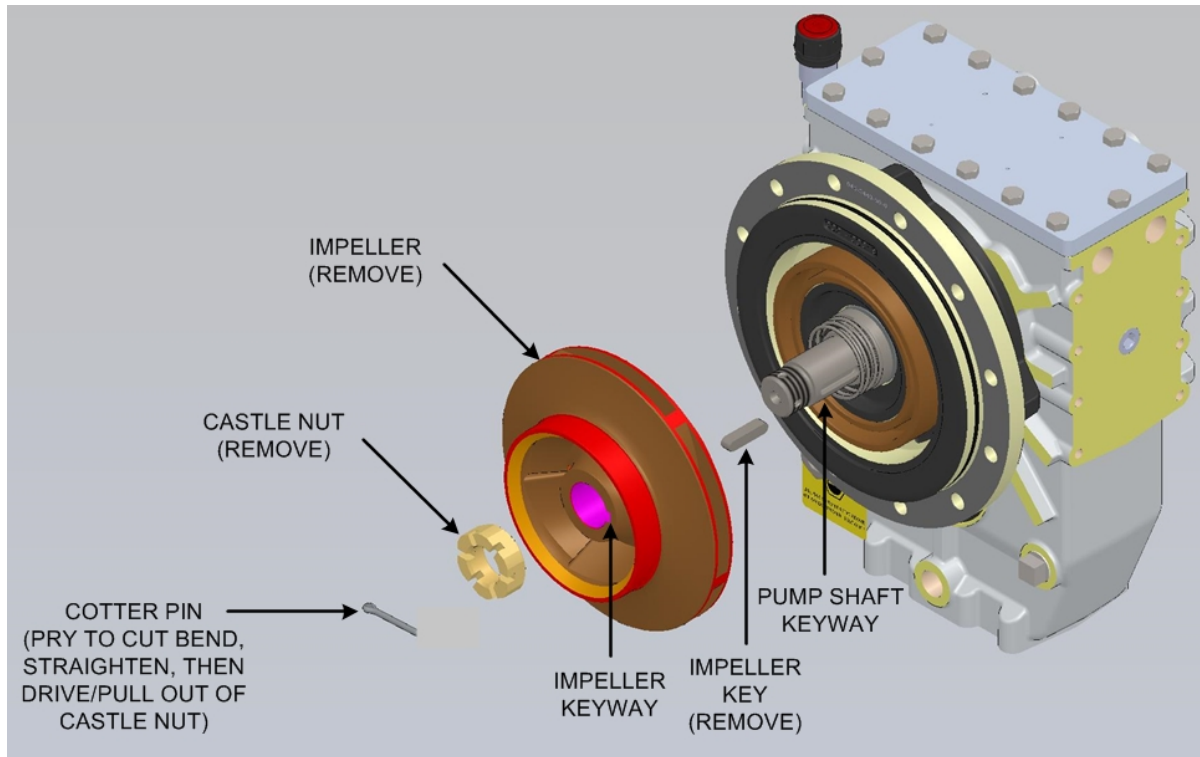


Figure 31. AP Impeller R&R

Refer to Table 31 for a list of tools and/or consumables required for this procedure.

Table 31. AP Impeller R&R Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	1 3/4-in Torque Limiting Socket (110 ft-lb [149 Nm])	Shop Rag(s) (As Required)
1 3/4-in Socket and Ratchet	Puller Set (See APPENDIX B)	Impeller <FSG-PL-01483, Sheet 4 Item 4>
Cold Cut Chisel		Impeller Nut, ZS-274 <FSG-PL-01483, Sheet 4 Item 3>
Flat Blade Screwdriver		Cotter Pin (Impeller Nut To Pump Shaft) <FSG-PL-01483, Sheet 4 Item 20>
Brush (For Grease)		Grease (See paragraph 5.7.2, page 49)
Hammer		
Heavy Wire Cutters		
Impact Driver		
Pin (or Drift) Punch		
Pliers		



Perform the following to remove and replace AP pump impeller.

Impeller Removal

- A. Remove cotter pin that secures impeller nut.
 - 1. Using flat blade screwdriver, pry bent portion of cotter pin so bend can be cut off.
 - 2. Using heavy wire cutters, cut off bent portion of cotter pin. (Or using pliers, bend cotter pin straight.)
 - 3. Using pliers (or hammer and pin punch), pull (or drive) cotter pin out of castle nut.
- B. Remove impeller nut.
 - 1. If using a 1 3/4-in socket and impact driver (set CCW):
 - a) Hold impeller by hand. (Use proper PPE.)
 - b) Using 1 3/4-in socket and impact driver (set CCW), loosen castle nut.
 - 2. If using a 1 3/4-in (or adjustable) wrench and strap wrench:
 - a) Hold impeller with a strap wrench.
 - b) Using 1 3/4-in (or adjustable) wrench, loosen (turn CCW) castle nut.
 - 3. Remove castle nut.

IMPORTANT ▲ NOTICE

DO NOT STRIKE THE IMPELLER. STRIKING THE IMPELLER MAY RESULT IN IRREPAIRABLE DAMAGE.

- C. Remove impeller.
 - 1. Pull impeller off pump shaft by hand if possible.
 - 2. If impeller can NOT be removed by hand, use wedges and puller to pull impeller. Loosen impeller as follows:
 - a) Install puller (See APPENDIX B, Test Equipment And Special Tool Information) on impeller.
 - b) Place 1/2-in (M12) flanged nut (flange toward pump shaft) between pump shaft and puller drive screw (protects shaft threads).
 - c) Using a wrench (or socket and ratchet), tighten puller drive screw until impeller comes loose.
 - d) Remove 1/2-in (M12) flanged nut and puller.
 - 3. Then pull impeller off pump shaft by hand.
 - 4. Remove impeller/pump shaft key.
- D. Inspect and clean all components. See paragraph 5.7.7, Cleaning And Inspection Guidelines. (See page 51.)
 - 1. If inspection indicates the clearance rings require replacement see paragraph 5.8.7.2, AP Pump Clearance Ring R&R. (See page 110.)
 - 2. If inspection indicates the impeller requires replacement see paragraph 5.8.4.7, Impeller R&R. (See page 83.)

3. If inspection indicates the pump shaft oil seal requires replacement see paragraph 5.8.4.13.1, Pump Shaft Oil Seal And O-ring. (See page 102.)
4. If inspection indicates the mechanical seal requires replacement see paragraph 5.8.4.9, Mechanical Seal R&R. (See page 90.)

Impeller Installation

- A. Remove mechanical seal spring.
- B. Install impeller key in pump shaft keyway. (Use small amount of grease to hold key in place.)
- C. Install mechanical seal spring.
- A. Apply a heavy coating of grease to impeller ends.

NOTE

The grease protects the clearance ring during the initial pump priming to prevent the ring from contacting the impeller.

- B. Carefully slide impeller over pump shaft, aligning key with impeller keyway.
- C. Install impeller nut.
 1. If using a torque limiting 1 3/4-in socket and impact driver (set CW):
 - a) Hold impeller by hand. (Use proper PPE.)
 - b) Using torque limiting 1 3/4-in socket and impact driver (set CW), tighten castle nut.
 2. If using a 1 3/4-in torque wrench and strap wrench:
 - a) Hold impeller with a strap wrench.
 - b) Using 1 3/4-in torque wrench, torque (turn CW) castle nut to 110 ft-lb (149 Nm).

IMPORTANT ▲ NOTICE

DO NOT LOOSEN THE CASTLE NUT TO INSTALL THE COTTER PIN. CONTINUE TO TIGHTEN THE CASTLE NUT UNTIL THE COTTER PIN CAN BE PUSHED THRU THE HOLE IN PUMP SHAFT. LOOSENING THE CASTLE NUT MAY RESULT IN EQUIPMENT DAMAGE.

IMPORTANT ▲ NOTICE

DO NOT INSTALL A USED COTTER PIN. A USED PIN MAY FAIL RESULTING IN DEBRIS GOING THRU THE PUMP AND/OR LOOSENING OF THE CASTLE NUT THAT SECURES THE IMPELLER RESULTING IN EQUIPMENT DAMAGE.

- D. Install new cotter pin to lock impeller nut in place.
 1. Insert new cotter pin until head of pin seats inside castle nut groove.
 2. Bend cotter pin 90° toward pump shaft. (Bend both halves toward shaft.)
 3. Using cold cut chisel and hammer, cut cotter pin flush at mating point of castle nut and pump shaft.
 4. Ensure cut away excess cotter pin is removed from the pump.

After performing this procedure, install the volute as described in the AP Volute Installation portion of paragraph 5.8.4.3, Volute R&R, on page 72.

5.8.4.8 CBP Impeller R&R

Prior to performing this procedure, remove the volute as described in paragraph 5.8.4.4, Volute R&R. (See page 74.)

Typically, the impeller would not require replacement for many years unless it has been damaged by allowing the pump to freeze with water in it or a large piece of debris was allowed into the pump by not using or maintaining strainers. Long term wear can damage an impeller to the point it (and the clearance rings) must be replaced to maintain pump performance specifications. Refer to Table 23 (page 53) for the impeller (and clearance rings) wear specifications. If the impeller requires replacement always inspect (measure) the clearance rings before installing the new impeller. If the clearance rings are out-of-tolerance they require replacement, see paragraph 5.8.7.2 on page 110. Figure 32 shows the pump with the volute removed and depicts the impeller removal.

NOTE

The CBP utilizes a self-locking impeller nut instead of a castle nut and cotter pin.

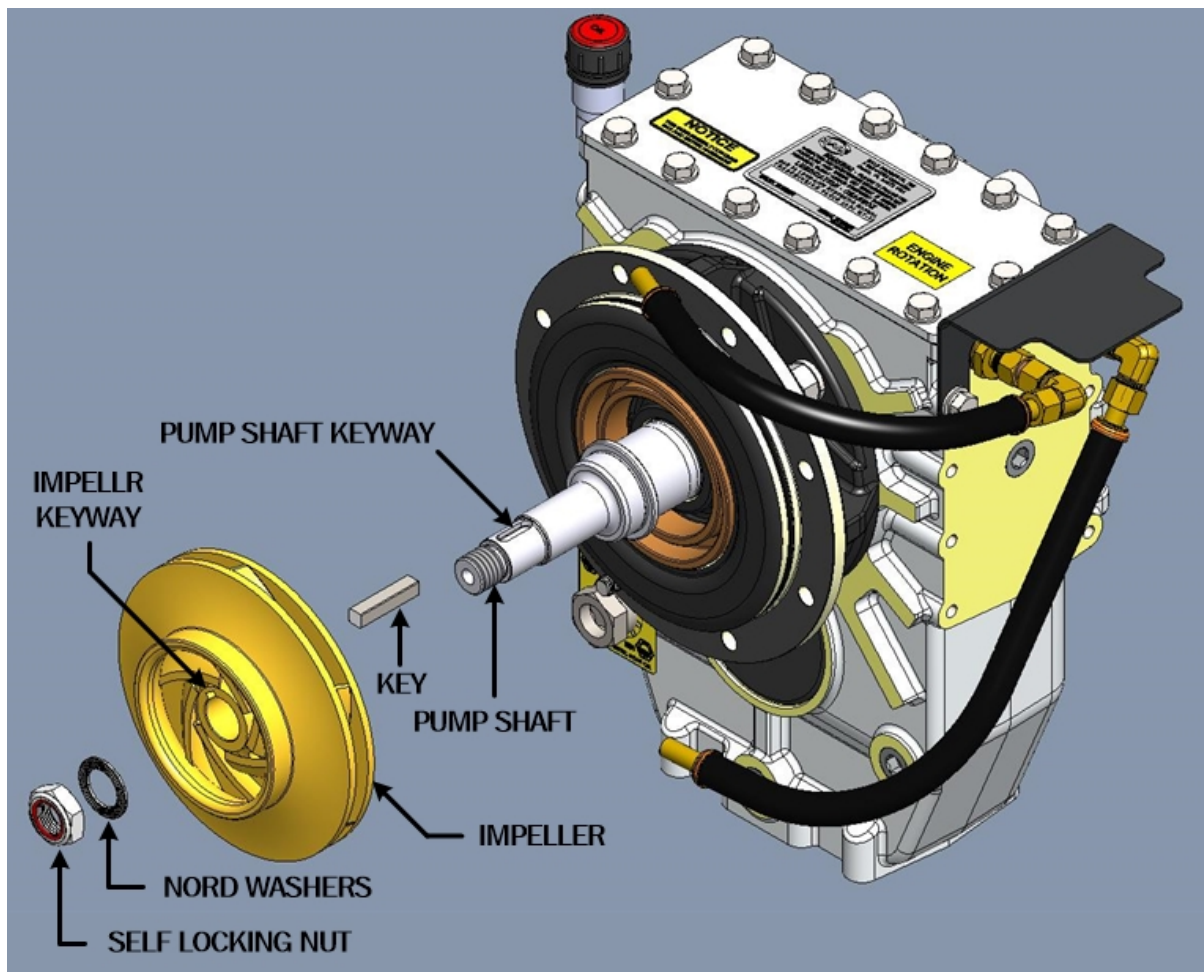


Figure 32. CBP Impeller R&R

Refer to Table 31 for a list of tools and/or consumables required for this procedure.

Table 32. CBP Impeller R&R Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	Torque Limiting Extension 110 ft-lb (149 Nm)	Shop Rag(s) (As Required)
1 1/16-in Socket	Puller Set (See APPENDIX B on page B-1)	Impeller CBP <FSG-PL-01482, Sheet 4 Item 5>
Impact Driver		NORD-Lock Washer <FSG-PL-01482, Sheet 4 Item 4>
Brush (For Grease)		Self Locking Nut (CBP Impeller Nut) <FSG-PL-01482, Sheet 4 Item 3>
Strap Wrench *		Grease (See paragraph 5.7.2, page 49)
Ratchet *		
Adjustable Wrench *		

* **Optional.**

Perform the following to remove and replace CBP pump impeller.

Impeller Removal

A. Remove impeller nut.

1. If using a 1 1/16-in socket and impact driver (set CCW):
 - a) Hold impeller by hand. (Use proper PPE.)
 - b) Using 1 1/16-in socket and impact driver (set CCW), loosen nut.
2. If using a 1 1/16-in (or adjustable) wrench and strap wrench:
 - a) Hold impeller with a strap wrench.
 - b) Using 1 1/16-in (or adjustable) wrench, loosen (turn CCW) nut.
3. Remove nut.

IMPORTANT ▲ NOTICE

DO NOT STRIKE THE IMPELLER. STRIKING THE IMPELLER MAY RESULT IN IRREPAIRABLE DAMAGE.

B. Remove NORD-lock washers.

(Note grooves verses wedges orientation for installation purposes.)

C. Remove impeller.

1. Pull impeller off pump shaft by hand if possible.
2. If impeller can NOT be removed by hand, use wedges and puller to pull impeller. Loosen impeller as follows:
 - a) Install puller on impeller. (See APPENDIX B, Test Equipment And Special Tool Information on page B-1.)

- b) Place 1/2-in (M12) flanged nut (flange toward pump shaft) between pump shaft and puller drive screw (protects shaft threads).
 - c) Using a wrench (or socket and ratchet), tighten puller drive screw until impeller comes loose.
 - d) Remove 1/2-in (M12) flanged nut and puller.
3. Then pull impeller off pump shaft by hand.
 4. Remove impeller/pump shaft key.
- D. Inspect and clean all components. See paragraph 5.7.7, Cleaning And Inspection Guidelines on page 51.
1. If inspection indicates the clearance rings require replacement see paragraph 5.8.7.2, Pump Clearance Ring R&R on page 110.
 2. If inspection indicates the mechanical seal requires replacement see paragraph 5.8.4.9, Mechanical Seal R&R on page 90.
 3. If inspection indicates the pump shaft oil seal requires replacement see paragraph 5.8.4.13.1, Pump Shaft Oil Seal And O-ring on page 102.

Impeller Installation

- A. Remove mechanical seal spring.
- B. Install impeller key in pump shaft keyway. (Use small amount of grease to hold key in place.)
- C. Install mechanical seal spring.
- D. Apply a heavy coating of grease to impeller ends.

NOTE

The grease protects the clearance ring during the initial pump priming to prevent the ring from contacting the impeller.

- E. Carefully slide impeller over pump shaft, align key with impeller keyway.
- F. Install NORD-lock washers. (See Figure 33.)

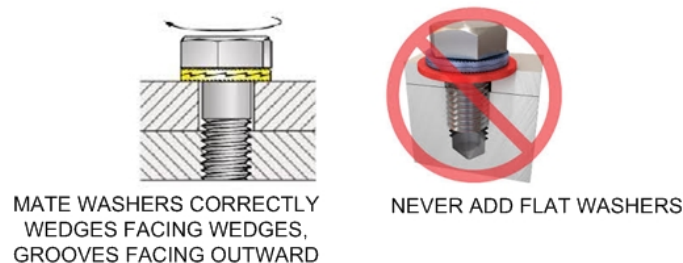


Figure 33. NORD-lock Washers Installation Details

- G. Install impeller nut.

IMPORTANT ⚠ NOTICE

DO NOT APPLY LOCTITE TO A SELF-LOCKING NUT. DO NOT REUSE A SELF-LOCKING NUT. REUSING A SELF-LOCKING NUT OR ADDING LOCTITE MAY RESULT IN THE ITEM FAILING TO BE SECURED.

1. If using a 1 1/16-in socket, torque limiting extension, and impact driver (set CW):
 - a) Hold impeller by hand. (Use proper PPE.)
 - b) Using 1 1/16-in socket, torque limiting extension, and impact driver (set CW), tighten nut.
2. If using a 1 1/16-in torque wrench and strap wrench:
 - a) Hold impeller with a strap wrench.
 - b) Using 1 1/16-in torque wrench, torque (turn CW) nut to 110 ft-lb (149 Nm).

After performing this procedure, install the volute as described in the Volute Installation portion of paragraph 5.8.4.4, Volute R&R. (See page 74.)

5.8.4.9 AP/CBP/MBP Mechanical Seal R&R

Before the mechanical seal can be replaced, the volute and impeller (including the inducer if applicable) must be removed from the pump. Refer to paragraph 5.8.4.3 or 5.8.4.4 (page 72 or page 74) for instructions to R&R the volute and if applicable (pump is an MBP) refer to paragraph 5.8.4.5 (page 76) for instructions to R&R the inducer and then refer to paragraph 5.8.4.6 (page 81), (AP or MBP) 5.8.4.7 (page 83), or paragraph 5.8.4.8 (CBP on page 87) for instructions to R&R the impeller.

Refer to Table 33 for a list of tools and/or consumables required for this procedure.

Table 33. AP/CBP/MBP Mechanical Seal Bench Procedure Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)		Shop Rag(s) (As Required)
Non-marring Hammer		Pac-Ease Lubricant (See paragraph 5.7.3.)
5/32-in (4 mm) Flat Blade Screwdriver		Alcohol Swabs (See paragraph 5.7.3.)
3/32-in or 7/64-in (2.5 or 3.0 mm) Hex Key (Allen Wrench)	Mechanical Seal Installation Tool <029-0760-00-0>	Mechanical Seal <See FSG-PL-01483, Sheet 4, Item 5> (AP) <See FSG-PL-01482, Sheet 4, Item 6> (CBP) <See FSG-PL-01486, Sheet 4, Item 8> (MBP)

The stationary part of the mechanical seal is located in the center bore of the pump head. The other part of the seal mounts on the pump shaft and seats against the drive side of the impeller. See Figure 5 for a diagram of how the seal fits in the pump and Figure 34 for a detailed diagram of the seal components.

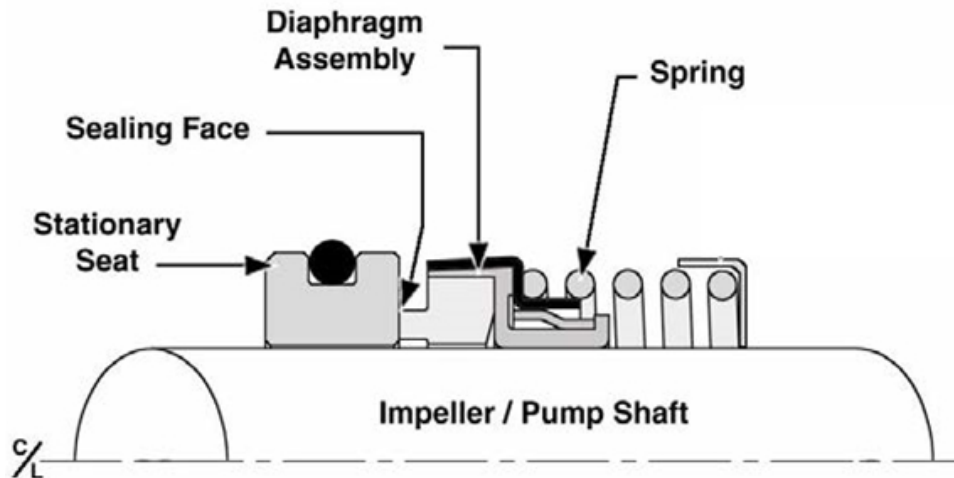


Figure 34. Typical Mechanical Seal Detail

Perform the following to remove and replace the pump seal.

Mechanical Seal Removal

- A. Remove mechanical seal.
 1. Pull spring off pump shaft.
 2. Remove diaphragm assembly.
 - a) Place two small screwdrivers (or two hook-type tools) between diaphragm assembly and stationary seat. Note: Place tools 180° apart.
 - b) Using steady, gentle pressure, pry diaphragm off shaft.
 3. Remove stationary seat portion of mechanical seal from pump head.
 - a) To remove stationary seat, without removing pump head perform the following.
 - b) Slide short end of a 3/32-in or 7/64-in (or 2.5 / 3.0 mm) hex key (Allen wrench) between back side of pump head and pump shaft.
 - c) Using steady, gentle pressure pry on hex key with a screwdriver (twist the screwdriver) to push stationary seat out of the pump head.

NOTES

Removing the mechanical seal renders it inoperative and it must be replaced with a new never installed seal.

Never reuse a mechanical seal that has been previously installed and removed.

Do NOT replace only the moving portion of a seal; ALWAYS replace the entire seal.

- B. Inspect and clean all components. See paragraph 5.7.7, Cleaning And Inspection Guidelines.

Mechanical Seal Installation

IMPORTANT ▲ NOTICE

A MECHANICAL SEAL IS A PRECISION ENGINEERED DEVICE. CARE MUST BE TAKEN NOT TO DAMAGE THE MATING FACES (SEAL FORMING PORTION) OF THE SEAL. ENSURE THE FACES REMAIN ABSOLUTELY CLEAN THROUGHOUT THE ENTIRE INSTALLA-

TION. SEAL FACES MUST BE CLEANED WITH THE ALCOHOL WIPES PROVIDED WITH THE REPAIR KIT.

