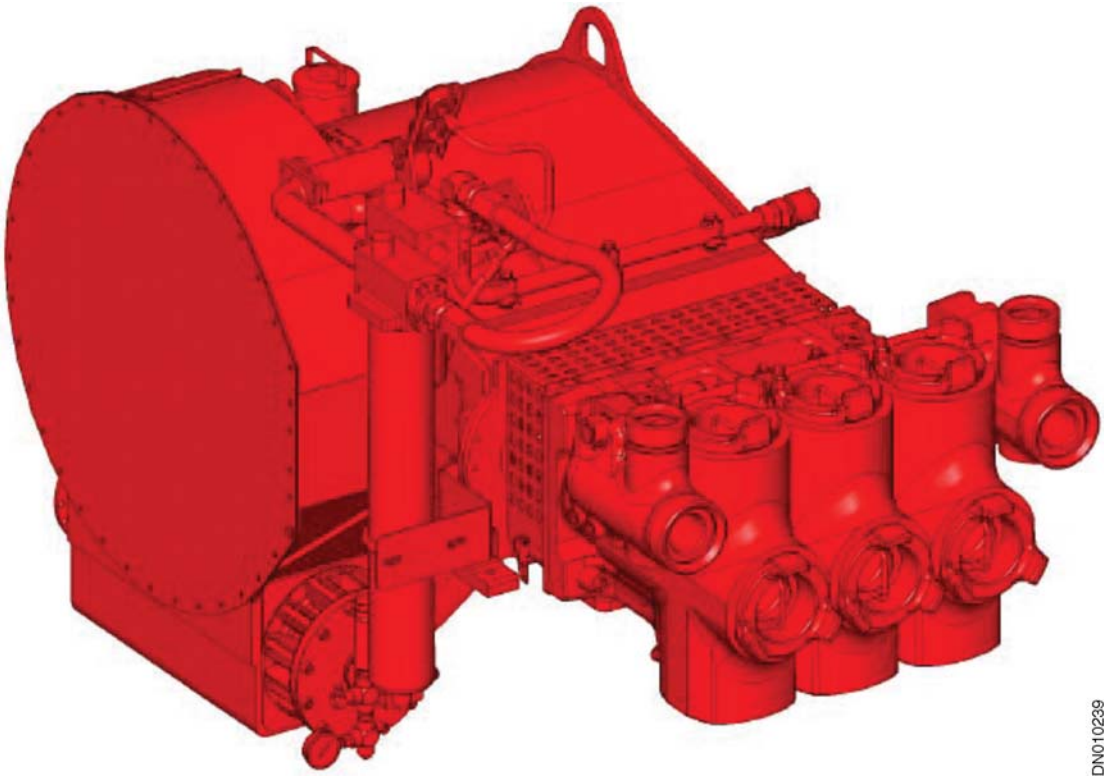
HT-400™ Pump
Maintenance and Repair Manual



HALLIBURTON

Part No. 100002809, Rev. 9

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Part No. 100002809, Rev. 9

Printed February 2008

Contents

Section 1—HT-400™ Pump Description

General Information 1-1

Assembled Pump 1-1

Power End 1-1

Spacer 1-2

Fluid End 1-2

HT-400™ Pump Power End 1-2
- Case 1-2
- Worm-Gear/Input-Shaft Drive Flange 1-2
- Worm and Ring Gears 1-3
- Crankshaft 1-3
- Connecting Rods, Crossheads, and Slides 1-3

Lube System 1-3
- Oil Sump 1-4
- Oil Pump 1-4
- Heat Exchanger 1-4
- Oil Filter/Strainer 1-4
- Crosshead Oilers, Injector, and Magnetic Seal 1-5

Right- and Left-Hand Pumps 1-5

Spacer 1-7
- Assemblies 1-7
- L-2 Spacer 1-7
- L-4 Spacer 1-7

Fluid End 1-8
- Fluid-End Sections 1-8
- Plungers 1-9
- Valves 1-9
- Valve Inserts 1-10
- Ball Valves 1-10
- Valve Springs 1-10

Valve Seats 1-10
Guide-Bushing Retainers 1-11
Suction-Valve Stops 1-11
Valve Covers (Standard HT-400™ Pump Fluid Ends) 1-11
Cylinder-Head Covers (Standard HT-400™ Pump Fluid Ends) 1-11
Pressure Packing 1-12
Flanges 1-12
Fluid-End Assembly (Standard HT-400™ Pump Fluid Ends) 1-12
Plunger Lubrication 1-13
HT-400™ Pump Specifications and Data 1-14

Section 2—General Maintenance

Introduction 2-1
General Maintenance Guidelines 2-2
Maintenance During the Job 2-3
Maintenance After the Job 2-4
Scheduled Preventive Maintenance 2-5
Every Five Jobs (or 10 Hours) 2-5
Every 3 Months (or 100 Hours) 2-5
Every 6 Months (or 200 Hours) 2-5
Lubrication System (Schroeder) 2-6
Things to Know 2-6
Dirt Alarm Characteristics 2-6
When to Clean the Strainer 2-7
How to Clean the Strainer 2-8
When to Change the Filter Elements 2-8
How to Change the Filter Elements 2-8
Safety Precautions 2-10
Troubleshooting 2-11
Power-End Lubricants 2-13
Packing Lubricants 2-15

Section 3—HT-400™ Pump Power-End Overhaul

Introduction 3-1

Disassembly Procedures 3-1
- Pump Preparation 3-1
- L Spacer 3-2
- Connecting Rod and Crossheads 3-3
- Crosshead Slides and Supports 3-6
- Worm Gear 3-8
- Ring Gear and Ring Gear Support 3-12
- Crankshaft 3-16
- Final Disassembly 3-17

Assembly Procedures 3-18
- Crankshaft 3-18
- Ring Gear 3-24
- Worm Gear 3-32
- Plunger Lube Recirculating Pump Assembly 3-41
- Crosshead Slides 3-42
- Final Power-End Assembly 3-48
- Power-End Lubrication System 3-49
- Spacer Installation 3-50

Section 4—HT-400™ Pump Power-End Parts

Introduction 4-1

Worm Gear Drive-End Assembly 4-2

Cone Drive (8.4:1) Worm Gear Thrust End Assembly 4-3

Holroyd (8.6:1) Worm Gear Thrust-End Assembly 4-5

Ring Gear Subassembly (A) 4-7

Ring Gear Subassembly (B) 4-9

Crankshaft Main Bearing Subassembly 4-11

Crosshead and Connecting Rod Subassembly 4-13

Crosshead Slide Subassembly 4-15

Schroeder Filter/Strainer Lubrication Subassembly 4-17

Power-End Lubrication Hose/Line Subassembly 4-19

Crankshaft Lubricator Subassembly 4-21
Case Cover Subassembly 4-22
L-2 Spacer Subassembly 4-24
L-4 Spacer Subassembly 4-26

Section 5—Standard HT-400™ Pump Fluid-End Maintenance and Repair

Introduction 5-1
Valves, Seats, and Retainers 5-2
Disassembly 5-2
Retainers and Seats 5-3
Assembly 5-5
Retainers and Seats 5-5
Valves 5-6
Two-Piece Valve-Guide Bushing 5-8
Insert Disassembly 5-8
Insert Assembly 5-8
Pressure Packing and Plungers 5-9
Disassembly 5-9
Assembly 5-10
Tie-bolts and Discharge Passage Seals 5-14
Disassembly 5-14
Assembly 5-14
Changing Fluid-End Assembly 5-15
Disassembly 5-15
Assembly 5-16
Discharge Flanges 5-18
Maintenance/Repair Procedure 5-18
Replaceable Packing Sleeves 5-19
Sleeve Removal Procedure 5-19
Sleeve Installation Procedure 5-19
Fastener Torque Requirements 5-21

Section 6—Standard Fluid-End Parts

Introduction 6-1

Suction Valve Subassembly 6-2

Discharge Valve Subassembly 6-5

Plunger/Cylinder Head Cover Subassembly 6-9

Packing Nut and Packing Subassembly 6-12

Straight Discharge Flange Subassembly 6-18

Curved Discharge Flange Subassembly 6-20

Blank Discharge Flange Subassembly 6-22

Fluid-End Section Subassembly 6-24
- 3-3/8-, 4 1/2-, 5.0-, and 6.0-inch Fluid Ends 6-24
- 4.0-inch Fluid Ends (Three Top Tie-Bolts) 6-24

Plunger Lube Pump Assembly 6-28

Recirculating Plunger Lube Pump Plumbing 6-29

Recirculating Plunger Lube Fluid-End Manifold Plumbing 6-31

Section 7—HCLE Fluid-End Repair Procedures

Introduction 7-1

Changing Valves and Valve Seats 7-2
- Disassembly 7-2

Changing Valves and Valve Seats 7-9
- Inspection Procedures 7-9
- Reassembly Procedure 7-9

Changing Plunger Packing 7-15
- Disassembly 7-15

Changing Plunger Packing 7-16
- Inspection Procedure 7-16
- Reassembly Procedure 7-16

Changing Fluid-End Assembly 7-21
- Removal Procedure 7-21
- Installation Procedure 7-22

Replacing Section Assemblies 7-24
- Disassembly Procedure 7-24
- Assembly Procedure 7-24

Replacing Packing Sleeves 7-26
Disassembly Procedure 7-26
Assembly Procedure 7-26

Section 8—HCLE Fluid-End Parts

Introduction 8-1
Fluid-End Overview 8-2
Discharge Detail (ISO View) 8-3
Access Cover/Suction Details 8-4
Plunger Detail 8-5
Bolting and Tie-Bolts (Triplex and Quintuplex) 8-6
Triplex Discharge Flanges, Seals, and Seal Plates 8-7
Quintuplex Discharge Flanges, Seals, and Seal Plates 8-8

Section 9—Pump Tools

Fluid-End Tools 9-1
For Removing and Replacing Valves 9-1
For Removing and Replacing Valve Seats 9-2
For Removing and Replacing Packing 9-2
For Removing and Replacing Plungers 9-3
For Removing and Replacing Discharge Flanges 9-3
For Removing and Replacing Fluid-End Assembly 9-3
Spacer Tools 9-4
Power-End Tools 9-4
Plunger Alignment Tool 9-5
Seat Pulling/Inserting Tools 9-6
Seat Pulling Tool 9-6
Seat Inserting Tool 9-7
Suction Valve Seat Puller 9-11
HCLE Fluid-End Tools 9-13

Section
1

HT-400™ Pump Description

General Information

The HT-400™ positive displacement triplex pump was originally designed for hydraulic fracturing service as a high-pressure slurry pump. Since the HT-400™ pump's original development, it has been utilized for a variety of duties inside and outside the oil and gas service industry.

Some of the features that separate the HT-400™ pump from other pumps include:

- Can pump at pressures as high as 20,000 psi (137.895 MPa) (depending on the fluid end size).
- Has a long working history of dependability, high performance, durability, and long life.
- Its compact design allows for ease of mounting and transporting.

Assembled Pump

The HT-400™ pump has three main assemblies: the power end, a spacer, and the fluid end. Originally the HT-400™ pump was used without the spacer assembly between power end and fluid end. In the event of a plunger nose seal failure, the fluid being pumped would be allowed to flow into the power end case, resulting in power end failures. The possibilities of these failures led to the development of the spacer that separates the fluid end from the power end.

Power End

The power-end assembly reduces speed, multiplies torque, and changes rotary motion into reciprocating motion. It takes energy created by the engine and changes it into energy that can be used by the fluid end. Power ends are customized to meet job requirements and conserve space on the trailer or truck unit. Cases are available in right- and left-hand versions. Since the early 1970s, fracturing pumps have been equipped with Cone drive (8.4:1) gears, while cementing pumps have Holroyd or Delroyd gear sets (8.6:1).

Other customizing features include the following:

- Lube systems
- Companion flanges
- Heat exchanger design

Spacer

On all current pump configurations, a steel spacer assembly is used between the fluid end and the power end. The spacer helps prevent fluids from communicating between the fluid end into the power end. All new pumps utilize spacers. Fracturing pumps use L-2 spacers and cement pumps use L-4 spacers.

Fluid End

The fluid end uses reciprocating motion created by the power end to pump cement, fracturing mediums, and other liquids and materials.

Two fluid ends are available for mounting on the HT-400™ pump, the standard fluid end (formally known as the HT-400™ pump fluid end) and the HCLE (high sand concentration, low erosion) fluid end. The standard fluid ends are available in five plunger sizes and the HCLE fluid ends are available in four sizes.

HT-400™ Pump Power End

Case

The case is a weldment made of high-strength steel that has bores for the worm gear, crankshaft, and crossheads. The case has lifting eyes on the top and four legs on the bottom used for machining and mounting. Eight access covers facilitate maintenance and repairs to specific parts. Twelve studs secure the fluid end to the power end.

Worm-Gear/Input-Shaft Drive Flange

The engine and transmission deliver energy to the pump through the worm-gear input shaft. This shaft can be equipped with sheaved or non-sheaved companion flanges. The sheaved flanges, although very uncommon, are still available.

Worm and Ring Gears

Energy is transferred through splines of the companion flange to the steel worm gear. From there, the energy passes through the teeth to the bronze ring gear. At that time, speed reduction and torque multiplication occur in the gear set. The two types of gear set available in an HT-400™ pump power end are:

- **Holroyd (8.6:1)**—This is a single enveloping gear set rated for a maximum input power of 600 hp (447.420 kW). It is the gear set commonly used in cement service.
- **Cone Drive (8.4:1)**—This is a double enveloping gear set rated for a maximum input power of 800 hp (596.560 kW). It is the gear set commonly used in hydraulic fracturing service.

Crankshaft

Energy moves from the ring gear to the crankshaft through a splined drive coupling. The crankshaft is rough-machined from a forged billet. It is heat-treated and then machine-finished, drilled, and ground. The three crankshaft journals are spaced 120° apart. Journal positioning from the center of the crankshaft results in an 8-in. stroke.

Connecting Rods, Crossheads, and Slides

The connecting rods are made of forged aluminum. The rods have split caps and insert bearings at the crank end. Crosshead ends of the rods are press-fitted with bronze bushings. The connecting rods convert the rotary motion of the crankshaft to a reciprocating motion at the crosshead. The cast-steel crossheads are connected to the rods by steel pins. Crosshead upper and lower faces are covered by bronze shoes. Steel slides, secured in the case by expanding clamps, contain and guide the crossheads in their movement.

Lube System

The HT-400™ pump utilizes a wet sump oiling system, meaning the lubricating oil is stored in the power-end case. The main components of the lube system are the:

- Oil sump
- Oil pump
- Heat exchanger
- Filter and strainer
- Bypass valve
- Oil line tube
- Oil injector

The flow path of the oil starts in the oil sump; it is pulled from the sump by the oil pump. From the oil pump, the oil goes through a heat exchanger. From there, the oil is pumped through a magnetic strainer and filter. Between the strainer and filter, the oil is exposed to a high-pressure bypass that redirects it back into the power-end case if pressure goes beyond the bypass set point. After the filter, the oil is pumped into the oil line tube where it is distributed to the crosshead oilers and crankshaft oil injector.

Oil Sump

The sump of the power end is the worm gear box, which is the lowest point in the pump. Oil drains through the power end and is collected here. The worm gear, worm thrust bearings, and worm support bearings are submerged in the oil sump. The oil pump pulls the oil directly from this point.

Oil Pump

The oil pump is a gear pump mounted locally (driven by the worm gear) or remotely (driven off a PTO on the unit transmission). The locally mounted pumps are common on cementing units and require short lengths of suction and discharge lines. The remotely mounted pumps are common on hydraulic fracturing units and require long lengths of suction and discharge lines. Locally mounted pumps are the larger of the two because of the lower drive speeds. The pump is mounted remotely so that during heavy loading and low speeds, the pump will receive adequate oil pressure and volume due to high engine speed.

Heat Exchanger

The heat exchanger is used to heat the power-end lubricating oil in cold environments to get the oil to the minimum required 40°F (4.44°C) and to cool the oil when needed. Some form of heat exchanger is always mounted in line with the lube system. On early units and cementing units, the heat exchanger is mounted directly to the pump case and is considered part of the pump assembly. These are engine coolant-to-oil heat exchangers used to bring the temperature up and to cool it. Some units direct the oil through an engine coolant-to-oil heat exchanger to warm the oil and then switch to an air-to-oil heat exchanger for cooling. Other heat exchanger units use seawater for coolant. The heat exchanger is necessary to maintain proper oil temperatures.

Oil Filter/Strainer

The magnetic strainer is used to remove any magnetic particles from the oil. When the oil flows through the strainer, it flows over several magnets. As magnetic particles flow through the magnetic field of the magnets, they separate from the oil stream and collect on the magnets.

The oil filter has three 25-micron elements that filter out additional debris from the oil stream.

Crosshead Oilers, Injector, and Magnetic Seal

The crosshead oilers consist of three injection points from the oil line tube. High-pressure oil is pumped through these oilers into holes in the top of the power-end case and out of holes in the upper crosshead slides to supply lubrication to the crosshead slides and shoes.

The oil line tube ends at the crankshaft injector, which is mounted to the injector cover on the side of the power-end case, opposite the ring gear housing. The injector is a mandrel that is stationary and supplies high-pressure oil to the crankshaft at the crankshaft rotation axis. The two-piece magnetic seal creates a seal between the stationary injector and the rotating crankshaft.

Right- and Left-Hand Pumps

There are two HT-400™ pump case configurations, right-hand and left-hand. These terms refer to the orientation of the gear sets with reference to the fluid ends. Looking at the pump from the fluid-end side, if the ring gear housing is on the right side, it is a right-hand pump; if it is on the left side, it is a left-hand pump. This is done to maximize the usage of space on pumping units. See **Figures 1.1** and **1.2**.

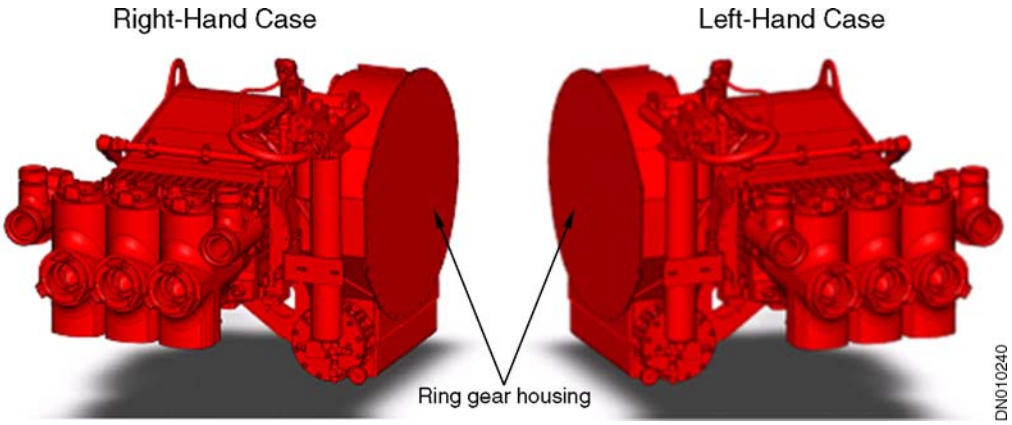


Figure 1.1—Viewing the pumps from the fluid-end side. If the ring gear housing is on the right, it is a right-hand pump; if it is on the left, it is a left-hand pump.

The ring gear is assembled differently for right- and left-hand power ends.

- Ring gear fastening
  - Left-hand: bearing clamp washers (outside face)
  - Right-hand: bearing clamp washers (outside face) and bearing clamp lugs (inside face)
- Ring gear support shimming
  - Left-hand uses less shimming thickness than right-hand pump

A ring of welding rod is used to fill the gap between the gear support and the race of the first main bearing on right-hand power ends caused by the greater number of gear support shims. These assembly differences are required to counteract ring gear thrust deflection caused by the rotating worm gear.

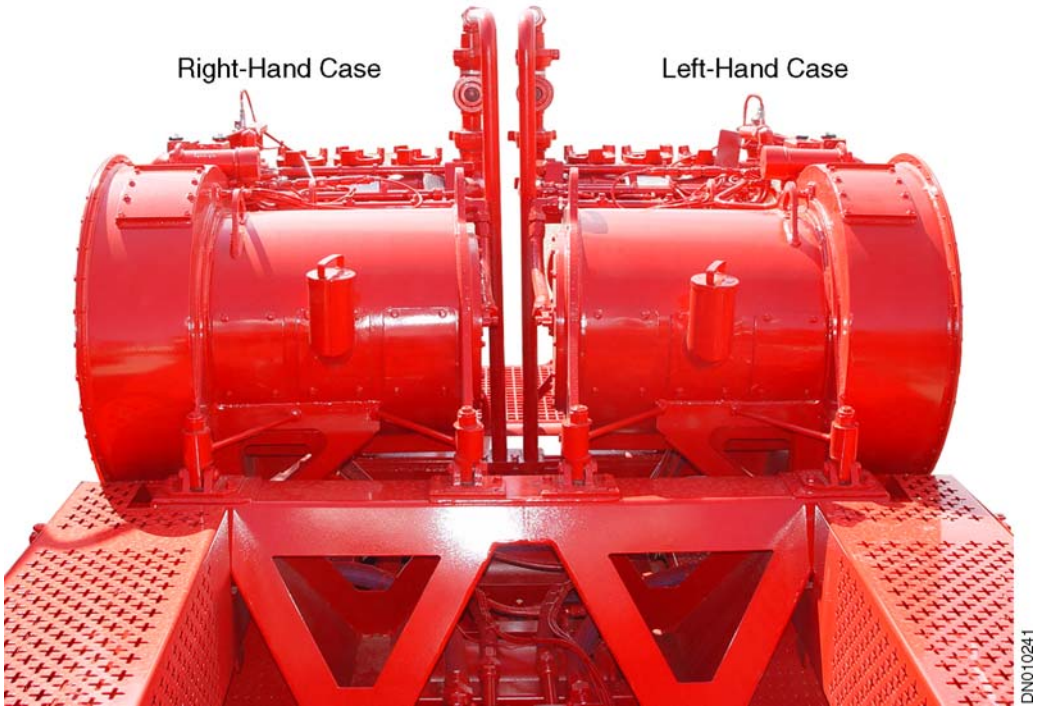


Figure 1.2—View from back side of HT-400™ pumps mounted on Panther™ unit.

Spacer

Assemblies

Current spacers come in two configurations, the L-2 and the L-4. The parts common to the two spacer assemblies are:

- **Fluid end-to-power end attaching studs**.
- **Tie rod**—Secures the push rod by tying the crosshead to the push rod retainer and transfers pulling force from the crosshead to the plunger tie bolt during the suction stroke.
- **Push rod adapter**—Adapts the push rod to the plunger. Fits over the push rod retainer. Transfers compressive force from the push rod to the plunger.
- **Push rod retainer**—Threaded onto the tie rod to secure the push rod. Other end is threaded to accept the plunger tie bolt to secure the plunger.
- **Push rod**—Transfers force to the plunger during the discharge stroke

L-2 Spacer

The main feature of the L-2 spacer that separates it from the L-4 spacer is that the spacer frame that separates the fluid end from the power end is a welded assembly. The pieces of the welded assembly are larger and heavier and include a fluid-end plate, which the L-4 assembly does not have.

Because of its heavier and sturdier construction, the L-2 spacer is intended for higher horsepower applications such as hydraulic fracturing service.

L-4 Spacer

The L-4 spacer frame is made up of a power-end seal plate and 12 separate spacer frame tubes. The mounting foot is bolted to the spacer tubes rather than welded.

Fluid End

Fluid-End Sections

The fluid-end section is the main body, or housing, of the fluid end. It creates the chamber that the fluids are pumped through. The chamber consists of a vertical bore and a horizontal bore. The main difference between the standard and HCLE fluid ends is that the standard fluid end is a cross-bore fluid end while the HCLE is a t-bore fluid end. This means that the two bores in the standard fluid end intersect through each other while the vertical bore in the HCLE dead ends when it intersects the horizontal bore. The standard fluid end uses the bottom of the vertical bore for suction and the top of the vertical bore for discharge. The HCLE uses the bottom of the vertical bore for suction and the outside end of the horizontal bore for discharge. Both fluid ends use the inside end of the horizontal bore to house the plunger.

The fluid-end section is a steel forging that is heat treated, machined, and pre-stressed. The size of a fluid end refers to the size plunger it was machined to accept. Different sized fluid ends appear the same externally because they are machined from the same forgings.

The different sized fluid ends are as follows:

Standard

- 3 3/8-in. (8.573-cm)
- 4-in. (10.160-cm)
- 4 1/2-in. (10.160/11.430-cm)
- 5-in. (12.700-cm)
- 6-in. (15.240-cm)

HCLE

- 4-in. (10.160-cm)
- 4 1/2-in. (10.160/11.430-cm)
- 5-in. (12.700-cm)
- 6-in. (15.240-cm)

Plungers

Plungers are used to pull fluid into the fluid end through the suction valve and push it out through the discharge valve. They do this by retracting from the fluid end to create volume in the fluid-end chamber and then extending back into the fluid-end chamber to displace volume and push the fluid out. This reciprocating motion is created by the crosshead in the power end, which is connected to the plunger by the push rod and tie bolt. The velocity of the plunger will determine the rate of the pumped fluid, and the fluid's resistance to being pumped out of the fluid end creates discharge pressure.

Plungers have a hard surface that is flame-sprayed and fused with a hard, metallic powder and then ground for smoothness. Hard-surfaced plungers can be used for all kinds of pumping.

Valves

Valves are used to direct the flow of the fluid through the fluid end and separate the suction side of the pump from the discharge side. As the plunger is pulled back, the pressure in the fluid end drops, causing the discharge valve to pull harder onto the discharge valve seat and also causes the suction valve to lift off its seat. With the suction header open to the pump chamber, fluid is pulled from the suction header into the chamber. Once the plunger has reached the end of the suction stroke, pressure in the pump chamber and suction header equalize, causing the suction valve spring to close the suction valve. The plunger then begins the discharge stroke, reducing volume in the pump chamber and increasing pressure. The increase in pressure causes the suction valve to press harder onto the suction valve seat while the discharge valve is lifted off its seat. Fluid is pushed out of the pump chamber into the discharge passage. At the end of the plunger discharge stroke, pressure in the pump chamber and discharge passage are equalized, allowing the discharge valve spring to close the discharge valve. The plunger then begins the suction stroke, starting the whole cycle again.