OIL AND GREASE (INCLUDING SKIN OILS) WILL DAMAGE THE MECHANICAL SEAL FACE. NEVER TOUCH THE MATING FACES OF THE MECHANICAL SEAL. WEAR PROTECTIVE GLOVES TO PREVENT TOUCHING THE SEAL FACES WITH YOUR BARE HANDS. (USE RUBBER, ACRYLIC, LATEX, ETC. – DO NOT USE CLOTH OR LEATHER.)

USE ONLY PAC-EASE RUBBER LUBRICANT EMULSION (OR EQUIVALENT) ON THE RUBBER MECHANICAL SEAL PARTS TO EASE INSTALLATION. USING ANY OTHER LUBRICANT CAN DAMAGE THE SEAL AND SEAT.

- A. If indicated by inspection, install a new oil seal on gearbox side of pump head. (See paragraph 5.8.4.13.1.)
- B. Install stationary portion of mechanical seal (seat) in pump head.

NOTE

Oil and grease will damage the mechanical seal face. Do NOT touch the face of the mechanical seal.

- 1. Using alcohol swabs, clean bore of pump head.
- 2. Without touching seat face, slide seat over pump shaft and align to bore of pump head.

NOTE

Use the top of the mechanical seal installation tool as a push tube to seat the stationary portion of mechanical seal in the bore of the pump head. Use PAC-EASE to lubricate the sides of the seat for easier installation.

- 3. Carefully push seat into bore of pump head until firmly seated.
- C. Install diaphragm.
 - 1. Using alcohol swabs, clean pump shaft.
 - 2. Apply a generous coating of PAC-EASE rubber lubricant emulsion (or equivalent) to diaphragm.
 - 3. Without touching mating face of seal ring, push diaphragm onto pump shaft.
 - 4. Using mechanical seal installation tool, push on diaphragm until sealing faces are in full contact (seated against each other).

NOTES

If binding occurs, apply additional PAC-EASE lubricant and slide the spring and diaphragm onto the pump shaft. The seal ring must mate completely and evenly with the stationary seat for the sealing faces to function properly.

If required a small non-marring hammer may be used to tap on the mechanical seal installation tool to fully and evenly seat the diaphragm on the pump shaft.

- D. Install spring.
 - 1. Keep shaft, diaphragm, and spring well lubricated with PAC-EASE.
 - 2. Place spring on pump shaft.
 - 3. Push spring onto diaphragm.

- E. Perform applicable Impeller Installation portion of Impeller R&R procedure. (See paragraph 5.8.4.6, [MBP] 5.8.4.7, paragraph 5.8.4.7 [AP], or paragraph 5.8.4.8 [CBP].)
- F. If applicable (pump is an MBP), perform Inducer Installation portion of the Inducer R&R procedure. (See paragraph 5.8.4.5 on page 76.)
- G. Perform Volute Installation portion of applicable Volute &R procedure. (See paragraph 5.8.4.3 or 5.8.4.4.)
- H. Perform paragraph 4.4.4.1.3, Performance Testing Test Procedure, to verify repair complete and pump in working condition.

NOTE

Repair any leaks or problems before returning apparatus to service.

- I. Update all maintenance log entries.
- J. Return apparatus to service.

5.8.4.10 RSD Mechanical Seal R&R

Before the mechanical seal can be replaced, the volute, inducer, and impeller must be removed from the pump. Refer to paragraph 5.8.4.2 (on page 69) for instructions to R&R the volute and then refer to paragraph 5.8.4.5 (on page 76) to remove the inducer, and the impeller as described in paragraph 5.8.4.6 (on page 81), RSD Impeller R&R. Refer to Table 34 for a list of tools and/or consumables required for this procedure.

The stationary part of the mechanical seal is located in the center bore of the pump head. The other part of the seal mounts on the pump shaft and seats against the drive side of the impeller. See Figure 5 for a diagram of how the seal fits in the pump and Figure 34 for a detailed diagram of the seal components.

Table 34. RSD Mechanical Seal Bench Procedure Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	Mechanical Seal Installation Tool <029-0760-00-0>	Shop Rag(s) (As Required)
Non-marring Hammer		Pac-Ease Lubricant (See paragraph 5.7.3.)
5/32-in (4 mm) Flat Blade Screwdriver		Alcohol Swabs (See paragraph 5.7.3.)
3/32-in or 7/64-in (2.5 or 3.0 mm) Hex Key (Allen Wrench)		Mechanical Seal <See FSG-PL-01487, Sheet 4, Item 20>
		Pin <See FSG-PL-01487, Sheet 4, Item 33>

Perform the following to remove and replace the pump seal.

RSD Mechanical Seal Removal

- A. Remove mechanical seal.

1. Pull spring off of pump shaft.
2. Remove diaphragm assembly.
 - a) Place two small screwdrivers (or two hook-type tools) between diaphragm assembly and stationary seat. Note: Place tools 180° apart.
 - b) Using steady, gentle pressure, pry diaphragm off of shaft.
3. Remove stationary seat portion of mechanical seal from pump head.
 - a) To remove stationary seat, without removing pump head perform the following.

NOTES

The mechanical seals stationary seat has a notch (see Figure 35) that fits over a roll pin (prevents the seat from spinning under extreme conditions). This provides a good place to catch the seat.

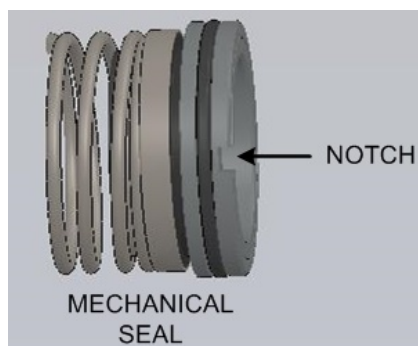


Figure 35. RSD Mechanical Seal Notch

- b) Slide short end of a 3/32-in or 7/64-in (or 2.5 / 3.0 mm) hex key (Allen wrench) between back side of pump head and pump shaft.
- c) Using steady, gentle pressure pry on hex key with a screwdriver (twist the screwdriver) to push stationary seat out of the pump head.

NOTES

Removing the mechanical seal renders it inoperative and it must be replaced with a new never installed seal.

Never reuse a mechanical seal that has been previously installed and removed.

Do NOT replace only the moving portion of a seal; **ALWAYS** replace the entire seal.

- B. Inspect and clean all components. See paragraph 5.7.7, Cleaning And Inspection Guidelines.
 1. Inspect oil seal on gearbox side of pump head.
 2. Inspect roll pin.
 - a) Inspect roll pin for corrosion or damage.
 - b) Measure roll pin height ($3/32 \pm 25/1000$ -in).
 - c) Replace roll pin ONLY if required.

NOTE

If the roll pin requires replacement perform RSD Mechanical Seal Anti Rotation Pin Bench Procedure. See paragraph 5.8.4.13.2 on page 103.

RSD Mechanical Seal Installation

IMPORTANT ▲ NOTICE

A MECHANICAL SEAL IS A PRECISION ENGINEERED DEVICE. CARE MUST BE TAKEN NOT TO DAMAGE THE MATING FACES (SEAL FORMING PORTION) OF THE SEAL. ENSURE THE FACES REMAIN ABSOLUTELY CLEAN THROUGHOUT THE ENTIRE INSTALLATION. SEAL FACES MUST BE CLEANED WITH THE ALCOHOL WIPES PROVIDED WITH THE REPAIR KIT.

OIL AND GREASE (INCLUDING SKIN OILS) WILL DAMAGE THE MECHANICAL SEAL FACE. NEVER TOUCH THE MATING FACES OF THE MECHANICAL SEAL. WEAR PROTECTIVE GLOVES TO PREVENT TOUCHING THE SEAL FACES WITH YOUR BARE HANDS. (USE RUBBER, ACRYLIC, LATEX, ETC. – DO NOT USE CLOTH OR LEATHER.)

USE ONLY PAC-EASE RUBBER LUBRICANT EMULSION (OR EQUIVALENT) ON THE RUBBER MECHANICAL SEAL PARTS TO EASE INSTALLATION. USING ANY OTHER LUBRICANT CAN DAMAGE THE SEAL AND SEAT.

- A. If indicated by inspection, install a new oil seal on gearbox side of pump head. (See paragraph 5.8.4.13.1 on page 102.)
- B. Install stationary portion of mechanical seal (seat) in pump head.

NOTE

Oil and grease will damage the mechanical seal face. Do NOT touch the face of the mechanical seal.

- 1. Using alcohol swabs, clean bore of pump head.
- 2. Lubricate seat with PAC-EASE.
- 3. Without touching seat face, slide seat over pump shaft, align seat to bore in pump head, and notch in seat to roll pin in pump head. See Figure 36.



Figure 36. Align Slot On Seal With Pin In Pump Head

NOTE

Use the top of the mechanical seal installation tool as a push tube to seat the stationary portion of mechanical seal in the bore of the pump head. PAC-EASE may be used to lubricate the sides of the seat for easier installation.

4. Carefully push seat into bore of pump head until firmly seated.
- C. Install diaphragm.
1. Using alcohol swabs, clean pump shaft.
 2. Apply a generous coating of PAC-EASE rubber lubricant emulsion (or equivalent) to diaphragm.
 3. Without touching mating face of seal ring, push diaphragm onto pump shaft.
 4. Using mechanical seal installation tool, push on diaphragm until sealing faces are in full contact (seated against each other).

NOTES

If binding occurs, apply additional PAC-EASE lubricant and slide the spring and diaphragm onto the pump shaft. The seal ring must mate completely and evenly with the stationary seat for the sealing faces to function properly.

If required, a small non-marring hammer may be used to tap on the mechanical seal installation tool to fully and evenly seat the diaphragm on the pump shaft.

- D. Install spring.

NOTE

It is easier to install the impeller key before installing the mechanical seal spring.

1. Keep shaft, diaphragm, and spring well lubricated with PAC-EASE.
 2. Place spring on pump shaft.
 3. Push spring onto diaphragm.
- E. Perform Impeller Installation portion of RSD Impeller R&R procedure. (See paragraph 81.)
- F. Perform Inducer Installation portion of RSD Inducer R&R procedure. (See paragraph 5.8.4.5.)
- G. Perform installation portion of RSD Volute R&R procedure. (See paragraph 5.8.4.2 on page 69.)
- H. Perform paragraph 4.4.4.1.3, Performance Testing Test Procedure, to verify repair complete and pump in working condition.

NOTE

Repair any leaks or problems before returning apparatus to service.

- I. Update all maintenance log entries.
- J. Return apparatus to service.

5.8.4.11 AP/CBP/MBP Pump Head R&R

Water leaking from pump head is typically NOT an indication of a failed pump head. The pump head openings are designed to allow water out when a mechanical seal is bypassing water. Simi-

larly, oil leaking from between the pump head and the gearbox is NOT typically the result of a failed pump head but a failed O-ring and/or oil seal. However pump head removal is required to repair either condition. Typically a pump head would NOT require replacement unless it has been damaged by allowing the pump to freeze with water in it or by improper clearance ring removal.

This procedure ONLY applies when the pump head requires removal from the gearbox, otherwise, use the instructions in paragraph 5.8.4.3 or 5.8.4.4 to remove the volute. If the pump is an MBP, next remove the inducer, as described in paragraph 5.8.4.5. Then remove the impeller as described in paragraph 5.8.4.6, 5.8.4.7, or 5.8.4.8 and the mechanical seal as described in paragraph 5.8.4.9. This process will leave the pump head isolated from the rest of the pump.

Refer to Table 35 for a list of tools and/or consumables required for this procedure.

Table 35. AP/CBP/MBP Pump Head R&R Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
3/4-in (19 mm) Wrench (Or Ratchet Wrench) (Or Pass Thru Ratchet)		O-RING, <040-1580-00-0> (Pump Head to Gearbox) (This O-ring is used for all three pumps.)
3/4-in (19 mm) Torque Wrench		O-ring Lubricant (See Table 20)
		AP Pump Head: (*) <See FSG-PL-01483 Sheet 4 Item 10>
		CBP Pump Head: (*) <See FSG-PL-01482 Sheet 4 Item 11>
		MBP Pump Head: (*) <See FSG-PL-01486 Sheet 4 Item 13>

*** (ONLY One Required – Select From:)**

If ONLY the pump head remains attached to the gearbox, perform the following to remove and replace the pump head.

Pump Head Removal

- A. Remove pump head to gearbox retaining hardware.
 1. Using a 3/4-in (19 mm) wrench loosen (CCW) four (4) M12 x 1.75 full nuts.
 2. Remove four (4) M12 x 1.75 full nuts.
 3. Remove four washers.

NOTE

Do NOT damage the pump shaft when removing the pump head.

- B. Pull pump head off gearbox.
- C. Remove gasket from mating surfaces.
 1. Clean mating surfaces of pump head and volute.
 2. If mineral deposits are present, clean mating surfaces of pump head and gearbox.
- D. Remove O- ring from pump head on gearbox side.

- E. Inspect and clean all components. See paragraph 5.7.7, Cleaning And Inspection Guidelines.
 - 1. Inspect oil seal, if inspection indicates replacement is required see paragraph 5.8.4.13.1, Oil Seals.
 - 2. Inspect and measure clearance rings, If inspection indicates clearance rings require replacement see paragraph 5.8.7.2, Pump Clearance Ring R&R.
 - 3. Inspect and measure impeller, if inspection indicates impeller requires replacement see paragraph 5.8.4.6 (MBP), 5.8.4.7 (AP), or 5.8.4.8 (CBP).
 - 4. If pump is an MBP and inspection indicated inducer replacement is required see paragraph 5.8.4.5.
 - 5. No need to inspect mechanical seal, O-rings, and gaskets as their replacement is ALWAYS required.

Pump Head Installation

- A. Prepare pump head for installation.
 - 1. Install new O-ring.
 - a) Lubricate O-ring. Refer to Table 20.
 - b) Install new O-ring on pump head on gearbox side.
- B. Install pump head on gearbox, do not damage oil seal or pump shaft.
- C. Secure pump head to gearbox.
 - 1. Install four washers.
 - 2. Install four (4) M12 x 1.75 full nuts.
 - 3. Using a 3/4-in (19 mm) wrench tighten (CW) four (4) M12 x 1.75 full nuts.
- D. Using a cross pattern, torque nuts. Refer to Table 22 for recommended torque values for fastener size and material.

With only the pump head installed on the pump, use the instructions in paragraph 5.8.4.9, Mechanical Seal R&R, and paragraph 5.8.4.6 (MBP), 5.8.4.7 (AP), or 5.8.4.8 (CBP) to install the seal and impeller. If the pump is an MBP, install the inducer, see paragraph 5.8.4.5. Then install the volute and test the pump as described in paragraph 5.8.4.3 or 5.8.4.4, Volute R&R.

5.8.4.12 RSD Pump Head R&R

As stated in paragraph 5.8.4.11, do not confuse oil or water leaks for a pump head failure. (See AP/CBP/MBP Pump Head R&R on page 96 for full details.)

This procedure ONLY applies when the pump head requires removal from the gearbox. Prior to performing this procedure, remove the RSD volute as described in paragraph 5.8.4.2, RSD Volute R&R. Then remove the inducer as described in paragraph 5.8.4.5, and the impeller as described in paragraph 5.8.4.6, MBP/RSD Impeller R&R, and the mechanical seal as described in paragraph 5.8.4.10, RSD Mechanical Seal R&R.

Refer to Table 36 for a list of tools and/or consumables required for this procedure.

Table 36. RSD Pump Head R&R Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
3/4-in (19 mm) Wrench (Or Ratchet Wrench) (Or Pass Thru Ratchet)		O-ring Lubricant (See Table 20)
Drift Punch		Grease (See paragraph 5.7.2, Recommended Lubricants.)
Hammer		O-Ring (Pump Head to Gearbox) <See FSG-PL-01487 Sheet 4 Item 15>
Hook-end Dental Pick (Or Hose Removal Tool)		O-Ring (Pump Head to Volute) <See FSG-PL-01487 Sheet 4 Item 30>
Seal Puller		Gasket (Pump Head to Volute) <See FSG-PL-01487 Sheet 4 Item 3>
Press		RSD Pump Head (*) <See FSG-PL-01487 Sheet 4 Item 17>
		Clearance Ring <See FSG-PL-01487 Sheet 4 Item 18>

* (ONLY One Required – Select From:)

If ONLY the pump head remains attached to the gearbox, perform the following to remove and replace the pump head.

RSD Pump Head Removal

- A. Remove four (4) M12 nuts and four (4) washers securing pump head to gearbox.
 1. Using 3/4-in (19 mm) wrench (or ratchet wrench or pass thru ratchet, set CCW), loosen four (4) M12-1.75 nuts.
 2. Remove four (4) M12-1.75 nuts.
 3. Remove four (4) washers.

NOTE

Do NOT damage the pump shaft when removing the pump head.

- B. Pull pump head off gearbox.
- C. Scrape gasket off mating surfaces. (Clean the mating surface of the volute.)

NOTE

Do NOT use any portion of a mechanical seal after removal from the pump head.

- D. Inspect and clean all components. See paragraph 5.7.7, Cleaning And Inspection Guidelines.

Measure impeller hub (see Table 23.), replace if out-of-tolerance. If the impeller has failed, perform MBP/RSD Impeller R&R (see paragraph 5.8.4.5). Always replace the mechanical seal, perform RSD Mechanical Seal R&R (see paragraph 5.8.4.10).

RSD Pump Head Installation

- A. Prepare pump head for installation.
 1. Place pump head on stable work surface, pump side up (see Figure 37). Install following items as described below.
 - a) Verify mechanical seal anti rotation pin (see Figure 37) installed in pump head. If NOT installed, perform Installation portion of RSD Mechanical Seal Pin R&R (see paragraph 5.8.4.13.2).
 - b) Install pump head clearance ring (see Figure 37). (Refer to paragraph 5.8.7.2 on page 110 for instructions).
 - c) Lubricate new Teflon O-ring (P/O mechanical seal system). Refer to Table 21.
 - d) Install new Teflon O-ring (see Figure 37).
 - e) Lubricate new O-ring. Refer to Table 20.
 - f) Install new O-ring (volute to pump head) on pump side of pump head. (See Figure 37.)
 - g) Apply a small amount of grease to new gasket. (The grease helps hold gasket in place during assembly.)
 - h) Place new gasket on pump head (see Figure 37).
 - i) Align gasket and pump head screw holes.

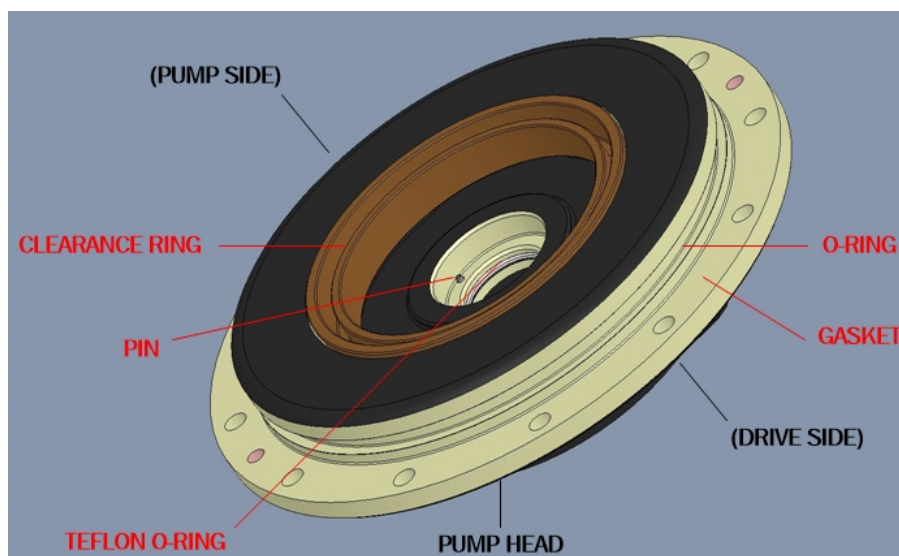


Figure 37. Pump Head (Pump Side)

2. Flip pump head over, drive side up (see Figure 38). Install following items as described below.

- a) Lubricate new O-ring (gearbox to pump head). Refer to Table 20.
- b) Install new O-ring on pump head.
- c) Lightly lubricate (grease) mating surface of new oil seal (and pump head bore). (Refer to paragraph 5.7.2 on page 49).
- d) Install new oil seal in pump head.

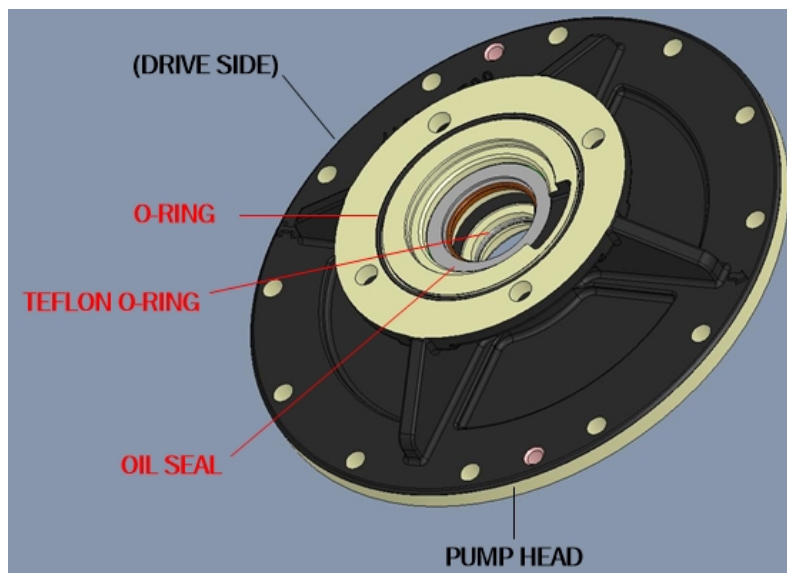


Figure 38. Pump Head (Drive Side)

- B. Install pump head on gearbox, do not damage oil seal or pump shaft.

NOTE

Unless the match marks differ, position weep holes at 12 and 6 o'clock with respect to vertical for installation of pump in the apparatus regardless of gearbox position used (Left, Right, or Down position is allowed).

- C. Clean original fastener threads (or replace with correct new fasteners). Then apply Loctite™ 243 (or equivalent) to threads.
- D. Secure pump head to gearbox.
 1. Install four washers.
 2. Install four (4) M12 x 1.75 full nuts.
 3. Using a 3/4-in (19 mm) wrench tighten (CW) four (4) M12 x 1.75 full nuts.
- E. Using a cross pattern, torque nuts. Refer to Table 22 for recommended torque values for fastener size and material.

With only the pump head installed, use the instructions in paragraph 5.8.4.10, RSD Mechanical Seal R&R, and paragraph 5.8.4.10, RSD Impeller R&R, to install the seal and impeller. Then refer to paragraph 5.8.4.5 for instructions to install the inducer and install the volute as described in 5.8.4.2, RSD Volute R&R. Finally, install the suction head and test the pump as described in paragraph, 5.8.4.1, RSD Suction Head R&R.

5.8.4.13 Pump Head R&R Bench Procedures

All oil seals are removed and replaced as part of a bench procedure since pump head or gearbox removal is required for access.

Only the pump shaft oil seal is located in the pump. All other oil seals are part of the Gearbox and their bench procedure is found in Section 5.9, Gearbox. Refer to paragraph 5.8.4.13.1, Pump Shaft Oil Seal And O-ring, for the pump shaft oil seal bench procedure. Refer to paragraph 5.9.2.1.1, Input Shaft Oil Seal (ONLY), for the input shaft oil seal R & R procedure.

5.8.4.13.1 Pump Shaft Oil Seal Bench Procedure

The pump shaft oil seal is located in the pump head on the drive side. This procedure requires pump assembly and gearbox (unit) removal and then pump removal from the gearbox prior to performance. This leaves the pump head as a loose item that can be taken to a bench for oil seal R&R. Use paragraph 5.8.2.1, General Pump Removal From The Apparatus (see page 56), to remove the unit from the apparatus.

After removing the unit, the pump portion (assemblies) must be removed from the gearbox to isolate the pump head. Use the **Removal** portion of the following procedures to isolate the pump head as a separate item.

- Volute R&R for an AP/MBP pump use paragraph 5.8.4.3, for a CBP pump use paragraph 5.8.4.4, and a RSD pump for use paragraph 5.8.4.2.
- Inducer R&R for an MBP/RSD pump use paragraph 5.8.4.5
- Impeller R&R for an AP pump use paragraph 5.8.4.7, for a CBP pump use paragraph 5.8.4.8, and for an MBP/RSD pump use paragraph 5.8.4.6.
- Mechanic Seal R&R for an AP/CBP/MBP pump use paragraph 5.8.4.9 and for a RSD use paragraph 5.8.4.10.)
- Pump Head R&R for an AP/CBP/MBP pump use paragraph 5.8.4.11 and for a RSD use paragraph 5.8.4.12.

Refer to Table 37 for a list of tools and/or consumables required for this procedure.

Table 37. Pump Shaft Oil Seal Bench Procedure Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
PPE (for Handling Oil)		Loctite Clean-Up Solvent™ (or equivalent)
Seal Removal Tool		Loctite 680™ (or equivalent)
Seal Driver Kit		Pump Shaft Oil Seal <See FSG-PL-01483, Sheet 4, Item 13> (AP) <See FSG-PL-01482, Sheet 4, Item 20> (CBP) <See FSG-PL-01486, Sheet 4, Item 16> (MBP) <See FSG-PL-01487, Sheet 4, Item 16> (RSD)
Non-marring Hammer		

Perform the following to remove and replace the pump shaft oil seal.

Pump Shaft Oil Seal Removal

- Remove pump shaft oil seal as follows.



1. Place pump head on stable work surface pump side down (oil seal facing up).
2. Using seal removal tool, remove pump shaft oil seal from pump head.
 - a) Place one end of removal tool in seal bore.
 - b) Pry pump shaft oil seal out of pump head.
- B. Using Loctite Clean-Up Solvent™ (or equivalent), remove residual Loctite 680™ from pump head bore.

Pump Shaft Oil Seal Installation

- A. Install pump shaft oil seal.
 1. Apply Loctite 680™ (or equivalent) to outer edge of new pump shaft oil seal.
 2. Place new pump shaft oil seal squarely and evenly into pump head with smooth part of seal body facing down (away).
 3. Using a seal driver (see note), drive pump shaft oil seal flush into pump head.

NOTES

Tap seal driver with non-marring hammer if required.

For an AP/CBP/MBP use a 65 mm (or larger) seal driver.

For a RSD use an 81 mm (up to 88 mm) seal driver.

- B. Perform Installation portion of Pump Head R&R. (For an AP/CBP/MBP pump use paragraph 5.8.4.11 and for a RSD use paragraph 5.8.4.12.)

5.8.4.13.2 RSD Mechanical Seal Anti Rotation Pin Bench Procedure

The RSD mechanical seal anti rotation pin prevents the mechanical seal seat from sinning inside the pump head bore. ONLY replace the pin if it is damaged to the point it may allow the seat to spin in the bore. The pin is made of 420 stainless steel and installs in a blind hole located on the pump side of the pump head.

Pin removal requires the plentiful use of penetrating oil prior to attempting to remove the pin.

NOTE

Spray penetrating oil on the pin, then strike the pump head lightly with a hammer. Tapping the pump head will allow the penetrating oil to penetrate the pin bore more thoroughly. Let pump head sit and soak for a minimum of 5 minutes for a lightly corroded pin or up to several hours for a more corroded pin.

Two methods of pin removal are provided: the first method uses a hammer, punch, and grease to drive the pin out of the blind hole while the second uses a drill, tap and #2 screw to push the pin out of the blind hole. The first method is the fastest way to remove the pin, however is does NOT always work. The second is the more dependable method of removing the pin.

Refer to Table 38 for a list of tools and/or consumables required for this procedure.

Table 38. Mechanical Seal Pin Bench Procedure Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
PPE (for Handling Oil)		Compressed Air
Shop Hammer		Penetrating Oil
1/16-in Pin Punch		Grease (See paragraph 5.7.2 on page 49.)
Drill *		Loctite LB 8008 (Anti seize Compound) (Or Equivalent)
#50 Drill Bit *		2-64 x 1-in Screw *
Tap (2-64 [UNF] threads) *		Pin <See FSG-PL-01487, Sheet 4, Item 33>
Screwdriver (fits #2 screw)		
Needle Nose Pliers		

* Optional (for second method).

Perform the following to remove and replace the mechanical seal anti rotation pin.

Pin Removal

NOTES

This method **ONLY** works, if the grease has a very heavy consistency and the punch fits very tightly into the bore of the pin without binding against the sides of the pin. The combination of the two allows the grease to be forced under the pin pushing it out of the blind hole.

When the punch nears the end of the pin/bottom of the blind hole, remove the punch and refill the pin with more grease.

If after several attempts of using the first method the pin has **NOT** moved, use the second method to remove the pin.

- A. Use first method to remove pin as follows.
 1. Soak pin and blind hole with abundant quantities of penetrating oil.
 2. Wait for penetrating oil to work.
 3. Remove excess penetrating oil. (Compressed air and shop rags.)
 4. Fill hole/pin with heavy grease. (See paragraph 5.7.2 on page 49.)
 5. Align a 1/16-in pin punch with bore in pin.
 6. Using a hammer, strike punch. (NOTE: Refill grease often as required between hammer strikes.)
- B. Otherwise, use second method to remove pin as follows.
 1. Using a drill and #50 drill bit, prepare bore of pin for tapping.
 2. Tap pin bore for 2-64 (UNF) threads.
 3. Use a 2-64 x 1-in screw, remove pin from blind hole as follows.

NOTE

ONLY use a screwdriver turned by hand to remove the pin. Do NOT use an electric, battery, or pneumatic type driver to tighten the screw.

- a) Hand start screw in pin.
- b) Using screwdriver (turn CW), screw #2 screw into pin until screw bottoms out in blind hole.
- c) Using care NOT to strip threads, tighten screw to force pin out of blind hole.

Pin Installation

- A. Clean and inspect pump area around pin bore. (See paragraph 5.7.7, Cleaning And Inspection Guidelines.)
- B. Coat inside of pump head pin bore and outside of pin with anti seize compound. (See Table 38.)
- C. Using needle nose pliers, align new pin with pin bore in pump head.
- D. Using shop hammer, gently tap pin into pump head pin bore until pin height is 3/32-in ($\pm 25/1000$ -in). See Figure 36 (on page 95).

The bench procedure is complete, return to the applicable R&R procedure.

5.8.5 Level 2 Procedures

Selected gearbox components (see Figure 25.) can be removed and replaced after removing the pump and gearbox assembly from the apparatus. Discharge and suction port hoses/plumbing will require removal before the pump removal procedure can be performed. Follow OEM instructions/procedures to remove and install discharge and/or suction port hoses/plumbing when required for pump component access. The following gearbox components can be removed and replaced after removing the pump and gearbox assembly from the apparatus.

- Bearings (See section 5.9.)
- Snap Rings (associated with bearing replacement) (See section 5.9.2.)

5.8.6 Level 3 Procedures

The gearbox gear set components (see Figure 25.) can be removed and replaced after removing the pump and gearbox assembly from the apparatus. Discharge and suction port hoses/plumbing will require removal before the pump removal procedure can be performed. Follow OEM instructions/procedures to remove and install discharge and/or suction port hoses/plumbing when required for pump component access. The gearbox gears can be removed and replaced after removing the pump and gearbox assembly from the apparatus.

- Drive Gear (See paragraph 5.9.2.1.4 on page 129.)
- Pump (Mating/Driven) Gear (See paragraph 5.9.2.2.3 on page 141.)
- Shaft Keys (associated with gear replacement) (See section 5.9 on page 118.)



5.8.7 Miscellaneous Procedures

Selected major pump/gearbox components (see Figure 21 thru Figure 26) can be removed and replaced after removing the pump and gearbox assembly from the apparatus. Discharge and suction port hoses/plumbing will require removal before the pump removal procedure can be performed. Follow OEM instructions/procedures to remove and install discharge and/or suction port hoses/plumbing when required for pump component access. The following pump/gearbox components can be removed and replaced after removing the pump and gearbox assembly from the apparatus.

- Cooling System (See paragraph 5.8.7.1, Cooling System R&R.)
- Volute (See paragraph 5.8.4.3 or 5.8.4.4, Volute R&Rs.)
- Clearance Rings (See paragraph 5.8.7.2, Pump Clearance Ring R&R.)
- Impeller (See paragraph 5.8.4.6 (MBP), 5.8.4.7 (AP), or 5.8.4.8 (CBP) for Impeller R&Rs.)
- Pump Head (See paragraph 5.8.4.11, Pump Head R&R.)
- Gearbox Components (See section 5.9 for Gearbox procedures.)

5.8.7.1 Cooling System

The gearbox cooling system circulates pump water to transfer heat from the gearbox oil to the pump discharge, thus maintaining lower gearbox operating temperatures. The gearbox cooling system has no internal joints to leak and should never require replacement. However allowing water to freeze in the gearbox cooling tubes can cause the cooling tubes to rupture.

In addition to a leak, cooling tube removal is required to access the gear set should the gears ever require replacement. Whenever the cooling tube is removed it is no longer usable and requires replacement with a new cooling tube. This is due to the U-shape design and that compression fittings are required to prevent vibration from moving the cooling tube during pump operation.

The cooling system is an option for all of the Hale Flex Series single stage booster pumps and can be included with the initial purchase or added after the pump has been in service for any period of time. If the cooling system is added after the pump is factory built, contact Hale Customer Service (800-533-3569) for a parts listing and installation/drain details.

Refer to Table 39 for a list of tools and/or consumables required for this procedure.

Table 39. Gearbox Cooling Tube R&R Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
PPE (for Handling Oil)		Cooling Tube (Gearbox) <See FSG-PL-01481, Sheet 2, Item 21>
Hacksaw		Gasket (Gearbox Cover) <See FSG-PL-01481, Sheet 2, Item 14>
Midget/Mini Tube Cutter (for 3/8-in tube)		Adapter 1/2 Male NPT X 3/8 Tube (Gearbox) <See FSG-PL-01481, Sheet 2, Item 30>
** 7/16-in Wrench		Bushing 3/4 MNPT X 1/4 NPT <See FSG-PL-01483, Sheet 4, Item 25> (AP) <See FSG-PL-01486, Sheet 4, Item 26> (MBP)
** 1/2-in Wrench		Bushing 3/4 X 1/4 NPT <See FSG-PL-01487, Sheet 4, Item 28> (RSD)
** 13 mm Wrench (or socket and driver))		Elbow 1/4 NPT X 3/8 Comp <See FSG-PL-01482, Sheet 4, Item 26> (CBP)
** 9/16-in Wrench		Elbow 3/8 Comp X 3/8 MNPT <See FSG-PL-01483, Sheet 4, Item 21> (AP) <See FSG-PL-01486, Sheet 4, Item 27> (MBP) <See FSG-PL-01487, Sheet 4, Item 6> (RSD)
** 5/8-in Wrench		Elbow 3/8 Comp X 3/8 Comp <See FSG-PL-01483, Sheet 4, Item 19 *> (AP) <See FSG-PL-01482, Sheet 4, Item 17 *> (CBP) <See FSG-PL-01486, Sheet 4, Item 22> (MBP) <See FSG-PL-01487, Sheet 4, Item 14> (RSD)
** 16 mm Wrench		Fitting 3/8 Hose Barb X 3/8 Tube <See FSG-PL-01483, Sheet 4, Item 23> (AP) <See FSG-PL-01482, Sheet 4, Item 16> (CBP) <See FSG-PL-01486, Sheet 4, Item 23> (MBP) <See FSG-PL-01487, Sheet 4, Item 7> (RSD)
** 7/8-in Wrench		Hose (Water Line) <See FSG-PL-01483, Sheet 4, Item 22> (AP) <See FSG-PL-01482, Sheet 4, Item 22> (CBP) <See FSG-PL-01486, Sheet 4, Item 24> (MBP) <See FSG-PL-01487, Sheet 4, Item 25> (RSD)
** 1-1/16-in Wrench		Tee 3/8 Comp X 1/4 MPT X 1/4 FPT <See FSG-PL-01482, Sheet 4, Item 25> (CBP)
		Tee 3/8 Comp X 1/4 MNPT <See FSG-PL-01483, Sheet 4, Item 24> (AP) <See FSG-PL-01486, Sheet 4, Item 25> (MBP) <See FSG-PL-01487, Sheet 4, Item 27> (RSD)
		Loctite™ 580 (Or Equivalent)

* Alternate part is a Tee (3/8 Comp union).

** Alternatively a 10 inch (thru 15 inch) adjustable wrench may be used.



5.8.7.1.1 Cooling Tube R&R

Perform the following to remove and replace the gearbox cooling tube.

Cooling Tube Removal

- A. Disconnect both cooling water lines (at gearbox end of water line).
 1. Remove 90° elbow from cooling tube (supply line).
 - a) Using 1/2-in wrench (or adjustable wrench), hold 90° elbow stationary.
 - b) Using 5/8-in wrench (or adjustable wrench), loosen nut (turn CCW) on cooling tube side of elbow.
 - c) Remove nut.
 - d) Pull 90° elbow off cooling tube.
 2. Remove remaining 90° elbow from cooling tube (return line). Repeat steps 1. a) thru d) above.

NOTE

The nuts and the compression rings stay on the cooling tube.

- B. Prepare cooling tube for removal.
 1. Using 5/8-in wrench (or adjustable wrench), loosen (turn CCW) supply side compression nut on adapter (1/2 male NPT X 3/8 tube).
 2. Using 5/8-in wrench (or adjustable wrench), loosen (turn CCW) return side compression nut on adapter (1/2 male NPT X 3/8 tube).
 3. Slide both nuts out-of-the-way.

NOTE

Use care when cutting the cooling tube NOT to damage the fitting. The compression ring is NOT reused and can be sacrificed (cut/damaged) without issue. If the fitting is damaged it requires replacement.

4. Using a hacksaw, cut gearbox cooling tube between compression ring and compression fitting.
5. Remove adapter (1/2 NPT to 3/8 compression).
 - a) Using 1-1/16-in wrench (or adjustable wrench), loosen (turn CCW) adapter.

NOTE

The cooling tube may require deburring before the adapter can be removed. Do NOT gouge the inside of the adapter or it may leak.

- b) Unscrew adapter and pull adapter off gearbox cooling tube.
- C. Remove gearbox cooling tube.
 1. Using a 13 mm wrench (or socket and driver), remove 16 M8 x 1.25 x 20 mm long gearbox cover screws.
 2. Remove 16 washers.
 3. Remove cover.
 4. Pull cooling tube out of gearbox.

Inspect and clean all components. See paragraph 5.7.7, Cleaning And Inspection Guidelines. Clean mating surfaces of cover and gearbox. (Do NOT allow gasket material to fall into the gearbox.) When opening a gearbox, as a minimum, inspect the following.

- Gearbox fluid, replace if water is in fluid. Refer to paragraph 4.4.6.1, Gearbox Oil Change.
- Gearbox oil seals, if inspection indicates replace damaged/failed seals. Refer to paragraph 5.8.4.13.1 (on page 102), or 5.9.2.1 (on page 121).
- Gearbox bearings, if inspection indicates damage/excessive wear replace bearings. Refer to section 5.9.2.
- Gear set (including keys), if inspection indicates damage/excessive wear replace keys. Refer to section 5.9.2.

Cooling System Installation

A. Install gearbox cooling tube.

1. Install cooling tube into gearbox.
 - a) Push cooling tube thru gearbox adapter openings.
 - b) Apply Loctite 580 to adapter threads.
 - c) Slide adapter (1/2 NPT to 3/8 compression) over cooling tube end (supply side) and hand start adapter into gearbox threads.
 - d) Using 1-1/16-in wrench (or adjustable wrench), tighten (turn CW) adapter.
 - e) Repeat Step b) thru Step d) except for return side.
2. Install compression fittings.
 - a) On adapters, install new compression rings and nuts. (One on each adapter ring first.)

NOTE

Hold cooling tube in proper position until both compression nuts are tightened.

- b) Using 5/8-in wrench, tighten compression nuts. (Do NOT over tighten nuts.)
- c) Slide new compression nut and then a new compression ring onto each side of cooling tube (supply and return).
- d) Push supply side 90° elbow onto cooling tube until fully seated.
- e) Using 16 mm wrench (or adjustable wrench), tighten (turn CW) compression nut while using a 1/2-in wrench to hold elbow stationary.
- f) Repeat Step c) thru Step e) above except for return side elbow.

B. Install gearbox cover as follows.

1. Align new cover gasket with top of gearbox.

NOTE

Do NOT use grease to hold the gasket in place for ease of assembly. Grease is NOT compatible with the fluid used in the Flex gearbox.

2. Align cover with screw holes in gearbox.
3. Install cover screws as follows.
 - a) Install one (1) washer on each cover screw.

- b) Apply Loctite™ 580 (or equivalent) to threads of each screw.
- c) Hand start 16 M8 x 1.25 x 20 mm long screws (each with one (1) washer).
- d) Using 13 mm wrench (or socket with driver), tighten cover screws.
- e) Using a circular pattern, tighten screws evenly and torque IAW Table 22.
(Do NOT over tighten.)

C. Perform Gearbox Fluid Change (see paragraph 4.4.6.1 on page 42.)

5.8.7.2 Pump Clearance Ring R&R

When new, the radial clearance between the impeller hub and the clearance ring is between 0.006 and 0.0085 inch. Any increase will allow more bypass and result in lower performance. It should not be necessary to replace clearance rings and impeller until the average radial clearance exceeds 0.012 to 0.017 inch, as measured with calipers. Refer to Table 23.

This procedure does NOT provide access instructions, ONLY steps to R&R the clearance rings are provided herein.

The Flex series pumps utilize two styles of clearance rings, For an AP/CBP/MBP a typical brass ring style is located in the volute while for a RSD this style ring is located in the suction head. All pumps utilize a wraparound style ring located in the pump head.

If pump is an AP, CBP, or MBP; refer to paragraph 5.8.4.3 (see page 72) or paragraph 5.8.4.4 (see page 74) for volute removal. If the pump is a RSD refer to paragraph 5.8.4.1 (see page 67) for suction head removal. Then for pump head removal instructions refer to paragraph 5.8.4.11 (see page 96) or paragraph 5.8.4.12 (see page 98).

Refer to Table 40 for a list of tools and/or consumables required for this procedure.

Table 40. Pump Clearance Ring R&R Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
Cutting Wheel (Electric or Pneumatic)		Clearance Ring (Volute Side) <See FSG-PL-01483 Sheet 4 Item 2> (AP) <See FSG-PL-01482 Sheet 4 Item 2> (CBP) <See FSG-PL-01486 Sheet 4 Item 3> (MBP)
L-shaped Pry Bar (12-in Recommended) (Three [3] Required)		Clearance Ring (Pump Head Side) <See FSG-PL-01483 Sheet 4 Item 8> (AP) <See FSG-PL-01482 Sheet 4 Item 8>(CBP) <See FSG-PL-01486 Sheet 4 Item 11>(MBP)
Hammers (Non-marring and shop)		Loctite 680 (Or Equivalent)
Hydraulic Press **		Loctite Clean-Up Solvent (Or Equivalent)
Cold Cut Chisel		Wire Brush
1/ 4-in Drill Bit		
Drill		
Mechanics Vise (14-in Recommended)		

**** A non-marring hammer may be used being careful NOT to bend, warp, or chip the clearance ring.**

Perform the following to remove and replace pump clearance ring(s).

AP/CBP/MBP Volute Clearance Ring Removal

NOTE

Use cribbing to prevent volute from tipping or moving if required.

- A. Place volute on stable work surface with suction opening down.

IMPORTANT ▲ NOTICE

DO NOT CUT THRU THE CLEARANCE RING. CUTTING THRU THE CLEARANCE RING WILL DAMAGE THE VOLUTE AND MAY RESULT IN PUMP FAILURE.

- B. Using cutting wheel, cut two slots (180° apart - opposite each other) into failed clearance ring. See Figure 39.

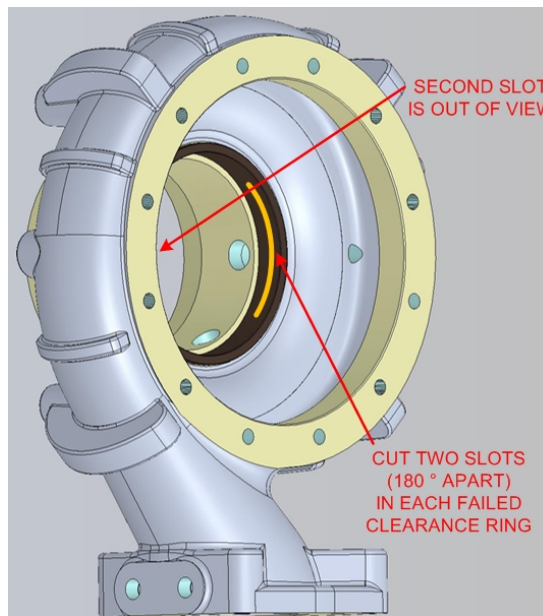


Figure 39. Slots Cut In Clearance Ring-Volute

- C. Place volute on stable work surface with suction opening up.
- D. Using a chisel and hammer, drive clearance ring out of volute. See Figure 40.