Valves are machined from forgings and are carburized, which means that they go through a process to increase the carbon content of the metal to a shallow depth. The surface is hard and long-wearing, but the core remains soft and ductile. Valves are available in three diameters; #3, #4, and #5. Uses of the different valve sizes are shown in **Table 1.1**.

Table 1.1—Valve Size Applications

Standard Fluid End		
FE Size	**Suction**	**Discharge**
3 3/8-in.	#3	
4-in.	#3	
4 1/2-in.	#4	
5-in.	#5	
6-in.	#5	

HCLE		
FE Size	**Suction**	**Discharge**
4-in.	#4	#3
4 1/2-in.	#5	#4
5-in.	#5	
6-in.	#5	

Valve Inserts

Valve inserts are molded elastomer rings installed on the valves to provide the primary sealing needed to control fluid movement through the pump. The inserts are held onto the valve by elastic force and a locking lip that engages a groove machined into the valve. The type of insert used is dependent on the fluid being pump. The size of the insert is matched to the size of the valve to which it is being installed.

Ball Valves

Ball valves are used in low-rate/high-sand concentration service.

Low rates are considered 2 to 5 bbl/min (0.318 to 0.795 m^3/min) per pump. Ball valves are designed for temporary installation. A pump may be outfitted for a special high-sand-concentration job and then returned to normal after the job is completed. While ball valves are expedient for low-rate/high-sand-concentration service, the use of ball valves restricts all sizes of pumps to a maximum recommended pumping rate of 5 bbl/min (0.795 m^3/min). Higher rates, even during prime-up or wash-up, can cause insert malfunction. Even a 5-bbl/min rate causes some parts to erode, especially in the discharge area.

Valve Springs

Valve springs cause the valves to contact the seats during zero pressure differential conditions and are required for directing valve movement for proper valve closing. Cylinder-shaped springs can go into the chamber with either side up, but the cone-shaped springs must be installed with the small end toward the plunger. Improper or opposite installation prevents the valves from fully opening because the coils of conical springs become stacked before the valves reach the end of travel. A stiff stainless-steel spring is used on most valves. A limber stainless-steel spring can be used on the suction valve when no centrifugal pump is used to charge (boost) the HT-400™ pump, which makes priming somewhat easier.

Valve Seats

The valve seat used with frac valves is not the same as the seat used with single- and double-guided valves described in earlier manuals. Because the ID is smaller, the seating area is greater. The frac valve seat is completely hardened (carburized), but only the surfaces subjected to wear are carburized on the seat for single- and double-guided valves. The frac-valve seat OD is tapered. It wedges into the adapter that expands against the bore. O-rings on the OD of the seat and adapter seal the seat and adapter and reduce erosion caused by the fluids being pumped. New fluid ends are tapered, and the adapter is eliminated. In contrast, the OD of the seat for single- and double-guided valves is cylindrical. A seal is made with the bore by an O-ring and a copper seal ring on older pumps. Tapered valve seats were first used in early 1977. Single- and double-guided valves can be used with frac-valve seats, but frac valves deteriorate rapidly when used with the seat for single- and double-guided valves.

HCLE fluid ends use an integrated discharge valve seat that combines the valve seat with the guide bushing retainer. The integrated valve seat is machined with two valve face surfaces so that it is reversible.

Guide-Bushing Retainers

Guide-bushing retainers are installed in the bores beneath the valve seats. These retainers look like wagon wheels with two spokes. Rubber guide bushings in the hubs guide the lower stems of the valves. Retainers are available in two styles, but both have the same part number. The newer style has identical top and bottom sides that can be installed with either side facing upward. The older style must be installed with the notched side of the spokes up and the larger chamfer of the rim down. The older style is stamped: THIS SIDE UP.

Suction-Valve Stops

The upper stem of the valve used in the suction end of the chamber is guided by a rubber guide bushing in the suction-valve stop. The stop is what the valve spring pushes against.

The stop has protrusions, or ears, that are covered by rubber boots and fit into a groove cut into the ID of the chamber. A lock spring extending beyond one of the ears snaps into a vertical groove to lock the stop into position.

Valve Covers (Standard HT-400™ Pump Fluid Ends)

The upper stem of the valve used in the discharge end of the chamber is guided by a rubber guide bushing in the discharge-valve cover. The cover backs up the valve spring and plugs the top of the chamber. The covers, like the chambers, vary in diameter.

Threads in the top of the chamber secure the discharge-valve cover and a gasket and spacer ring seal it. To minimize damage to the gasket, the cover has two pieces; the cover assembly remains stationary while the cover retainer is screwed in.

HCLE fluid ends do not have valve covers.

Cylinder-Head Covers (Standard HT-400™ Pump Fluid Ends)

A cylinder-head cover, which looks like a valve cover without a guide bushing, seals the end of the horizontal bore for the plunger. It uses the same gasket and spacer ring as the valve covers. Cylinder-head covers vary in diameter, as do the bores. A pump can be damaged during a high-sand concentration job when sand builds up in front of the plunger. The plunger bottoms out against the sand and either stretches the fluid-end attachment studs or pushes the fluid end off the spacer/power end. In addition, the plunger can be severely damaged. A special protective cylinder-head cover is available for high sand-concentration pumping or for fluid systems that have low proppant carrying abilities, such as water. The cover ruptures before the plunger or fluid-end attaching studs are damaged. A special

cylinder-head cover retainer is required for the protective covers. This retainer catches the center portion of the cover when a sand-out occurs.

Pressure Packing

The pressure packing creates a seal around the moving plunger to contain the fluid being pumped. The packing arrangement consists of the following seven components that work together to achieve this.

- Spacer ring
- Header ring
- Packing ring
- Female adapter
- Seal carrier
- Seal carrier O-ring
- Packing lube seal

The main component is the packing ring, which is a v-type seal and is the primary seal against pressure and fluid loss. The header ring is used to “set up” the packing ring and prevent solid particles from damaging the packing ring. The seal carrier houses the packing lube seal and helps to contain the packing lube that lubricates the plunger, packing ring, and header ring.

Flanges

For simplicity, the fluid-end information is presented in terms of one fluid-end section and its contents, but actually, the HT-400™ pump is a triplex. Every fluid-end assembly has three sections. Pressure strokes of the single-acting plungers in the sections are evenly staggered to make the fluid-end discharge and the power-end load more constant.

Discharge passages of the sections are united by seals and spacers. Flanges bolt to the two outside sections and are sealed into the passage with more seals and spacers.

Blank flanges seal off the end of the passage. The blank is used when clearance is extremely limited. The discharge manifolding is connected by straight flanges (single outlets) and ell flanges (two outlets).

Fluid-End Assembly (Standard HT-400™ Pump Fluid Ends)

Suction manifolding is connected to the lower ends by means of a suction header, and is considered part of the unit that the pump is installed onto rather than part of the pump. The suction header is a 1-into-3 header that attaches to the bottom of the fluid-end assembly.

Fluid-end assemblies have two possible tie-bolt configurations. The first configuration has a top and bottom tie-bolt. The second configuration has three top tie-bolts. Both configurations secure the flanges and tie the upper ends of the fluid-end sections together. The single top tie-bolt configuration requires a smaller bottom tie-bolt running through holes in the bottom of the sections to tie the lower ends together. The three fluid-end sections used in a fluid-end assembly are the same size. They are identical and interchangeable. Fluid-end assemblies take their size designation from the plungers installed in them. Maximum working pressures have been assigned to each of the five available sizes of fluid-end assembly. The amount of load the power end can withstand determines the maximum working pressure.

Fluid-end assemblies are secured with internal wrenching nuts that fasten to studs attached to the power end and go through the spacer.

Plunger Lubrication

Currently, pumps are outfitted with a recirculating plunger lube system. This system consists of a small gear pump driven off the thrust end of the power-end worm gear/manifolding and hoses that direct the lube from a reservoir to the packing seal carrier and then back to the reservoir.

Some pumps have a pneumatic lube system that consists of an air-energized oil reservoir that supplies pressurized oil to the packing seal carrier and does not recirculate.

HT-400™ Pump Specifications and Data

Table 1.2—Power End

Companion flange	1800 Series Spicer
Input spline	3-in.—10 (7.62 cm)
Input rotation	Clockwise
Maximum input torque	7,215 lbf (9,782.227 N·m)
Maximum input horsepower	(8.4 Gear) 800 hp (596.560 kW) (8.6 Gear) 600 hp (447.420 kW)
Input speed w/8.4:1 or 8.6:1 gears	2,400 (Maximum rev/min)
Gear train	Steel worm and bronze ring w/8.4:1 or 8.6:1 ratio (standard)
Crankshaft	Forged steel, four main bearings
Connecting rods	Three, forged aluminum, split caps, and insert bearings
Plunger stroke	8 in. (203.2 mm)
Crossheads	Three, cast steel
Case	High-strength steel weldment
Bearing type	Roller and race
Oil system	Gear pump driven off worm (std) or remote
Oil filter	Replaceable elements and magnetic strainer (Schroeder)
Oil capacity	22 U.S. gal (0.083 m^3)
Oil type	Power end lubricants, Section 2, Pages **2-13** to **2-14**
Oil pressure	80 to 100 psi (0.552 to 0.689 MPa) Schroeder 35 to 40 psi (0.241 to 0.276 MPa) at 190 worm-gear rev/min
Minimum oil flow	36 gal/min (136.275 m^3/min)
Weight (wet)	3,864 lb (1,752.681 kg)

Table 1.3—Pump Assembly Weight

Size, in. (cm)	Spacer, lb (kg)		
	No Spacer	L-4 Spacer	L-2 Spacer
3 3/8 (8.573)	5,589 (2535.128)	5,731 (2599.538)	5,843 (2650.340)
4 (10.160)	5,414 (2455.749)	5,556 (2520.159)	5,668 (2570.962)
4 1/2 (11.430)	5,455 (2474.346)	5,597 (2538.757)	5,709 (2589.559)
5 (12.700)	5,392 (2445.770)	5,534 (2510.180)	5,646 (2560.983)
6 (15.240)	5,331 (2418.101)	5,473 (2482.511)	5,585 (2533.313)

Table 1.4—Fluid End

Fluid-end type	Horizontal, triplex, three-piece forged steel
Plunger type	Single-acting, hard-surfaced
Valve type	Double-guided, carburized, high-contact
Valve seats	Carburized and replaceable
Pressure packing	Sealing achieved by the pairing of a packing ring and a header ring. The header ring acts as an initial seal and is shaped to “set up” the packing ring, which is the primary seal.
Discharge flange	(1) Blank, straight with one outlet or (2) Ell with two outlets
Oil system	External; uses pneumatic reservoir or recirculating system

Table 1.5—Fluid-End Weight

Size, in. (cm)	Weight, lb (kg)
3 3/8 (8.573)	1,835 (834)
4 (10.160)	1,652 (749)
4 1/2 (11.430)	1,810 (821)
5 (12.700)	1,659 (752.5)
6 (15.240)	1,603 (727.1)

Table 1.6—Discharge Pressure

Size, in. (cm)	Maximum Working Pressure, psi (MPa)
3 3/8 (8.573)	20,000 (137.895)
4 (10.160)	14,000 (96.527)*
4 1/2 (11.430)	11,200 (77.221)
5 (12.700)	9,000 (62.053)
6 (15.240)	6,250 (43.092)

*For static pressure testing, such as testing lines, BOP stacks, etc., the 4-in. (10.160-cm) fluid end is rated to 15,000 psi (103.421 MPa) maximum pressure.

Table 1.7—Spacer Weight, lb (kg)

L-4	L-2
142 (64.410)	254 (115.213)

Table 1.8—HT-400™ Pump Duty Ratings, hp

Rating	Operating Duration	Gear Ratio	Max. BHP Limit	Max. HHP Limit	% Max. Rod Load Limit
Intermittent	0 - 4	8.6:1	600	576	100%
		8.4:1	800	768	
Intermediate	4 - 8	8.6:1	390	374	75%
		8.4:1	520	499	
Continuous	8 - 24	8.6:1	275	264	50%
		8.4:1	367	352	
Best Life	24 - 40	8.6:1	150	144	25%
		8.4:1	200	192	

Table 1.9—HT-400™ Pump Duty Ratings

Operating Duration	FE Size	Max. Pressure Limit (psi)	Max. Rate Limit, bbl/min
Intermittent (0 - 4 hrs)	3.375	20000	6.1
	4	14000	8.5
	4.5	11200	10.8
	5	9000	13.4
	6	6250	19.2
Intermediate (4 - 8 hrs)	3.375	15000	5.5
	4	10500	7.8
	4.5	8400	9.8
	5	6750	12.1
	6	4688	17.5
Continuous (8 - 24 hrs)	3.375	10000	2.7
	4	7000	3.7
	4.5	5600	4.7
	5	4500	5.8
	6	3125	8.4
Best Life (24 - 40 hrs)	3.375	5000	2.7
	4	3500	3.7
	4.5	2800	4.7
	5	2250	5.8
	6	1563	8.4

Section
2

General Maintenance

Introduction

The HT-400™ pump must be maintained to run reliably and economically. Relatively minor repairs can be made in camp or on location, but major overhauls should be made at a Halliburton pump-rebuild center. Consistent maintenance helps ensure that the pump is active in the field and not out of commission in the shop having a major overhaul. Preventive maintenance is performed before the HT-400™ pump is taken to location. During a job, the operator performs preventive maintenance by closely watching the oil-pressure gauges, checking the packing, and adhering to the predetermined discharge pressure. Post-job maintenance may seem repetitive since many of the steps will be performed again before the HT-400™ pump is taken to the next job location. However, post-job maintenance allows operators to identify repairs that will require parts to be ordered and to provide the time to make the needed repairs. Maintenance is a continuous process.

General Maintenance Guidelines

For information about fluid-end lubricants, refer to **Table 2.1**.

For information about various brands of oil regarding grade and temperature, refer to **Tables 2.4** through **2.6**.

1. Check the oil quantity and quality in the power end. Add oil if the dipstick shows that the level is low. Change the oil under the following conditions:
   - If it is contaminated. A milky white appearance indicates the presence of water. A high oil level can also be a sign of contamination.
   - If it is not right for the existing ambient temperatures. Use the heaviest grade of oil possible, making sure that the pour point is at least 10°F (-12.2°C) below the anticipated overnight low temperature in your area.

   Important **Do not mix different types of oil.**

2. Check the dirt alarm indicator on both the Schroeder strainer and filter. The dirt alarm is a red indicator that will pop up in the sight glass on the top of the strainer and filter head. To reset the dirt alarm, press the button at the base of the sight glass.
3. Check the oil quantity and quality in the plunger lubricator reservoir. Add an approved rock drill oil if the sight glass shows that the level is low. Change the oil under the following conditions:
   - If it is contaminated. A milky white appearance indicates the presence of water.

   Important **Do not use motor oil to lubricate plungers and packing. Generally, it is more expensive than rock drill oil, and packing life is shortened.**

4. Open the plunger lube shut-off valve.
5. In cold weather, warm up the power end by circulating engine coolant through the heat exchanger. The oil temperature should be 40°F (4.4°C) or higher before the pump is put into operation.

Maintenance During the Job

1. As the pump is put into operation, watch the gauges. At operating speeds, the oil pressure should be 80 to 100 psi (0.552 to 0.689 MPa) with the Schroeder filter/strainer system. At idle (190 worm rev/min), oil pressure with the Schroeder system may drop to 35 to 40 psi (0.241 to 0.276 MPa). Do not operate the pump at this oil pressure for any extended period.
2. Keep the discharge pressure below the maximum working pressure for the fluid-end size being used (refer to Table 2.1).

Caution **Exceeding the maximum working pressure will overload the power end, which can cause death, severe injury, and equipment damage.**

Table 2.1—Maximum Working Pressure

Size, in. (cm)	Maximum Working Pressure, psi (MPa)
3 3/8 (8.573)	20,000 (137.895)
4 (10.160)	14,000 (96.527)
4 1/2 (11.430)	11,200 (77.221)
5 (12.700)	9,000 (62.053)
6 (15.240)	6,250 (43.092)

3. Periodically check the packing to see if it is leaking or smoking. If it is leaking, tighten the pressure packing by running out the wiper gland nut. This procedure applies to conventional packing arrangements only. If the packing continues to leak, change it.

   If the packing is failing prematurely, check for worn packing bores.

Note Use clean water to break in the packing. In 2,000-psi (13.790-MPa) steps, build to two-thirds maximum operating pressure and maintain this pressure for 20 to 30 minutes while tightening the packing nuts.

Table 2.2 shows the break-in pressures for the various fluid-end sizes. The break-in pressure should not exceed the maximum expected working pressure.

Table 2.2—Packing Break-in Pressures

Fluid End, in. (cm)	Break-in Pressure, psig (MPa)
3 3/8 (8.573)	13,000 (89.632)
4 (10.160)	9,300 (64.121)
4 1/2 (11.430)	7,500 (51.711)
5 (12.700)	6,000 (41.369)
6 (15.240)	4,200 (28.958)

Maintenance After the Job

1. Turn off the plunger lubricator using the shutoff valve.
2. If acid or cement has been pumped, flush the fluid end thoroughly with water.
3. In cold weather, drain the fluid end to keep it from icing by using the drain tool to lift the three suction valves. Remove the discharge manifold at the fluid end to drain the discharge valves.
4. Check the oil quantity and quality in the power end, especially after pumping acid. A high level or milky appearance indicates that the oil is contaminated. Eliminate the source of the contamination and change the oil.
5. Observe dirt alarms on the filter and strainer. If either of the alarms have been activated the unit requires service.

Scheduled Preventive Maintenance

Every Five Jobs (or 10 Hours)

Check the fluid-end valve system

Every 3 Months (or 100 Hours)

Remove the bypass valve or access plate and check the ring gear. If the teeth are being shaved down, the worm gear is cracked. If the gear has turned black, as a result of heat, the teeth are probably severely pitted. In either case, replace the worm and ring gears.

Warning **Do not operate the HT-400™ pump if you detect cracks or if more than 50% of the gear-tooth surfaces are pitted. Operating a pump having cracked or severely pitted gear teeth can result in severe or fatal injury as well as equipment damage.**

Every 6 Months (or 200 Hours)

Change the oil. Flush the power end and heat exchanger with diesel fuel.

Note If you are using synthetic oil such as Mobil SHC-634, you can extend the time between oil changes to 2 years or 1,000 working hours.

Choose the heaviest grade of oil possible. Ensure that the oil pour point is at least 10°F (-12.2°C) below the anticipated low temperature. Replace the Schroeder filter elements and clean the magnetic strainer regardless of dirt alarm indicators. Establish a maintenance cycle that includes performing service every fall and spring to help ensure thorough planned maintenance and to help prepare the pump for more drastic temperature variations.

Lubrication System (Schroeder)

The oil filtering system on most HT-400™ pumps is a Schroeder Brothers strainer and filter system. This system obtains better oil filtration and increases the life of the power end.

Important **Maintain the filtering system properly and regularly.**

Things to Know

- Both the Schroeder filter and strainer have 25-psi (0.172-MPa) differential bypasses built into their heads (see **Figure 2.1**).
- Surface scoring on a gear, crosshead slide, or crankshaft indicates that at some time, the oil was contaminated by abrasive particles. Heat blackening is a sign that the supply of lubricant is or has been inadequate.
- The oil pressure will not decrease if the strainer is dirty. The oil pump is a positive-displacement type and pumps about the same amount of oil, regardless of backpressure. The HT-400™ pump bypass valve is downstream from the strainer; therefore, the bypass determines the oil pressure to the filter.

Dirt Alarm Characteristics

The dirt alarm is not activated until the filter or strainer is almost plugged with dirt.

Note If the pump is started while the power end is cold, the dirt alarm on the strainer may activate when the strainer is not dirty. After the oil warms, and the dirt alarm is reset, the dirt alarm will indicate the true condition of the strainer.

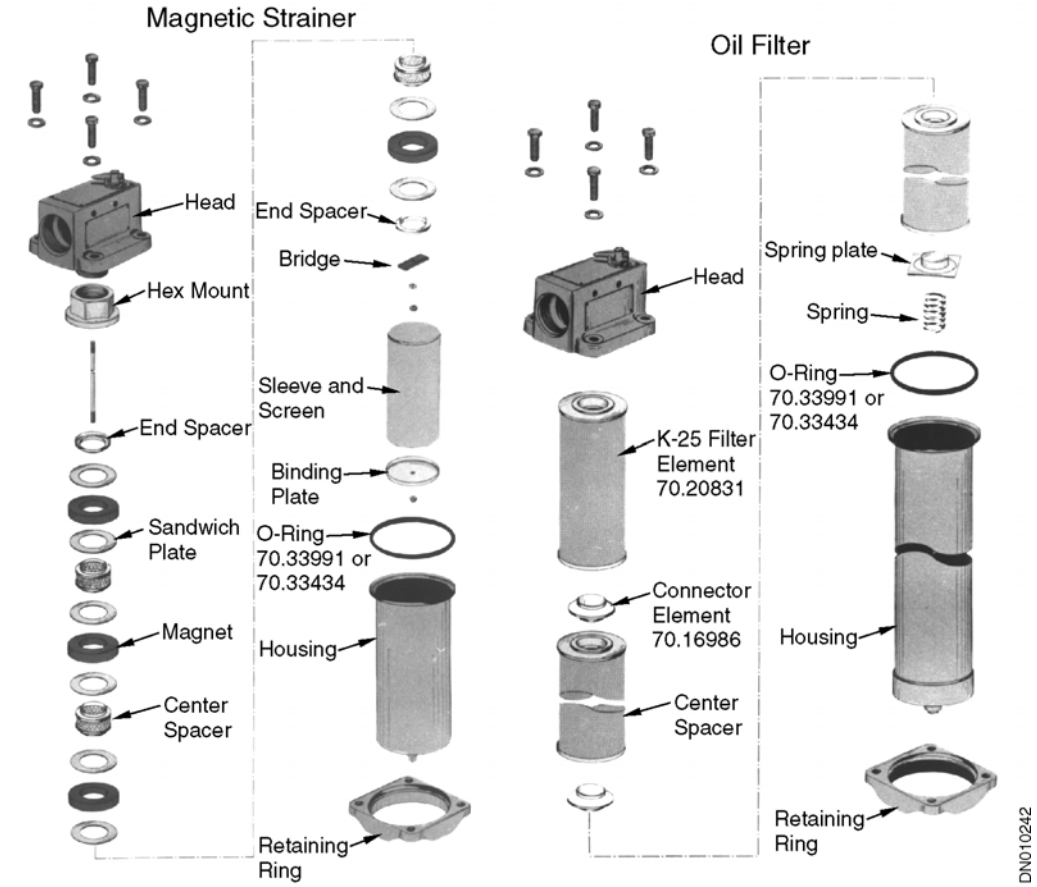


Figure 2.1—Parts for the Schroeder strainer and oil filter

When to Clean the Strainer

Clean the strainer based on the following conditions:

- When the dirt alarm is activated
- When the power-end oil is changed
- Every 6 months, even if the dirt alarm has not been activated

Caution	**Clean the strainer routinely. A dirty strainer will not cause a pressure decrease at the oil-pressure gauge.**

How to Clean the Strainer

1. Drain the oil by removing the plug in the bottom of the strainer housing.
2. Reinstall the plug and remove the housing.
3. Remove the entire magnetic separator from the head by unscrewing it.

Important **Do not take the magnetic separator apart; it is extremely difficult to reassemble.**

4. Wash the magnetic separator and use shop air to blow it as clean as possible. Some small particles may remain on the magnets inside the sleeve and screen, but they should not wash off into the oil system.
5. Wash out the housing.
6. Check the O-ring that seals between the housing and the filter head. Replace the O-ring if necessary.
7. Reassemble the strainer.

When to Change the Filter Elements

Change the filter elements based on the following conditions:

- When the dirt alarm is activated
- When the power-end oil is changed
- Every 6 months, even if the dirt alarm is not activated

Anytime the oil-pressure gauge indicates a 20 to 25-psi (0.138 to 0.172-MPa) drop, change the filter elements to double-check the dirt alarm on the filter (but not the alarm on the strainer).

How to Change the Filter Elements

1. Remove the bottom plug from the housing and drain the oil below the housing flange.
2. Reinstall the housing plug and remove the housing.
3. Disassemble the filter.

Caution **Disassemble the filter carefully. Connectors between the elements and a spring plate and spring must be reused.**

4. Remove the two element connectors, one spring plate, and one spring from the elements.
5. Discard the dirty elements.

6. Wash the housing, element connectors, spring plate, and spring in solvent.
7. Check the condition of the O-ring that seals the housing to the head.
8. Install three new elements in the housing and reassemble the filter.

Safety Precautions

Warning **Failure to follow all precautions could result in serious or fatal injury.**

1. Wear personal protective equipment (PPE). Review the PPE manual for specifications on hard hat, goggles, gloves, steel-toed shoes, etc.
2. Flush the pump to remove any acids or other harmful chemicals that could cause bodily harm if contacted.
3. Carefully bleed pressure from the fluid end. Isolate the pump from pressure and vent the pump to atmosphere before beginning work.
4. Turn off the prime mover (engine or electric motor).

Warning **Never place your hands into the fluid end or spacer area of a pump when the prime mover is on. Serious or fatal injury could result.**

5. Disengage the prime mover from the pump (transmission in neutral) or lock the electric motor to prevent accidental startup.
6. File down or replace parts that have sharp or jagged edges.
7. Use a remote-operated choke to build pressure in a positive-displacement pump (HT-400™, HT-150™, etc.).