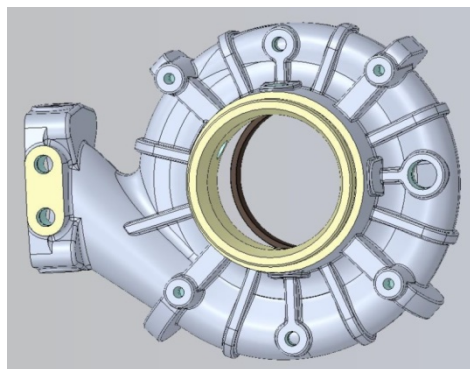


Figure 40. Clearance Ring Driven Out-Volute



AP/CBP/MBP Volute Clearance Ring Installation

- A. Clean volute to remove old Loctite. (Use Loctite Clean-Up Solvent and a wire brush.)

NOTE

Use cribbing to prevent volute from tipping or moving if required.

- B. Place volute on stable work surface with suction opening down.
- C. Coat ONLY outer mating surface of new clearance ring with Loctite 680.
- D. Align new clearance ring to volute.

IMPORTANT ▲ NOTICE

DO NOT DRIVE THE CLEARANCE RING INTO THE VOLUTE AT AN ANGLE OR UNEVENLY (ALL THE WAY FROM ONE SIDE AT A TIME). BENDING, WARPING, OR CHIPPING THE CLEARANCE RING MAY RESULT IN POOR PERFORMANCE OR PUMP FAILURE.

NOTE

A circular piece of plate steel the size of the outside diameter of the clearance ring may be used to prevent the ring from tipping or jamming inside the volute.

- E. Using hydraulic press, install clearance ring into volute.

AP/CBP/MBP Pump Head Clearance Ring Removal

The AP and MBP utilize the same pump head however; each pump utilizes a different sized wrap around clearance ring. The AP wrap around clearance ring presses onto the inside shoulder of the pump head cavity while the MBP wrap around clearance ring presses on to the outside shoulder. The CBP is similar to the MBP configuration however; the CBP utilizes both a different pump head and a different sized wrap around clearance ring. All of the pump heads utilize a raised center hub (supports the pump seal and pump shaft) and wrap around clearance rings (must stronger structurally than typical rings) which dictate the use of the following method to remove the wrap around clearance ring.

- A. Place pump head in a vise with drive side down (clearance ring up).

IMPORTANT ▲ NOTICE

DO NOT DRILL INTO THE PUMP HEAD HOWEVER DRILL THRU THE CLEARANCE RING. DRILLING INTO THE PUMP HEAD WILL DAMAGE THE PUMP HEAD AND MAY RESULT IN PUMP FAILURE.

- B. Using drill with 1/4-in bit, drill two holes approximately 1-in apart into failed clearance ring (directly over one of the three (3) recesses (voids) in the pump head). See Figure 41 and Figure 42.

NOTES

- Start the drill before contacting the material to help prevent the bit from binding in the impeller groove.
- Start the bit at approximately a 45° angle (spanning the impeller groove) then slowly increase the angle until drilling straight down into the impeller groove.
- Feed the bit into the material very slowly to help prevent the bit from binding.

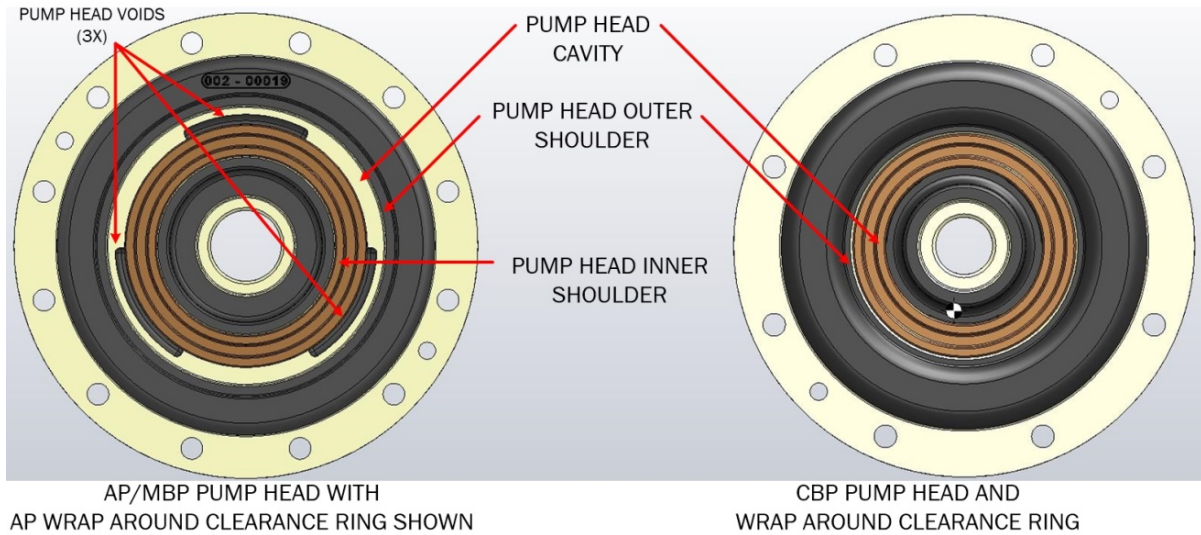


Figure 41. Wrap Around Clearance Rings – Pump Heads

- C. Drill thru clearance ring but NOT into pump head. See Figure 42.

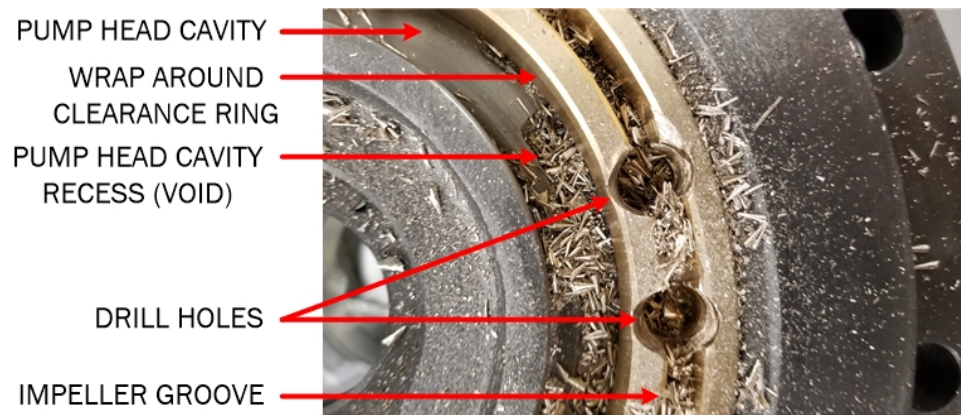


Figure 42. Clearance Ring Drilled Out (MPB Pump Head)

- D. Using a chisel and hammer, bend clearance ring slightly inward at holes. Then cut clearance ring thru with chisel. See Figure 43.



Figure 43. Clearance Ring Bent Inward And Cut Thru

- E. Remove clearance ring.

AP/CBP/MBP Pump Head Clearance Ring Installation

- A. Clean pump head to remove old Loctite. (Use Loctite Clean-Up Solvent and a wire brush.)
- B. Place pump head on stable work surface with drive side down (clearance ring up).
- C. Coat ONLY mating surface of new clearance ring with Loctite 680 as follows.
 1. If AP, coat inner diameter (mating) surface of new clearance ring.
 2. If CBP or MBP, coat outer diameter (mating) surface of new clearance ring.

NOTES

The pump head and wrap around clearance ring are designed utilizing an interference fit. The MBP and the CBP utilize the outer surface of the pump head cavity while the AP utilizes the inner surface of the pump head cavity to provide that interference fit.

If the pump under repair is an AP or an MBP ensure the correct clearance ring is being installed (since both rings will fit in the pump head but ONLY the correct ring will mate with the impeller).

- D. Align new wrap around clearance ring to pump head.

IMPORTANT ▲ NOTICE

DO NOT DRIVE THE CLEARANCE RING INTO THE PUMP HEAD AT AN ANGLE OR UNEVENLY (ALL THE WAY FROM ONE SIDE AT A TIME). BENDING, WARPING, OR CHIPPING THE CLEARANCE RING MAY RESULT IN POOR PERFORMANCE OR PUMP FAILURE.

NOTE

A circular piece of plate steel the size of the outside diameter of the clearance ring may be used to prevent the ring from tipping or jamming inside the pump head.

- E. Using hydraulic press, install clearance ring into pump head.
- F. Apply a heavy coating of grease to clearance rings.

NOTE

The grease protects the clearance ring during the initial pump priming to prevent the ring from contacting the impeller.

RSD Suction Head Clearance Ring Removal

NOTE

Use cribbing to prevent suction head from tipping or moving if required.

- A. Place suction head on stable work surface with suction opening down.

IMPORTANT ▲ NOTICE

DO NOT CUT THRU THE CLEARANCE RING. CUTTING THRU THE CLEARANCE RING WILL DAMAGE THE SUCTION HEAD AND MAY RESULT IN PUMP FAILURE.

- B. Using cutting wheel, cut two slots (180° apart - opposite each other) into failed clearance ring. See Figure 44.

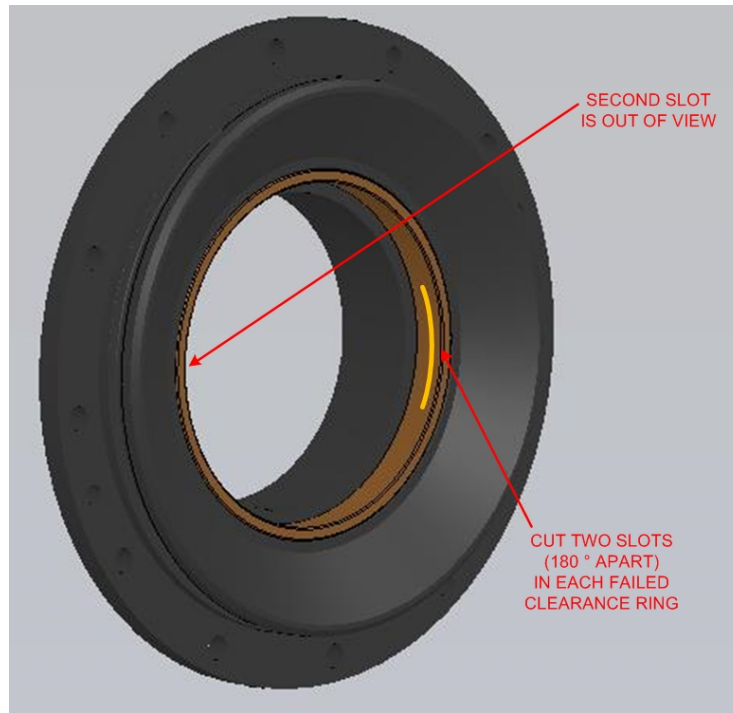


Figure 44. Slots Cut In Clearance Ring - Suction Head

- C. Place suction head on stable work surface with suction opening up.
- D. Using a chisel and hammer, drive clearance ring out of suction head. See Figure 45.

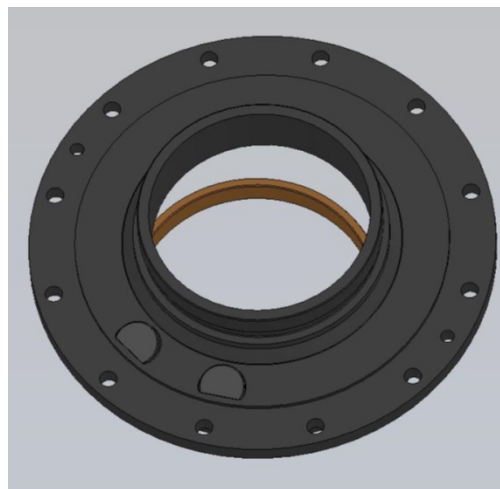


Figure 45. Clearance Ring Driven Out – Suction Head

RSD Suction Head Clearance Ring Installation

- A. Clean suction head to remove old Loctite. (Use Loctite Clean-Up Solvent and a wire brush.)
- B. Place suction head on stable work surface with suction opening down.
- C. Coat ONLY outer (mating) surface of new clearance ring with Loctite 680.

- D. Align new clearance ring to suction head.

IMPORTANT ▲ NOTICE

DO NOT DRIVE THE CLEARANCE RING INTO THE SUCTION HEAD AT AN ANGLE OR UNEVENLY (ALL THE WAY FROM ONE SIDE AT A TIME). BENDING, WARPING, OR CHIPPING THE CLEARANCE RING MAY RESULT IN POOR PERFORMANCE OR PUMP FAILURE.

NOTE

A circular piece of plate steel the size of the outside diameter of the clearance ring may be used to prevent the ring from tipping or jamming inside the suction head.

- E. Using hydraulic press, install clearance ring into suction head.
F. Apply a heavy coating of grease to clearance ring.

NOTE

The grease protects the clearance ring during the initial pump priming to prevent the ring from contacting the impeller.

RSD Pump Head Clearance Ring Removal

- A. Place pump head on stable work surface with drive side down.

NOTE

As an alternate method for removing ONLY the 750–1250 gpm RSD wrap around clearance ring, the thick portion of the clearance ring may be drilled and tapped for two (2) 3/8–16 X 1-1/2-in long (all thread) jackscrews. See Figure 46. Position the jackscrew holes to be within any two of the pump head recesses and 180° apart.

THINNER OUTER WALL AND WIDER IMPELLER GROOVE WIDER OUTER WALL AND THINNER IMPELLER GROOVE

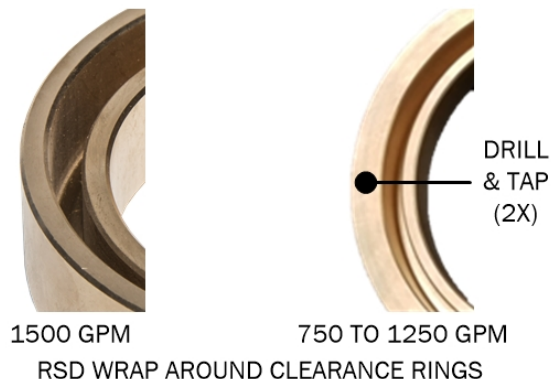


Figure 46. RSD Wrap Around Clearance Rings

- B. Using three (3) L-shaped pry bars and a shop hammer, drive a pry bar under failed clearance ring at each of three (3) recesses in pump head casting. (The cavities/recesses are spaced 120° apart around the pump head.) See Figure 47.

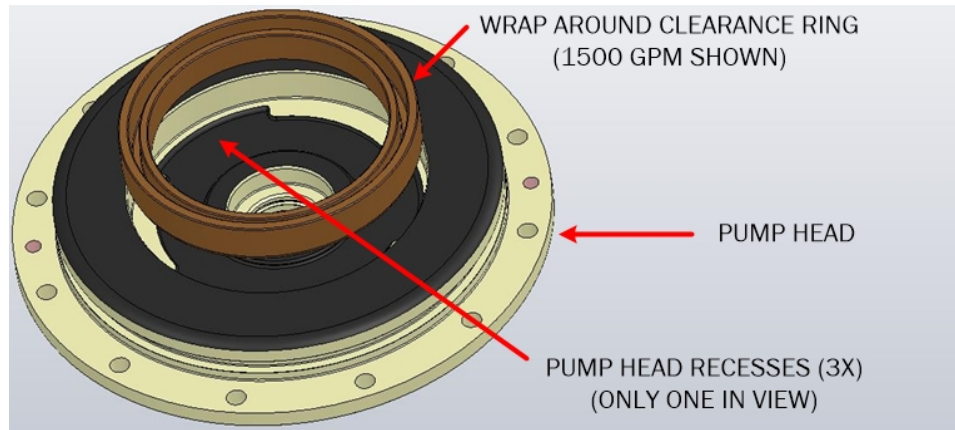


Figure 47. RSD Wrap Around Clearance Ring R & R

- C. Apply force to pry bars (two-at-a-time works best) to remove clearance ring.

RSD Pump Head Clearance Ring Installation

- A. Clean pump head to remove old Loctite. (Use Loctite Clean-Up Solvent and a wire brush.)
- B. Place suction head on stable work surface with suction opening down.
- C. Coat ONLY outer mating surface of new clearance ring with Loctite 680.
- D. Align new clearance ring to suction head.

IMPORTANT ⚠ NOTICE

DO NOT DRIVE THE CLEARANCE RING INTO THE SUCTION HEAD AT AN ANGLE OR UNEVENLY (ALL THE WAY FROM ONE SIDE AT A TIME). BENDING, WARPING, OR CHIPPING THE CLEARANCE RING MAY RESULT IN POOR PERFORMANCE OR PUMP FAILURE.

NOTE

A circular piece of plate steel the size of the outside diameter of the clearance ring may be used to prevent the ring from tipping or jamming inside the suction head.

- E. Using hydraulic press, install clearance ring into suction head.
- F. Apply a heavy coating of grease to clearance ring.

NOTE

The grease protects the clearance ring during the initial pump priming to prevent the ring from contacting the impeller.

5.8.8 General Install On The Apparatus

After completing repairs and/or maintenance, install the pump and gearbox assembly (unit) on the apparatus.

- A. Prepare unit for installation.
 - 1. Verify magnetic oil drain plug installed.
 - 2. Verify gearbox filled with fluid. (See paragraph 4.4.6.1 on page 42.)
 - 3. Attach an appropriated rated lifting device and rigging (or jack).



B. Install unit.

1. Using appropriately rated lift equipment and rigging (or jack), lift unit and position in apparatus. (As noted or match marked.)
2. Connect mounting brackets. (Use grade 5 or better fasteners.)
3. Torque fasteners to values provided in Table 22.
4. Connect drive shaft to drive flange.
 - a) If reusing fasteners, clean Loctite from threads.
 - b) Apply Loctite™ to fasteners (drive line fasteners must be grade 8 or better).
 - c) Torque fasteners to PTO manufacturer's specifications.

C. If applicable, connect any electronics, airlines and tachometer cable.

D. Connect suction and discharge piping to pump.

E. Perform paragraph 4.4.4.1.3, Performance Testing Test Procedure, to verify repair complete and pump in working condition.

NOTE

Repair any leaks or problems before returning apparatus to service.

F. Update all maintenance log entries.

G. Return apparatus to service.

5.9. Gearbox

IMPORTANT ▲ NOTICE

DO NOT USE GREASE DURING GEARBOX ASSEMBLY. IN ALL OTHER CASES IT IS ACCEPTED PRACTICE TO HOLD COMPONENTS IN PLACE OR LUBRICATE THEM FOR EASE OF ASSEMBLY USING GREASE, HOWEVER DURING GEARBOX ASSEMBLY USE ONLY GEAR OIL. GREASE IS NOT COMPATIBLE WITH THE SYNTHETIC GEAR OIL AND MAY CAUSE DRAIN HOLES TO CLOG PREVENTING CRITICAL LUBRICATION.

The Flex series gearbox provides the latest in gearbox technology, a wider range of gear ratios, and decreased preventive maintenance. The gearbox new technology utilizes increased cooling, a longer lasting high quality bearing, gear, and shaft design, along with full synthetic lubrication to increase the gear oil change interval to three (3) years. It previously took three separate gearboxes to provide the 22 various gear ratios (1.14:1 to 4.93:1) used for all models of Hale booster pumps. The Flex series gearbox provides eight (8) gear ratios (1.14:1, 1.31:1, 1.65:1, 1.90:1, 2.33:1, 2.60:1, 2.91:1, and 3.74:1) in a single gearbox which is now used for all Hale Flex Series booster pumps (including two stage pumps see FSG-MNL-00197). Unlike the previous gearboxes (utilizing spur gears) the gearbox utilizes only helical gears, provides a gear oil level sight glass, and cooling tubes are standard on the large Flex series pumps (previously optional). The overall result of the gearbox is a better, more reliable product at a reduced cost with greater interchangeability for all Hale Flex Series booster pumps.

5.9.1 Gearbox R&R

Prior to performing this procedure, remove the pump and gearbox assembly from apparatus as described in paragraph 5.8.2.1, General Pump Removal From The Apparatus.

General Gearbox Removal

A. Remove drive flange snap ring.

1. Expand and remove retaining ring.
 - a) Using snap ring pliers, insert tips of pliers into holes in snap ring and expand snap ring.
 - b) Pull snap ring off input shaft.
 - c) Release and remove snap ring pliers.
2. Discard snap ring.
- B. Remove volute as described below:
 1. If pump is a RSD, perform Removal portion of RSD Volute R&R (see paragraph 5.8.4.2 on page 69).
 2. If pump is an AP or MBP, perform Removal portion of AP/MBP Volute R&R (see paragraph 5.8.4.3 on page 72).
 3. If pump is a CBP, perform Removal portion of CBP Volute R&R (see paragraph 5.8.4.4 on page 74).
- C. If pump is an MBP or RSD, remove inducer as described in Removal portion of MBP/RSD Inducer R&R (see paragraph 5.8.4.5 on page 76).
- D. Remove impeller as described below:
 1. If pump is an MBP or RSD, perform Removal portion of MBP/RSD Impeller R&R (see paragraph 5.8.4.6 on page 81).
 2. If pump is an AP, perform Removal portion of AP Impeller R&R (see paragraph 5.8.4.7 on page 83).
 3. If pump is a CBP, perform Removal portion of CBP Impeller R&R (see paragraph 5.8.4.8 on page 87).
- E. Remove mechanical seal as described below:
 1. If pump is an AP/CBP/MBP, perform Removal portion of AP/CBP/MBP Mechanical Seal R&R (see paragraph 5.8.4.9 on page 90).
 2. If pump is a RSD, perform Removal portion of RSD Mechanical Seal R&R (see paragraph 5.8.4.10 on page 93).
- F. Remove pump head as described below:
 1. If pump is an AP/CBP/MBP, perform Removal portion of AP/CBP/MBP Pump Head R&R (see paragraph 5.8.4.11 on page 96).
 2. If pump is a RSD, perform Removal portion of RSD Pump Head R&R (see paragraph 5.8.4.12 on page 98).

The gearbox is now isolated from the pump and ready to perform any of the bench procedures listed in paragraph 5.9.2. When the bench procedure is completed return to this procedure for pump installation.

General Gearbox Installation

- A. Install pump head as described below:
 1. If pump is an AP/CBP/MBP, perform Installation portion of AP/CBP/MBP Pump Head R&R (see paragraph 5.8.4.11 on page 96).