Warning **Never use a full-closing valve to build pressure in a positive displacement pump. A sudden overpressure could occur, causing serious injury or equipment damage.**

8. Use care when lifting or moving pump parts.

Caution **Never lift pump parts without assistance. Many of these parts are heavy enough to cause injury if improperly handled. Lift parts with other personnel or use a hoist or other lifting device.**

9. If the pump input shaft is turned by a strap wrench, remove the tool immediately after use.

Caution **Do not start the pump when the tool is still attached to the driveshaft. Serious damage or injury could occur.**

10. Before starting the pump, make sure all discharge valves are open and all protective guards are installed.
11. Never weld on a pressure-containing part (such as a fluid end, discharge flange, etc.).

Troubleshooting

Use **Table 2.3** to help solve basic maintenance problems.

Table 2.3—Troubleshooting Guide

Symptoms	Causes	Possible Solutions
Cylinder-head cover is being hammered.	Displaced suction valve stop.	Replace; check lock springs, and replace if necessary.
	No seal plates installed.	Install seal plate.
	Sand trapped ahead of plunger; fracturing.	Install protective cylinder-head covers.
Discharge flange is leaking.	Damaged seal.	Replace seal.
	Insufficient torque on top tie-bolt.	Retorque to 1,500 ft/lb. (2033.727 N_m).
	Washed-out discharge bore.	Replace fluid-end section.
Fluid end is leaking between sections	Damaged seal.	Replace seal.
	Insufficient torque on top tie-bolt.	Retorque to 1,500 ft/lb. (2033.727 N_m).
	Washed-out discharge bore.	Replace fluid-end section.
Oil is contaminated	Leaking packing.	Repack.
	Leaking plunger nose.	Tighten nose; replace seal if necessary.
Oil filter is clogged repeatedly.	Badly pitted ring gear.	Replace ring gear.
	Cracked worm gear.	Replace worm gear.
	Oil is coking because of extreme heat.	Check condition of heat exchanger. Use heavier grade of oil.
Oil level is down.	Leaking wiper.	Replace wiper seal; center the seal.
	Leaking worm seal.	Replace seal.
Oil level is too high.	Leaking plunger nose seal.	Replace seal; tighten nose.
Oil pressure is low.	Bypass stuck open.	Disassemble and clean bypass valve; check condition of spring.
	Clogged heat exchanger, oil-side.	Clean heat exchanger.
	Clogged oil filter.	Replace elements; clean strainer.
Oil pressure is low.	Leaking injector seal.	Replace seal.
	Leaking O-ring cup seal on crankshaft.	Replace O-rings.
	Wrong size bearings on crank throws.	Check ID plate on pump; verify bearing part number, replace if necessary.
Oil pressure is high at low speed.	Bypass stuck closed.	Check spring; clean bypass if necessary.

Table 2.3—Troubleshooting Guide (Continued)

Symptoms	Causes	Possible Solutions
Oil temperature is too high.	Clogged crosshead lube system.	Clean system.
	Fouled heat exchanger, water-side.	Clean heat exchanger.
	Insufficient coolant supply.	Check for leaks, clogging.
	Low oil pressure.	Check oil supply, pump speed, oil pump.
	Wrong oil in power end.	Replace oil.
	Clogged lubricator line.	Clean.
Packing is smoking.	Pressure-locked pressure packing.	Repack.
	Stuck check valve.	Clean.
Packing life is short.	Clogged lubricator line.	Clean.
	Damaged plunger finish.	Replace plunger.
	Packing not broken in.	Follow break-in procedure.
	Stuck check valve.	Clean.
	Worn packing bore.	Replace fluid-end section or replace sleeve.
	Excessive crosshead clearance.	Reshim crosshead.
Priming is difficult.	Broken valve spring.	Replace.
	Leaking suction manifold.	Check O-ring under suction header for loose connection.
Pump is running rough.	Badly worn or cut valve(s).	Replace valve(s).
	Badly worn or cut valve seat(s).	Replace seat(s).
	Broken valve spring(s).	Replace.
	Leaking suction manifold.	Check O-ring under suction header for loose connection.
	Reversed cone-shaped spring-No. 5 valve.	Replace.
	Reversed retainer, old style.	Replace.
	Pumped-out discharge valve seat(s).	Replace.

Power-End Lubricants

Table 2.4—AGMA #7S Synthetic (ISO Viscosity Grade 460)*

Manufacturer	Brand Name	Pour Point, °F (°C)
Chevron/Texaco	Chevron Clarity Synthetic PMO 460	-33 (-36)
Chevron/Texaco	Texaco Pinnacle 460	-20 (-29)
Cognis Corporation	Emgard 2843 Synthetic WGL	-30 (-34)
Kestone/Total Fina Elf	KSL-460 Sythetic Lubricant	-40 (-40)
ExxonMobil	Mobil SHC634 Synthetic Lubricant	-44 (-42)

*1. This list supersedes lists dated before July 2006, including any in pump manuals.
2. Change oil more frequently when the operating temperature exceeds 175°F.
3. Consult the Halliburton Energy Services Duncan Technology Center before using lubricants not listed
4. Mixing conventional lubricants with synthetics reduces effectiveness. No sludge emulsion is formed.

Table 2.5—AGMA #8 Compound (NON-E.P.) (ISO Viscosity Grade 680)*

Manufacturer	Brand Name	Pour Point, °F (°C)
Amoco	Cylinder Oil 680	15 (-9)
Behnke Lubricants Inc.	Jax Super Cylinder	30 (-1)
Bel-Ray Company, Inc.	Steam Cylinder Oil 150	5 (-15)
Bel-Ray Company, Inc.	No-Tox Worm Gear Lube (Food Grade H1) Oil ISO 680	5 (-15)
Chevron Products Co.	Cylinder Oil W-ISO #680	10 (-12)
Citgo Petroleum Corp.	Cylinder Oil #680-7	15 (-9)
Conoco Inc.	Inca Oil #680	30 (-1)
Engineered Lubricants	Enlubol SCO-3400	15 (-9)
Exxon Co.	Cylesstic TK 680	20 (-7)
Fiske Brothers Refining	*Lubriplate SPO-288	20 (-7)
Imperial/Esso Oil	Cylesso TK 680	37 (3)
Mobil Oil Corp.	600W Super Cyl. Oil	20 (-7)
Phillips 66 Co.	Hector 630-S	10 (-12)
Schaeffer Mfg. Co.	#147 Steam Cylinder Oil	10 (-12)
Shell Oil Products Co.	Valvata J-680	20 (-7)
Texaco Lubricants Co.	Vanguard 680	20 (-7)

*1. This list supersedes lists dated before July 2006, including any in pump manuals.
2. Change oil more frequently when the operating temperature exceeds 175°F.
3. Consult the Halliburton Energy Services Duncan Technology Center before using lubricants not listed
4. Mixing conventional lubricants with synthetics reduces effectiveness. No sludge emulsion is formed.

Table 2.6—AGMA #8A Compound (NON-E.P.) (ISO Viscosity Grade 1000)*

Manufacturer	Brand Name	Pour Point °F (°C)
Amoco	Cylinder Oil 1000	15 (-9)
BP Oil	Energol DC-C 1000	6 (-14)
Behnke Lubricants Inc.	Jax Super Cylinder	15 (-9)
Bel-Ray Company, Inc.	Steam Cylinder Oil 250	10 (-12)
Bel-Ray Company, Inc.	No-Tox Worm Gear Lube (Food Grade H1) Oil ISO 1000	5 (-15)
Chevron Products Co.	Cylinder Oil W-ISO #1000	10 (-12)
Conoco Inc.	Inca Oil #1000	35 (2)
Engineered Lubricants	Enlubol SCO-193 Comp.	15 (-9)
Exxon Company	Cylesstic TK 1000	30 (-1)
Fiske Brothers Refining	Lubriplate CP-8A	35 (2)
Imperial/Esso Oil	Cylesso TK 1000	37 (3)
Mobil Oil Corp.	Extra Hecla Super Cyl. Oil	30 (-1)
Texaco Lubricants Co.	Vanguard 1000	25 (-4)

*1. This list supersedes lists dated before July 2006, including any in pump manuals.
2. Change oil more frequently when the operating temperature exceeds 175°F.
3. Consult the Halliburton Energy Services Duncan Technology Center before using lubricants not listed
4. Mixing conventional lubricants with synthetics reduces effectiveness. No sludge emulsion is formed.

Packing Lubricants

Note — This list supersedes lists dated before July 2006, including those in pump manuals.

Table 2.7—Packing Lubricants

Company	Product	Pour Point °F (°C)	Lube Selector by Outside Temp. °F (°C)		
			Above 50 (10)	50 to 20 (10 to -6.7)	Below 20 (-6.7)
CHEVRON	Vistac - Grade 320X	16 (-8.9)	X	—	—
	Vistac - Grade 220X	5 (-15)	X	—	—
	Vistac - Grade 150X	5 (-15)	X	X	—
	Vistac - Grade 100X	0 (-17.8)	—	X	X
	Vistac - Grade 68X	-11 (-23.9)	—	—	X
CONOCO	EP Rock Drill Grade 17	-5 (-20.6)	—	—	X
	EP Rock Drill Grade 49	+10 (-12.2)	X	X	—
	EP Rock Drill Grade 78	+10 (-12.2)	X	—	—
DA Lubricants	Plunger Fluid-Std	-20 (-28.9)	X	X	X
	Plunger Fluid-Lo Temp	-65 (-53.9)	—	—	X
EXXON	Arox EP 46	-30 (-34.4)	—	—	X
	Arox EP 150	-20 (-28.9)	X	X	—
SHELL Shell Oil Co.	Torcula 32	-50 (-45.6)	—	—	X
	Torcula 100	-20 (-28.9)	X	X	—
	Torcula 320	-10 (-23.3)	X	—	—
TEXACO Texaco, Inc.	Aries 46	-20 (-28.9)	—	—	X
	Aries 100	-15 (-26.1)	X	X	—
	Aries 320	15 (-9.4)	X	—	—

Section
3

HT-400™ Pump Power-End Overhaul

Introduction

The pump used to illustrate disassembly and assembly procedures in this section is a right-hand case, 8.6:1 Holroyd gear set pump with an L-4 spacer. Other illustrations and instructions have been added to cover the repair procedures required for all configurations of the HT-400™ pump power end.

Disassembly Procedures

Pump Preparation

1. Remove the fluid end from the power end.
2. Drain oil from the power-end case.
3. Disconnect the driveshaft from the companion flange.
4. Disconnect the lube system supply hose from the strainer assembly and the lube system suction hose from the bottom of the worm housing.
5. Disconnect the packing oil lines and the sending unit wires from the plunger lubrication pump.
6. Remove the power end from the unit.
7. Secure the power end on a rotating pump stand.
8. Remove the external oil lines, gauges, oil filter, strainer, and bypass assemblies.
9. Remove the gear housing cover plate, connecting rod access covers, ring gear inspection plate, and the long and short crosshead slide covers.

L Spacer

1. Remove all three push rod adapters (nose adapters) (Figure 3.1).

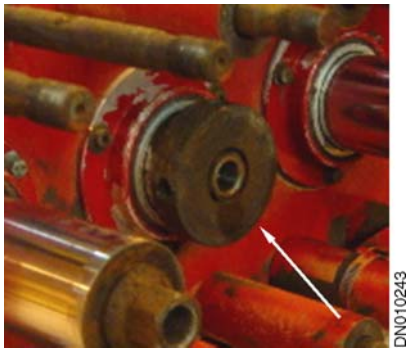


Figure 3.1—Push rod adapter

2. Remove all three push rod retainers (Figure 3.2).



Figure 3.2—Push rod retainer removal

3. Remove all three push rods (Figure 3.3).
4. Break the seal between the power end and spacer, and remove the spacer assembly.
5. Remove the fluid-end attaching studs with a pipe wrench and cheater bar.



Figure 3.3—Push rod removal

Connecting Rod and Crossheads

1. Break loose all three tie rods and leave them in the crossheads (Figure 3.4).
2. Working on one connecting rod/crosshead assembly at a time:
   a. Rotate the input shaft of the pump until the rod end cap of the connecting rod you are working with is inline with the connecting rod access opening in the pump case.
   b. Cut the safety wire securing the connecting rod cap bolts and remove the connecting rod cap bolts (4 per rod) (Figure 3.5).
   c. Remove the connecting rod cap through the inspection opening.



Figure 3.4—Loosened tie rods in crossheads



Figure 3.5—Removing cap bolts

3. Use the tie rod to pull the crosshead out far enough to expose the wristpin. You may need to guide the connecting rod from the inspection opening to prevent it from becoming hung up on the crosshead slide (Figure 3.6).



Figure 3.6—Pulling the crosshead out

4. Remove the wristpin retaining bolt and cup washers (**Figure 3.7**).



Figure 3.7—Removing wristpin retaining bolt and cup washers

5. Remove the wristpin from the crosshead/connecting rod. The crosshead wristpin has an interference fit with the crosshead. To remove it, the wristpin can be driven out using a large punch or it can be pressed out with the crosshead/connecting rod removed from the pump case (**Figure 3.8**).



Figure 3.8—Hammering out the wristpin

6. Remove the crosshead from the connecting rod (**Figure 3.9**).

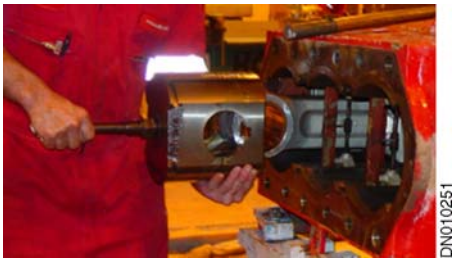


Figure 3.9—Removing the crosshead

7. Remove the connecting rod from the case (**Figure 3.10**).
8. Number the crossheads and connecting rods (No. 1 is closest to the ring gear).

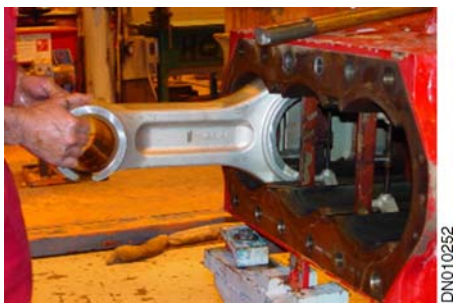


Figure 3.10—Removing the connecting rod

9. Repeat Steps 2–8 for the two remaining crosshead/ connecting rod assemblies (**Figure 3.11**).



Figure 3.11—Connecting rod assemblies removed

10. Check the connecting rods. Replace any rod if any of the following conditions are present:
    - The rod has been blackened by heat.
    - The rod is cracked (a dye penetrant process can be used to locate cracks).
    - The dowel in the cap has been sheared and the bearing has been turning in the connecting rod.
11. Blow air through the drilled oil passages in the connecting rods to ensure that they are clear.
12. Check the bearings. Replace the bearings if any of the following conditions is present:
    - The bearings are blackened or scored.
    - The dowel holes in the bearings are egg-shaped.
    - The connecting rods have been replaced.
13. Inspect the crosshead shoes. If they are badly scored, replace them.
14. Examine the pin bores of the crossheads. If a crosshead is cracked or a bore is worn larger than 3.501 in. (8.89 cm), replace the crosshead. Use magnetic particle inspection to locate small cracks.
15. Measure the crosshead-pin bushing. If the clearance between the pin and bushing is more than 0.012 in. (0.03 cm), replace it.
16. To determine whether the pin or bushing is defective, compare the OD of a new pin [3.499 to 3.500 in. (8.887 to 8.890 cm)] to the ID of a new bushing installed in a connecting rod [3.505 to 3.506 in. (8.903 to 8.905 cm)]. If the pump is being overhauled because of age, you will likely have to replace both the pin and the bushing.

Crosshead Slides and Supports

1. Cut off the stovepipe wire securing the crosshead slide clamps. Work from front-to-back to avoid being scratched or cut by the ends of the stovepipe wire (Figure 3.12).



Figure 3.12—Cutting the stovepipe wire

2. Install crosshead aligning jacks (Part No. 316.1197) in through the large crosshead opening (Figure 3.13).



Figure 3.13—Installing aligning jacks

3. Set up the crosshead aligning jack so that the top bar prevents the top slides from falling while the slide clamps are removed, but is still loose enough to allow the slides to be pulled out when the clamps are removed (Figure 3.14).

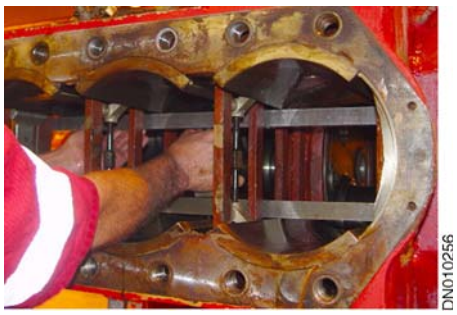


Figure 3.14—Setting up the crosshead aligning jack

4. Remove the inboard slide clamps. Once the pressure caused by the inboard clamps is relieved, the top slides will be free to move enough to remove the outboard slide clamps (**Figure 3.15**).



Figure 3.15—Removing the inboard side clamps

5. Remove all three top crosshead slides (**Figure 3.16**). Write down notes regarding the slide shims behind the face of each slide; these notes will provide a starting point during reassembly.
6. Remove the crosshead aligning jack back through the long crosshead opening, then remove the lower crosshead slides and shims. Again, take notes regarding the number of shims and their locations.
7. Inspect the slides. If they are scored or corroded, replace them.



Figure 3.16—Removing the crosshead slides

Worm Gear

1. Rotate the power-end case 90° with the ring gear facing up.
2. Prevent the worm gear from turning (Figure 3.17).



Figure 3.17—Preventing the worm gear from turning

3. If the pump is equipped with a worm gear driven recirculating plunger lube system, remove the plunger lube recirculating pump, the pump to thrust plate adapter, and thrust bearing retainer plate.

   The lube pump adapter can be removed from the lube pump by loosening the set screw in the adapter (Figure 3.18). If the pump is equipped with a worm gear driven power-end lube pump or thrust plate, remove it. Make a note of the number of shims under the thrust bearing retainer plate or lube pump.

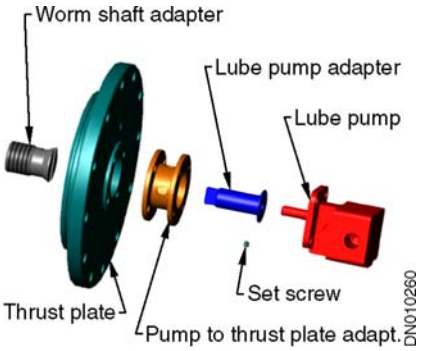


Figure 3.18—The plunger lube recirculating pump, the pump to thrust plate adapter, and thrust bearing retainer plate makeup

4. Remove the worm shaft adapter from the thrust end of the worm gear (**Figure 3.19**).
5. Remove the first thrust race and first roller assembly of the worm thrust bearing stack.
6. Bend back the locking tab(s) on the worm gear thrust-end lock nut star washer. Remove the worm gear thrust-end lock nut and star washer.



Figure 3.19—Removing the worm shaft adapter

7. Using a puller secured by 5/16-in. screws, remove the bearing bushing along with the remainder of the thrust bearing assembly and the worm-thrust bearing key (**Figure 3.20**).
8. Remove the worm shaft thrust end bearing.



Figure 3.20—Removing the bearing bushing, remainder of the thrust bearing assembly, and the worm-thrust bearing key

9. Remove the worm-thrust-end bearing retainer using screws threaded into the retainer housing (**Figure 3.21**).



Figure 3.21—Removing the worm-thrust-end bearing retainer

10. Carefully remove the worm gear. Be sure to have it fully supported before completely removing it from the power-end case (**Figure 3.22**).
11. Remove the oil seal retainer cover (**Figure 3.23**).
12. Remove the worm-drive-end bearing retainer and drive-end worm-shaft bearing assembly (**Figure 3.24**).



Figure 3.22—Removing the worm gear

13. Check the clearance of the drive-end bearing. Fit the bearing on the race, which is still on the worm gear. If a 0.010-in. (0.03-cm) feeler gauge fits under at least three of the rollers, replace the bearing.
14. If the drive-end bearing does not have excessive clearance, inspect it. If the rollers or races are badly spalled, replace the bearing.
15. Inspect the drive-end bearing race (on worm gear). If the bearing or the oil seal has damaged it, remove the race.



Figure 3.23—Removing the oil seal retainer cover

16. Check the clearance of the thrust-end bearing. Fit the bearing on the race (on the worm gear). If a 0.010-in. (0.03-cm) feeler gauge can be positioned under at least three rollers, replace the bearing.
17. If the thrust-end bearing does not have excessive clearance, inspect it. If the rollers or races are badly spalled, replace the bearing.
18. Inspect the thrust-end bearing race. If it is pitted, remove it by expanding it with heat.



Figure 3.24—Removing the worm-drive-end bearing retainer and drive-end worm-shaft bearing assembly

19. To remove the bearing races from the worm-gear-thrust end and drive end, heat them evenly and let them fall off the gear shaft (**Figure 3.25**).

Note	Do not reuse bearings removed in this manner.



Figure 3.25—Heating the bearing races

20. Inspect the thrust bearing. If the rollers or races are badly spalled, replace the entire thrust bearing. If the bushing is damaged, replace it. Always replace the key.

21. Inspect the worm gear. If possible, use magnetic particle inspection to check for invisible cracks. Check for wear and corrosion. Replace cracked, worn, or corroded worm gears. If the ring gear is being replaced, replace the worm gear.

Ring Gear and Ring Gear Support

1. Remove the cotter pin and the hex slot nut from the center of the crankshaft thrust retainer spider (**Figure 3.26**). Cut the stovepipe wire and remove the spline drive cap screws from the outside of the spider.



Figure 3.26—Removing the spline drive cap screws from the outside of the spider

2. Remove the spider, the spider spacer bushing, and the crankshaft axial positioning shims (**Figure 3.27**). Make note of the number of shims used.



Figure 3.27—Removing the spider, spider spacer bushing, and crankshaft axial positioning shims

3. Cut and remove the stovepipe wire securing the gear clamp mounting ring cap screws. Remove the cap screws and the left-hand gear bearing clamp washers w/mounting ring (**Figure 3.28**).



Figure 3.28—Removing the cap screws and the left hand gear bearing clamp washers w/ mounting ring

4. Remove the gear spline drive flange (umbrella) (Figure 3.29).

   Then for **right-hand only**, remove the clamp ring adapter.



Figure 3.29—Removing the gear spline drive flange (umbrella)

5. Cut and remove the stovepipe wire, the cap screws, and the gear bearing thrust ring (Figure 3.30). Remove the shims from under the thrust ring and note the total number of shims.



Figure 3.30—Removing the gear bearing thrust ring

6. Remove the first gear-support-bearing thrust bearing and race (Figure 3.31).

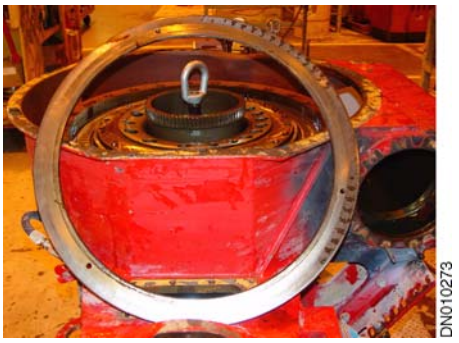


Figure 3.31—Removing the first gear support bearing thrust bearing and race

7. Remove the ring gear and the second thrust bearing (Figure 3.32).
8. Check the ring gear, and if any of the following conditions exists, replace the gear set to avoid further damage to the power end:
   - Teeth shaved down by a cracked worm gear
   - Badly pitted teeth blackened by heat
   - Oil filter chronically clogged by bronze chips
9. If you are disassembling a right-hand pump, remove the gear bearing clamp lugs that are retaining the gear support bearing in the ring gear.
10. Support the ring gear (splined-side down) with lifting eyes attached to chains that meet at a swivel so that the ring gear can be spun while remaining in a stationary location. Spin and heat the ring gear with a rosebud-tipped torch until its expansion releases the gear support bearing. (can take up to 30 min) (Figure 3.33).



Figure 3.32—Removing the ring gear

Caution **Take all safety precautions with the open flame and be aware that the support bearing will drop out without warning.**



Figure 3.33—Heating the spinning ring gear to release the gear support bearing

11. Remove the inner-gear-support-bearing thrust bearing (Figure 3.34).



Figure 3.34—Removing the inner-gear-support-bearing thrust bearing

12. Install lifting eyes in the inner-gear-support-bearing thrust race. Apply tension to the lifting eyes and evenly heat the gear-support-bearing radial race. Once the radial race releases, lift out both races (Figure 3.35).



Figure 3.35—Apply tension to the lifting eyes and evenly heat the gear-support-bearing radial race

13. Remove the screws securing the ring gear bearing support (Figure 3.36).



Figure 3.36—Removing the screws that secure the ring gear bearing support

14. Remove the bearing support and the shims underneath the support (Figure 3.37). Note the number of shims used.



Figure 3.37—Removing the bearing support and shims underneath

Crankshaft

1. Before removing the crankshaft, check the clearance of the four main bearings. The outboard mains are accessible from the ends. The inboard mains, as well as the outboard mains, are accessible through the access holes in the back of the case. If the entire length of a 6-in. × 0.012-in. (15.24 × 0.03-cm) feeler gauge fits between the roller and the outer race of any of the main bearings, replace all the main bearings.
2. Carefully lift and remove the crankshaft assembly and the crankshaft spline drive coupling (**Figure 3.38**).
3. If the main bearing clearance is within specification inspect the bearings for badly spalled rollers, broken cages, and worn rivets. Inspect the four main bearing races in the case. If the races are badly pitted, replace all the main bearings and their races. If the races have worn into the race washers that secure them, remove the races and check the bores.
4. If the main bearings were out of specification you will need to replace them along with the races still in the case.
5. To remove the crankshaft main bearings, remove the bearing retainer bolts and washers from the crankshaft (**Figure 3.39**).

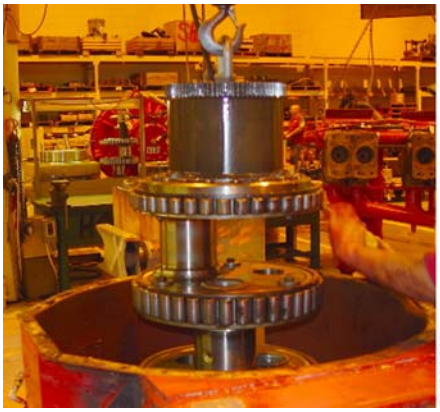


Figure 3.38—Removing the crankshaft assembly and crankshaft spline drive coupling

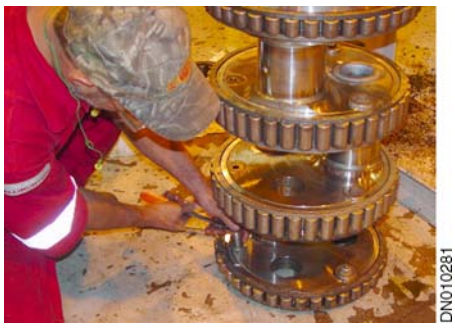


Figure 3.39—Removing the crankshaft main bearing retaining bolts and washers

6. Evenly heat the main bearings with a rosebud tipped torch (Figure 3.40). Use a brass hammer to tap the bearings when they fall and become misaligned with the lower main journals.

Caution **Be aware that the bearings will drop unexpectedly.**

7. To remove the crankshaft main bearing races, remove the twelve outer race washers.
8. Drive the races and the outer retaining ring from either end of the power-end case.
9. Measure the main bearing bores with a micrometer. A bore is oversized if it measures more than 17.004 in. (43.19 cm). If a bore is oversized, the race has been turning in the case and not creeping. (Races that creep prevent wear from being concentrated in one area.) Make note of oversized bores; oversized bores found in shop facilities must be knurled to new dimensions.
10. Pull the magnetic seal bushing from the injector end of the crankshaft.



Figure 3.40—Heating the main bearings to remove them

11. Inspect the crankshaft.
    a. If the journals are badly scored, replace or regrind the crank.
    b. If the journals are in good condition, measure them with a micrometer, comparing readings to 5.125 in. (13.0175 cm), which is the diameter of new crankshaft journals.
        - Replace or regrind the crankshaft if any of the journals are undersized more than 0.006 in. (0.015 cm) or out-of-round more than 0.003 in. (0.008 cm).
        - Replace the crankshaft if cracks are discovered. Cracks are sometimes found radiating from the drilled oil holes in the journals.

Final Disassembly

1. Finish disassembly of the pump case by removing the inside gear housing baffle (cover plate under the ring gear) and any other brackets or mounts that may still be on the pump case.

Assembly Procedures

Refer to **Table 3.8 (Page 3-51)** for torque values when assembling the HT-400™ pump power end.

Crankshaft

1. Apply a cylindrical assembly retaining compound such as **Loctite® 638** to the outside of the **insulator and counter-drive magnetic seal bushing** (PN 100002821, **Figure 3.41**) and drive it into the injector side of the crankshaft (**Figure 3.42**).



Figure 3.41—Retaining compound applied to PN 100002821 (insulator/counter-drive magnetic seal bushing)

Figure 3.42—Driving the insulator and counter drive magnetic seal bushing into the crankshaft

2. Lubricate the **magnetic seal** (PN 100013035) and push it into the brass seal bushing, small end first (**Figure 3.43**).



Figure 3.43—Pushing the lubricated magnetic seal (PN 100013035) into the seal bushing

3. Install the **retaining ring** (PN 100028033) to secure the magnetic seal in the brass bushing (Figure 3.44).



Figure 3.44—Installing retaining ring (PN 100013035)

For Early-style Crankshafts

1. Install **seal retainer cups** (PN 100058096) with **O-rings** (PN 100015415) and secure them with the **seal retainer cap screws** (PN 100058097) (Figure 3.45a).
2. The outside of the spline drive rod journal uses a **plug** (PN 100058099) rather than a cup because of clearance with the spline drive. Use **RTV silicone sealer** to seal the plug (Figure 3.45b).



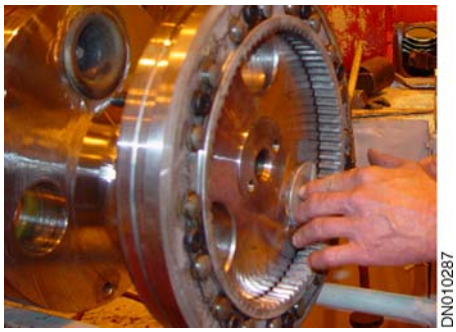


Figure 3.45(a)—Installing seal retainer cups (b) Installing outside rod journal plug

3. Evenly heat the crankshaft main bearings to 200°F.
4. Stand the crankshaft up on the spline drive side (Figure 3.46) and perform the following:
   a. Wearing hot-work gloves, slide the evenly heated **main outboard bearing** (thin bearing, PN 100058283) down and over the crank main journals until it reaches the final journal.
   b. Line the oil hole in the bearing 180° from the oil hole in the crank journal. Make sure the inner race is completely seated against the splined drive flange before the bearing race cools.
   c. Once cooled, secure the bearing with the **inner race retainer washers** (PN 100058233) and **self-locking nuts** (PN 100030907, ½-in 13 NC).



Figure 3.46—Sliding the evenly heated main outboard bearing (thin bearing, PN 100058283) down and over the crank main journals

5. Install the bearing retainer washers on the bottom side of the lower inboard main journal to act as a stop when installing the bearing (Figure 3.47). Perform the following steps:

   a. Slowly guide the evenly heated **inboard bearing** (wide bearing, PN 100058282) over the journals until it seats against the retainer washers (PN 100058095).

   b. Line the oil hole in the bearing 180° from the oil hole in the crank journal. The bearing race will cool quickly once it contacts the crankshaft. Repeat this step for the other inboard main bearing.

   c. Once cooled, install the remaining **bearing retainer washers** by securing them with the **hex cap screws** (PN 100028494, ½-in. 13NC × 3 ½-in.) and **self-locking nuts** (PN 100030907, ½-in. 13 NC).

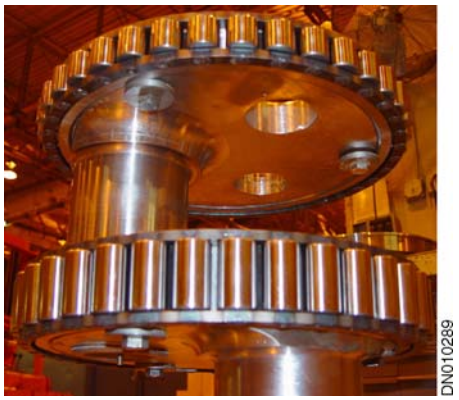


Figure 3.47—Bearing retainer washers on the bottom side of the lower inboard main journal

6. Install the three inner race retainer washers and self-locking nuts (to support the bearing when installed) as follows:

   a. Carefully guide the **bearing** (thin bearing, PN 100058283) over the journal and seat it against the **retainer washers** (PN 100058233).

   b. Line the oil hole in the bearing 180° from the oil hole in the crank journal.

   c. Once the bearing has cooled, secure it with the remaining washers, the **hex cap screws** (PN 100028496, ½-in 13NC x 2 ¾-in) and **self-locking nuts** (PN 100030907, ½-in 13 NC) (Figure 3.48).



Figure 3.48—Installing one of the three inner race retainer washers

7. Install the **crankshaft main outer race washers** (PN 100058709) on one side of an inner main bearing bore to act as a stop when installing the main bearing outer race (Figure 3.49).

   For proper race positioning, install a **.0625-in. flat washer** (PN 101384369; 5/16-in., 1/16-in. thick) under the outer race washers used to secure the outboard outer races (Figure 3.50).



Figure 3.49—Installing the crankshaft main outer race washers on one side of an inner main bearing bore

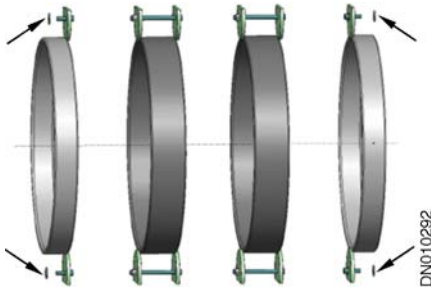


Figure 3.50—Installing .0625-in. flat washer (PN 101384369) under the outer race washers

8. Install the main bearing outer races as follows:

   a. Apply a generous and even amount of cylindrical assembly retaining compound such as **Loctite 638** to the mating surface of the main outer race bearing bore (**Figure 3.51**).



Figure 3.51—Applying cylindrical assembly retaining compound

   b. Before installing the bearing races, reduce their diameter by placing them in a deep freezer (**Figure 3.52**).



Figure 3.52—Reducing diameter of bearing races by placement in a deep freezer

   c. Using hot-work gloves or a rag to protect your hands from frostbite, slowly guide the bearing race to the subject bearing bore (**Figure 3.53**). Once the bearing is in place, it will gain diameter quickly so make sure it is aligned correctly in the main bearing bore. Install the two remaining crankshaft main outer race washers and secure them with the **retainer cap screws** (PN 100058266) and **elastic stop nut** (PN 100026483; 5/16-in., 18-NC × 1 in.).

   d. Repeat this process for the remaining inner main bearing race followed by the outer races. Secure the outer races with a hex socket screw and lock washer. Repeat this process for the other inboard main bearing outer race.



Figure 3.53—Guiding the bearing race to the subject bearing bore

9. Install the **outboard crankshaft bearing race retainer ring** (PN 100058274) with the space toward the top of the case (Figure 3.54).

10. Install the **oil injector cover plate** (PN 100058237) and **gasket** (100009528) and secure with **5/16-in. screws** (PN 100028435; 5/16-in. 18NC x ½-in hex cap screws) and **lock washers** (100009677). Install the **long crosshead cover** (PN 100058273) and **gasket** (100011698).

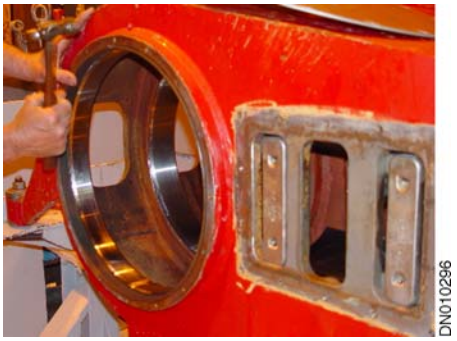


Figure 3.54—Installing the outboard crankshaft bearing race retainer ring (PN 100058274)

Because the crosshead cover screw holes are drilled into the case, use a **seal washer** (PN 100013115, 5/16-in.) under a **flat washer** (PN 100029873, 5/16-in.) with the 5/16-in. screws. It is also advisable to seal the threads with an **RTV silicone** to prevent possible oil seepage. Index the injector cover as shown in Figure 3.55.

11. Attach the **flanged crank thrust stud** (PN 100058101) with two **spline drive cap screws** (PN 100058092). After tightening, wire the screws.



Figure 3.55—Indexing of the injector cover

12. Attach a lifting eye to the flanged stud and the crankshaft into the power-end case. Be careful lowering the crankshaft into the case, allowing the bearings to line up with the already installed bearing races (Figure 3.56). The crank will rest on the oil injector cover plate until the flanged stud is pulled up to the crankshaft spider later in the assembly.



Figure 3.56—Lowering the crankshaft into the case

Ring Gear

1. When the power-end case is being fabricated and machined, a measurement is taken from the centerline of the worm gear bore to the mounting surface for the bearing support. This number is then stamped on the thrust end of the worm gear housing (Figure 3.57).

   The paint may need to be sanded off the power-end case to make the numbers legible. Take care not to remove any metal and obscure the stamping.

   Two numbers are stamped at this location. One is a number between 12.450 and 12.500 (used for worm thrust alignment). For ring gear alignment, you need the other number, which is between 3.160 and 3.311.

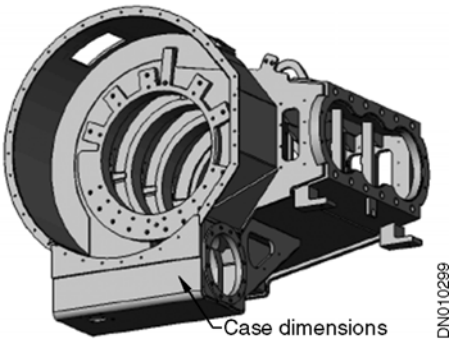


Figure 3.57—Numbers stamped on the thrust end of the worm gear housing

2. To calculate the number of shims to be used under the bearing support, first use a micrometer to measure the bearing support flange (Figure 3.58). This measurement should be between 0.927 and 0.931 inches.



Figure 3.58—Using a micrometer to measure the bearing support flange

3. Use a micrometer to measure the flange on the ring gear support bearing (Figure 3.59). The measurement should be between 0.3075 and 0.3125 inches.



Figure 3.59—Using a micrometer to measure the flange on the ring gear support bearing

4. Measure the thickness of the flange on the ring gear that the support bearing flange will be mated against (**Figure 3.60**). This measurement should be between 1.874 and 1.876 inches.

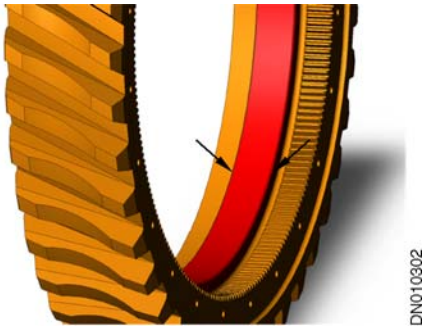


Figure 3.60—Measure the thickness of the flange on the ring gear

5. Measure the diameter of the rollers in the thrust cage bearing (**Figure 3.61**). They should be 0.500-in.
6. Measure the thickness of the thrust bearing race. It should be 0.500-in.
7. Use the measurement values taken in Steps 2 through 6 to calculate the bearing stack height, which is the distance from the bottom of the bearing support to the centerline of the ring gear:



Figure 3.61—Measure the diameter of the rollers in the thrust cage bearing

Bearing stack height =

$$Bearing\ Support + \frac{Gear\ Thickness}{2} + Bearing\ Lip + Bearing\ Roller + Bearing\ Race$$

Total shims =

$$Case\ Dimension - Bearing\ Stack \pm Offset\ *$$

***Offset Determination**

Gear Ratio	Hand	Offset
8.6	Right	+0.045
8.6	Left	-0.045
8.4	Right	+0.040
8.4	Left	-0.040

8. Install the required number of shims on the power-end case mounting surface for the ring gear bearing support.
9. Using three lifting eyes, install the **ring gear bearing support** (PN 100058112). Two of the holes will not line up with the tapped holes in the case, this is intended.
10. Torque the bearing support screws 50 ft-lb (67.8 N-m) if using a molybdenum-based thread lubricant and 100 ft-lb (135.6 N-m) if using oil for a thread lubricant (Figure 3.62). (**Hex socket screw**: ½-in. 13NC × 1 1/4-in., PN 100028247; **lock washer**: ½-in., PN 100029934).



Figure 3.62—Torque the bearing support screws

11. Install the ring gear thrust bearing race bevel-side down toward the bearing support (Figure 3.63). (Gear support bearing PN 100058122).



Figure 3.63—Installing the ring gear thrust bearing race

12. Heat the inner gear support bearing race to approximately 200°F. Lightly oil the inside surface of the race and install it on the bearing support (Figure 3.64).



Figure 3.64—Lightly oil the inside surface of the race and install it on the bearing support

13. Lubricate the thrust cage bearing for the gear support bearing and install it on the race (Figure 3.65). The thrust cage bearing is included with the gear support bearing but can also be purchased separately if needed (PN100058120).



Figure 3.65—Lubricate the thrust cage bearing for the gear support bearing and install it on the race

14. Ensure that the mating surfaces of the ring gear support bearing and ring gear are clean and free of debris. With the gear evenly heated to 200°F, carefully lower the gear support bearing into the ring gear (Figure 3.66).
    - **Left-hand pump**: Install the gear support bearing into the ring gear with the gear's splined side up.
    - **Right-hand pump**: Install the gear support bearing into the ring gear with the gear's splined side down.



Figure 3.66—Lowering gear support bearing into the ring gea

Right-Hand Case Only

1. Install the gear bearing clamp lugs PN 100058129). The lugs should be joined by a 95-in. long piece of 1/8-in L-61 welding rod. When tightening the cap screws (PN 100058111), try to line up wiring holes to ease the process of safety wiring (**Figure 3.67a**).
2. Wire the cap screws together, using 19-gauge stovepipe wire. Run wire continuously through all screws and then back the other direction on the outside of the screws. At the starting point, cut the wire from the source and twist the ends together. Between each screw head, twist the wires together from the midpoint (**Figure 3.67b**).

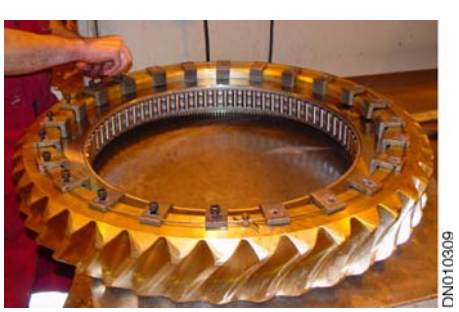




Figure 3.67(a)—Installing gear bearing clamp lugs (b) Wiring cap screws together

15. Using three lifting eyes, install the ring gear, splined-side up (**Figure 3.68**).



Figure 3.68—Installing the ring gear

16. Lubricate and install the thrust cage bearing followed by the outer race (bevel-side up) (Figure 3.69).



Figure 3.69—Installing the thrust cage bearing and outer race

17. Check the standoff between the gear support and thrust bearing race (Figure 3.70). Install enough shims to make the clearance between 0.000 and 0.003 inches (refer to Table 3.1).

Table 3.1—Gear Support Bearing Clearance Shims

Part No.	Shim Size, in.
100058117	0.003.
100058118	0.005
100058119	0.010
100058121	0.020

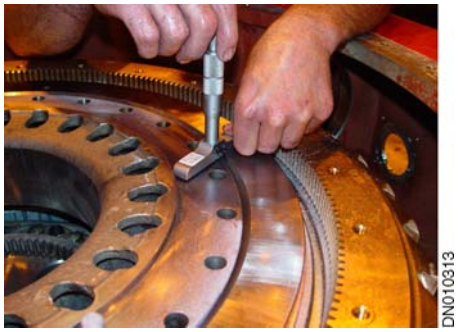


Figure 3.70—Checking the standoff between gear support and thrust bearing race

18. Install the **gear bearing thrust ring** (PN 100058123) and tighten the **worm housing cap screws** (PN 100011699) (Figure 3.71).

Note — Two of the holes will not line up with the threaded holes in the bearing support, this is intended.



Figure 3.71—Installing the gear bearing thrust ring

19. Mount a dial indicator to the case with the indicator pin against the ring gear (Figure 3.72).

    Pry up on the gear and check the clearance. If the clearance is not 0.002 to 0.003 inches, repeat the shimming procedure.

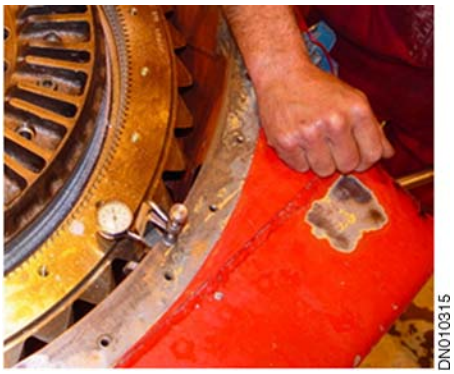


Figure 3.72—Mount a dial indicator to the case with the indicator pin against the ring gear

20. If using a molybdenum-based thread lubricant, torque the cap screws to 60ft-lb (81.4 N-m). If using oil on the threads, torque to 120 ft-lb (162.7 N-m) (Figure 3.73).

21. Wire the cap screws together with 19-gauge stovepipe wire.

Right-Hand Case Only

Install the **clamp ring adapter** (PN 100058128) onto the flange below the splines on the ring gear.



Figure 3.73—Torque the cap screws

22. Lower the gear spline drive over the gear bearing thrust ring (Figure 3.74). Mesh the teeth on the outside of the flange (PN 100058127) with the teeth on the inside of the ring gear.



Figure 3.74—Lowering the gear spline drive over the gear bearing thrust ring

23. Secure the **gear spline drive flange** (PN 100058127) with the **outboard gear bearing clamp washers** (PN 100058125–24 required) and **ring mounting gear clamp cap screws** (PN 100058111–24 required). Then wire the cap screws together with 19 Ga. stovepipe wire (Figure 3.75).



Figure 3.75—Secure the gear spline drive flange

24. Install the **crankshaft spline drive coupling** (PN 100058110) through the center of the ring gear assembly. The teeth of the coupling will mesh with the crankshaft on one side and with the gear spline drive flange on the other side (Figure 3.76).

Caution **Be careful of pinch points when lowering the coupling.**



Figure 3.76—Install the crankshaft spline drive coupling

25. Install the **crankshaft thrust retainer spider** (PN 100058107) as follows:

a. Install 0.060-in. of shims (left hand pumps) or 0.120-in. (right hand pumps) on the flanged crankshaft thrust stud (refer to Table 3.2).

Table 3.2—Crankshaft Axial Positioning Shims

Part No.	Shim Size, in.
100058100	0.020
100058104	0.040
100058109	0.060

b. Install the **spider spacer bushing** (PN 100058105) on the thrust stud followed by the crankshaft thrust retainer spider (Figure 3.77).

c. Secure the thrust spider with a **1-in. hex slot nut** (PN 100026544, 1-in. 14 NF) with a **cotter pin** (PN 100027204, 1 ½ × 1/8-in.) and four **spline drive cap screws** (PN 100025092–4 required).

d. Once the cap screws are tightened, wire them together with 19-gauge stovepipe wire.



Figure 3.77—Install the crankshaft thrust retainer spider

Worm Gear

1. Evenly heat the worm gear thrust-end and drive-end inner races (PN 100058139) to 200°F (**Figure 3.78**). Install the thrust-end inner race and the drive-end inner race on the worm gear (the drive end of the worm gear is the splined end).



Figure 3.78—Heat the worm gear thrust-end and drive-end inner races to 200°F

2. Install the **worm drive-end bearing retainer** (PN 100058137) with a gasket (PN 100007816) and the **drive-end bearing** (PN 100058140) (**Figure 3.79**). Lubricate the bearing. The flat cut into the retainer faces the ring gear for clearance.

Note	The drive side of the power-end case is the side opposite the fluid-end mounting face.



Figure 3.79—Install the drive-end bearing retainer

3. Check the gear contact pattern after the ring gear and worm gear are installed. Start this procedure before installing the worm gear by painting Dykem Steel Blue on the load face of the worm in the following two locations:
   - The first set of locations is on the thrust end of the gear from the start of the worm threads (teeth) to about 4 inches inboard.
   - The second set of locations is on the drive end of the worm gear from the start of the worm threads (teeth) to about 10 inches inboard.

4. Install the worm gear through the thrust end (Figure 3.80).

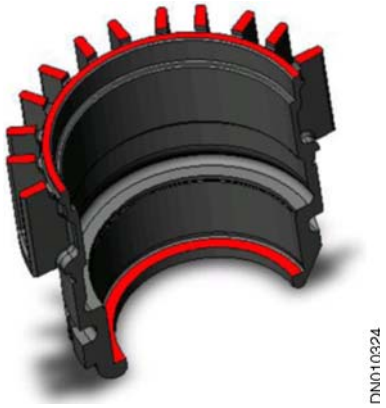
Caution **Be careful not to scar the gear surfaces.**



Figure 3.80—Installing the worm gear

For Cone Drive Only

1. Using a depth gauge, measure from the outer face of the thrust-end bearing retainer to the deepest inside shoulder face. This will be Dimension "A." (Figure 3.81a).
2. Using a micrometer, measure the thickness of the outside flange of the thrust-end bearing retainer. This will be Dimension "B." (Figure 3.81b).



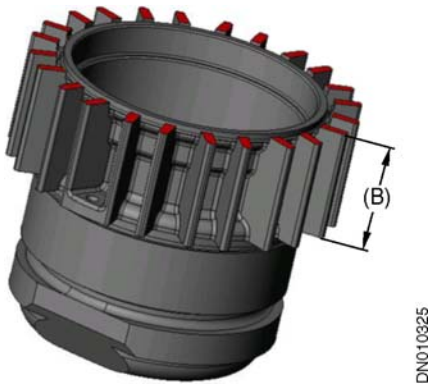


Figure 3.81(a)—Dimension A shown in red, and (b) Dimension B as indicated.

For Cone Drive Only (continued...)

3. Note the dimension of the crankshaft centerline to the mounting face for the thrust-end bearing retainer. The case dimension is stamped on the worm housing of the power-end case (**Figure 3.82**). The number is between 12.450 and 12.500.

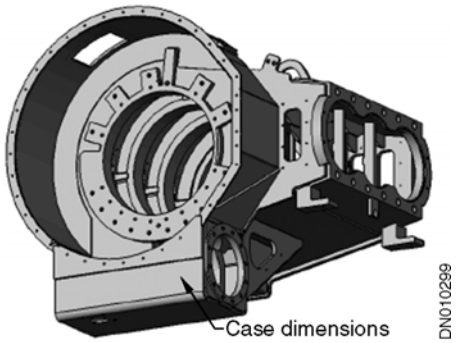


Figure 3.82—Case dimension stamped on the worm housing of the power-end case

4. To determe the worm positioning shim stack:

   a. To calculate the number of shims to put between the case and the thrust-end bearing retainer, start by subtracting Dimension B from Dimension A.

      Retainer dimension = *DimA – DimB*

   b. Subtract 0.010 (bearing preload) from the retainer dimension and add 7.750 (worm constant).

      Installed worm center = *retainer dimension – 0.010 + 7.750*

   c. Subtract the case dimension from the installed worm center, then subtract 0.030 (installation offset).

      Number of shims = *installed worm center – case dimension – 0.030*

Table 3.3—Worm Thrust Bearing Clearance Shims

Part No.	Shim Size, in.
100058150	0.003
100011686	0.005
100011687	0.010
100011688	0.020

5. Put a new **O-ring** (PN 100015435; 90D-8, 7 ¾ ×1/8 in.) on the **worm shaft thrust-end bearing retainer** (PN 100058147). Install the thrust-end bearing retainer, shims, and **worm shaft thrust-end bearing** (PN 100058141) (**Figure 3.83**). Temporarily secure the retainer with a bolt and washer.