2. If pump is a RSD, perform Installation portion of RSD Pump Head R&R (see paragraph 5.8.4.12 on page 98).
- B. Install mechanical seal as described below:
 1. If pump is an AP/CBP/MBP, perform Installation portion of AP/CBP/MBP Mechanical Seal R&R (see paragraph 5.8.4.9 on page 90).
 2. If pump is a RSD, perform Installation portion of RSD Mechanical Seal R&R (see paragraph 5.8.4.10 on page 93).
- C. Install impeller as described below:
 1. If pump is an MBP or RSD, perform Installation portion of MBP/RSD Impeller R&R (see paragraph 5.8.4.6 on page 81).
 2. If pump is an AP, perform Installation portion of AP Impeller R&R (see paragraph 5.8.4.7 on page 83).
 3. If pump is a CBP, perform Installation portion of CBP Impeller R&R (see paragraph 5.8.4.8 on page 87).
- D. If pump is an MBP or RSD, install inducer as described in Installation portion of MBP/RSD Inducer R&R (see paragraph 5.8.4.5 on page 76).
- E. Install volute and test the pump as described below:
 1. If pump is a RSD, perform Installation portion of RSD Volute R&R (see paragraph 5.8.4.2 on page 69).
 2. If pump is an AP or MBP, perform Installation portion of AP/MBP Volute R&R (see paragraph 5.8.4.3 on page 72).
 3. If pump is a CBP, perform Installation portion of CBP Volute R&R (see paragraph 5.8.4.4 on page 74).
- F. Install drive flange snap ring.
 1. Expand and install retaining ring.
 - a) Using snap ring pliers, insert tips of pliers into holes in snap ring and expand snap ring. Do NOT release pliers until instructed. (NOTE: Refer to paragraph 5.7.5 for proper ring orientation.)
 - b) Push snap ring over end of input shaft and locate directly over groove in shaft.
 2. Release snap ring pliers and verify ring seats in groove.

After performing this procedure, install the pump and gearbox assembly on the apparatus as described in paragraph 5.8.8, AP Install On The Apparatus.

5.9.2 Gearbox Bench Procedures

Prior to performing any bench procedure the pump and gearbox (unit) must be removed from the apparatus as a single assembly. Use paragraph 5.8.2.1, General Pump Removal From The Apparatus to remove the unit from the apparatus. These instructions also provide for gear oil removal, to further prepare the gearbox for the performance of bench procedures.

After removing the unit, the pump portion (assemblies) must be removed from the gearbox to isolate the gearbox before any bench procedure can be performed. Use the **General Gearbox Removal** portion of paragraph 5.9.1 to separate the gearbox from the pump assemblies to isolate the gearbox as a separate assembly.

Gearbox bench procedures consist of removal and replacement procedures of all gearbox components (with the exception of pump shafts and gear ratios). Gearbox bench procedures are identical for all four Flex series single stage pumps once the pump has been removed from the gearbox. All of the subparagraphs in this section (bench procedures) provide removal and replacement procedures for selected Gearbox components and apply to all four booster pumps. Figure 25 and Figure 26 show exploded views of the Gearbox.

When the bench procedure(s) is (are) completed, the pump portion (assemblies) must be reinstalled on the gearbox before the unit can be reinstalled on the apparatus. Use the **General Gearbox Installation** portion of paragraph 5.9.1 to install the pump assemblies onto the gearbox.

After assembling the pump to the gearbox reinstall the unit on the apparatus, use paragraph 5.8.8 for instructions to reinstall the unit on the apparatus.

5.9.2.1 Input Shaft

This procedure requires gearbox removal prior to performance to provide input shaft access. See the previous paragraph for references to remove the unit from the apparatus and then the pump assemblies from the gearbox. Refer to Table 41 for a list of tools and/or consumables required for this procedure.

Table 41. Input Shaft Bench Procedure Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
PPE (for Handling Oil)		Loctite 680
Bearing And Seal Drivers (90 and 95 mm)		Ø 1.5-in (38 mm) Wood Dowel (Between 8-in [200 mm] and 12-in [305 mm] long)
Oil Safe Catch Container (1.5 L or larger)		Endcap 90 mm <See FSG-PL-01481, Sheet 2, Item 26>
Seal Removal Tool		Oil Seal (Input Shaft) <See FSG-PL-01481, Sheet 2, Item 2>
Snap Ring Pliers		Bearing (Qty = 2) <See FSG-PL-01481, Sheet 2, Item 4>
Non-marring Hammer		Input Shaft <See FSG-PL-01481, Sheet 2, Item 5>
Shop Hammer		Gear Oil (See FSG-MNL-00183, Flex Series Single Stage Booster Pump OIM, paragraph 7.4.4.1.1.)
Press (Mechanical or Hydraulic)		* Steel Rod (Short Length of Approximately 1/2-in)
9/16-in Wrench (or 8 pt. socket)		
Ratchet		
* 10 mm Hex Socket		
* Slide Hammer and Puller Set		
* Chisel (Long Thin)		

* **Optional.**



Perform the following to remove and replace an input shaft.

Input Shaft Removal

- A. Remove input shaft oil seal.
 1. Drain any remaining gear oil from gearbox.
 - a) Position oil safe catch container under drain plug.
 - b) Remove magnetic (and/or adjacent) drain plug(s).
 - i. Using 9/16-in wrench (or 8 pt. socket and ratchet – set for CCW), loosen magnetic drain plug. NOTE: If required using 10 mm hex socket and ratchet – set for CCW, loosen adjacent drain plug.
 - ii. Remove drain plug(s).
 - c) Inspect drain plug for metal fragments or other abnormalities that may provide clues as to condition of internal gearbox components. (See Section 5.1, Troubleshooting.)
 - d) Install magnetic (and/or adjacent) drain plug(s).
 - i. Hand start drain plug.
 - ii. Using 9/16-in wrench (or 8 pt. socket and ratchet – set for CW), tighten magnetic drain plug. NOTE: If required using 10 mm hex socket and ratchet – set for CW, tighten adjacent drain plug. (NOTE: Plug should be approximately flush with the housing when tighten.)
 2. Using seal removal tool, remove input shaft oil seal.
 - a) Drive removal tool into seal body.
 - b) Pry input shaft oil seal out of gearbox.
 3. Discard seal.
- B. Remove drive side bearing retaining ring.
 1. Compress and remove retaining ring.
 - a) Using snap ring pliers, insert tips of pliers into holes in retaining ring and compress retaining ring.
 - b) Pull retaining ring out of gearbox.
 2. Discard retaining ring.
- C. Remove input shaft endcap.
 1. Using seal removal tool, remove input shaft endcap (pump side of gearbox).
 - a) Drive removal tool into endcap.
 - b) Pry input shaft endcap out of gearbox.

NOTES

If a heavy enough tool is NOT available, using a hammer drive a long thin chisel into the endcap, then use a short length of steel rod as a fulcrum and pry (the hammer may again be used) the endcap out of the gearbox.

The endcap is NOT serviceable after removal.

2. Discard endcap.
- D. Remove input shaft and drive side bearing.

NOTES

Both keyways on the input shaft are in line with each other.

The drive gear is keyed to the input shaft, do NOT allow key to fall into gearbox while removing the shaft and bearing. Keep keyways up to prevent key loss.

1. Drive input shaft with drive side bearing out of gearbox.

NOTE

A slide hammer with an M12 (1.75) threaded adapter may be used instead of the hammer and dowel to remove the shaft and bearing if preferred.

- a) Using shop hammer and dowel align dowel with input shaft so dowel will slide thru pump side bearing.
 - b) From pump side hit dowel to drive input shaft (with drive side bearing still on shaft) thru gearbox until loose.
 - c) Pull input shaft and drive side bearing out of gearbox.
2. Remove drive gear key.

NOTE

ONLY remove the drive side bearing if the shaft is being repaired and reused, otherwise discard entire assembly.

3. If required, remove drive side bearing from input shaft.
 - a) Press (or tap with non-marring hammer) input shaft out of bearing.
 - b) Discard bearing.
- E. Remove pump side pump shaft bearing.
 1. Compress and remove retaining ring.
 - a) Using snap ring pliers, insert tips of pliers into holes in retaining ring and compress retaining ring.
 - b) Pull retaining ring out of gearbox.
 2. Discard retaining ring.
 3. Remove pump side bearing.
 - a) From drive side of gearbox, insert dowel into input shaft bore, pass dowel thru drive gear bore, and align dowel to contact pump side bearing.
 - b) Using hammer and dowel drive pump side bearing out of gearbox.
 - c) Discard bearing.
- F. Using Loctite Clean-Up Solvent (or equivalent) and wire brush, clean gearbox endcap (pump side) and oil seal (drive side) bores. (NOTE: Use care NOT to allow cleaner or debris to enter the gearbox.)



Input Shaft Installation

A. Prepare new input shaft for installation.

1. Install drive side bearing on input shaft.

NOTE

The preferred method of assembly is to heat the bearing and cool the input shaft to allow a slip fit. Using a bearing heater, heat bearing to 250 °F (121 °C) (Do NOT exceed 8 hrs.). Using dry ice in an alcohol bath, cool shaft to -65 °F (-54 °C) (Do NOT exceed 1 hr.). Use appropriate PPE to handle/assemble bearing and shaft.

- a) Lubricate input shaft and bearing center bore with gear oil.
- b) Configure press bolster plate with opening/bore hole or cribbing so shaft passes thru bearing. (NOTE: The plate must support the inner race to prevent bearing damage during assembly, bearing-to-shaft is an interference fit.)
- c) Place bearing on press bolster plate.
- d) Place drive end of input shaft (threaded hole for input flange toward bearing) squarely into bearing.
- e) Press input shaft into bearing until seated against shaft collar.

NOTES

If the preferred method or a press is NOT available, use a 3 inch long piece of 2-in DOM steel tube (Use ONLY 0.188 wall tube.) and a dead-blow hammer to assemble the bearing and shaft. Grease the shaft and bearing inner bore to aide in assembly. Clean parts thoroughly after assembly; do NOT allow grease to enter the gearbox.

Do NOT strike the shaft or the outer race of the bearing with a hammer to assemble the parts.

2. Install drive gear key.

NOTE

Inspect key and drive gear keyway for damage and/or burrs. Repair or replace as required before proceeding.

- a) Partially fill input shaft keyway with gear oil.
- b) Install key in input shaft keyway (gear oil holds key in place).

B. Install input shaft.

1. Using gear oil, lubricate bore of pump side bearing, entire pump side of input shaft, outside of drive side bearing, and drive side bearing bore in gearbox.

NOTES

Both keyways on the input shaft are in line with each other.

Do NOT allow the key to fall into the gearbox while installing the shaft. Keep keyways up to prevent key from falling.

2. Place input shaft and key (pump side of shaft) into gearbox, align key with drive gear, and drive gear keyway.
3. Push input shaft through drive gear until it stops.

NOTES

The input shaft should slide easily through the drive gear; however, a light tap from a non-marring hammer may be required.

If the input shaft does not slip through the drive gear with a light tap, STOP, remove input shaft, and check for burrs on and alignment of the key and shaft.

4. If required, using a non-marring hammer, tap input shaft and bearing into gearbox until drive side bearing seats in gearbox.
5. Compress and install a new drive side bearing retaining ring.
 - a) Using snap ring pliers, insert tips of pliers into holes in a new retaining ring and fully compress ring. (NOTE: Refer to paragraph 5.7.5 for proper ring orientation.)
 - b) Push retaining ring into gearbox until aligned with snap ring groove.
 - c) Release and remove snap ring pliers.
 - d) Verify retaining ring is seated in groove.
- C. Install pump side input shaft bearing.
 1. Turn gearbox (pump side up), place input shaft on bolster plate, and using cribbing level and support gearbox housing.
 2. Using gear oil, lubricate bore of pump side bearing, entire pump side of input shaft, outside of pump side bearing, and pump side bearing bore in gearbox.
 3. Place new pump side input shaft bearing on input shaft and into gearbox bore ONLY far enough to verify alignment of shaft in bearing and bearing in gearbox.
 4. Using press (without pusher tube), simultaneously press, pump side bearing onto input shaft and into gearbox until nearly flush with gearbox housing.
 5. Add pusher tube and continue pressing bearing until seated in gearbox.
- D. Install a new pump side bearing retaining ring.
(NOTE: Refer to paragraph 5.7.5 for proper ring orientation.)
 1. Compress a new pump side bearing retaining ring.
 - a) Using snap ring pliers, insert tips of pliers into holes in a new retaining ring.
 - b) Fully compress ring.
 2. Install retaining ring.
 - a) Push retaining ring into gearbox until aligned with snap ring groove.
 - b) Release and remove snap ring pliers.
 - c) Verify retaining ring is seated in groove.
- E. Install new endcap.
 1. Coat outer surface (mates with gearbox) of new endcap with Loctite 680™ (or equivalent).
 2. Place endcap onto gearbox with smooth part of cap facing outward.

3. Using 95 mm seal driver, press endcap into gearbox until flush.
- F. Install new input shaft oil seal.
1. Turn gearbox over.
 2. Coat outer surface (mates with gearbox) of input shaft oil seal with Loctite 680™ (or equivalent).
 3. Place input shaft oil seal onto input shaft with smooth part of seal body facing end of shaft (outward).
 4. Push input shaft oil seal down input shaft until seal mates with gearbox.
 5. Using seal driver, drive input shaft oil seal into gearbox until flush.

Return to the calling bench procedure or paragraph 5.9.2, Gearbox Bench Procedures (on page 120), for gearbox to pump (unit) assembly and unit installation in apparatus instructions references.

5.9.2.1.1 Input Shaft Oil Seal (ONLY)

If the oil seal is the ONLY input shaft component requiring replacement perform this procedure to replace ONLY the input shaft oil seal.

The oil seal for the input shaft is located on the drive side of the gearbox. The oil seal utilizes a metal body that surrounds the seal. The oil seal must be replaced whenever the input shaft is removed since the oil seal is Loctited in place (this prevents seal movement which would cause an oil leak) and there is no way to remove the oil seal without damaging it. Therefore, the oil seal is typically replaced as part of any input shaft or drive gear R&R procedure.

Replacing the input shaft oil seal without the removing the pump and gearbox is the preferred method for this procedure however, this procedure typically requires gearbox removal prior to performance due to limited access. If the pump and gearbox must be removed for access purposes, see paragraph 5.8.2.1 for reference to the required Removal From The Apparatus procedure. Refer to Table 42 for a list of tools and/or consumables required for this procedure.

Table 42. Input Shaft Oil Seal Bench Procedure Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
PPE (for Handling Oil)		Loctite 680
Oil Safe Catch Container (1.5 L or larger)		Oil Seal (Input Shaft, Drive Side Of Gearbox) <See FSG-PL-01481, Sheet 2, Item 2>
9/16-in Wrench (or 8 pt. socket)		3-in PVC Pipe (Schedule 40 ONLY) 3 Inches Long (Pusher Tube)
Seal Removal Tool		
Seal Driver Kit		
Ratchet		
Non-marring Hammer		
* 10 mm Hex Socket		

* **Optional.**

Perform the following to remove and replace ONLY the input shaft oil seal.

- A. Remove input shaft oil seal.
 1. Drain any remaining gear oil from gearbox.
 - a) Position oil safe catch container under drain plug.
 - b) Remove magnetic (and/or adjacent) drain plug.
 - i. Using 9/16-in wrench (or 8 pt. socket and ratchet – set for CCW), loosen magnetic drain plug. NOTE: If required using 10 mm hex socket and ratchet – set for CCW, loosen adjacent drain plug.
 - ii. Remove drain plug(s).
 - c) Inspect magnetic drain plug for metal fragments or other abnormalities that may provide clues as to condition of internal gearbox components. (See Section 5.1, Troubleshooting.)
 - d) Install magnetic (and/or adjacent) drain plug(s).
 - i. Hand start drain plug.
 - ii. Using 9/16-in wrench (or 8 pt. socket and ratchet – set for CW), tighten magnetic drain plug. NOTE: If required using 10 mm hex socket and ratchet – set for CW, tighten adjacent drain plug.
 2. Using seal removal tool, remove input shaft oil seal.
 - a) Drive removal tool into seal body.
 - b) Pry input shaft oil seal out of gearbox.
- B. Install new input shaft oil seal.
 1. Apply Loctite 680 (or equivalent) to mating surface of seal.
 2. Using gear oil, lubricate mating surfaces of oil seal and input shaft.
 3. Place oil seal onto input shaft with smooth part of seal body facing end of shaft (outward).
 4. Push oil seal down input shaft until seal mates with gearbox.
 5. Using seal driver and non-marring hammer, drive input shaft oil seal flush with gearbox.
 6. Using pusher tube, seal driver, and non-marring hammer, drive input shaft oil seal into gearbox until seated.

This procedure may have required the removal of the pump and gearbox (as a single assembly) for access; if so install the pump and gearbox after performance. Use paragraph 5.8.8 (on page 117) to install the pump and gearbox assembly on the apparatus after this bench procedure is completed.

5.9.2.1.2 Input Shaft Bearings (ONLY)

IMPORTANT ▲ NOTICE

ALWAYS INSTALL NEW BEARINGS WHEN INSTALLING THE PUMP GEAR OR PUMP SHAFT (ESPECIALLY IF METAL WAS FOUND IN THE GEAR OIL). FAILURE TO INSTALL NEW BEARINGS MAY RESULT IN PREMATURE PUMP FAILURE OR ADDITIONAL EQUIPMENT DAMAGE.

The input shaft utilizes two (2) double row angular contact roller ball bearings; one located on the drive side and the other located on the pump side of the input shaft. Both of these bearings are one-piece bearings installed in the gearbox housing. Using good practices; whenever a shaft bearing requires replacing ALL bearings on that shaft should be replaced at the same time.

Since both bearings are an interference fit to the input shaft, it is impossible to R&R ONLY the bearings. Therefore, perform the input shaft bench procedure (see paragraph 5.9.2.1 on page 121) and reuse the existing input shaft.

5.9.2.1.3 Input Shaft Endcap (ONLY)

The endcap functions similar to a wheel bearing dust/grease cap. It keeps the lubricant in and the dirt/dust/debris out. The endcaps are more efficient than cover plates and are installed using Loctite to prevent leaks or loosening from vibration.

This procedure may NOT require unit removal from the apparatus or gearbox removal prior to performance (depending on the tools available). If removal is required, see paragraph 5.8.2.1 (on page 56) for reference to the required **Removal From The Apparatus** procedures. If gearbox removal is required prior to bench procedure performance, see paragraph 5.9.1 (on page 118) for reference to the required **Removal** portion of the **Gearbox R&R** procedures.

Refer to Table 43 for a list of tools and/or consumables required for this procedure.

Table 43. Input Shaft Endcap Bench Procedure Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
PPE (for Handling Oil)		Loctite Clean-Up Solvent™ (or equivalent)
Seal Removal Tool		Loctite 680™ (Or Equivalent)
Oil Safe Catch Container (1.5 L or larger)		Endcap (90 mm) <See FSG-PL-01481, Sheet 2, Item 26>
9/16-in Wrench (or 8 pt. socket)		* Steel Rod (Short Length of Approximately 1/2-in)
Seal Drivers (90 - 95 mm)		
Ratchet		
* 10 mm Hex Socket		
* Chisel (Long Thin)		
* Shop Hammer		

* **Optional.**

Perform the following to remove and replace ONLY the input shaft endcap.

Input Shaft Endcap Removal

- A. Remove input shaft endcap.
 1. Drain any remaining gear oil from gearbox.
 - a) Position oil safe catch container under drain plug.
 - b) Remove magnetic (and/or adjacent) drain plug.
 - i. Using 9/16-in wrench (or 8 pt. socket and ratchet – set for CCW), loosen magnetic drain plug. NOTE: If required using 10 mm hex socket and ratchet – set for CCW, loosen adjacent drain plug.

- ii. Remove drain plug(s).
- c) Inspect magnetic drain plug for metal fragments or other abnormalities that may provide clues as to condition of internal gearbox components. (See Section 5.1, Troubleshooting.)
- d) Install magnetic (and/or adjacent) drain plug(s).
 - i. Hand start drain plug.
 - ii. Using 9/16-in wrench (or 8 pt. socket and ratchet – set for CW), tighten magnetic drain plug. NOTE: If required using 10 mm hex socket and ratchet – set for CW, tighten adjacent drain plug.
- 2. Using seal removal tool, remove input shaft endcap (located on pump side of gearbox).
 - a) Drive removal tool into input shaft endcap.
 - b) Pry input shaft endcap out of gearbox.

NOTES

The endcap is NOT serviceable after removal.

If a heavy enough tool is NOT available, using a hammer drive a long thin chisel into the endcap, then use a short length of steel rod as a fulcrum and pry (the hammer may again be used) the endcap out of the gearbox.

- B. Discard endcap.

Input Shaft Endcap Installation

- A. Install new input shaft endcap.
 - 1. Apply Loctite 680 (or equivalent) to mating surface of new endcap.
 - 2. Place endcap over gearbox opening with smooth part of cap facing outward.
 - 3. Using seal driver, drive endcap into gearbox until flush.
- B. Perform Gearbox Oil Level Check. (Refer to paragraph 4.3.2.)

This procedure may require gearbox installation after performance. If so, use paragraph 5.9.1 (on page 118) for instructions to reassemble the gearbox and pump assemblies (unit) and paragraph 5.8.8 (on page 117) to install the unit on the apparatus after this bench procedure is completed.

5.9.2.1.4 Drive Gear (Input Shaft)

The input shaft turns the drive gear, which mates with and drives the pump gear, which turns the pump shaft. The pump shaft turns faster than the input shaft, how much faster depends on the GR selected. The Flex series gearbox design requires gearbox cover removal for gear set access and pump gear removal for drive gear removal. If the drive gear requires R&R the pump gear requires close inspection to check for possible damage requiring pump gear R&R. Inspect for damaged and/or worn teeth, indications of overheating, stress cracking, etc.

This procedure requires unit removal from the apparatus followed by pump removal from the gearbox prior to performance to provide input shaft access. See paragraph 5.9.2 (on page 120) for reference to the required Removal From The Apparatus and Gearbox R&R procedures.



Additionally, perform this procedure after the **Removal** portion of the procedures listed and in the listed order.

NOTES

For this procedure, reuse the existing input and pump shafts (if serviceable), the pump gear (if serviceable), and the gearbox cover (if serviceable).

Do NOT reuse bearings, gaskets, gear oil, mechanical (pump) seal, O-rings, oil seals, and retaining rings.

Refer to Table 41, Table 44, and Table 47 for a list of tools and/or consumables required for this procedure.

Table 44. Drive Gear Bench Procedure Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
PPE (for Handling Oil)		Drive Gear (ONLY ONE REQUIRED – SELECT FROM:) <See FSG-PL-01481, Sheet 2, Item 8 Table>

Perform the following to inspect the drive gear for wear or damage and to remove and replace the gear if required.

Drive Gear Removal

- A. Remove gearbox cooling tube IAW paragraph 5.8.7.1.1 (on page 108).
- B. Remove pump shaft IAW paragraph 5.9.2.2 (on page 131).
- C. Remove pump gear IAW paragraph 5.9.2.2.3 (on page 141).
- D. Remove input shaft IAW paragraph 5.9.2.1 (on page 121).
- E. Remove drive gear. (Lift gear out of gearbox.)

Inspections

- A. Thoroughly clean gearbox and all major components, removing all metal and/or plastic debris.
- B. Visually inspect gears (input and pump) for damage.
 1. Inspect for overheating (discoloring [typically blue], irregular coloring, micro pitting, temper failure, etc.).
 2. Inspect teeth for damage (rounded, worn, irregular shaped, cracked, chipped, broken, etc.).
 3. Inspect keyway for burrs, chipping, rounding, wear, etc.
- C. Visually inspect all keys for damage.
- D. Visually inspect shafts (input and pump) for damage.
 1. Inspect for overheating (discoloring [typically blue]).
 2. Inspect keyway for burrs, chipping, rounding, wear, etc.

Drive Gear Installation

- A. Install drive gear.
 1. Place gearbox flat on stable work surface with input side up.
 2. Place drive gear inside gearbox.
- B. Install input shaft IAW paragraph 5.9.2.1 (on page 121).
- C. Install pump gear IAW paragraph 5.9.2.2.3 (on page 141).
- D. Install pump shaft IAW paragraph 5.9.2.2 (on page 131).
- E. Install gearbox cooling tube IAW paragraph 5.8.7.1.1 (on page 108).

Return to paragraph 5.9.2, Gearbox Bench Procedures (on page 120), for gearbox to pump (unit) assembly and unit installation in apparatus instructions references.

5.9.2.2 Pump Shaft

Typically, a pump shaft would not require replacement during the life of a pump. However, inducer/impeller retaining thread damage, keyway damage, or bearing failure (typically, only a spun bearing would damage a shaft) may result in the need to replace a pump shaft.

When the pump shaft requires replacement, performing this procedure requires removal of the entire pump assembly from the apparatus and then pump removal from the gearbox prior to performance. See paragraph 5.8.2.1 (on page 56) for pump removal from an apparatus and paragraph 5.9.1 (on page 118) for reference to the required Gearbox R&R procedure.

Performing the removal portion of this procedure places a lot of stress on the pump shaft bearings, requiring their replacement. Additionally, pump shaft installation always requires all associated gaskets, O-rings, seals, snap rings, and endcap replacement. Also, note that pump shaft associated gearbox components vary depending on GR and pump model.

Refer to Table 45 for a list of tools and/or consumables required for this procedure.

Table 45. Pump Shaft Bench Procedure Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	Torque Wrench (17 Nm or 12 ft-lb)	Endcap (80 mm) <See FSG-PL-01482, Sheet 5, Item 13>(CBP) <See FSG-PL-01483, Sheet 5, Item 13>(AP) <See FSG-PL-01486, Sheet 5, Item 14>(MBP) <See FSG-PL-01487, Sheet 5, Item 14>(RSD)
PPE (for Handling Oil)		Snap Ring (Drive Side) (Pump Shaft Retainer – All Except 3.74:1 GR) <See FSG-PL-01482, Sheet 5, Item 12>(CBP) <See FSG-PL-01483, Sheet 5, Item 12>(AP) <See FSG-PL-01486, Sheet 5, Item 13>(MBP) <See FSG-PL-01487, Sheet 5, Item 13>(RSD) (Pump Shaft Retainer – ONLY 3.74:1 GR) <See FSG-PL-01482, Sheet 5, Item 17>(CBP) <See FSG-PL-01483, Sheet 5, Item 17>(AP) <See FSG-PL-01486, Sheet 5, Item 19>(MBP)

Table 45. Pump Shaft Bench Procedure Tools And Consumables List – CONTINUED

Bearing And Seal Driver Set (81 mm)		Snap Ring (Pump Side Pump Shaft Retainer) <See FSG-PL-01482, Sheet 5, Item 5>(CBP) <See FSG-PL-01483, Sheet 5, Item 5>(AP) <See FSG-PL-01486, Sheet 5, Item 6>(MBP) <See FSG-PL-01487, Sheet 5, Item 6>(RSD)
Hydraulic Press (a large arbor press may work)		** Snap Ring (Drive Side Bearing Retainer – All Except 3.74:1 GR) <See FSG-PL-01482, Sheet 5, Item 10>(CBP) <See FSG-PL-01483, Sheet 5, Item 10>(AP) <See FSG-PL-01486, Sheet 5, Item 11>(MBP) <See FSG-PL-01487, Sheet 5, Item 11>(RSD)
Seal Removal Tool (Heavy Duty)		Pump Shaft (ONLY ONE REQUIRED – SELECT FROM:) <See FSG-PL-01482, Sheet 5, Item 1>(CBP) <See FSG-PL-01483, Sheet 5, Item 1>(AP) <See FSG-PL-01487, Sheet 5, Item 1>(RSD) (Pump Shaft – All Except 3.74:1 GR) <See FSG-PL-01486, Sheet 5, Item 1>(MBP) (Pump Shaft – ONLY 3.74:1 GR) <See FSG-PL-01486, Sheet 5, Item 15>(MBP)
Non-marring Hammer		Shop Rag(s) (As Required)
13 mm Socket		Gearbox Lubricant (See paragraph 5.7.2 on page 49.)
Ratchet		Pusher Ø 1.5-in (38 mm) (Wood Dowel or Metal Rod – Approximately 2-in [50 mm] long)
Snap Ring Pliers		

**** This retainer is NOT used when the gearbox is configured for a 3.74:1 GR.**

Perform the following to remove and replace a pump shaft.

ATTENTION ⚠ WARNING

A PRESS PRESENTS A POTENTIAL CRUSH HAZARD (FROM MOVING PARTS) AND/OR STRIKE HAZARD (FROM EJECTED PARTS). WEAR APPROPRIATE PPE.

Pump Shaft Removal

- A. Perform **Removal** portion of paragraph 5.9.2.2.2, Pump Shaft Endcap (ONLY).
- B. Remove pump shaft snap ring. See Figure 48.
(The snap ring is located on the pump shaft at the drive side bearing.)
 1. Expand and remove retainer.
 - a) Using snap ring pliers, insert tips of pliers into holes in snap ring and expand snap ring.
 - b) Pull snap ring off pump shaft.
 - c) Release and remove snap ring pliers.
 2. Discard snap ring.

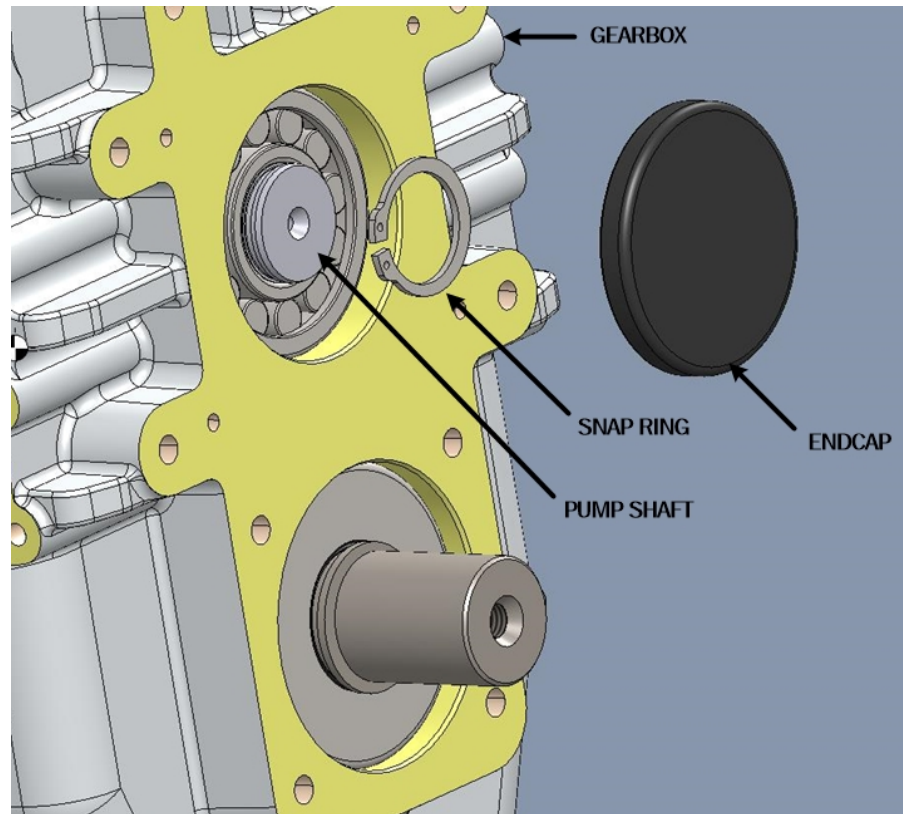


Figure 48. Pump Shaft Assembly

C. Remove pump shaft assembly.

1. Using a hydraulic press (a large arbor press may work), press pump shaft assembly out of drive side bearing and gearbox as follows.

NOTES

If the pump head studs are in place the bolster plate bore diameter should be at least 6.25-in (~16 cm). If the studs and the breather/oil fill (including the elbow) are removed, the plate bore can be 3.75 in (9.5 cm) or larger. The bore will allow the pump shaft seal and bearing to pass thru the plate while supporting the gearbox.

If using cribbing to support/suspend the gearbox above the bolster plate the gearbox is required to be held securely, safely, and stable enough to press the shaft out of the drive side bearing (an interference fit) and gearbox (multiple slip fits). Using cribbing for the shaft removal requires approximately six (6) to nine (9) inches of clearance between the gearbox and the bolster plate. (Pump shaft travel varies depending on pump model.)

- a) Configure hydraulic press bolster plate with opening/bore hole or cribbing per NOTES above.
- b) Place gearbox (pump shaft side down) on bolster plate (or cribbing) so gearbox is stable and secure and pump shaft assembly will pass thru plate opening or cribbing.

NOTE

The drive side pump shaft bearing is held in place by a snap ring, Do NOT place excessive pressure on the gearbox by allowing the press to exert force on the bearing. The pump shaft must pass thru the bearing with the force applied to the shaft and NOT the bearing.

- c) Begin pressing pump shaft with press piston in direct contact with shaft.
 - d) Just before press piston contacts drive side bearing, add a pusher (wood dowel or metal rod) between piston and pump shaft and align pusher with pump shaft so pusher slides thru drive side bearing with minimal resistance.
2. Catch pump shaft assembly or pull it out of gearbox.

NOTE

Note/record spacer notch orientation before removing spacer.

- D. Remove drive side spacer from pump shaft. (Should pull off by hand.)

NOTES

The pump gear (ONLY 3.74, 2.91, 2.60, and 2.33:1 gear ratios) will pass thru the gearbox bore when the pump shaft assembly is pressed out and requires removal from the pump shaft. All other ratio pump gears will NOT pass thru the bore and must be removed from the gearbox after the cover is removed.

ONLY remove gearbox cover if pump gear remains inside the gearbox and requires inspection and/or replacement.

- E. If required, remove gearbox cover.
1. Using 13 mm socket and impact driver (or ratchet), loosen 14 M8-1.25 X 20 mm long screws.
 2. Remove 14 M8-1.25 X 20 mm long screws with washers.
 3. Remove cover.
 4. Remove all remaining gasket material from mating surfaces of cover and gearbox.
- F. Remove pump gear from pump shaft or inside of gearbox.
(See NOTES above.)
- G. Remove key from keyway (pump gear/pump shaft).

NOTE

Note/record spacer notch orientation before removing spacer.

- H. If applicable (spacer NOT used with 3.74:1 GR), remove pump side spacer from pump shaft. (Should pull off by hand.)
- I. Remove pump side pump shaft snap ring from pump shaft.
1. Expand and remove retainer.
 - a) Using snap ring pliers, insert tips of pliers into holes in snap ring and expand snap ring.
 - b) Pull snap ring off pump shaft.
 - c) Release and remove snap ring pliers.
 2. Discard snap ring.

Pump Shaft Installation

Flex series single stage booster pump pump shafts vary by model and GR yet appear similar without detailed examination. It is therefore important to verify the replacement pump shaft prior to installation. With the exception of the RSD (which is NOT available with the 3.74:1 GR) Flex series booster pumps require a different pump shaft when configured with the 3.74:1 GR. See Figure 49 for an AP or a CBP and Figure 50 for a MBP or RSD pump shaft differences detailed. Note drive side shaft diameters and the difference in spacers.

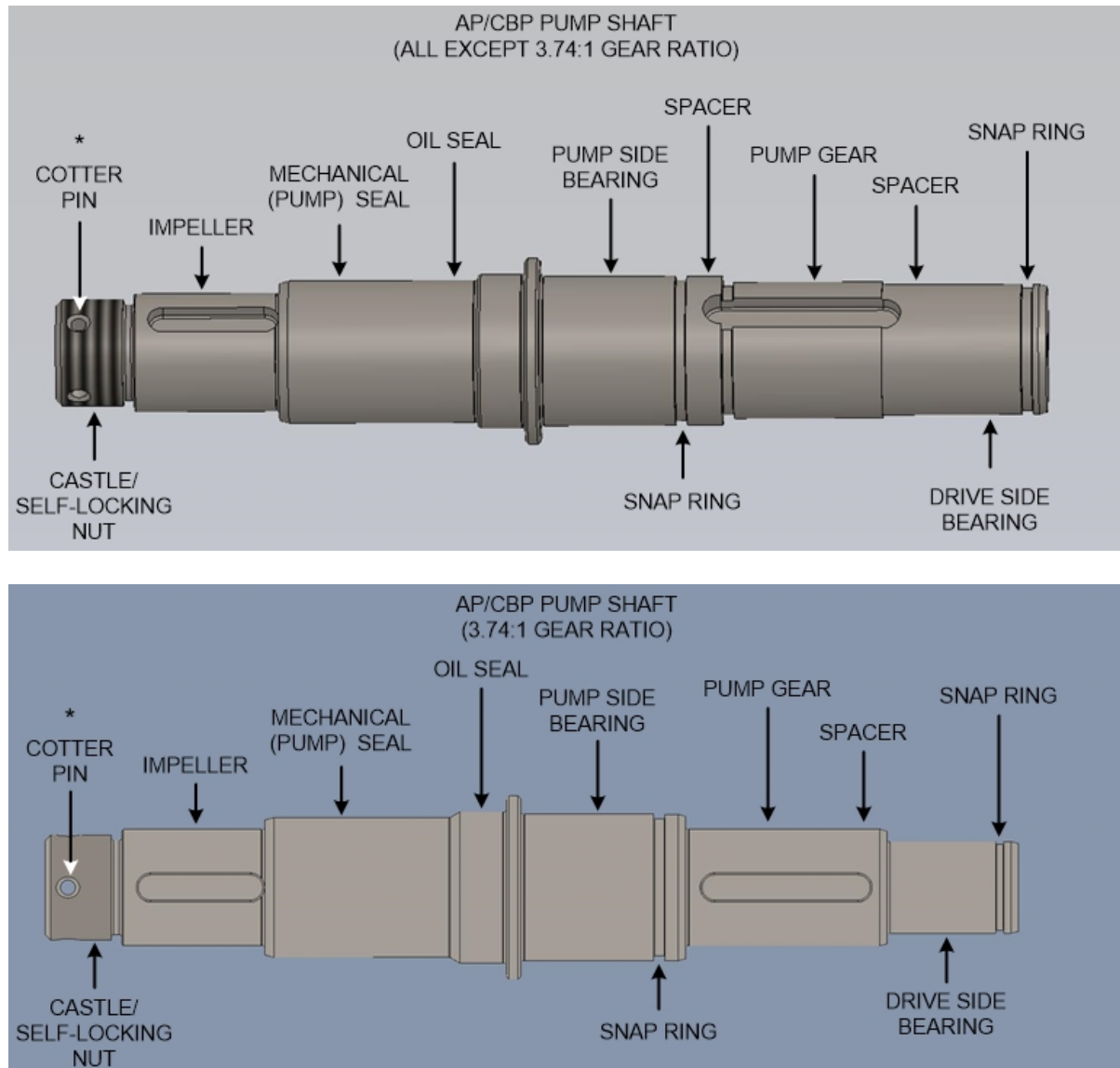


Figure 49. AP/CBP Pump Shaft

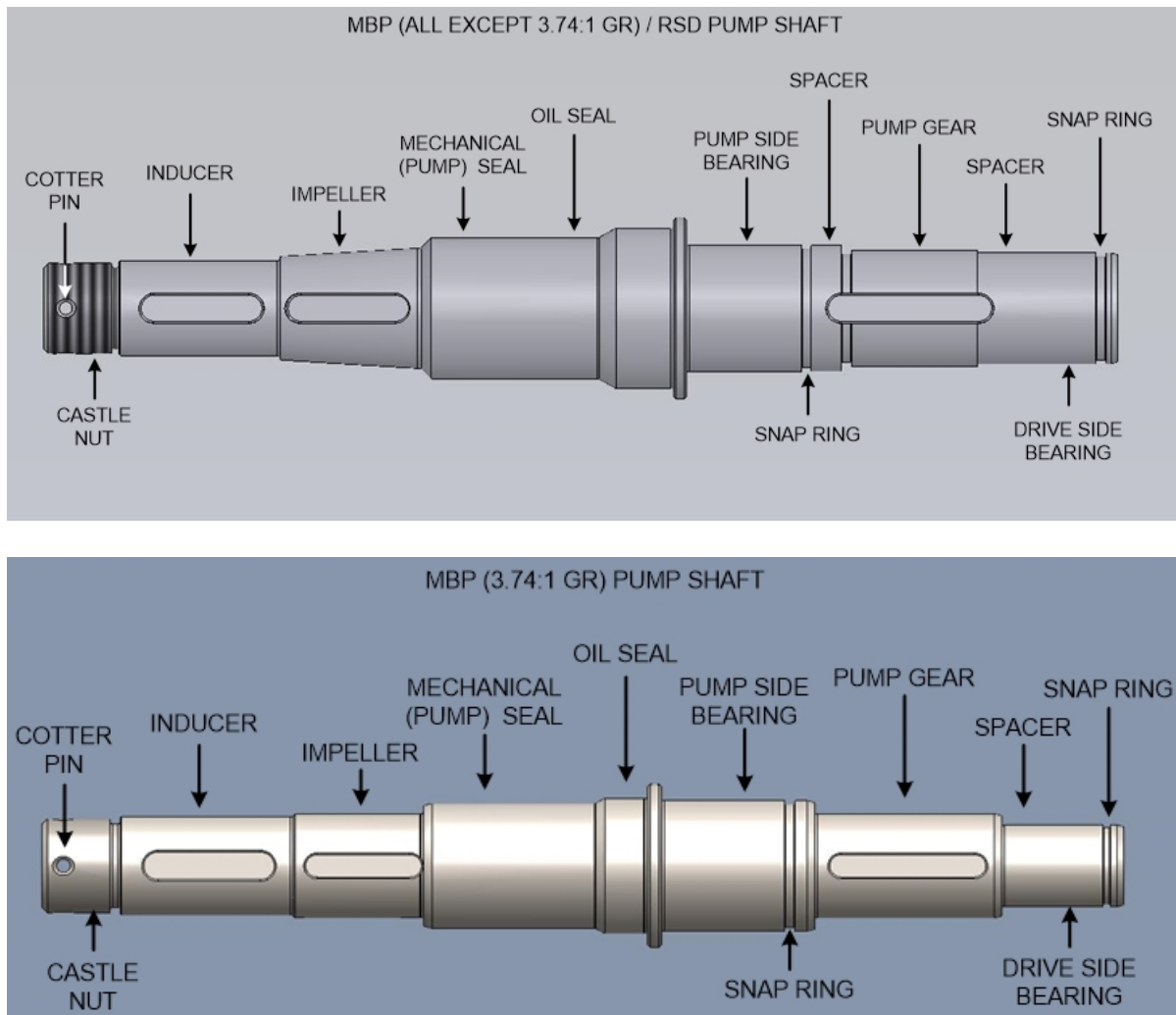


Figure 50. MBP/RSD Pump Shaft

- A. Prepare new pump shaft for installation.
1. Install pump side bearing on pump shaft.

NOTE

The preferred method of assembly is to heat the bearing and cool the pump shaft to allow a slip fit. Using a bearing heater, heat bearing to 250 °F (121 °C) (Do NOT exceed 8 hrs.). Using dry ice in an alcohol bath, cool shaft to -65 °F (-54 °C) (Do NOT exceed 1 hr.). Use appropriate PPE to handle/assemble bearing and shaft.

- a) Lubricate pump shaft and bearing center bore with gear oil.
- b) Configure press bolster plate with opening/bore hole or cribbing so shaft passes thru bearing. (NOTE: The plate must support the inner race to prevent bearing damage during assembly, bearing-to-shaft is an interference fit.)
- c) Place bearing on press bolster plate.

- d) Place drive end of pump shaft squarely into bearing. (Threaded end for impeller/inducer nut facing away from bearing.)
- e) Press pump shaft into bearing until seated against shaft collar.

NOTES

If the preferred method or a press is NOT available, use a 6 inch long piece of 2-in DOM steel tube (Use ONLY 0.188 wall tube.) and a dead-blow hammer to assemble the bearing and shaft. Grease the shaft and bearing inner bore to aide in assembly. Clean parts thoroughly after assembly; do NOT allow grease to enter the gearbox.

Do NOT strike the shaft or the outer race of the bearing with a hammer to assemble the parts.

- 2. Install a new pump side bearing snap ring.
(NOTE: Refer to paragraph 5.7.5 for proper ring orientation.)
 - a) Using snap ring pliers, insert tips of pliers into holes in a new snap ring.
 - b) Fully expand snap ring.
 - c) Push snap ring into gearbox until aligned with snap ring groove.
 - d) Release and remove snap ring pliers.
 - e) Verify snap ring is seated in groove.

NOTES

The 3.74:1 GR configuration does NOT use a pump side spacer.

The notch in the spacer faces the pump gear.

- 3. For all except 3.74:1 GR pumps, install pump side pump gear spacer.
- 4. Install pump gear key.
 - a) Partially fill pump shaft keyway with gear oil.
 - b) Install key in pump shaft keyway (gear oil holds key in place).
- 5. For ONLY 3.74, 2.91, 2.60, and 2.33:1 gear ratio pumps, install pump gear. Push gear on to pump shaft until seated against spacer.

NOTE

The pump gear (ONLY 3.74, 2.91, 2.60, and 2.33:1 gear ratios) will pass thru the gearbox bore when the pump shaft assembly is installed. All other ratio pump gears will NOT pass thru the bore of the gearbox housing and must be installed from the top of the gearbox with the cover removed.