Figure 3.83—Installing the worm shaft thrust-end bearing

6. Visually check for clearance between the thrust-end retainer and the ring gear (**Figure 3.84**).



Figure 3.84—Check for clearance between the thrust-end retainer and the ring gear

7. Install the thrust-end bearing thrust race. Use grease to hold it in place (**Figure 3.85**).



Figure 3.85—Use grease to hold the thrust-end bearing thrust race in place.

8. Install the inner thrust bearing stack race, bevel down, on the thrust bearing (PN 100058142) bushing (Figure 3.86).

Important **Never mix inner or outer spacers between bearing sets. The spacers are matched and must be used only as originally packaged. If spacers from different sets are mixed, clearances will not be correct, which will cause premature bearing failure.**

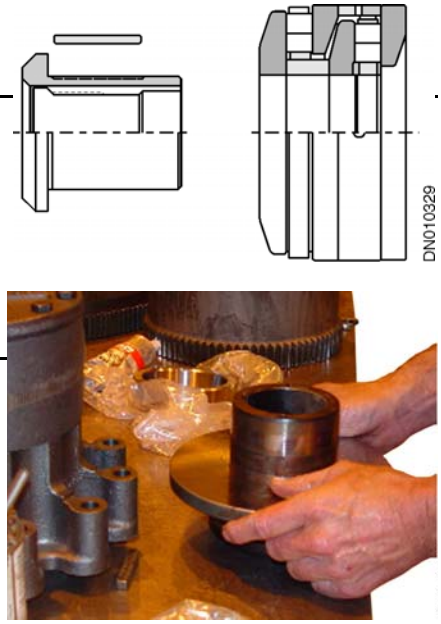


Figure 3.86—(Top) Worm thrust stack race order (Bottom) Install the inner thrust bearing stack race (bevel down) on the thrust bearing bushing

9. Install the thrust bearing inner spacer on the thrust bearing bushing (Figure 3.87).

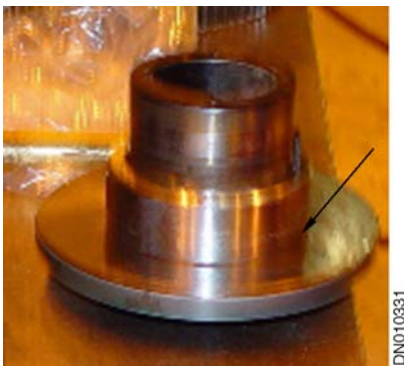


Figure 3.87—Thrust bearing inner spacer on the thrust bearing bushing

10. Oil one of the thrust bearings and install it over the inner spacer (**Figure 3.88**).



Figure 3.88—Thrust bearing installed over the inner spacer

11. Install the thrust bushing over the worm gear shaft (**Figure 3.89**).
12. Install the **worm thrust bearing spacer key** (PN 100057938) on the worm gear and the **worm bearing thrust key** (PN 100058145) on the worm thrust bearing bushing (**Figure 3.89**).



Figure 3.89—Thrust bushing installed over the worm gear shaft

13. Install the **lock nut and star washer** (PN 100058210). Lock the nut into place with at least one of the tabs on the star washer (**Figure 3.90**).



Figure 3.90—Installing the lock nut and star washer

14. Install the next thrust race with the bevel out (toward the installer) (**Figure 3.91**).



Figure 3.91—Install the next thrust race with the bevel out

15. The next thrust race is installed with the bevel in (away from installer), and contacting the inner spacer (**Figure 3.92**).



Figure 3.92—Install the next thrust race with the bevel in (away from installer), contacting the inner spacer

16. Install another well oiled bearing and follow it with the outer spacer (**Figure 3.93**, shown in hand) of the thrust bearing.



Figure 3.93—Install another well oiled bearing and follow it with the outer spacer

17. The final component of the thrust bearing to install is outer thrust race with the bevel out (towards installer) (**Figure 3.94**).



Figure 3.94—Install the outer thrust race with the bevel out

18. Coat the threads of the plunger lube adapter with thread locker (**Figure 3.95**) and thread it into the end of the worm gear shaft. Tighten it with a hammer and a large brass punch.



Figure 3.95—Coating the threads of the plunger lube adapter with thread locker

19. To determine the number of shims to install between the bearing retainer and bearing retainer plate, perform the following steps:

    a. **Measurement A**—Determine the distance between the mounting face of the retainer to the outer face of the last thrust bearing race to the nearest .001 inch (**Figure 3.96**).



Figure 3.96—Measure the distance between the mounting face of the retainer to the outer face of the last thrust bearing race

b. **Measurement B**—Measure the distance from the mounting face of the plate to the bearing race contact face on the plate to the nearest .001 inch (Figure 3.97).

c. To calculate the number of shims to start with, first subtract Measurement A from Measurement B. Then add 0.009-inch to the difference. The accuracy of the shim count will be checked later with a dial indicator.

Number of shims = *MeasurementB – Measurement A +0.009 in.*

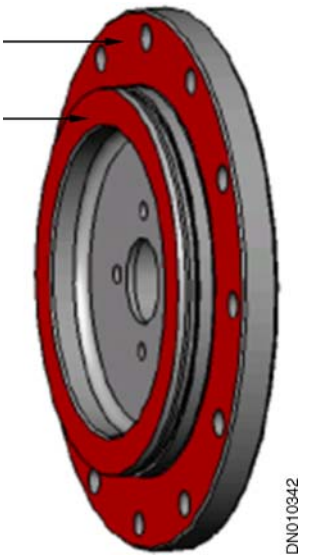


Figure 3.97—Measure the distance from the mounting face of the plate to the bearing race contact face on the plate

Table 3.4—Worm Thrust Bearing Clearance Shims

Part No.	Shim Size, in.
100058150	0.003
100011686	0.005
100011687	0.010
100011688	0.020

20. Install an **O-ring** (PN 100015435; 90D, 8, 7 ¾×1/8-in.) on the thrust plate.

21. Install the thrust plate with the proper amount of shims to the bearing retainer and the correct **fasteners** (PN 100028380—12 required; 1/2-in. 13 UNC × 5 ½ drilled head hex socket screw).

22. Check the clearance of the worm gear thrust bearing stack by attaching a dial indicator to the power-end case and putting the tip of the indicator on the input of the worm gear (Figure 3.98).

    Use a pry bar to shift the worm gear back and forth and determine the total thrust movement. The thrust movement should be .008 to .010 inches. If out of this range, remove the thrust plate and add or subtract shims as necessary.



Figure 3.98—Check the clearance of the worm gear thrust bearing stack

23. Install a new oil seal in the oil seal retainer cover (PN 100058134) with the lip facing the power end (Figure 3.99). Use a new gasket (PN 100029186) and install the cover using the correct fasteners.

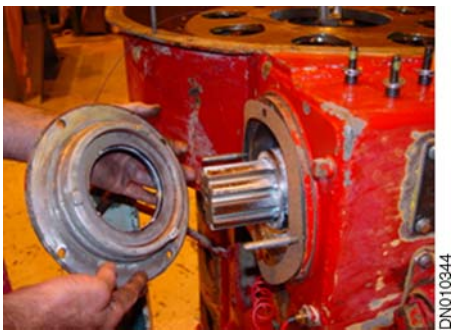


Figure 3.99—Install a new oil seal in the oil seal retainer cover

Plunger Lube Recirculating Pump Assembly

1. With the worm shaft adapter and the thrust plate installed, the next step is to attach the pump to the thrust plate adapter with four flat washers (PN 13431–4 required; 3/8-in. 16 NC×1¼-in. hex socket screws and PN 100029874–4 required; 3/8-in. flat washers) (Figure 3.100).
2. When the lube pump adapter and lube pump are installed on the pump-to-thrust plate adapter, a small clearance is needed between the bottom of the notch in the worm shaft adapter and the tip of the lube pump adapter (Figure 3.101). Once the position of the lube pump adapter on the lube pump input shaft is determined, tighten the set screw in the lube pump adapter.
3. Install the lube pump/lube pump adapter onto the plate adapter and secure it with four screws and washers (PN 13431–4 required; 3/8-in. 16 NC×1¼-in. hex socket screws and PN 100029874–4 required; 3/8-in. flat washers).

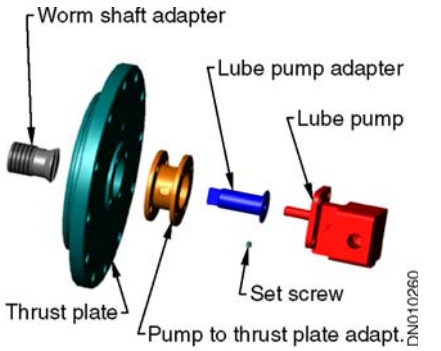


Figure 3.100—Attach the pump to the thrust plate adapter

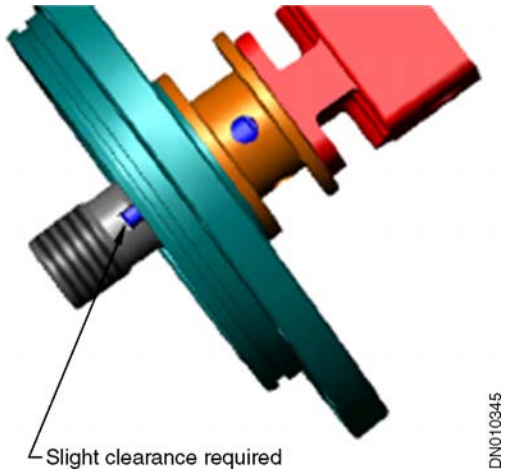


Figure 3.101—Clearance needed to install the lube pump adapter and lube pump on the pump-to-thrust plate adapter

Crosshead Slides

1. Install the crosshead slides (Top slides: PN 100058161; Bottom slides: PN 100058162). Secure the upper slides (w/oil holes) temporarily with 5/16-in. screws and nuts (Figure 3.102).



Figure 3.102—Installing crosshead slides

2. Check the standoff of the crosshead slides with a depth micrometer (Figure 3.103).



Figure 3.103—Checking standoff

3. The standoff should be between .001 and .003 inches. Install shims as necessary (refer to Table 3.5 and Figure 3.104).

Table 3.5—Crosshead Slide Shims

Part No.	Shim Size, in.
100058177	0.002
100058178	0.005
100065179	0.010

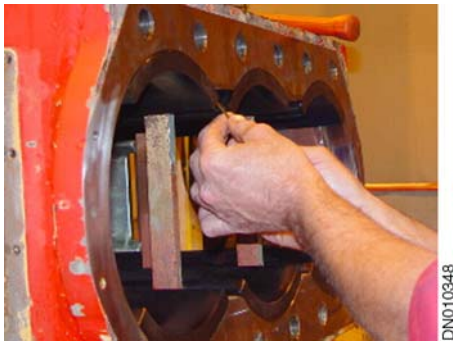


Figure 3.104—Installing shims

4. Install a crosshead aligning jack. Rotate the crosshead slides so that both inside edges of each slide are contacting the jack (Figure 3.105).

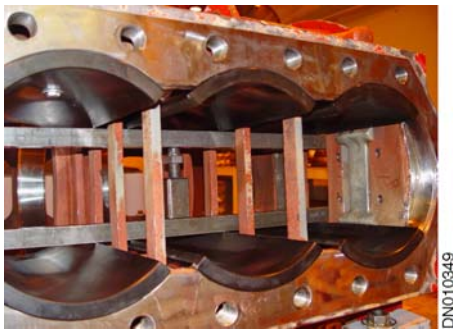


Figure 3.105—Crosshead aligning jack installed

5. Install the four **inboard slide clamps** (Right-hand slide clamp foot: PN 100058164 and Left-hand foot: PN 100058169) with the fingers pointing forward, touching the power-end case braces (Figure 3.106). Use **crosshead slide clamps screws** (PN 100058166). DO NOT TIGHTEN THEM YET.



Figure 3.106—Installing inboard slide clamps

6. Install the **outboard crosshead slide clamps** (PN 100058286). Adjust the long set screws out evenly, making sure both screws for each clamp (PNs 100028806 and 100028805; ¼-in. 20 NC × ¼-in. hex socket screws) are touching the crosshead while the clamp is square with the crossheads and case. Visually align the clamp to assure there is sufficient clearance once the crosshead is installed (Figure 3.107).

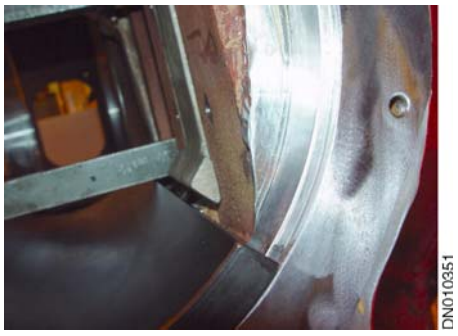


Figure 3.107—Install outboard slide clamps

7. Tighten the inboard clamps, making sure not to over-tighten and buckle the assemblies. Ensure that the set screws of the outboard clamps are tight, then lock them with the short set screws. Next, lock the inboard clamps to the case braces by wiring (PN 100030594; 19-gauge stovepipe wire). When wiring, work from the back to the front to avoid contact with the sharp ends of the cut wire (Figure 3.108).
8. Remove the screws and nuts used to temporarily support the upper crosshead slides.

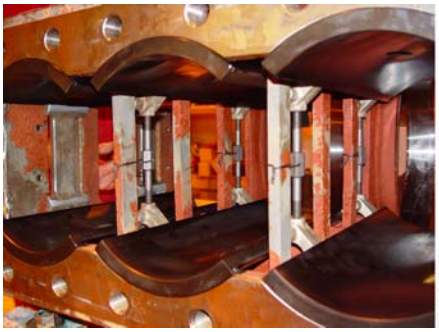


Figure 3.108—Wire the inboard clamps to the case to lock

9. Temporarily install the numbered **crossheads** (PN 100002817 machined crossheads) with **shoes** (PNs 100058170–top and 100058175–bottom) attached and shimmed (into the bores from which they came) as they were when the assemblies were removed. Check the crosshead slide/crosshead clearance.

   Crosshead clearance is .006 to .008 inches. Add or remove shims from the top shoe (Refer to Table 3.6 and Figure 3.109).

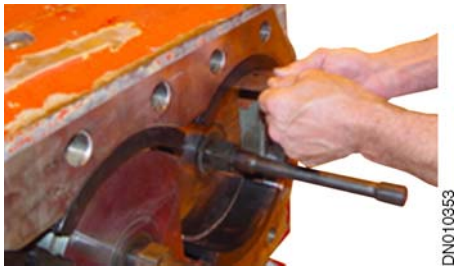


Figure 3.109—Check crosshead/crosshead slide clearance

Important **Do not exceed .031 in. of shims to the top shoe. If excessive clearance still exists, shim the bottom shoe.**

Note Before attempting to remove the retaining screws in the crosshead shoes, tap them with a hammer and punch to break the thread-locker bonds.

Table 3.6—Crosshead Shoe Shims

Part No.	Shim Size, in.
Top Crosshead Shoe Shim	
100058172	0.003
100058171	0.005
100058173	0.010
100058174	0.020
Bottom Crosshead Shoe Shim	
100058180	0.005
100058181	0.010

10. If using old rods, press new **connecting rod pin bushings** (PN 100058186) into the connecting rods using fixture blocks that seat completely against the connecting rod (Figure 3.110). The new bushing is used to "chase" the old bushing out.

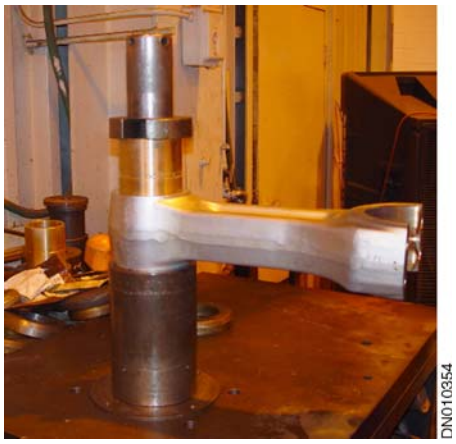


Figure 3.110—Installing a connecting rod pin bushing in a connecting rod

11. Slide each numbered crosshead over its corresponding connecting rod (rod assembly PN 100011691) (Figure 3.111).

    The top of the connecting rod has the punched number code; the top of the crosshead has the smaller shoe.



Figure 3.111—Numbered crossheads over corresponding connecting rods

12. Join the connecting rods to the crossheads with the **crosshead pins** (PN 100002813). The crosshead pins will need to be cooled in a freezer before installing them in the crossheads. If interference still exists, the crossheads may need to be heated to 200°F. Lock the pins to the crossheads with the **crosshead pin keys** (PN 100011690–2 required) (Figure 3.112).

    The key may need to be tried in several different orientations to find the best fit before driving it into the key slot with a brass hammer.



Figure 3.112—Crosshead pins and pin keys installed

13. Secure the crosshead pins with the **dished washers** (PN 100057933), crosshead **pin retaining cap screws** (PN 100058176), and **elastic stop nuts** (PN 100026445; 5/16-in. 24 NF) (**Figure 3.113**).

    It is important that the nylon inserts in the elastic stop nuts be completely engaged by threads of the pin retaining cap screws.



Figure 3.113—Crosshead pin secured with dished washer

14. Install the connecting rod top bearings onto the connecting rods and the connecting rod bottom bearings to the connecting rod caps (**Figure 3.114**).

    Before installing the bearings, thoroughly clean both mating surfaces. The current new issue crankshaft has 5.125-in. diameter connecting rod journals (0.125-in. oversize).

Note	Do not oil the backs of the connecting rod bearings before installation.



Figure 3.114—Installed connecting rod bearings

Connecting rod bearing part numbers:

- **5.125-in. (.125-in. oversize)**–Top: PN 100011759; Bottom: PN 100011758
- **5.000-in. (.000-in. undersize)**–Top: PN100058188; Bottom: PN 100058187
- **4.960-in. (.040-in. undersize)**–Top: PN13532; Bottom: PN 13531
- **4.920-in. (.080-in. undersize)**–Top: PN100058212; Bottom: PN 100058213

15. Lubricate the crankshaft journal surfaces and the connecting rod bearing surfaces with some form of assembly oil (spray-on white lithium grease used in **Figure 3.115**).



Figure 3.115—Crankshaft lubricated with spray-on white lithium grease

16. Carefully guide the first crosshead/connecting rod into the corresponding crosshead bore and onto the crankshaft journal (**Figure 3.116**).



Figure 3.116—Guiding the first crosshead/ connecting rod into the corresponding crosshead bore

17. Install the connecting rod cap (**Figure 3.117**).



Figure 3.117—Installing the connecting rod cap

18. Torque the connecting rod screws to specification in multiple steps (Figure 3.118). Finish by wiring the connecting rod screws together with stovepipe wire.
19. Repeat Steps 16–18 for the remaining two crossheads/ connecting rods.
20. Looking through the access holes in the back of the case, check the clearance between each of the crossheads and the connecting rods. If the spacing is uneven, add or remove shims from under the crankshaft thrust retainer spider (refer to Table 3.7).



Figure 3.118—Torque the connecting rod screws

Table 3.7—Crankshaft Axial Positioning Shims

Part No.	Shim Size, in.
100058100	0.020
100058104	0.040
100058109	0.060

Final Power-End Assembly

1. Install the **gear housing cover plate** (PN 100058084) with a new **gasket** (PN 100002810). Secure the cover with **screws** (PN 100028435, 5/16-in. 18 NC× ½-in. hex cap), flat washers, and **seal washers** (PN 100013115, 5/16-in. Barwood). Use pipe sealant on screw threads where the tapped holes go completely through the case.
2. If the pump is to be equipped with a volume counter, install the **counterdrive shaft** (PN 100002816, gallon) with a new and well-lubricated **O-ring** (PN 100001944; 90D, 9/16×3/8×3/32-in.) insert first through the injector cover, then into the end of the crankshaft oil passage (Figure 3.119).



Figure 3.119—Install the counterdrive shaft

3. Install a new **gasket** (PN 100011700) onto the **crankshaft oil injector** (PN 100011695, with No. 20 hose adapter). Lubricate the outside of the non-threaded end.

   Insert the crankshaft oil injector through the injector cover. Guide the injector over the gallon countershaft, if so equipped, and carefully allow the drive shaft O-ring to seat in the injector housing (Figure 3.120).

   Secure the injector with four **hex cap screws** (PN 100028439; 5/16-in. 18 NC×1-in.) and **lock washers** (PN 100015040, 15/16-in.).

   If a gallon counter is not being used, thread an **oil injector plug** (PN 100058269, HT-400™ pump oil injector plug) on the outside of the injector housing once the injector is installed.



Figure 3.120—Installing the crankshaft oil injector

4. Install the gear inspection cover and connecting rod access covers with new gaskets.

Power-End Lubrication System

1. Install the **bypass valve** (PN 100058201 assembly, left-hand pump) onto the power-end case with the flange facing out toward the ring gear.
2. Install the oil strainer and filter manifold onto the bypass flange with the inlet and outlet flanges facing the fluid-end mounting face.
3. Install the discharge end of the **magnetic strainer assembly** (PN 100021413) to the input flange (inboard) of the manifold.
4. Install the input side of the oil filter assembly to the discharge (outboard) flange of the manifold. Secure the **oil filter** (PN 100021412) onto the **filter bracket** (PN 100058298, Schroeder) with the **exhaust clamp** (PN 100023268, 4 1/2-in.).
5. Place 1/2-in. **washer seals** (PN 100002324) in the crosshead oiler ports followed by the **crosshead oiler saddles** (PN 100011693) with **O-rings** (PN 100000946, 90D, 1 1/16×7/8×3/32-in) installed in the saddles.
6. Install the **oil line tube** (assembly PN 101284157) with the two small ports at the ring gear end onto the saddles.
7. Install three more O-rings onto the crosshead oiler saddles. Place the saddles over the three holes in the oil line tube and put three washer seals over the saddles. Secure the saddles and the tube with **crosshead oiler saddle bolts** (PN 100011692).

8. If not already installed, install the 90° elbows to the ends of the oil line tube and then attach the hose assemblies to the ends of the elbows. The longer of the two hoses attaches at the ring-gear end and connects to the oil filter using a flanged hose adapter. The shorter hose connects the oil line tube to the injector.
9. The larger of the two ports on the oil line tube is connected to the hose that splits oil flow to the worm gear thrust plate and the top of the ring gear through a tee.
10. The smaller port on the oil line tube is connected to a hose leading to the oil pressure gauge.

Spacer Installation

1. Inspect the push rod seals and replace as necessary. Leave the seal housing retainers loose to allow the seal housing to float during pushrod installation.
2. Thoroughly clean the sealing face on the front of the power end to remove silicone sealer and oil.
3. Lubricate the threads of the fluid-end attaching stud (shouldered side), and thread all 12 studs into the power-end case.
4. Tighten each stud to 200 ft-lb using the stud driver (SAP 100058242).
5. Apply a thin bead (about 1/8-in.) of RTV silicone to the front face of the power end, going around each stud (**Figure 3.121**).
6. Clean the sealing face on the back of the spacer thoroughly and install it over the attaching studs and onto the power end.
7. Immediately install the fluid-end assembly to squeeze down the silicone seal. Tighten the fluid-end attaching stud nuts to the appropriate torque specification.

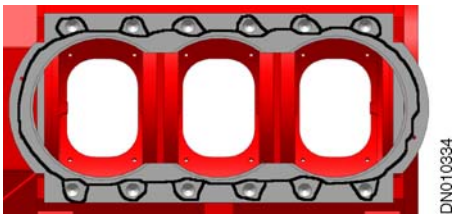


Figure 3.121—Apply a thin bead of RTV silicone around each stud

Table 3.8—Pump Fastener Torque Values*
(Torque Table from Specification 316.00100, Rev. H)

Fastener	Thread Diameter		Copper-based	Moly-based	Oil	Copper-based	Moly-based	Oil
			Torque					
	(in.)	n	(ft-lb)			(N-m)		
Fluid end attaching stud into power end (all)	1.000	14	183	200	350	249	271	475
Nut to fluid-end attaching stud (not more than 1/2 turn of nut after snug to 75 ft-lb)			750	830	1432	1017	1126	1941
Top tie bolt	1.375	12	1374	1500	2640	1862	2034	3579
Bottom tie bolt	0.750	16	184	200	348	249	271	472
Discharge flange stud to fluid end	1.000	14	183	200	349	248	271	474
Nut to discharge flange stud			403	440	770	547	597	1044
Pushrod tie-bolt to crosshead			288	314	550	391	426	746
Pushrod retainer to pushrod tie-bolt			236	257	450	320	349	610
Plunger tie-bolt to pushrod retainer			183	200	350	249	271	475
Plunger tiebolt to pushrod retainer			131	143	250	178	194	339
Connecting rod cap bolt	0.750	10	119	130	220	162	176	298
Gear support flange	0.500	13	46	50	84	63	68	114
Gear support thrust plate		13	56	60	101	75	82	137
Grizzly™ pump gear case bolt and nut	0.625	11	162	175	296	219	238	401
Grizzly™ pump gear case bolt only			143	155	262	194	210	355
Suction header stud			92	100	168	125	135	228
Suction header nut			139	150	253	188	203	343
Allison Transmission nut	2.000	16	730	800	1430	990	1085	1938
Grizzly™ pump input flange	0.500	13	70	75	127	95	102	172

*Torque values will vary depending on the thread lubricant used

Section
4

HT-400™ Pump Power-End Parts

Introduction

This section provides parts lists for various HT-400™ pump power-end assemblies/subassemblies.

Worm Gear Drive-End Assembly

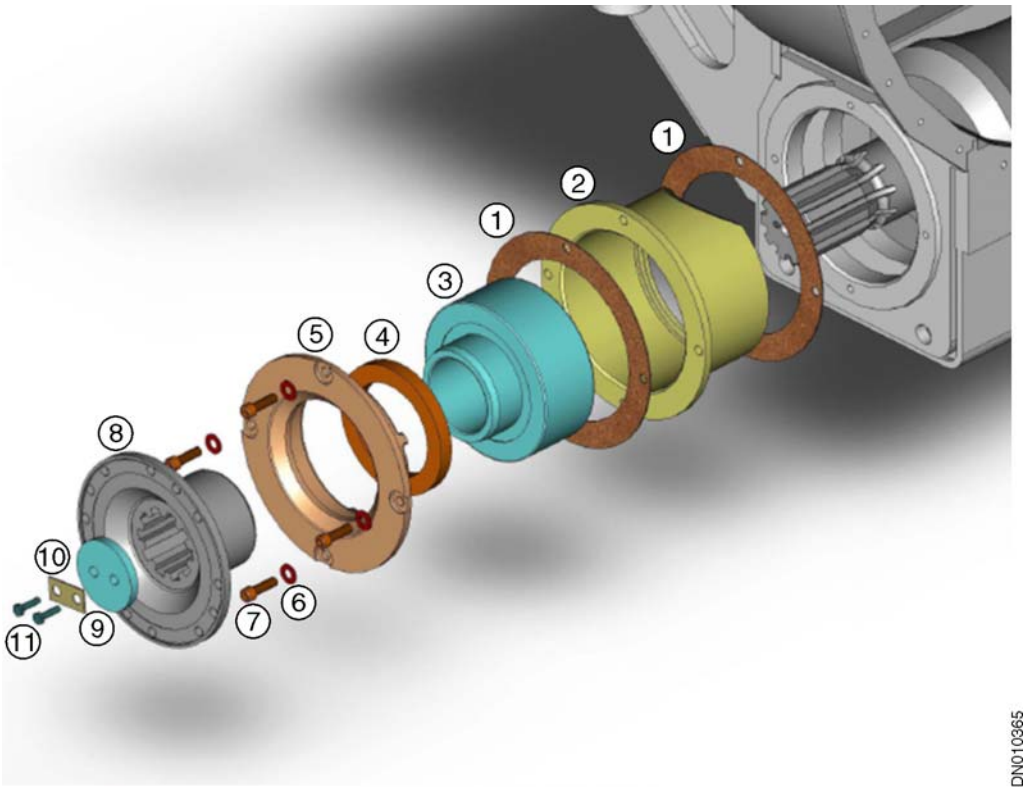


Table 4.1—Worm Gear Drive-End Assembly

Loc	SAP PN	Legacy No.	Qty	Description
1	100007816	316.11631	2	Gasket, Worm Housing Input End
2	100058137	316.11619	1	Retainer, Bearing, Worm-Drive End
3	100058140	316.11625	1	Bearing, Drive End-Worm Shaft
3a	100058139	316.11620	1	Inner Race for 316.11625
4	100029186	70.46241	1	Seal, Oil, 53-in. x 7448, Fl, 4-in. B x 5 1/2-in. OD x 1/2-in. Wide
5	100058134	316.11615	1	Cover, Oil Seal Retainer
6	100029874	70.58806	4	Washer, Flat, 3/8-in. WI, Pl
7	13431	70.43839	4	Screw Hex Socket, 3/8-in.16NC x 1 1/4-in., Unbrako/Loc-Wel
8	100054533	280.03021	1	Flange, Companion, 1810 Series, 3.0 - 10 Spline
9	100058133	316.11613	1	Washer, Worm Yoke Retainer
10	100058132	316.11611	1	Washer, Lock, Worm Yoke Retainer
11	100028455	70.43816	2	Screw, Hex Cap, 3/8-in. 16UNC x 1 1/4-in., Pl

Cone Drive (8.4:1) Worm Gear Thrust End Assembly

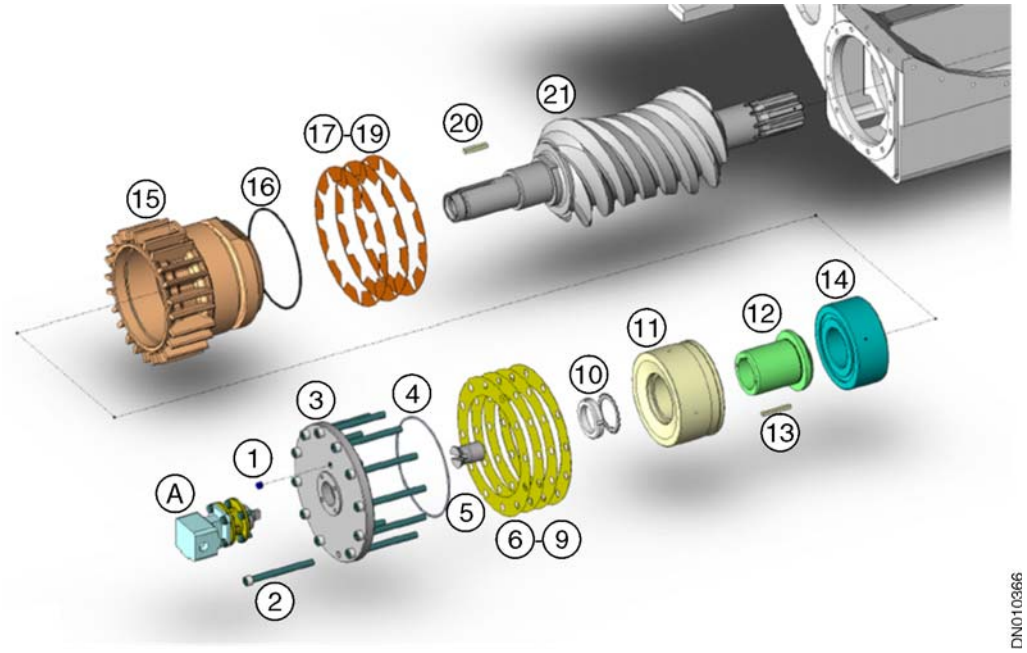


Table 4.2—Cone Drive (8.4:1) Worm Gear Thrust End Assembly

Loc	SAP PN	Legacy No.	Qty	Description
1	100058310	316.16416	1	Plug, Orifice, 1/8-in. NPT, 0.157-in. Diameter Hole
2	100028380	70.43680	12	Screw, Hex Socket, 1/2-in. 13UNC x 5 1/2-in., Drilled Head
3	100058235	316.13200	1	Plate, thrust, bearing retainer modified for plunger lube pump
4	100015435	8.34062	2	O-Ring, 90D, 8, 7 3/4-in. x 1/8-in.
5	100011748	317.51064	1	Adapter, HQ, Worm Shaft, Plunger Lube
6	100058150	316.11667	as req.	Shim, Clearance, Worm Thrust Bearing, 0.003 in.
7	100011686	316.11669	as req.	Shim, Clearance, Worm Thrust Bearing, 0.005 in.
8	100011687	316.11671	as req.	Shim, Clearance, Worm Thrust Bearing, 0.010 in.
9	100011688	316.11673	as req.	Shim, Clearance, Worm Thrust Bearing, 0.020 in.
10	100058210	316.13100	1	Nut, Lock, HT400, worm thrust end, nut and star washer
11	100058142	316.11629	1	Bearing, Thrust, Stack Worm
12	100058144	316.11633	1	Bushing, Worm Thurst Bearing
13	100058145	316.11634	1	Key, Worm-Thrust Bearing
14	100058141	316.11627	1	Bearing, Thrust-End, Worm Shaft
15	100058147	316.11645	1	Retainer, Iron Worm-Thrust End Bearing

Table 4.2—Cone Drive (8.4:1) Worm Gear Thrust End Assembly (Continued)

Loc	SAP PN	Legacy No.	Qty	Description
16	100015435	8.34062	2	O-Ring, 90D, 8, 7 3/4-in. x 1/8-in.
17	100058249	316.13253	as req.	Shim, 0.005-in., Worm Positioning
18	100058250	316.13254	as req.	Shim, 0.010-in., Worm Positioning
19	100058251	316.13255	as req.	Shim, 0.020-in., Worm Positioning
20	100057938	315.31154	1	Key, Worm-Thrust Bearing Spacer
21	100058285	316.13522	1	Worm, Gear, 8.4 to 1 Ratio, Cone Drive
A				Plunger Lube Pump Assembly

Holroyd (8.6:1) Worm Gear Thrust-End Assembly

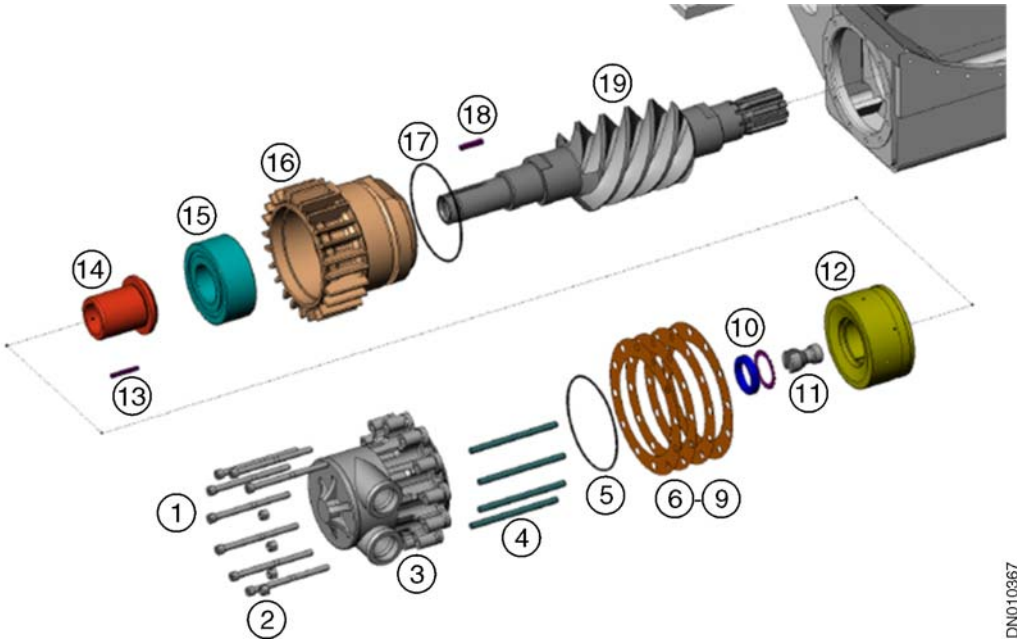


Table 4.3—Holroyd (8.6:1) Worm Gear Thrust-End Assembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100011699	316.13657	8	Screw, Cap, Worm Housing, RH
2	100012919	70.32821	4	Nut, Elastic Stop, 1/2-13 NC, Heavy, PL
3	100011684	316.11637	1	Pump, Assembly, Oil, 100 GPM, Tuthill, HT-400™ PE
4	100058267	316.13306	4	Stud, Long Loc Insert, Tuthill Oil Pump Mounting
5	100013727	8.34061	1	O-Ring, 90 Duro 7 3/4 X 7 1/2 X 1/8, 568-264
6	100058150	316.11667	as req.	Shim, Clearance, Worm Thrust Bearing, 0.003 in.
7	100011686	316.11669	as req.	Shim, Clearance, Worm Thrust Bearing, 0.005 in.
8	100011687	316.11671	as req.	Shim, Clearance, Worm Thrust Bearing, 0.010 in.
9	100011688	316.11673	as req.	Shim, Clearance, Worm Thrust Bearing, 0.020 in.
10	100058210	316.13100	1	Nut, Lock, HT400, Worm Thrust End, Nut and Star Washer
11	100058146	316.11644	1	Adapter, Brown and Sharp Lubricator Pump
12	100058142	316.11629	1	Bearing, Thrust, Stack Worm
14	100058144	316.11633	1	Bushing, Worm Thurst Bearing
13	100058145	316.11634	1	Key, Worm-Thrust Bearing

Table 4.3—Holroyd (8.6:1) Worm Gear Thrust-End Assembly (Continued)

Loc	SAP Part No.	Legacy No.	Qty	Description
15	100058141	316.11627	1	Bearing, Thrust-End, Worm Shaft
16	100058147	316.11645	1	Retainer, Iron Worm-Thrust End Bearing
17	100015435	8.34062	1	O-Ring, 90D, 8, 7 3/4-in. x 1/8-in.
18	100057938	315.31154	1	Key, Worm-Thrust Bearing Spacer
19	100058130	316.11601	1	Gear, Worm, 8.6:1 Ratio, Holroyd, HT-400™ PE

Ring Gear Subassembly (A)

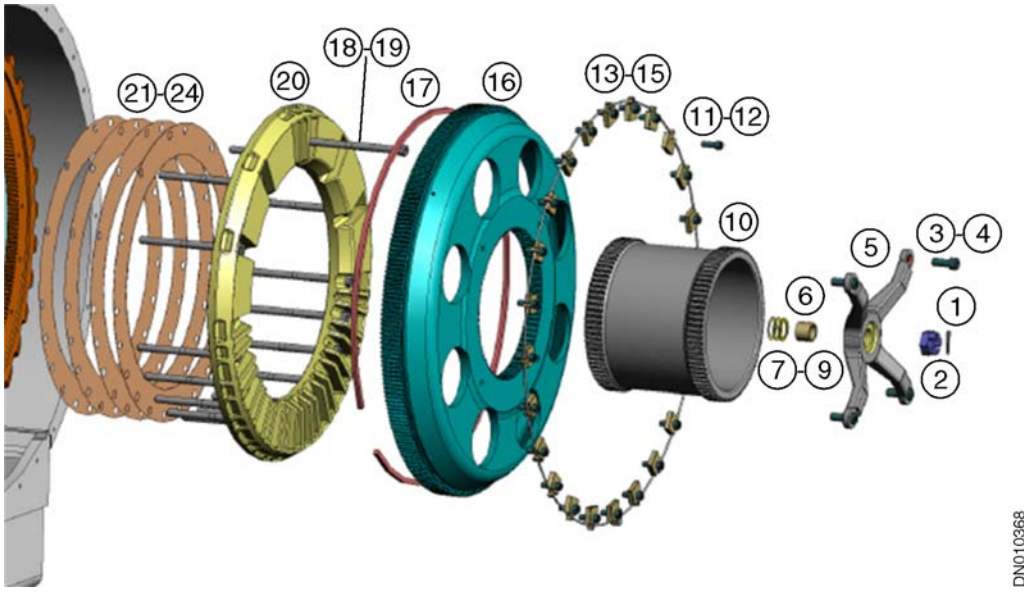


Table 4.4—Ring Gear Subassembly (A)

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100027204	70.35712	1	Pin, Cotter, 1/8-in. x 1 1/2-in., Spring Steel
2	100026544	70.32970	1	Nut, Hex Slot, 1-in. 14NF, Pl
3	100058092	316.11407	4	Screw, Cap, Spline Drive
4	100030594	70.62391	1	Wire, Stove Pipe, 19 Ga., 72-in. Long
5	100058107	316.11521	1	Spider, Crankshaft Thrust Retainer
6	100058105	316.11519	1	Bushing, Spider Spacer
7	100058100	316.11512	as req	Shim, Positioning, Crankshaft Axial, 0.020-in.
8	100058104	316.11518	as req	Shim, Positioning, Crankshaft Axial, 0.040-in.
9	100058109	316.11522	as req	Shim, Positioning, Crankshaft Axial, 0.060-in.
10	100058110	316.11523	1	Coupling, Crankshaft, Spline Drive
11	100030594	70.62391	1	Wire, Stove Pipe, 19 Ga., 190-in. Long
12	100058111	316.11524	24	Screw, Cap, Ring, Mounting, Gear Clamp
13	100058125	316.11548	24	Washer, Left-Hand Gear Bearing Clamp
14	100028108	70.42965	1	Rod, Welding, L-61, 1/8-in., 95-in. Long
15	100023759	70.17324	1	Connector, No. 8, 128-B Reliance
16	100058127	316.11551	1	Flange, Gear Spline Drive

Table 4.4—Ring Gear Subassembly (A) (Continued)

Loc	SAP Part No.	Legacy No.	Qty	Description
17	100058128	316.11553	1	Adapter, Clamp Ring, HT-400™, PE, Right-Hand Only
18	100011699	316.13657	16	Screw, Cap, Worm Housing, Right-Hand
19	100030594	70.62391	1	Wire, Stove Pipe, 19 Ga., 120-in. Long
20	100058123	316.11545	1	Ring, Thrust, Gear Bearing
21	100058117	316.11535	as req	Shim, Clearance, Gear Support Bearing, 0.003-in.
22	100058118	316.11537	as req	Shim, Clearance, Gear Support Bearing, 0.005-in.
23	100058119	316.11539	as req	Shim, Clearance, Gear Support Bearing, 0.010-in.
24	100058121	316.11541	as req	Shim, Clearance, Gear Support Bearing, 0.020-in.

Ring Gear Subassembly (B)

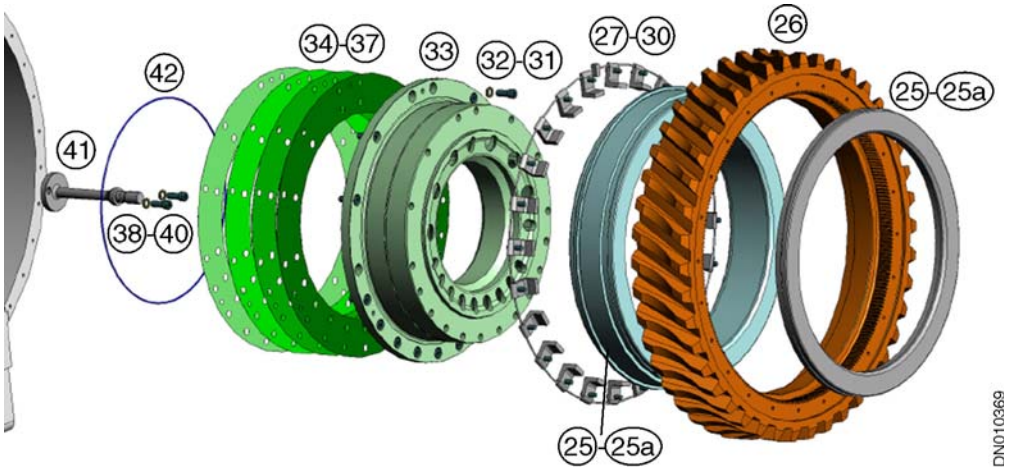


Table 4.5—Ring Gear Subassembly (B)

Loc	SAP Part No.	Legacy No.	Qty	Description
25	100058122	316.11543	1	Bearing, Gear Support
25a	100058120	316.1154	2	Thrust Cage Assembly for 316.11543
26a	100058284	316.13521	1	Gear, Ring, 8.4 to 1 Ratio, Cone Drive Use only with Cone Drive worm gear (100058285).
26b	100058103	316.11517	1	Gear, Ring, 8.6 to 1 Ratio Holroyd Use only with Holroyd worm gear (100058130)
27	100058129	316.11556	24	Lug, Gear Bearing Clamp, Right Hand Only
28	100028108	70.42965	1	Rod, Welding, L-61, 1/8-in., 95-in. Long, Right Hand Only
29	100058111	316.11524	24	Screw, Cap, Ring Mounting, Gear Clamp, Right Hand Only
30	100023759	70.17324	1	Connector, No. 8, 128-B Reliance, Right Hand Only
31	100028247	70.43381	16	Screw, Hex Socket, 1/2-in. 13NC x 1 1/4-in.
32	100029934	70.58986	16	Washer, Lock, 1/2-in., Int Shakeproof, Pl
33	100058112	316.11525	1	Support, Bearing, Ring Gear
34	100058113	316.11527	as req	Shim, Positioning, Gear Side, 0.003-in.
35	100058114	316.11529	as req	Shim, Positioning, Gear Side, 0.005-in.

Table 4.5—Ring Gear Subassembly (B) (Continued)

Loc	SAP Part No.	Legacy No.	Qty	Description
36	100058115	316.11531	as req	Shim, Positioning, Gear Side, 0.010-in.
37	100058116	316.11533	as req	Shim, Positioning, Gear Side, 0.020-in.
38	100058092	316.11407	2	Screw, Cap, Spline Drive
39	100030594	70.62391	1	Wire, Stove Pipe, 19 Ga., 24-in. Long
40	100081184	70.58959	4	Washer, Lock, 1/2-in., Stl-Pl
41	100058101	316.11514	1	Stud, Flanged, Crankshaft Thrust
42	100028108	70.42965	1	Rod, Welding, L-61, 1/8-in., 54-in. Long, Right Hand Only

Crankshaft Main Bearing Subassembly

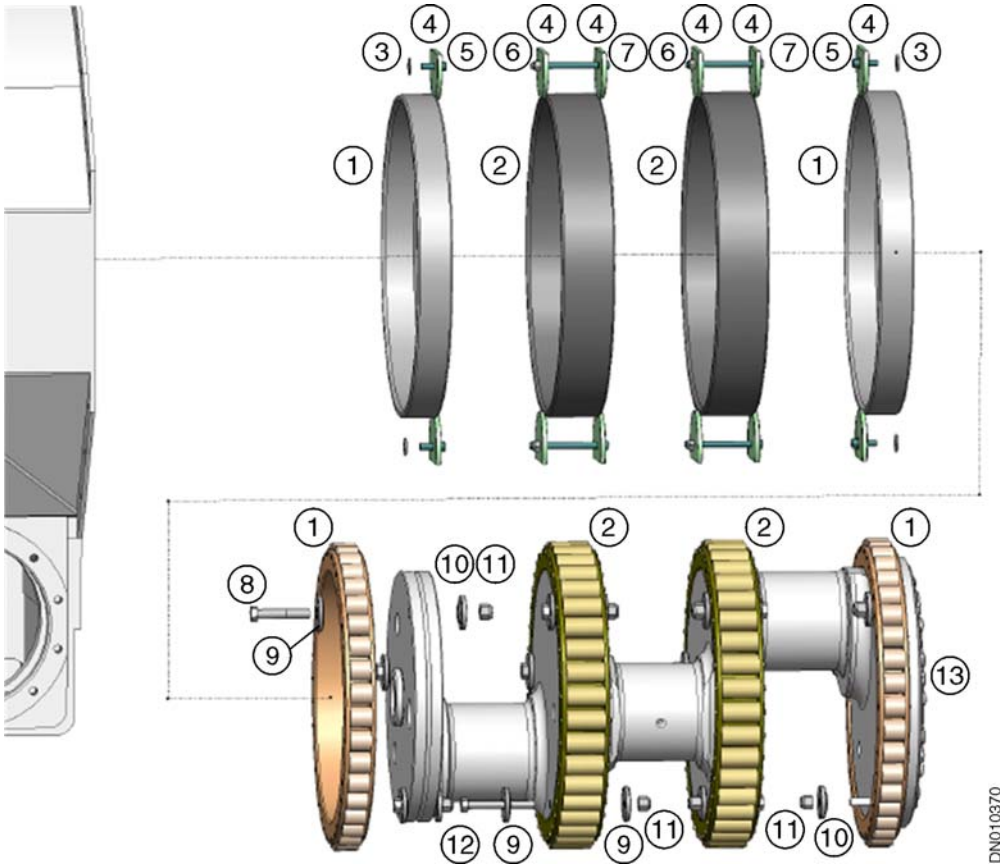


Table 4.6—Crankshaft Main Bearing Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100058283	316.13503	2	Bearing, Main Outboard
2	100058282	316.13501	2	Bearing, Main Inboard
3	101384369		4	Washer, Flat, SAE 5/16, 11/32 ID, 11/16 OD, 1/16 Thk, Stl
4	100058709	317.51017	12	Washer, Outer Race, Crankshaft, Main Bearing, HQ
5	100002166	70.43363	4	Screw, Hex Socket, 5/16-in. 18NC x 1-in.
6	100026483	70.32811	4	Nut, Elastic Stop, 5/16-in. 18NC, Heavy, Pl
7	100058266	316.13304	4	Screw, Cap, Inboard Bearing Race Retainer
8	100028496	70.43877	3	Screw, Hex Cap, 1/2-in. 13NC x 2 3/4-in.