- 6. For ONLY 3.74, 2.91, 2.60, and 2.33:1 gear ratio pumps, install drive side pump gear spacer.
- B. Install pump shaft assembly.
- 1. Install drive side bearing retaining ring.
 - a) Using snap ring pliers, insert tips of pliers into holes in a new retaining ring.
(NOTE: Refer to paragraph 5.7.5 for proper ring orientation.)
 - b) Fully compress ring.
 - c) Push retaining ring into gearbox until aligned with snap ring groove.

- d) Release and remove snap ring pliers.
- e) Verify retaining ring is seated in groove.

NOTES

The notch in the spacer faces the pump gear.

The 3.74:1 GR configuration spacer does NOT have a notch.

- 2. For ONLY 1.90, 1.64, 1.31 and 1.14:1 gear ratio pumps, install pump gear.
 - a) Place pump gear inside gearbox.
 - b) Align pump gear and drive gear teeth.
- 3. Place gearbox on its side. (This position allows access to both sides of the gearbox.)
- 4. Install pump shaft assembly as follows.
 - a) Pass drive side of pump shaft thru pump side bearing bore and into gearbox.
 - b) For ONLY 1.90, 1.64, 1.31 and 1.14:1 gear ratio pumps, install pump gear on pump shaft.
 - i. Align pump shaft and pump gear key with pump gear bore and keyway. Then push pump shaft thru pump gear.
 - ii. Verify alignment of pump gear and drive gear teeth.
- 5. Seat pump side bearing in gearbox pump side bearing bore.
 - a) Using gear oil, lubricate pump side bearing outer race and gearbox housing bore.
 - b) Align bearing outer race squarely in gearbox housing bore.
 - c) Push pump side bearing (already installed on pump shaft) into gearbox housing bore until seated in housing.

NOTES

If required, use a non-marring hammer to tap bearing into place.

Do NOT strike pump shaft threads.)

- C. For ONLY 1.90, 1.64, 1.31 and 1.14:1 gear ratio pumps, install drive side pump gear spacer.
- D. Install drive side pump shaft bearing on pump shaft and into gearbox housing.
 - 1. Turn gearbox (pump side down), place pump shaft on bolster plate, and using cribbing level and support gearbox housing.
 - 2. Using gear oil, lubricate both drive side pump shaft bearing races and gearbox housing bore.
 - 3. Place new drive side pump shaft bearing on input shaft and into gearbox bore ONLY far enough to verify alignment of shaft in bearing and bearing in gearbox. Align bearing squarely in gearbox housing bore.
 - 4. Using hydraulic press (without pusher tube), press drive side bearing onto pump shaft and into gearbox until nearly flush with gearbox housing.

5. Add pusher tube and continue pressing bearing until seated against gearbox housing snap ring.
- E. Install pump shaft snap ring. See Figure 48.
 1. Compress a new pump side bearing snap ring.
 - a) Using snap ring pliers, expand pump shaft snap ring. Do NOT release pliers until instructed. (NOTE: Refer to paragraph 5.7.5 for proper ring orientation.)
 - b) Push pump shaft snap ring over end of pump shaft and locate directly over groove in shaft.
 2. Release snap ring pliers and verify ring seats in groove.
- F. Perform Installation portion of Pump Shaft Endcap (ONLY) procedure. See paragraph 5.9.2.2.2 (on page 139).

Return to the calling bench procedure or paragraph 5.9.2, Gearbox Bench Procedures (on page 120), for gearbox to pump (unit) assembly and unit installation in apparatus instructions references.

5.9.2.2.1 Pump Shaft Bearings (ONLY)

IMPORTANT ⚠ NOTICE

ALWAYS INSTALL NEW BEARINGS WHEN INSTALLING THE PUMP GEAR OR PUMP SHAFT (ESPECIALLY IF METAL WAS FOUND IN THE GEAR OIL). FAILURE TO INSTALL NEW BEARINGS MAY RESULT IN PREMATURE PUMP FAILURE OR ADDITIONAL EQUIPMENT DAMAGE.

The pump shaft utilizes two (2) double row angular contact roller ball bearings; one located on the drive side and the other located on the pump side of the pump shaft. Both of these bearings are one-piece bearings pressed onto the pump shaft and installed in the gearbox housing. Using good practices; whenever a shaft bearing requires replacing ALL bearings on that shaft should be replaced at the same time.

Since both bearings are an interference fit to the pump shaft, it is impossible to R&R ONLY the bearings. Therefore, perform the pump shaft bench procedure (see paragraph 5.9.2.2 on page 131) and reuse the existing pump shaft.

5.9.2.2.2 Pump Shaft Endcap (ONLY)

Removing the pump shaft endcap may NOT require pump and gearbox removal depending on gearbox access when installed in the apparatus. If the endcap is accessible without pump and gearbox removal, perform the steps listed below. Otherwise, prior to performing the steps listed below, remove the pump and gearbox, as a single assembly, for access purposes see paragraph 5.8.2.1 (on page 56) for reference to the required Removal From The Apparatus procedure. Refer to Table 46 for a list of tools and/or consumables required for this procedure.

Table 46. Pump Shaft Endcap R&R Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (Eye and Hand Protection)	None	Shop Rag(s) (As Required)
PPE (for Handling Oil)		Loctite Clean-Up Solvent™ (or equivalent)
Ratchet		Loctite 680™ (Or Equivalent)

Table 46. Pump Shaft Endcap R&R Tools And Consumables List – CONTINUED

Standard Tools	Special Tools	Consumables
Oil Safe Catch Container (1.5 L or larger)		Endcap (80 mm) <See FSG-PL-01482, Sheet 5, Item 13>(CBP) <See FSG-PL-01483, Sheet 5, Item 13>(AP) <See FSG-PL-01486, Sheet 5, Item 14>(MBP) <See FSG-PL-01487, Sheet 5, Item 14>(RSD)
9/16-in Wrench (or 8 pt. socket)		* Steel Rod (Short Length of Approximately 1/2-in)
Seal Removal Tool (Heavy Duty)		
Seal Drivers (81 mm)		
* 10 mm Hex Socket		
* Chisel (Long Thin)		
* Shop Hammer		

*** Optional.**

Perform the following to remove and replace ONLY the pump shaft endcap.

Pump Shaft Endcap Removal

A. Remove pump shaft endcap.

1. Drain any remaining gear oil from gearbox.
 - a) Position oil safe catch container under drain plug.
 - b) Remove magnetic (and/or adjacent) drain plug.
 - i. Using 9/16-in wrench (or 8 pt. socket and ratchet – set for CCW), loosen magnetic drain plug. NOTE: If required using 10 mm hex socket and ratchet – set for CCW, loosen adjacent drain plug.
 - ii. Remove drain plug(s).
 - c) Inspect magnetic drain plug for metal fragments or other abnormalities that may provide clues as to condition of internal gearbox components. (See Section 5.1, Troubleshooting.)
 - d) Install magnetic (and/or adjacent) drain plug(s).
 - i. Hand start drain plug.
 - ii. Using 9/16-in wrench (or 8 pt. socket and ratchet – set for CW), tighten magnetic drain plug. NOTE: If required using 10 mm hex socket and ratchet – set for CW, tighten adjacent drain plug.
2. Using seal removal tool, remove pump shaft endcap (located on drive side of gearbox).
 - a) Drive removal tool into pump shaft endcap.
 - b) Pry pump shaft endcap out of gearbox.

NOTES

The endcap is NOT serviceable after removal.

If a heavy enough tool is NOT available, using a hammer drive a long thin chisel into the endcap, then use a short length of steel rod as a fulcrum and pry (the hammer may again be used) the endcap out of the gearbox.

- B. Discard endcap.

Pump Shaft Endcap Installation

- A. Install in pump shaft endcap.
 - 1. Apply Loctite 680 (or equivalent) to mating surfaces of new pump shaft endcap.
 - 2. Place new pump shaft endcap over gearbox opening with smooth part of cap facing outward.
 - 3. Using non-marring hammer and seal driver, drive pump shaft endcap flush with gearbox.
- B. Perform Gearbox Oil Level Check. (Refer to paragraph 4.3.2.)

This procedure may have required the removal of the pump from the gearbox; if so use the installation portion of paragraph 5.9.1 (on page 118) for instructions to reassemble the gearbox and pump assemblies (unit) and paragraph 5.8.8 (on page 117) to install the unit can on the apparatus after this bench procedure is completed.

5.9.2.2.3 Pump Gear (ONLY)

The pump gear is located on the pump shaft inside the gearbox. The input shaft via the drive gear mating with the pump gear turns the pump shaft. The pump shaft turns faster than the input shaft, how much faster depends on the gear ratio selected when the pump was designed/manufactured. The Flex series gearbox design requires gearbox cover removal for GR 1.14, 1.31, 1.64, and 1.90:1 since the pump gear diameter exceeds the pump shaft bearing bore preventing pump gear removal via the bore.

This procedure requires unit removal from the apparatus followed by pump removal from the gearbox prior to performance to provide pump gear and/or pump shaft access. See paragraph 5.9.2 (on page 120) for reference to the required Removal From The Apparatus and Gearbox R&R procedures.

Performing the removal portion of this procedure places a lot of stress on the pump shaft bearings, requiring their replacement. Additionally, pump shaft installation always requires all associated gaskets, O-rings, seals, snap rings, and endcap replacement. If the pump gear requires R&R the drive gear requires close inspection to check for possible damage requiring drive gear R&R. Inspect for damaged and/or worn teeth, indications of overheating, stress cracking, etc.

NOTES

For this procedure, reuse the existing pump shaft (if serviceable) and the gearbox cover (if serviceable).

Do NOT reuse bearings, gaskets, gear oil, mechanical (pump) seal, O-rings, oil seals, and retaining rings.

Refer to Table 45 and Table 47 for a list of tools and/or consumables required for this procedure.

Table 47. Pump Gear Bench Procedure Tools And Consumables List

Standard Tools	Special Tools	Consumables
PPE (for Handling Oil)	None	Shop Rag(s) (As Required)
PPE (Eye and Hand Protection)		Pump Gear (ONLY ONE REQUIRED – SELECT FROM ASSOCIATED TABLE:) <See FSG-PL-01482, Sheet 5, Item 7>(CBP) <See FSG-PL-01483, Sheet 5, Item 7>(AP) <See FSG-PL-01486, Sheet 5, Item 8>(MBP) <See FSG-PL-01487, Sheet 5, Item 8>(RSD)

ATTENTION ⚠ WARNING

A PRESS PRESENTS A POTENTIAL CRUSH HAZARD (FROM MOVING PARTS) AND/OR STRIKE HAZARD (FROM EJECTED PARTS). WEAR APPROPRIATE PPE.

Perform the following **Removal** portion of the procedures listed and perform the procedures in the listed order.

- A. Remove gearbox cooling tube IAW paragraph 5.8.7.1.1 (on page 108).
- B. Remove pump shaft IAW paragraph 5.9.2.2 (on page 131).

Perform the following to remove and replace **ONLY** the pump gear.

Pump Gear Removal

- A. If GR is 1.14, 1.31, 1.64, or 1.90:1, remove loose pump gear from gearbox.
- B. If GR is 2.33, 2.60, 2.91, or 3.74:1, remove pump gear from pump shaft assembly as follows.
 1. If GR is 3.74:1, remove pump gear from pump shaft assembly as follows.
 - a) Remove drive side pump gear spacer.
 - b) Remove pump gear.
 2. For all remaining gear ratios, remove pump gear from pump shaft assembly as follows.
 - a) Note/match mark drive side pump gear spacer notch orientation.
 - b) Remove drive side pump gear spacer.
 - c) Remove pump gear.
 - d) Note/match mark pump side pump gear spacer notch orientation.
 - e) Remove pump side pump gear spacer.

Pump Shaft Preparation For Pump Gear Installation

- A. Expand and remove pump side bearing retaining ring.
 1. Using snap ring pliers, insert tips of pliers into holes in snap ring and expand snap ring.
 2. Pull snap ring off pump shaft.

3. Release and remove snap ring pliers.
4. Discard snap ring.
- B. Remove pump side bearing from pump shaft.
 1. Using a hydraulic press (a large arbor press may work), press pump shaft out of pump side bearing.

NOTE

The bolster setup for the press must allow the pump shaft to pass thru the bearing and the bolster while securely supporting the bearing.

- a) Configure hydraulic press bolster plate with opening/bore hole or cribbing per NOTE above.
- b) Place pump shaft (impeller/inducer end down) on bolster plate (or cribbing) so bearing is stable and secure and pump shaft will pass thru bearing and plate opening or cribbing.
2. Catch pump shaft or pull it out of bearing.
- C. Install pump side bearing on pump shaft.
 1. Using hydraulic press bolster plate configuration from removal above.
 2. Lubricate pump shaft and bore of inner race of bearing with gear oil.
 3. Place bearing on plate opening or cribbing so bearing is stable and secure and pump shaft will pass thru bearing.
 4. Align pump shaft (drive side toward bearing) squarely with bearing bore.
 5. Press pump shaft into bearing until bearing is seated against shaft collar.
- D. Install a new pump side bearing snap ring.
(NOTE: Refer to paragraph 5.7.5 for proper ring orientation.)
 1. Using snap ring pliers, insert tips of pliers into holes in a new snap ring.
 2. Fully expand snap ring.
 3. Push snap ring onto pump shaft until aligned with snap ring groove.
 4. Release and remove snap ring pliers.
 5. Verify snap ring is seated in groove.

NOTES

The 3.74:1 GR configuration does NOT use a pump side spacer.

The notch in the spacer faces the pump gear.

- E. For all except 3.74:1 GR pumps, install pump side pump gear spacer per note/march mark.
- F. Install pump gear key.
 1. Partially fill pump shaft keyway with gear oil.
 2. Install key in pump shaft keyway (gear oil holds key in place).

Pump Gear Installation

NOTE

The pump gear (ONLY 3.74, 2.91, 2.60, and 2.33:1 gear ratios) will pass thru the gearbox bore when the pump shaft assembly is installed. All other ratio pump gears will NOT pass thru the bore of the gearbox housing and must be installed from the top of the gearbox with the cover and cooling tube removed.

- A. Install pump gear.

IMPORTANT ⚠ NOTICE

DO NOT ALLOW PUMP GEAR TO SLIDE THRU SUPPORTS. DO NOT ALLOW THE NEW OIL SEAL TO BE CUT ON THE KEYWAY OR PINCHED BETWEEN THE ADJACENT PUMP SHAFT COMPONENTS OR BE DAMAGED IN ANY OTHER WAY. DAMAGING THE OIL SEAL WILL RESULT IN AN OIL LEAK AND POSSIBLE EQUIPMENT DAMAGE AND/OR FAILURE.

1. For ONLY 3.74, 2.91, 2.60, and 2.33:1 gear ratio pumps:
 - a) Push pump gear on to pump shaft until seated against spacer.
 - b) Noting notch orientation, push spacer on to pump shaft until seated against gear.
 2. For all other GR pumps:
 - a) Place pump gear in gearbox from open top.
 - b) Align pump gear with drive gear teeth and gearbox pump shaft bores.
- B. Install pump shaft assembly.
1. For all EXCEPT 3.74:1 gear ratio pumps, install drive side bearing retaining ring in gearbox.
 - a) Using snap ring pliers, insert tips of pliers into holes in a new retaining ring. (NOTE: Refer to paragraph 5.7.5 for proper ring orientation.)
 - b) Fully compress ring.
 - c) Push retaining ring into gearbox until aligned with snap ring groove.
 - d) Release and remove snap ring pliers.
 - e) Verify retaining ring seats in groove.
 2. Place gearbox on its side. (This position allows access to both sides of the gearbox.)
 3. Install pump shaft assembly as follows.
 - a) Pass drive side of pump shaft thru pump side bearing bore and into gearbox.
 - b) For ONLY 1.90, 1.64, 1.31 and 1.14:1 gear ratio pumps, slide pump shaft thru pump gear as follows.
 - i. Align pump shaft and pump gear key with pump gear bore and keyway. Then push pump shaft thru pump gear.
 - ii. Verify alignment of pump gear and drive gear teeth.
 4. Seat pump side bearing in gearbox pump side bearing bore.
 - a) Using gear oil, lubricate pump side bearing outer race and gearbox housing bore.

- b) Align bearing outer race squarely in gearbox housing bore.
- c) Push pump side bearing (already installed on pump shaft) into gearbox housing bore until seated in housing.

NOTES

If required, use a non-marring hammer to tap bearing into place.

Do NOT strike pump shaft threads.)

- C. For ONLY 1.90, 1.64, 1.31 and 1.14:1 gear ratio pumps, install drive side pump gear spacer.
- D. Install drive side pump shaft bearing on pump shaft and into gearbox housing.
 - 1. Turn gearbox (pump side down), place pump shaft on bolster plate, and using cribbing level and support gearbox housing.
 - 2. Using gear oil, lubricate pump shaft, both drive side pump shaft bearing races, and gearbox housing bore.
 - 3. Place new drive side pump shaft bearing on pump shaft and into gearbox bore ONLY far enough to verify alignment of shaft in bearing and bearing in gearbox. Align bearing squarely with pump shaft and in gearbox housing bore.
 - 4. Using hydraulic press (without pusher tube), press drive side bearing onto pump shaft and into gearbox until nearly flush with gearbox housing.
 - 5. Add pusher tube and continue pressing bearing until seated against gearbox housing snap ring.
- E. Install pump shaft snap ring. See Figure 48.
 - 1. Expand and install a new pump side bearing snap ring.
 - a) Using snap ring pliers, expand pump shaft snap ring. Do NOT release pliers until instructed. (NOTE: Refer to paragraph 5.7.5 for proper ring orientation.)
 - b) Push pump shaft snap ring over end of pump shaft and locate directly over groove in shaft.
 - 2. Release snap ring pliers and verify ring seats in groove.
- F. Perform installation portion of paragraph 5.9.2.2.2, Pump Shaft Endcap (ONLY).

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APPENDIX A. TIGHTENING (TORQUE) INFORMATION

Utilize the torque specifications provided within each procedure if one is stated, otherwise use the torques provided below.

Screws and Studs

FASTENER	USED ON	Nm	FT-LB	IN-LB
M8–1.25 Screw (20 mm Long)	Gearbox Cover	16	12	140
M10–1.5 Full Nut	Gearbox (Drive Side)	23	17	200
M10–1.5 Stud (25 mm Long)	Gearbox (Drive Side)	32	24	280
M12–1.75 Full Nut	Gearbox To Pump Head	39	29	345
M12–1.75 Stud (25 mm Long)	Gearbox To Pump Head	54	40	478
M12–1.75 Screw (35 mm Long)	Input Shaft for Hydraulic Cou- pling	54	40	478
3/8–16 Screw Grade 8 (0.88-in Long)	Volute Screw (Iron)	68	50	600
3/8–16 Screw SS (0.88-in Long)	Volute Screw (Bronze Pump)	39	28	349
7/16–14 Stud 2.63-in Long	Volute Stud (RSD)	32	23.5	280
7/16–14 Screw Grade 8 (1.25-in Long)	Volute Screw (Iron)	95	70	840
7/16–14 Screw SS (1.25-in Long)	Volute Screw (Bronze Pump)	50	37	442
7/16–14 Screw Grade 8 (1.25-in Long)	K Port Flange (Iron)	95	70	840
7/16–14 Screw Grade 8 (2-in Long)	K Port Flange (Iron)	95	70	840
7/16–14 Screw Grade 8 (2.25-in Long)	K Port Flange (Iron)	95	70	840
7/16–14 Screw SS (1.25-in Long)	K Port Flange (Bronze)	39	28	349



Plugs

FASTENER	USED ON	Nm	FT-LB	IN-LB
Gearbox Drain Plugs	Gearbox Drain Holes	<u>1</u> /	<u>1</u> /	<u>1</u> /
Magnetic Drain Plug	Gearbox Oil Drain	N/A	N/A	N/A

1/ Tighten until flush or below flush to provide flat mounting surface for OEM. Use grease and impact gun to drive these plugs.

Nuts

FASTENER	USED ON	Nm	FT-LB	IN-LB
1-12 Castle Nut Brass	Inducer Nut (RSD) (MBP) 110-7040-00-0	148	110	N/A
1-1/8-12 Castle Nut Brass	Impeller Nut (AP) 110-7040-00-0	148	110	N/A
3/4-16 Nut (Nylon-Lock SS)	Impeller Nut (CBP)	169	125	N/A

APPENDIX B.

TEST EQUIPMENT AND SPECIAL TOOL INFORMATION

B.1. SPECIAL TOOL INFORMATION

Torque Limiting Sockets

A precision torque limiter can be attached to any standard drive tool to provide torque control. Torque limiters are available in two types: adjustable and preset. Once an adjustable torque limiter is set, the torque limiter prevents the applied force from exceeding the setting. When a preset torque limiter is used, the limiter releases (an audible click is heard) when the preset torque value is reached.

Torque Wrench

A precision torque wrench is adjustable over a specific torque range and can be attached to any standard socket or open end wrench tool to provide torque control. Once adjusted and locked the torque wrench is set, the torque wrench then prevents the applied force from exceeding the setting. Any torque wrench that adjusts to the torque specified in the procedure can be used. The required torque is listed for Nm and then shown converted into ft-lb and then in-lb providing a variety of torque scales. The torque required for use on the booster pump specific component is listed in each applicable procedure and in general in APPENDIX A and range as follows:

Nm	Ft-lb	In-lb
169	125	N/A
148	110	N.A
95	70	840
68	50	600
54	40	478
50	37	442
39	28	349
32	24	283
23	17	200
16	12	140

Puller

A puller is primarily utilized to remove the impeller and bearings. The impeller does NOT typically pull off by hand. If the puller uses legs with claws, the puller requires extra-long legs and very thin claws as shown on the left-hand picture. This is due to the limited clearance between the volute and the impeller. Two legs are all that are required to remove the impeller although a three leg puller will work provided the legs are adequately long with thin jaws. The forcing screw must also be longer than typical to provide the spread and travel required to pull the large diameter and deeply recessed impeller.

Removable leg type pullers (middle picture – Snap On OG270 with OG250-10 legs) are easier to attach to the impeller since the legs detach allowing them to be turned/maneuvered between the volute and impeller and then reattached to the puller.



OR

Puller For The Impeller Or Bearings

Infrared Thermometer (Precise Non-Contact IR)

Always use an infrared thermometer to determine the temperature of an expected hot item. Do NOT touch an expected hot surface with bare skin. Use an infrared thermometer to verify TRV opening or closing temperatures. Take note the temperature may be as hot as 75° C (167° F).



Infrared Thermometer (Precise Non-Contact IR)

Hydraulic Press

A 20 ton (or greater) hydraulic press is primarily used to press gearbox components (typically bearings). on or off the pump or input shafts. (NOTE: A large arbor press may work.)