Table 4.6—Crankshaft Main Bearing Subassembly (Continued)

Loc	SAP Part No.	Legacy No.	Qty	Description
9	100058095	316.11505	15	Washer, Bearing Retainer, Forged
10	100058233	316.13198	6	Washer, Retainer, Inner Race, Heavy-Duty Main Bearing
11	100030907	70.70309	12	Nut, Self-Locking, 1/2-in. 13NC x 3 1/2-in., Pl
12	100028494	70.43875	6	Screw, Hex Cap, 1/2-in. 13NC x 3 1/2-in., Pl
13	100058898	317.55208	1	Crankshaft Assembly, Machined, +0.125, No Nitride

Crosshead and Connecting Rod Subassembly

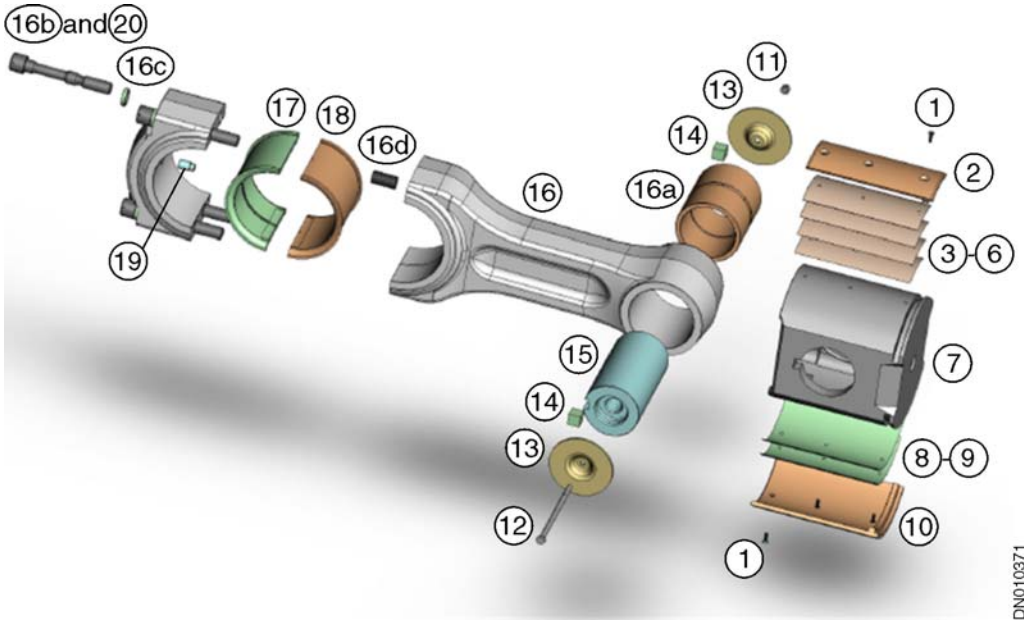


Table 4.7—Crosshead and Connecting Rod Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100138092	70.4319	18	Screw, FH Cap, 1/4-in. 20NC x 5/8-in., Hex Socket
2	100058170	316.11819	3	Shoe Top, Crosshead
3	100058172	316.11823	as req	Shim, Crosshead Shoe, Top, 0.003-in.
4	100058171	316.11821	as req	Shim, Crosshead Shoe, Top, 0.005-in.
5	100058173	316.11825	as req	Shim, Crosshead Shoe, Top, 0.010-in.
6	100058174	316.11827	as req	Shim, Crosshead Shoe, Top, 0.020-in.
7	100002817	316.13811	3	Crosshead, Heavy Duty
8	100058180	316.11847	*	Shim, Bottom Crosshead, 0.005-in.
9	100058181	316.11848	*	Shim, Bottom Crosshead, 0.010-in.
10	100058175	316.11832	3	Shoe Bottom, Crosshead
11	100026445	70.32721	3	Nut, Elastic Stop, 5/16-in. 24NF, LT, 21NE-054
12	100058176	316.11833	3	Screw, Cap, Retaining, Crosshead Pin
13	100057933	315.1193	6	Washer, Dished
14	100011690	316.11831	6	Key, Crosshead Pin
15	100002813	316.11829	3	Pin, Crosshead

Table 4.7—Crosshead and Connecting Rod Subassembly (Continued)

Loc	SAP Part No.	Legacy No.	Qty	Description
16	100011691	316.11910	3	Connecting Rod, Forging, Machined
16a	100058186	316.11913	3	Bushing, Connecting-Rod Pin
16b	100058184	316.11911	12	Screw, Connecting-Rod
16c	100058185	316.11912	12	Washer, Connecting-Rod Cap
16d	100025800	70.27196	12	Helicoil Insert, No. 1185, 12-in. x 1 7/8-in. Long
17	100011758	317.55214	3	Bearing, Bottom, Connecting Rod, + 0.125, HQ2000
18	100011759	317.55215	3	Bearing, Top, Connecting Rod, + 0.125, HQ2000
19	100057932	315.11416	3	Dowel, Connecting-Rod Cap
20	100030594	70.62391	1	Wire, Stove Pipe, 19 Ga., 144-in. Long

Crosshead Slide Subassembly

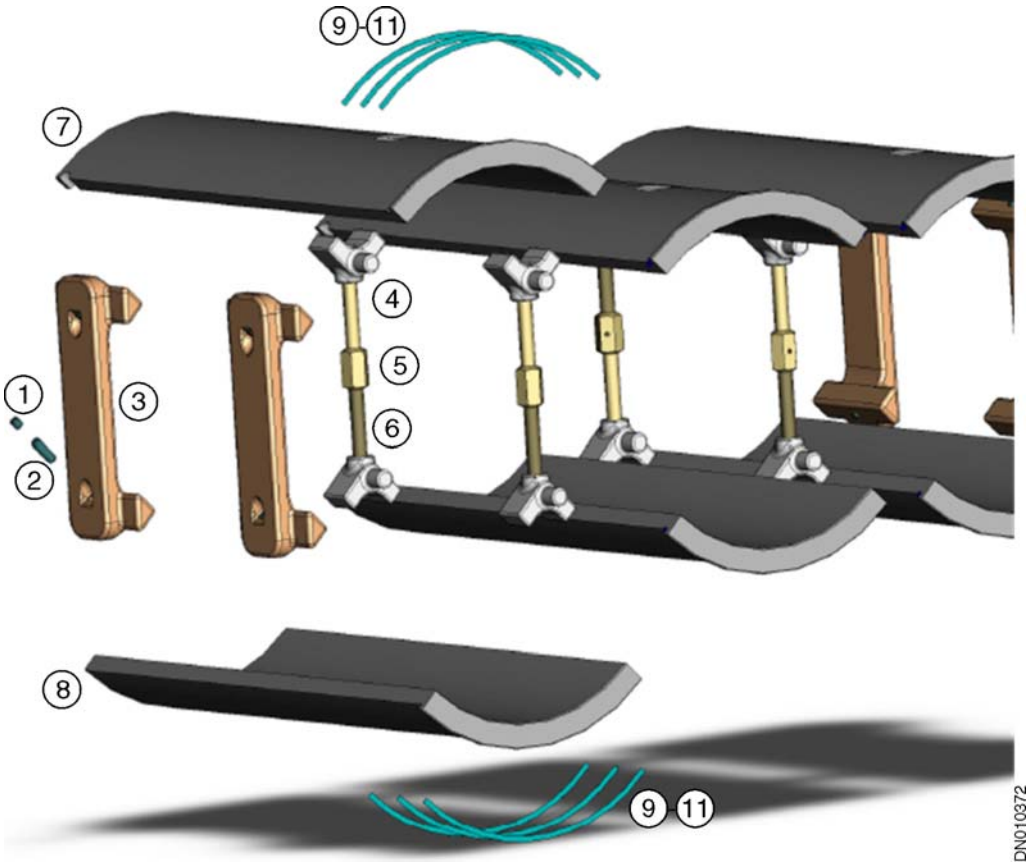


Table 4.8—Crosshead Slide Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100028805	70.44781	8	Screw, Set, 1/4-in. 20NC x 1/4-in., Cup Pt, Hex Socket, Pl
2	100028806	70.44782	8	Screw, Set, 1/4-in. 20NC x 3/4-in., Cup Pt, Hex Socket, Pl
3	100058286	316.13802	4	Clamp, Outboard, Crosshead Slide
4	100058164	316.11805	4	Foot, Right-Hand Crosshead Slide Clamp
5	100058166	316.11807	4	Screw, Crosshead Slide Clamp
6	100058169	316.11817	4	Foot, Left-Hand Crosshead Slide Clamp
7	100058161	316.11801	3	Slide, Top Crosshead
8	100058162	316.11803	3	Slide-Bottom, Crosshead

Table 4.8—Crosshead Slide Subassembly (Continued)

Loc	SAP Part No.	Legacy No.	Qty	Description
9	100058177	316.11834	as req	Shim, Crosshead Slide, 0.002-in.
10	100058178	316.11835	as req	Shim, Crosshead Slide, 0.005-in.
11	100058179	316.11836	as req	Shim, Crosshead Slide, 0.010-in.

Schroeder Filter/Strainer Lubrication Subassembly

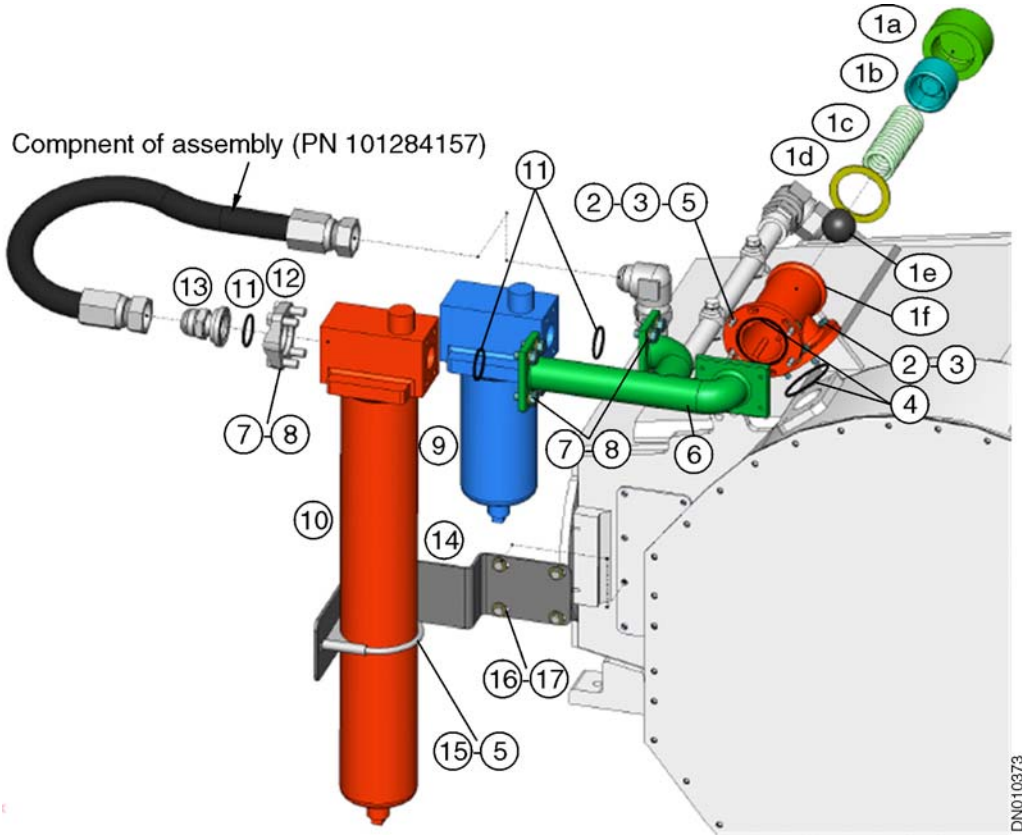


Table 4.9—Schroeder Filter/Strainer Lubrication Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1a	100058197	316.11964	1	Cap, By-Pass, Schroeder Oil System
1b	100058198	316.11965	1	Screw, Adjust, Bypass, Schroeder Oil System
1c	100011694	316.11932	1	Spring, Bypass, Oil Pressure 80 to 100 psi
1d	100058200	316.11966	1	Gasket, Cap, Screw, Bypass, Schroeder Oil Systems
1e	100001377	70.00427	1	Ball, Steel, 2-in., Chrome Steel, Grade 50
1f	100058195	316.11963	1	Body, Valve, Bypass, Schroeder Oil System
2	100028439	70.43786	6	Screw, Hex Cap, 5/16-in.18NC x 1-in., Plated
3	100015040	70.58952	8	Washer, Lock, 5/16-in., Stl, Pl
4	100000966	8.34031	2	O-Ring, 90D, 3 1/4-in. x 3-in. x 1/8-in.
5	100029873	70.58805	6	Washer, Flat, 5/16-in., Wi, Pl

Table 4.9—Schroeder Filter/Strainer Lubrication Subassembly (Continued)

Loc	SAP Part No.	Legacy No.	Qty	Description
6	100058193	316.11959	1	Manifold, Oil Strainer and Filter, Machined
7	100028485	70.43864	16	Screw, Hex Cap, 1/2-in.13NC x 1-in., Pl
8	100081184	70.58959	16	Washer, Lock, 1/2-in., Stl, Pl
9	100021413	70.06262	1	Strainer, Oil, Magnetic Element, 100 gpm, 300 psi
10	100021412	70.06260	1	Filter, Oil, 100 gpm, 300 psi
11	100000961	8.34022	4	O-Ring, 90D, 2 1/8-in. x 1 7/8-in. x 1/8-in.
12	100024782	70.23477	4	Flange, Half, 1 1/2-in., 3,000 psi, SF-2522-24
13	100036060	70.97198	1	Adapter, Hose, Straight, 1 5/8-12 JIC Male x 1.5 C61 Flange Head
14	100058298	316.14147	1	Bracket, Schroeder, Filter
15	100023268	70.15975	1	Clamp, Exhaust, 4 1/2-in., Stemco
16	100028435	70.43781	4	Screw-Hex Cap, 5/16-in. 18NC x 1/2-in., Pl
17	100013115	70.76708	35	Washer, Seal, 5/16-in., Barwood

Power-End Lubrication Hose/Line Subassembly

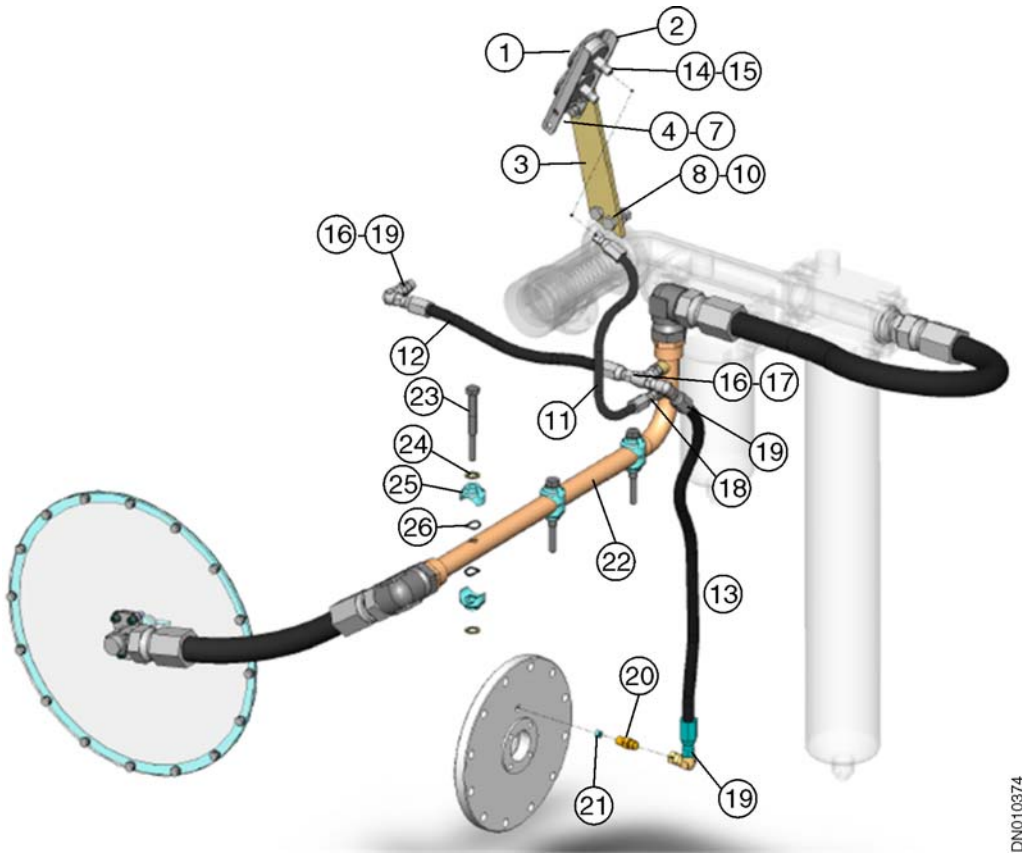


Table 4.10—Power-End Lubrication Hose/Line Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100002493	70.88352	1	Gauge, Oil Pressure, 0 to 150 lb, Microswitch
2	100049565	270.08673	1	Bracket, Heat Indicator, Murphy Gauge
3	100058080	316.11188	1	Bracket, Gauge, Oil Temp and Press-Schroeder
4	100013017	70.43814	2	Screw, Hex Cap, 3/8-in. 16NC x 1-in., Pl
5	100013059	70.58955	2	Washer, Lock, 3/8-in., Stl, Pl
6	100029874	70.58806	2	Washer, Flat, 3/8-in. WI, Pl
7	100012921	70.32912	2	Nut, Hex, 3/8-in. 16NC, Pl
8	100028488	70.43868	2	Screw, Hex Cap, 1/2-in.13NC x 1 1/2-in., Pl
9	100081184	70.58959	2	Washer, Lock, 1/2-in., Stl, Pl

Table 4.10—Power-End Lubrication Hose/Line Subassembly (Continued)

Loc	SAP Part No.	Legacy No.	Qty	Description
10	100026525	70.32914	2	Nut, Hex, 1/2-in. 13NC, Pl
11	100058261	316.1328	1	Hose Assembly, Lube Pressure, HT-400™ Power End
12	100058262	316.13282	1	Hose Assembly, Gear Support Bearing Lube, HT-400™ Power End
13	100058263	316.13283	1	Hose Assembly, Thrust Bearing Lube, HT-400™ Power End
14	100025591	70.26634	1	Adapter, Hose, 070102-4-2C, 7-16-20 JIC Male x 1/8-27 NPT Male, Steel
15	100016618	27.00101	1	Coupling, 1/8 NOM 27V, Standard, Steel
16	100025640	70.26763	2	Adapter, Hose, Straight, 9/16-18 JIC Male x 3/8-18 NPT Male, Steel
17	100031391	70.72665	1	Adapter, Hose, Tee, 2 x 9/16-18 JIC Male x 9/16-18 JIC SWVL FML, STL
18	100025641	70.26764	1	Adapter, Hose, Straight, 7/16-20 JIC Male X 3/8-18 NPT Male, Steel
19	100012853	70.26364	3	Adapter, Hose, Elbow, 9/16-18 JIC Male x 9/16-JIC SWVL FML, STL
20	100025596	70.26644	1	Adapter, Hose, Straight, 9/16-18 JIC Male X 1/4-18 NPT Male, Steel
21	100058310	316.16416	1	Plug, Orifice, 1/8 NPT, 0.157 Dia Hole
22	101284157		1	Tube, Oil Line, General, HT-400™ Pump Power End, (Includes Rubber Lines and Fittings)
23	100011692	316.11917	3	Bolt, Saddle, Crosshead Oiler
24	100002324	70.72129	6	Washer, Seal, 1/2-in.
25	100011693	316.11918	6	Saddle, Oil Line, Crosshead Oiler
26	100000946	8.33929	6	O-Ring, 90D, 1 1/16-in. x 7/8-in. x 3/32-in.

Crankshaft Lubricator Subassembly

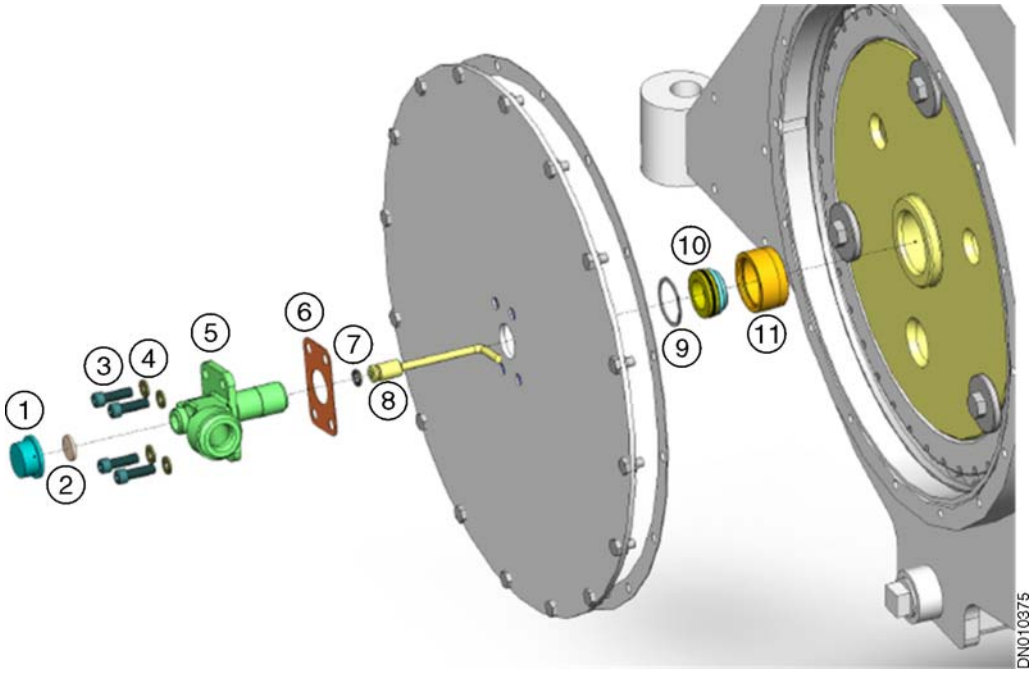


Table 4.11—Crankshaft Lubricator Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100010084	106.53475	1	Nut, 63121, Thread Protector, 7/8-in., S-W
2	100057942	315.32351	1	Gasket, Drive-Adapter Cap, Gallon Counter
3	100028439	70.43786	4	Screw, Hex Cap, 5/16-in. 18NC x 1-in., Pl
4	100015040	70.58952	4	Washer, Lock, 5/16-in., Stl, Pl
5	100011695	316.13197	1	Injector, Oil, Crankshaft, With l lb 20 Adapter
6	100011700	316.16414	1	Gasket, Injector, Crankshaft Oil, With No. 20 Adapter
7	100001944	70.33947	1	O-Ring, 90D, 9/16-in. x 3/8-in. x 3/32-in.
8	100002816	316.13308	1	Shaft, Drive, Gallon Counter
9	100028033	70.42144	1	Ring, Retaining, 5000, 156-H, Int, Truarc
9a	100013005	70.42128	1	Ring, Retaining, UR-165-S, Stnls, Spirolox (Used on pre-1981 pumps)
10	100013035	70.45847	1	Seal, Magnetic Shaft, MSC-65152, Rev B
11	100002821	316.14142	1	Bushing, Magnetic Seal, Insulator & Counter Drive

Case Cover Subassembly

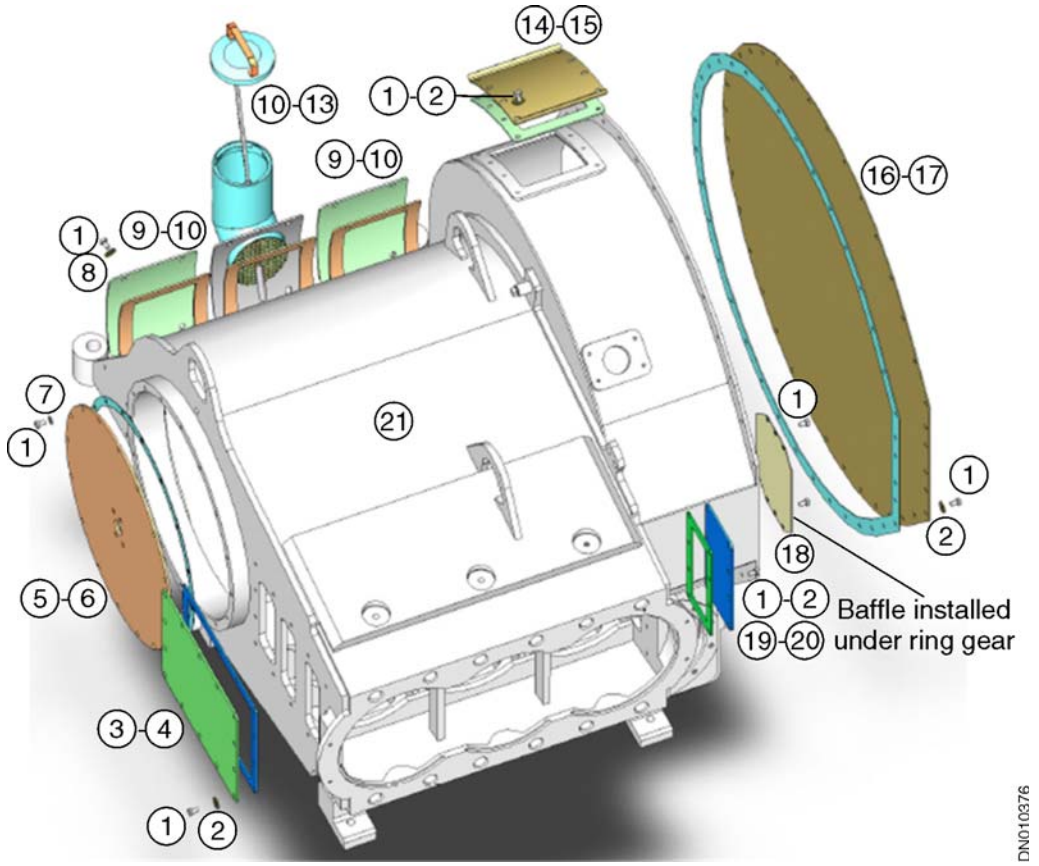


Table 4.12—Case Cover Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100028435	70.43781	97	Screw-Hex Cap, 5/16-in. 18NC x 1/2-in., Pl
2	100013115	70.76708	67	Washer, Seal, 5/16-in., Barwood
3	100058273	316.13321	1	Cover, Long, Crosshead Slide
4	100011698	316.13323	1	Gasket, Long Cover, Crosshead Slide
5	100058237	316.13210	1	Plate, Cover, Oil Injector
6	100009528	316.13301	1	Gasket, Oil Injector, Cover Plate
7	100009677	70.58981	16	Washer, Lock, 5/16-in., Internal, Shakeproof, Pl
8	100029873	70.58805	12	Washer, Flat, 5/16-in., Wi, Pl
9	100058086	316.11344	2	Cover, Connecting Rod Access

Table 4.12—Case Cover Subassembly (Continued)

Loc	SAP Part No.	Legacy No.	Qty	Description
10	100011682	316.11345	3	Gasket, Connecting Rod Access Cover
11	100011696	316.13244	1	Cover Assembly, Con Rod Access, W/4 1/4-in. OD Filler Neck
12	100002844	70.12486	1	Cap, Filler, Wisco, Vented
13	100002815	316.13249	1	Dipstick, Oil, 4 1/4-in. OD Filler Neck
14	100058070	316.11143	1	Cover, Inspection, Gear
15	100011680	316.11144	1	Gasket, Cover, Inspection Gear
16	100058084	316.11311	1	Cover, Plate, Gear Housing
17	100002810	316.11313	1	Gasket, Cover Plate, Gear
18	100058085	316.11315	1	Baffle, Inside, Gear Housing
19	100058271	316.13317	1	Cover, Short Crosshead Slide
20	100011697	316.13319	1	Gasket, Short Cover, Crosshead Slide
21	100058208	316.131	1	Power-End Case, Machined, Right-Hand Drive
21	100058299	316.161	1	Power-End Case, Machined, Left-Hand Drive