Pusher Tubes

The input shaft seal pusher tube is made of a piece of 3-inch diameter, schedule 40, PVC pipe, 3-inches long and is required to fully seat the input shaft seal in the gearbox housing.

Pump shaft pusher tube is made of a piece of 1.5-in diameter (38 mm) by 2-in long (50 mm) wooden dowel or metal rod and is required to press the pump shaft thru the bearing.

Shaft bearing pusher tube is made of a piece of 2-in diameter (use ONLY 0.188 wall tube) by 3-in long DOM steel tube and is required to press the pump and input shaft bearing fully onto the shaft (because of housing recess).

APPENDIX C.

ANCILLARY PUMP EQUIPMENT

In addition to the basic parts of Hale booster pumps described above, the following items are available to enhance pump operation:

- Priming Systems
- Temperature Control Devices

C.1. PRIMING SYSTEMS

Priming pumps are used to evacuate air in the suction hose and the pump. The vacuum created allows atmospheric pressure to push water from the static source through the suction hose and into the pump. Hale booster pumps use Rotary Vane Positive Displacement type pumps for priming. See Figure 51.

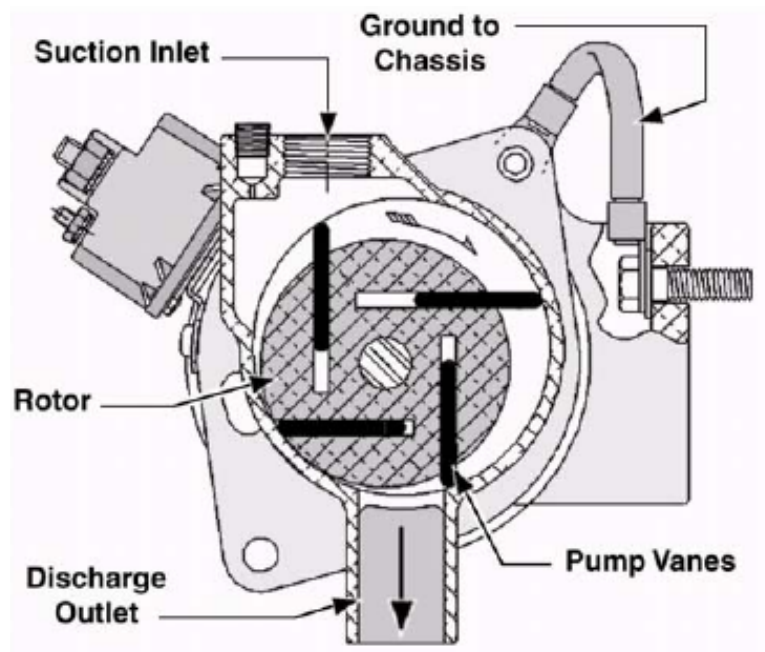


Figure 51. Rotary Vane Positive Displacement Type Priming Pump

C.1.1 Priming Pump

A priming pump draws air out of the pump body and suction piping allowing water to enter. The priming pump has a rotor mounted off-center (eccentric) to the housing. The eccentric position creates a large gap (air space) at the suction inlet which decreases to no gap (air space) at the discharge outlet. The vanes in the rotor slide in grooves and are held against the housing by centrifugal force. As each vane turns toward the discharge outlet, it recedes into the rotor as the air space decreases compressing the air and forcing it out the discharge. As the rotor continues past the discharge point, the vanes move outward in the grooves remaining against the housing to catch more air at the suction inlet to begin the next cycle. See Figure 51 and Figure 52.



Figure 52. Rotor And Vanes

During each cycle, the space between the rotor and the housing fills with air. The vanes, acting as wipers, forces the air out the discharge, creating a vacuum in the booster pump allowing atmospheric pressure to push water into the suction hose and fill the suction side of the booster pump.

The Hale ESP-series priming pump is an environmentally friendly primer that does not require a separate lubricant reservoir. The vanes and volute are self-lubricating for maintenance free operation. Figure 52 shows an ESP priming pump.



Figure 53. ESP Priming Pump

A Hale ESP priming pump utilizes a single control, the PVG (opens the priming valve and turns on the ESP), which is located between the booster pump and the priming pump.

C.1.2 Priming Valves

Hale priming valves open when the priming pump is operated to control priming of the booster pump. There are two types of priming valves available:

PVG

The PVG (Figure 54) is mounted on the pump operator panel. The PVG is a combination valve and switch. When the PRIME handle is pulled out, the valve opens and the switch energizes the primer motor. Pushing the handle de-energizes the motor and closes the valve.



Figure 54. PVG Priming Valve

SPV/SPVR

The SPV/SPVR (Figure 55) simplifies the priming operation of your booster pump allowing for faster priming and longer primer life. The SPVR is a remotely mounted valve (the SPV) and a separate panel mounted switch (the PRIME button).

The SPV is a diaphragm operated valve that opens using the vacuum generated by the priming pump and automatically closes when prime is established. The valve is attached to the priming tap on the volute of the booster pump and is connected to the priming pump by a hose.

When the PRIME button is pushed the switch energizes the priming pump motor. Releasing the button de-energizes the motor.



Figure 55. SPVR Priming Valve

C.2. TEMPERATURE CONTROL DEVICES

Hale temperature control devices consist mainly of TRVs which automatically protect your pump from overheating that may be caused by deadheading or other low flow conditions. Minimizing the need for operator attention to overheating during pumping operations, the TRV automatically dumps a controlled amount of water to atmosphere (ground) or back to the tank. The TRV opens when the pump water temperature exceeds the preset value of the relief valve, and then automatically closes when the pump water cools. When ordered with indicator light option (TRV-L), a visual warning lamp is lit when the TRV valve is open. The TRV-L combines the functions of water bypass with an operator warning system.

C.2.1 TRV

The TRV (see Figure 56) protects the pump from overheating. The optional TRV unit can be attached to the discharge piping either by flange mounting or 1- $\frac{1}{4}$ -in NPT threaded connection (38 mm for the TRVM). The valve monitors the temperature of the water in the pump. When the temperature exceeds 120° F (48.9° C), the valve automatically opens and depending on the installation, discharges a small amount of water either to the ground or into the water tank allowing cooler water to enter. After the temperature returns to a safe level, the valve closes. The TRV will flow up to 1-2 gpm (3-7 Lpm). For repair information see Hale Service Bulletin (SB-160) and PL729 on the Hale website (www.Haleproducts.com).



Figure 56. TRV

C.2.2 TRV-L Kit

The TRV-L kit (Figure 57) includes a chrome panel placard with a warning lamp, lamp test button, and a preassembled wiring harness. The light illuminates whenever the TRV is open and discharging water. An optional buzzer provides audible warning. The buzzer mounts on the operator panel. For repair information see Hale Service Bulletin (SB-160) and PL729 on the Hale website (www.Haleproducts.com).



Figure 57. TRV-L



C.3. ANCILLARY EQUIPMENT PREVENTIVE MAINTENANCE PROCEDURES

Regular preventive maintenance assures continued dependable operation of the ancillary equipment used with the Hale single stage booster pumps. This section provides recommended actions to be completed for the ancillary equipment listed in this appendix. The pump preventive maintenance actions listed are scheduled to be completed after each use and on a weekly, quarterly and annually basis.

C.3.1 Weekly Maintenance

Perform each the following procedures weekly.

C.3.1.1 Pump Shift Warning Indicator Lights

Verify the parking brake is set and the wheels are chocked to prevent any movement of the apparatus.

- A. Follow operating procedures in (Section 3 — OPERATING PROCEDURES) to engage pump if no local procedures exist.
- B. Verify warning indicators in cab and on pump control panel function properly.
- C. Verify indicator lights on control panel function properly and agree with indicators in cab. Repair or replace any malfunctioning indicators.

C.3.1.2 Check Valves

Properly functioning valves are integral to the proper operation of the pump. Refer to the valve manual for proper valve maintenance procedures.

- A. Lubricate all suction and discharge valves using an approved lubricant.
- B. Verify each valve operates easily and closes completely.
- C. Inspect and lubricate all valve linkages. Repair or replace any damaged or nonfunctional linkages.

C.3.1.3 Check And Clean Intake Strainers

Remove the strainers. Clean any debris out of the intake. Flush the pump if required by department procedures. Repair or replace any damaged strainers.

C.3.1.4 Check All Gauges

Any gauge that is repeated in the cab or another panel, must agree with the gauge on the operator's panel. Gauges not reading within 10% of the calibrated test gauge must be removed from service and recalibrated.

C.3.1.5 Check Pump Controls

Operate the pump drive controls to verify the pump can be engaged. Verify the indicator lights work properly.

C.3.1.6 Inspect Water and Foam Tanks

Visually inspect water and foam tanks for proper level and gauge readings. If any debris is present, flush the tanks to protect the pump from wear caused by dirty water or foam concentrate.

C.3.1.7 Check Roof and Bumper Turrets

If the apparatus is so equipped, verify the turrets function properly, and no leaks are present.

C.3.1.8 Check Auxiliary Fire Suppression Equipment

Visually inspect all piping and valves on the pump and auxiliary equipment for corrosion or damage.

C.3.2 Monthly Maintenance

Perform the following monthly.

- Perform a dry Vacuum Test (primer pump)
- Check the drive line bolts

C.3.2.1 Priming System Test (Dry Vacuum Test)

NOTE

Refer to NFPA 1901 or NFPA 1911.

Perform a dry Vacuum Test for the pump as follows.

- A. Close all valves and drains. Cap all suction openings and (if equipped) outlet of suction side relief valve.
- B. On pump panel, connect a vacuum gauge (or manometer) to intake test gauge connection.

IMPORTANT ▲ NOTICE

DO NOT RUN THE PRIMER FOR MORE THAN 45 SECONDS IF PRIME IS NOT ACHIEVED. IF PRIME IS NOT ACHIEVED IN 45 SECONDS, STOP AND LOOK FOR CAUSES (AIR LEAKS OR BLOCKED SUCTION HOSE). RUNNING THE PRIMER FOR LONGER PERIODS WITHOUT ACHIEVING PRIME MAY RESULT IN PRIMER AND/OR PUMP DAMAGE OR FAILURE.

- C. Engage priming pump (see Figure 58) until gauge indicates at least 22 (\pm 2) inHg vacuum.



Figure 58. Engage Priming Pump

- D. Compare readings of test gauge and apparatus gauge. Record any difference.
- E. Stop priming pump and observe gauge. If vacuum falls more than 10 inHg in five minutes, at least one air leak is indicated.

NOTE

Vacuum leaks may often be detected by ear if the apparatus engine is turned off. Correct leaks before returning the pump to service.

Test the suction hose as follows.

- A. Attach suction hose to pump.
- B. Place a suction tube cap on end of hose (in place of strainer).
- C. Close all valves and drains. Cap all suction openings and (if equipped) outlet of suction side relief valve.
- D. On pump panel, connect a calibrated vacuum gauge (or manometer) to intake test gauge connection.
- E. Engage priming pump until gauge indicates at least 22 (\pm 2) inHg vacuum.
- F. Verify calibrated gauge and apparatus gauge displays same reading.

NOTE

Repair or replace any gauge(s) that do not display the correct pressure before returning the pump to service.

- G. Watch gauges. If vacuum falls more than 10 inHg in 5 minutes, at least one air leak is indicated.

If leaks cannot be located by following this procedure, hydrostatically test the pump.

- A. Open all valves.
- B. Place caps on all valves.

ATTENTION ⚠ WARNING

DO NOT EXCEED LOWEST MAXIMUM PRESSURE FOR ALL CONNECTED EQUIPMENT.

- C. Connect a positive pressure water source. (Typically 60 to 100 psi.)
- D. Inspect pump for leaks.

C.3.2.2 Drive Line And Flange Bolts

Check all drive line and flange bolts to ensure the following.

- No bolts are missing.
- All bolts are tight.

NOTE

Use a torque wrench to torque bolts to the drive train manufacturer's recommended specifications.

- SAE bolts used are Grade 8 (or better) strength. Metric bolts used are Class 10.9 (or better) strength.

NOTE

Visually check all bolts for Grade 8 (see Figure 59) or Class 10.9 (see Figure 60) markings.



Figure 59. Grade 8 Bolt Marking



Figure 60. Class 10.9 Bolt Marking



C.3.3 Annual Maintenance

Perform the following as a minimum to maintain pump dependability and optimum performance.

- Check individual drain lines from the pump to the multi-drain to ensure proper drainage and protection from freezing.
- If installed, clean ESP primer.
- Perform tank to pump flow rate test.

C.3.3.1 Check Drain Lines to Multi-Drain

Drains are supplied on the pump and piping at the lowest points where water could collect and freeze rendering the pump useless. Most of these drains are piped together to a multi-drain to allow the entire system to be drained by one valve.

It is necessary to inspect each line to the multi- drain to ensure the entire system is draining when the valve is operated.

Inspect each connection and verify the individual lines to the multi-drain are free of debris. Repair or replace any lines that are damaged, kinked, or corroded.

C.3.3.2 Tank To Pump Flow Rate Test

NOTE

This procedure is provided for basic information only. It does NOT supersede any local procedure.

- A. Fill water tank until it overflows.
- B. Close tank fill line, bypass cooling line, and all pump intakes.
- C. Attach sufficient hose(s) and nozzle(s) to flow desired discharge rate.
- D. With pump in gear, open discharge to attached hose(s) and begin flowing water.
- E. Increase engine throttle until maximum constant pressure is obtained on discharge gauge. Record discharge gauge pressure.

NOTE

The bypass valve may be opened while the discharge valve is closed to prevent pump overheating.

- F. Close discharge valve without changing throttle setting. Refill tank through top fill opening or a direct tank line.
- G. Open discharge valve and adjust engine throttle to bring pressure back to previously recorded discharge gauge pressure.
- H. Check flow at nozzle(s) using a pitot tube or flowmeter.
- I. Compare flow rate measured to NFPA minimum (or designed rate of the pump).

NOTES

The pump should experience no mechanical problems, power loss, or overheat during the test.

If the flow rate is lower, a problem exists in the tank to pump line. The minimum flow rate should be discharged continuously until 80% of the tank is discharged.

C.3.3.3 ESP Primer Maintenance

The Hale ESP primer (see Figure 61) is relatively maintenance free. If after testing the primer fails to pull 22 (\pm 2) inHg of vacuum one of the following may be the cause.

- Vanes may be worn (require replacement)
- Seals/O-rings may be damaged (replace all seals/O-rings)
- Excessive deposit built up (clean primer)

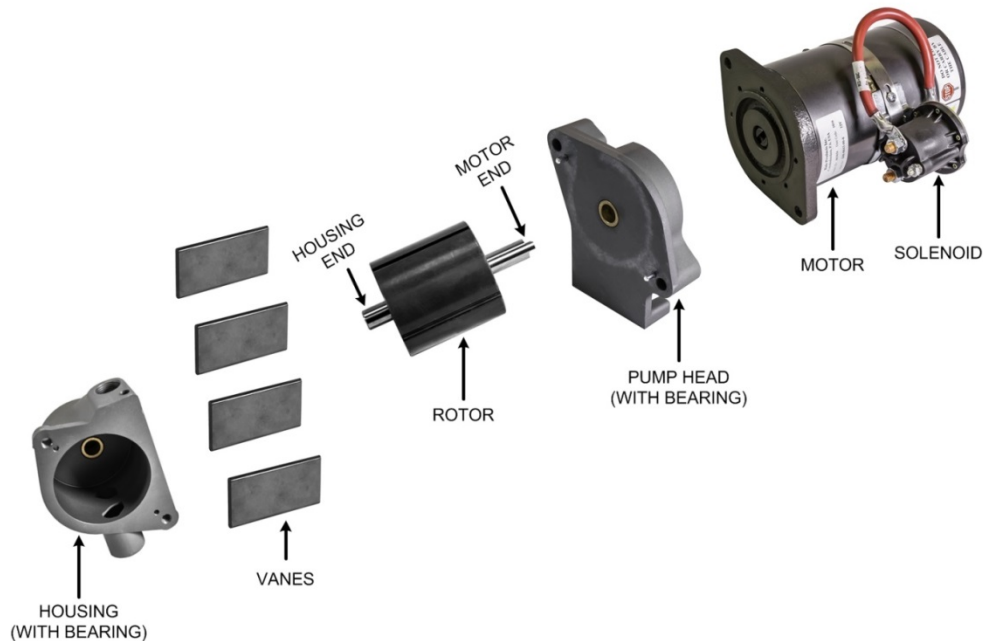


Figure 61. ESP Exploded View

Perform the following to maintain the primer.

NOTE

Before beginning disassembly note/match mark/tag the position and locations of components to ensure correct assembly.

Disassemble Pump

- A. Remove primer from mounting point according to OEM instructions.
- B. Tag and disconnect wires.
 1. Tag and disconnect battery connection.
 2. Tag and disconnect solenoid connection.
 3. Tag and disconnect ground connection.
- C. Tag and disconnect hose(s).
 1. Tag and disconnect suction hose.
 2. If applicable, tag and disconnect discharge hose.

- D. Remove pump from motor.
 - 1. Loosen nuts on studs (or bolts- depending on version) that secure primer to mounting pad.
 - 2. Remove primer to suitable work area.
- E. Separate pump from motor.
 - 1. Remove one (1) 3/8-in –16 UNC X2-1/2 in long bolt.
 - 2. Remove nut from stud.

NOTE

If reusing the vanes, do NOT remove the pump head from the pump body until the vanes have been match marked/noted for each primer vane location.

Using a non-marring hammer (use ONLY gentle tapping) may be required to carefully separate pump head from pump body.

- 3. Do NOT remove pump from motor but carefully separate pump from motor.
- F. Match mark/note each primer vane location.
- G. Disassemble pump.
 - 1. Remove shaft and rotor assembly.
 - 2. Remove vanes from pump body.
 - 3. Remove seal from pump head.

Inspect all components for corrosion, deposits, abnormal wear, or pinching, cuts, or cracking. Clean all components using Safety Kleen™ or Stoddard Solvent. Obtain new components if unserviceable. Contact Hale Customer Service (800-533-3569) for information about ordering new components or the ESP-PVG Primer Repair Kit (P/N 546-1410-03-0). The kit contains new seal, O-rings, vanes, and panel mounted SPV switch as shown on Figure 62.

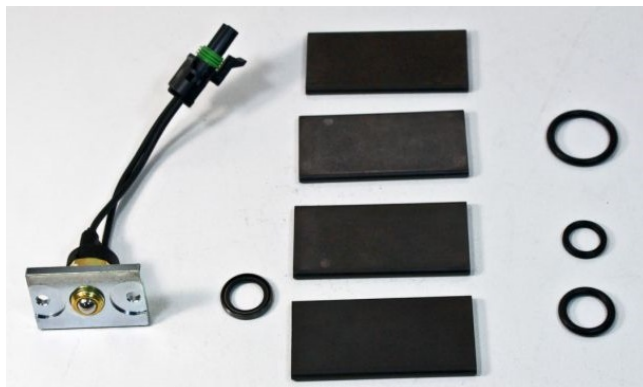


Figure 62. ESP-PVG Primer Repair Kit (P/N 546-1410-03-0)

Assemble Pump

- A. Install new parts from ESP-PVG Primer Repair Kit.
 - 1. Carefully press new seal into pump head.
 - 2. Insert rotor and shaft into pump body.

IMPORTANT ▲ NOTICE

DO NOT LUBRICATE VANES OR VANE SLOTS. USING LUBRICANT ON THE VANES OR VANE SLOTS DURING DISASSEMBLY, CLEANING, OR ASSEMBLY EVENTUALLY CAUSES A GUMMY RESIDUE TO DEVELOP, RENDERING THE SYSTEM INOPERATIVE.

3. Slide new vanes into slots in rotor.
4. Rotate rotor and shaft, verify vanes move freely in rotor slots.

NOTE

If required, install new pins in the pump head assembly.

- B. Install pump head onto pump body.
 1. Align pins with holes in pump body and slide pump head over rotor/shaft.
 2. Once head is seated against pump body, make sure rotor turns freely in pump.
- C. Install motor on pump and secure.
 1. Install one (1) 3/8-in –16 UNC X 2-1/2 in long bolt.

NOTE

Install wiring according to tags/notes/match marks.

2. Install nut (3/8-in –16 UNC) to connect pump head to pump body.
3. Tighten nut and bolt. See Table 22.
- D. Connect hose(s) according to tagging.
- E. Connect wiring according to tagging.
- F. Install primer on mounting point and secure primer according to OEM instructions.



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APPENDIX D. OPERATOR MAINTENANCE LOG

OPERATOR MAINTENANCE LOG

PUMP SERIAL NUMBER : _____

Use this Log to record all maintenance actions and problems (faults, part replacements, tear downs, and major overhauls – as a minimum). Please contact Customer Services at Hale Products Inc. prior to any proposed return of either a single part, or a complete assembly.



DATE	HOURS RUN	MAINTENANCE/ PROBLEM	PART(S) USED	REASON REPLACED	INITIALS



APPENDIX E.

MANUFACTURER'S INFORMATION

This section provides a list that includes the name, address, and telephone number of the manufacturer's points of contact. Each provides the name address and telephone number of the manufacturer's representative and/or service organization that can provide replacements and is most convenient to the project sight.

Additionally, included herein are warranty and returns information.

E.1. Manufacturer's Information

Division	Address	Telephone
Hale Products	Mailing: 607 NW 27th Ave, Ocala, FL 34475 Webmail: https://www.haleproducts.com/customer-support/	Tel: (800) 533.3569 FAX: (800) 520.3473
Godiva LTD (A Unit of IDEX Corp.)	Mailing: Charles Street, Warwick, England, CV34 5LR Email: godiva@idexcorp.com	Tel: +44 (0) 1926 623600 FAX: +44 (0) 1926 623666

E.2. Warranty

For all warranty information visit the Hale Products website (haleproducts.com) then search Warranty. Click on the Documents tab and then click on the Hale Warranty Statement link.

E.3. Returned Goods Procedure

If you identify a component or assembly that is worn, defective, supplied in incorrect quantity or to an incorrect specification, please complete the online Returns Form (www.haleproducts.com, at the top of the landing page hover over Customer Support and select Product Returns) or call our Customer Service Team on 800-533-3569. Please ensure, prior to calling us that you are in a position to provide us with the following information:

1. The reason that you wish to return the component or assembly.
2. The priority with which you require the problem to be resolved.
3. The product area:
(Vehicle Pumps, Portable Pumps, Trailer Pumps, PPV Fans, Rescue Tools, Foam Systems)
4. (a) For complete assemblies: Product serial number and/or Hale invoice number.
(b) For spares: Hale reference number ("C O" Number), Hale invoice number, and/or your own order number.
5. Hale part number.
6. Quantity of assemblies/components to be returned.

Thank you in advance for helping us to improve the speed of our response to you!