L-2 Spacer Subassembly

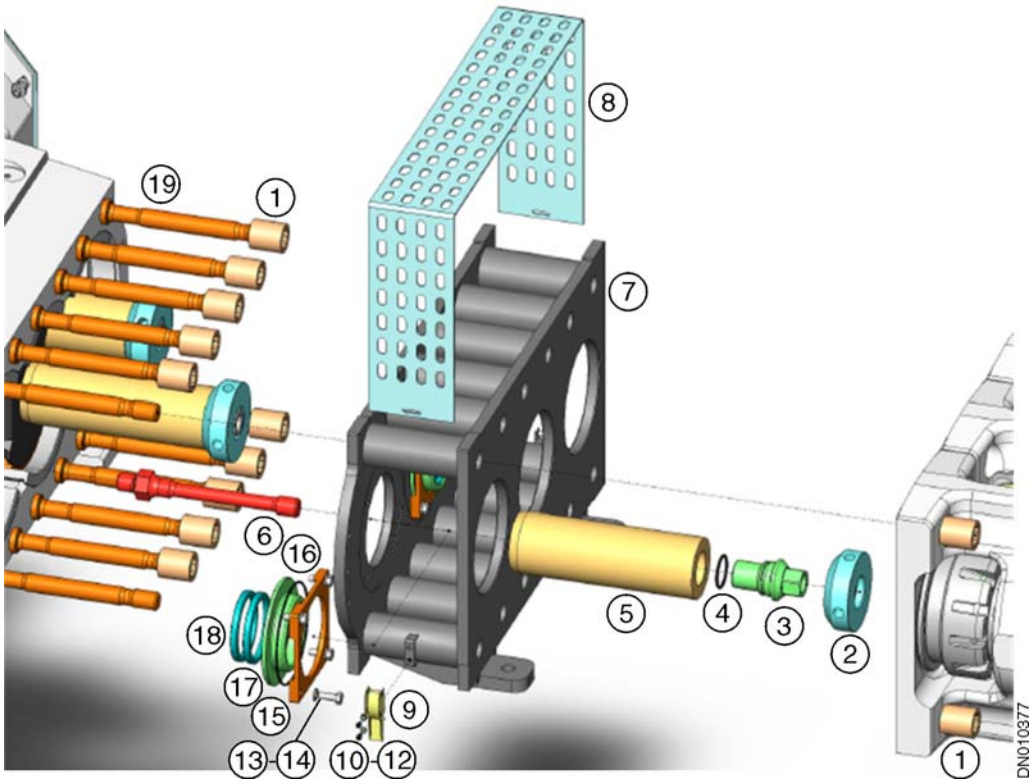


Table 4.13—L-2 Spacer Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100002811	316.11621	12	Nut, 1-14 NF, Internal Wrenching, 1.03 Thread Length
2			3	See Plunger Subassembly For Plunger Adapter Part No.
3	100002833	316.21066	3	Retainer, Push Rod, HT-400™, Two Piece Nose, L-Spacer
4	100000959	8.34020	3	O-Ring, 90 Duro, 1 7/8 x 1 5/8 x 1/8, 568-223
5	100002832	316.21065	3	Push Rod, Two Piece, L-Spacer, HT-400™
6	100002971	316.25166	3	Tie Rod, Push Rod, L-Spacer, HT-400™
7	100058516	316.25168	1	Spacer, L-Frame, Machined, HT-400™ FE & PE
8	100058513	316.25100	1	Guard Assembly, HT-400™, L-2 Spacer
9	100011067	106.63914	2	Hinge, DR-35, Latch, Hood, Bassick
10	100026633	70.33263	4	Nut, Clip, 10-24, Steel With Bright Green Finish

Table 4.13—L-2 Spacer Subassembly (Continued)

Loc	SAP Part No.	Legacy No.	Qty	Description
11	100028741	70.44540	4	Screw, Round Head, Machine, No 10-24 NC x 3/8, PL
12	100029918	70.58947	4	Washer, Lock, #10 ST Plated
13	100013017	70.43814	12	Screw, Hex Cap, 3/8-16 NC x 1, PL, Spec 70.43917
14	100013059	70.58955	12	Washer, Lock, 3/8, Steel, PL, Spec
15	100002804	316.10012	3	Retainer, Push Rod Seal Housing, L-2 Spacer, HT-400™ Pump
16	100001903	70.33739	3	O-Ring, 70 Duro, 5 11/16 x 5 1/2 x 3/32 568-161
17	100002805	316.10013	3	Housing, Push Rod Seal, Floating, L-2 Spacer, HT-400™
18	100002806	316.10014	6	Seal, Push Rod, L-Spacer, HT-400™
19	100002968	316.24923	12	Stud, Attaching, Fluid End to Power End, L Spacer, HT-400™ Pump

L-4 Spacer Subassembly

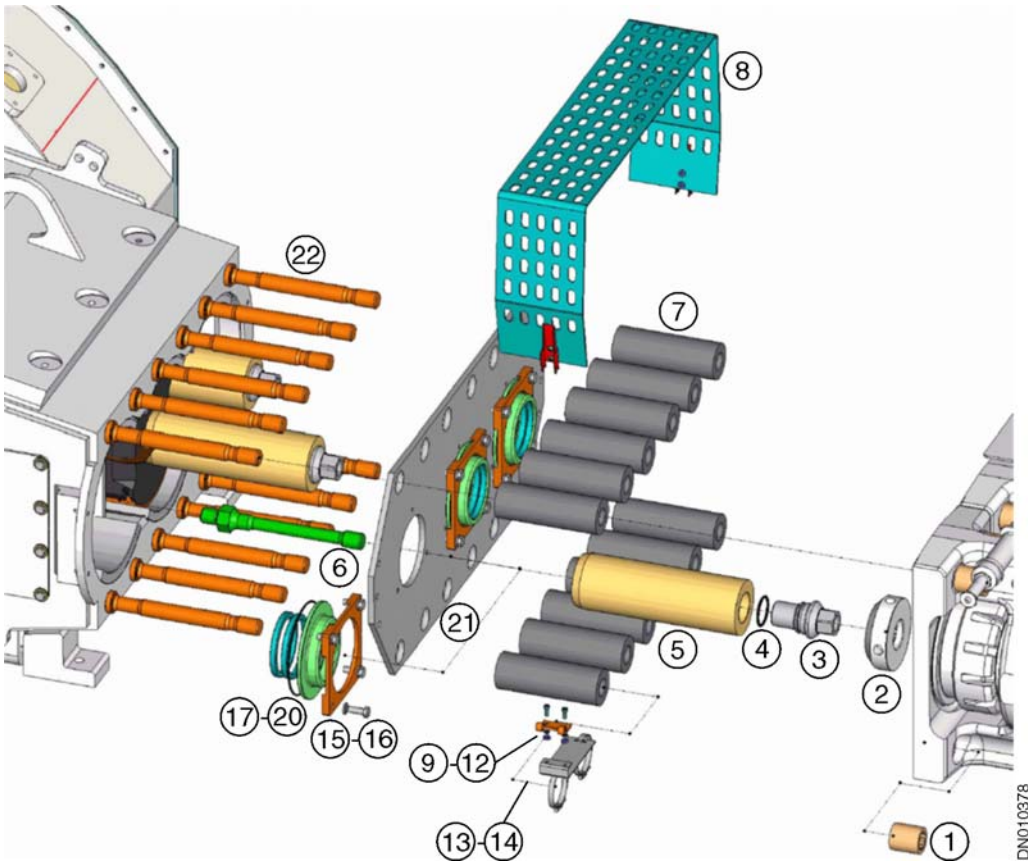


Table 4.14—L-4 Spacer Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100002811	316.11621	12	Nut, 1-14 NF, Internal Wrenching, 1.03 Thread Length
2			3	See Plunger Subassembly For Plunger Adapter Part No.
3	100002833	316.21066	3	Retainer, Push Rod, HT-400™, Two Piece Nose, L-Spacer
4	100000959	8.34020	3	O-Ring, 90 Duro, 1 7/8 x 1 5/8 x 1/8, 568-223
5	100002832	316.21065	3	Push Rod, Two Piece, L-Spacer, HT-400™
6	100002971	316.25166	3	Tie Rod, Push Rod, L-Spacer, HT-400™
7	100058500	316.24926	12	Tube, Frame, L-4 Spacer

Table 4.14—L-4 Spacer Subassembly (Continued)

Loc	SAP Part No.	Legacy No.	Qty	Description
8	100009593	316.25101	1	Guard Assembly, HT-400™, L-4 Spacer
9	100011068	106.63915	2	Fastener, Bar, Hood, Bassick, DH-40
10	100026443	70.32708	4	Nut, Elastic Stop, 10-32 NF
11	100028197	70.43289	4	Screw, Hex Socket, #10-32 NF x ½, SS
12	100029949	70.59015	4	Washer, Lock, #10 SS
13	100058335	316.21253	2	Mount, Latch, Guard, Aluminum Spacer, HT-400™ Pump
14	100023243	70.15877	4	Clamp, Hose, SAE #36, 1 7/16 – 2 3/4
15	100028439	70.43786	9	SCREW, HEX CAP, 5/16-18 NC X 1, PL,
16	100015040	70.58952	9	Washer, lock 5/16 , Steel Pl
17	100002818	316.14070	3	Retainer, Push Rod Seal Housing, L4 Spacer, HT-400™
18	100002025	70.34106	3	O-Ring, 70 Duro, 4 15/16 X 4 3/4 X 3/32 568-158
19	100002819	316.14072	3	Housing, Push Rod Seal, Floating, L4 Spacer, HT400
20	100002806	316.10014	6	Seal, Push Rod, L-Spacer, HT-400™
21	100058501	316.24927	1	Plate, PE, Steel, HT-400™, L-Spacer
22	100002968	316.24923	12	Stud, Attaching, Fluid End to Power End, L Spacer, HT-400™ Pump

Section

5

Standard HT-400™ Pump Fluid-End Maintenance and Repair

Introduction

This section provides various maintenance and repair information and procedures for the HT-400™ pump fluid end.

Warning **Most fluid-end maintenance and repair requires cycling the plungers. The only approved method for turning the pump driveshaft at the time of this publication is with a strap wrench. Use of a non-approved tool may damage the driveshaft.**

Valves, Seats, and Retainers

Disassembly

1. Remove the discharge valve covers and the cylinder-head covers by hammering the retainer lugs counterclockwise (**Figure 5.1**).

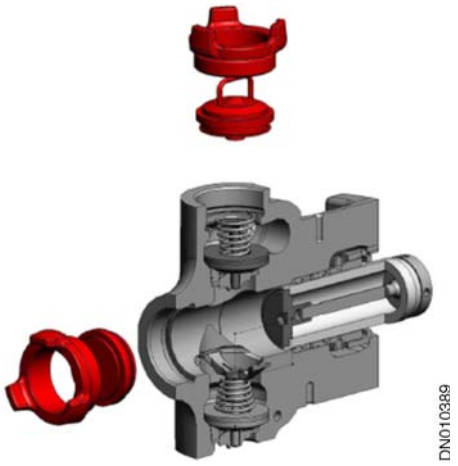


Figure 5.1—Remove discharge valve covers and cylinder-head covers

2. Remove the discharge valves and springs (**Figure 5.2**).
3. Remove the suction-valve stops using the tee wrench and adapter. Pry upward on the lock spring with a screw driver, and turn the stop 90° in either direction.

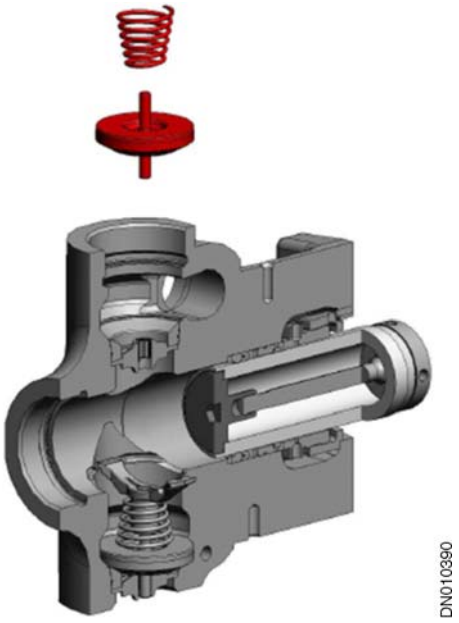


Figure 5.2—Remove discharge valves and springs

4. Remove the suction valves and springs (Figure 5.3).

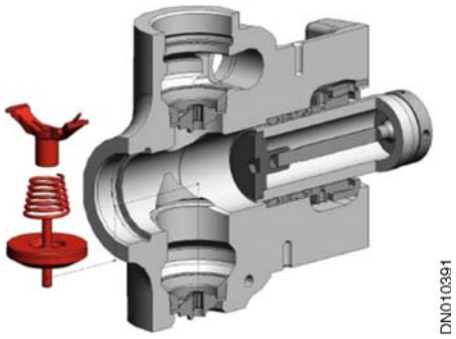


Figure 5.3—Remove suction valves, springs, and valve stop/spring retainers

Retainers and Seats

These steps are repeated for each of the discharge-valve seats.

1. If the valve seats, bushing retainers, or bushings are worn, install the spreader of the seat puller into one of the discharge valve retainers (No. 4 and No. 5 valves only).
2. Move the lug retainer upward off the seat puller, allowing the ends of the puller lugs to move together, spreading the O-ring. Install the puller assembly over the spreader already installed in the guide bushing, and guide the lugs through the valve seat, then engage the lugs underneath the valve seat.
3. Ensure that the engaging edges of the lugs are completely under the seat and that the end of the puller rod is contacting the top of the spreader. Then move the lug retainer back over the lugs to lock them in place.
4. Take a top guide (plate) from the correct-size valve seat installing tool and install it over the puller rod. The top guide will rest against the top of the fluid end, giving the puller something to push against.
   a. **(If using a hydraulic ram):** Install the ram over the puller rod, then thread the puller nut over the puller rod until it reaches the ram and pulls the slack from the puller assembly. Install the safety chain guard over the rod and onto the top of the ram. Secure the chains around the fluid end with enough slack to prevent the chains from binding during pulling.
   b. **(If NOT using a hydraulic ram):** Install the spacer followed by the thrust bearing over the puller rod and onto the top guide. Thread the puller nut over the puller rod until it reaches the ram and pulls the slack from the puller assembly. Tighten the nut with a pipe wrench to remove the seat.

5. Remove the guide bushing retainer from the valve seat bore (**Figure 5.4**).
6. Repeat Steps 1 through 6 for the other two discharge-valve seats.
7. Remove the suction-valve seats by repeating Steps 1 through 6 while using the further set of threads on the seat pulling tool rod.
8. After removing the final suction seat, inspect the fluid end for damage. Check the valve seat bores for fluid cutting. Also check the threads that secure the cylinder head covers and the crossbores for cracks.
9. Inspect the valve guide bushings, retainers, seats, valve stops, springs and valves. Replace the components that show signs of erosion or other damage.

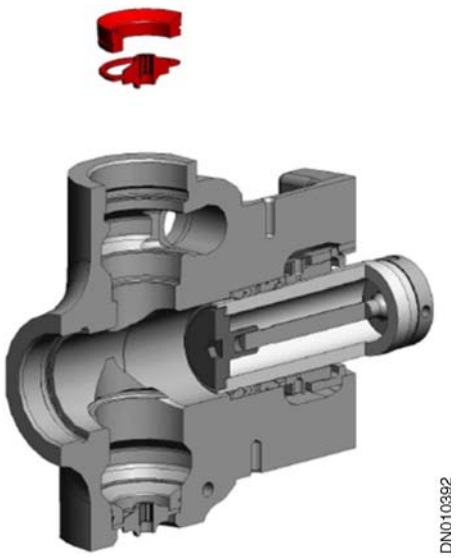


Figure 5.4—Remove discharge valve seat and guide bushing retainer from the valve seat bore

Assembly

Retainers and Seats

1. Fit the bushing retainers into the three suction-valve seat bores. Retainers are installed with the guide bushing offset toward the valve (**Figure 5.5**).
2. Install new O-rings on the valve seats, and using the seat inserter, drive the seats into the suction valve seat bores.
3. To fully seat the valve seats, pressurize the HT-400™ pump to the appropriate pressures before going on location (refer to **Table 5.1**).

Note — Improper installation of valve seats can result in seats being pumped out or the seat bores being fluid-cut.

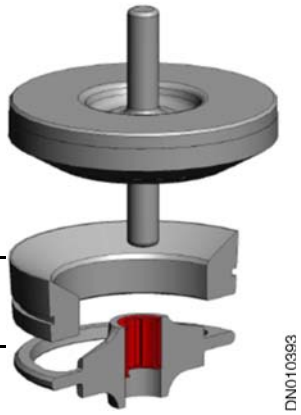


Figure 5.5—Guide bushing retainer installed with bushing towards valve

Table 5.1—Frac Valve Seat Seating Pressures

Fluid End (in.)	Seating Pressures psi (Mpa)
3 3/8	7,000 (48.263)
4	5,000 (34.474)
4 1/2	4,000 (27.579)
5	3,000 (20.684)
6	2,000 (13.790)

4. Repeat Steps 1 through 3 for the remaining suction-valve seats.
5. Fit the remaining bushing retainers into the discharge-valve seat bores with the guide bushings offset upward.
6. Drive the seats, with new O-rings in position, into the discharge-valve seat bores using the seat inserter.
7. To fully seat the valve seats, pressurize the HT-400™ pump to the appropriate pressures before going on location (refer to **Table 5.1**).

Valves

1. Ensure that the plastic suction stop boots, valve guide bushings, valve inserts, and valve bodies are in good shape. Replace these components if necessary.
2. Install the suction valves onto the suction valve seats with the plastic valve inserts contacting the valve seats.
3. Install the suction valve springs onto the suction valves. If the fluid end is 5.0- or 6.0-inch, make sure the small end of the spring is pointing up.
4. Lubricate the suction stop boots and install the suction valve stop and spring retainers over the suction valve springs. Use the stop and spring retainer installation tool to press down and turn so that the ears of the retainers are engaged in the grooves in the fluid end. Continue to turn the retainers 90° until the stop lock spring clicks into the notch in the fluid end.

Important	Ensure that the lock springs of the valve stops are well-seated in the short, vertical grooves.

Caution	**The lock springs must be seated properly to keep the stops from working out of the bores and into the path of the moving plungers.**

5. Inspect the front cylinder head cover gaskets and spacer rings for damage and replace if necessary. Install the covers with the lubricated gaskets and rings in place on the covers.
6. Inspect the threads of the cylinder head cover retainers for cracks. Lubricate and install the retainers over the cylinder head covers. To tighten the retainers, hit all the lugs of the retainers repeatedly until a sharp ringing is heard and the hammer strike results in an immediate bounce. Then hit the lugs a few more times to make sure they are very tight.

Note	Tightness of cylinder head cover retainers is absolutely necessary to maintain the structural integrity of the fluid-end sections. Failure to tighten (preload) the cylinder head cover retainers sufficiently will result in premature failure of the fluid end in the form of failed threads or fatigue cracks. If there is any doubt that the cylinder head cover retainers are sufficiently tight, tighten them a little more.

7. Install the discharge valves onto the discharge valve seats with the plastic inserts contacting the valve seats.
8. Install the discharge valve springs onto the discharge valves. If the fluid end is 5.0- or 6.0-inch, make sure the small end of the spring is pointing down onto the valve.

   Rule of Thumb – Both suction and discharge conical valve springs are always installed with the small end pointing toward the plunger.

9. Inspect the discharge valve cover gaskets, spacer rings, and valve guide bushings for damage and replace as necessary. Install the discharge valve covers with the lubricated gaskets and rings in place on the covers.
10. Inspect the threads of discharge valve cover retainers for cracks. Lubricate and install the retainers over the discharge covers. To tighten the retainers, hit all the lugs of the retainers clockwise repeatedly until a sharp ringing is heard and the hammer strike results in an immediate bounce.
11. After installing the frac-valve seats, pressurize the fluid end to one-third the maximum working pressure (**Table 5.1**). Pressurizing the fluid-end drives the seats into their bores, helping minimize chances of a seat being pumped out during a job.

Caution **Do not exceed the maximum pressure limit of the fluid end.**

Two-Piece Valve-Guide Bushing

The two-piece valve-guide bushing can be installed on any of the HT-400™ pumps and can be used interchangeably in the discharge covers, the guide-bushing retainers, and the suction-valve stops. You can replace the rubber insert without removing the discharge-valve seat or the bushing retainer. However, the suction-valve seat and retainer may have to be removed if the bushing is too difficult to reach.

Insert Disassembly

To disassemble the rubber insert, cut through the length of the insert and pull it out of the liner with a pair of needle-nose pliers.

Insert Assembly

1. Fold the new rubber insert lengthwise.
2. Fit the insert into the brass liner, and spread the rubber insert against the wall of the liner.
3. Clean and lightly lubricate the bushing bore. Use crocus cloth to remove burrs.
4. The new guide bushing is shorter than the bore in the discharge cover, the bushing retainer, and the suction-valve stop. Install the new guide bushing flush with the end of the bore and turn the retainer toward the frac valve (**Figure 5.6**).

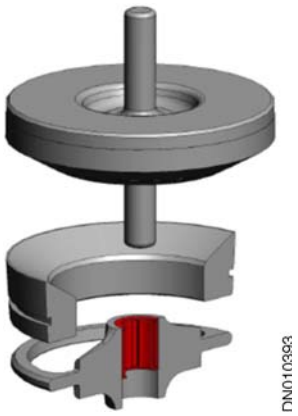


Figure 5.6—Guide bushing retainer installed with bushing towards valve

Pressure Packing and Plungers

Disassembly

1. Remove the cylinder-head covers by hammering the lugs of the cylinder head cover retainers counterclockwise (**Figure 5.7**).
2. Remove the plunger noses and seals (**Figure 5.8**) with a nose wrench and a support. Use a packing wrench inserted in the push rod adapter to keep the push-rod assembly from turning.
3. With the packing bar still inserted in the push rod adapter, remove the plunger tie-bolts using the socket wrench and a support (**Figure 5.9**).
4. Back off the packing nuts with the packing wrench.
5. Turn the power-end input shaft until the push rod is withdrawn into the power end as far as possible. Insert the plunger removing tool into the plunger. Position the removing tool so that the short lobe is between the end of the plunger and the push-rod adapter.

   Turn the input shaft so that the push rod pushes the plunger out of the packing into the fluid end chamber. Remove the plunger from the fluid end.

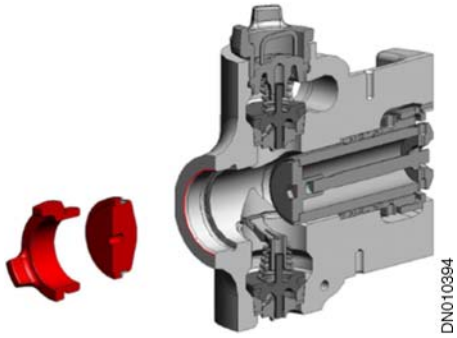


Figure 5.7—Remove the cylinder-head covers

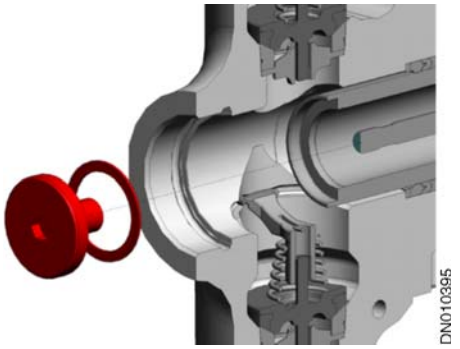


Figure 5.8—Remove plunger noses and seals

6. Repeat Steps 1 through 5 for the other two plungers.
7. Completely collapse the packing nut assemblies and remove them from the fluid end.
8. Remove the packing assemblies from the packing bores. Use a piece of wood to knock out the entire packing assembly if they cannot be removed by hand.

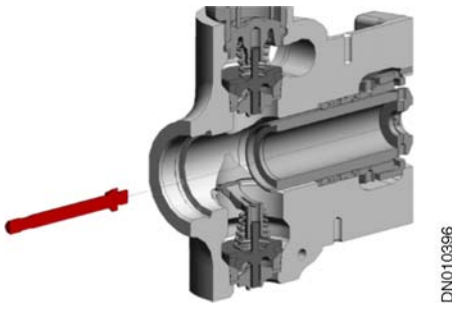


Figure 5.9—Remove the plunger tie bolts

Assembly

1. Clean the packing bores thoroughly. Make sure no cement or other material is stuck to the bores or the shoulders that the spacers press against. Check the packing bores for wear in the area of where the packing ring is installed.

Note	For pumps used in fracturing service, it is essential to clean out all sand fines using pressurized water. Small sand particles (flour) are almost impossible to remove by wiping with a towel. When these small particles of sand are pressed against the packing bore and cycled back and forth by the packing rings, steel is quickly removed from the packing bores, resulting in packing and packing bore failure.

   a. Using a micrometer, measure each bore at this point. Greatest wear occurs where the packing ring is installed because of packing movement coupled with the outward sealing pressure created as the header ring expands the packing ring (Figure 5.10).

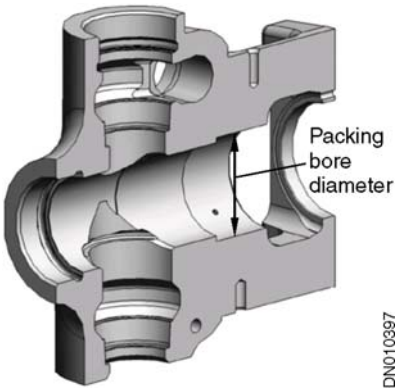


Figure 5.10—Use a micrometer to measure the packing bore diameter where the packing ring is installed

Table 5.2—Packing Bore Dimensions

Fluid End in. (cm)	Dimensions "A" in. (cm)
3 3/8 (8.573)	4.375/4.381 (11.113/11.128)
4 (10.160)	5.000/5.006 (12.700/12.715)
4 1/2 (10.160 to 11.430)	5.500/5.506 (13.970/13.985)
5 (12.700)	6.000/6.006 (15.240/15.255)
6 (15.240)	7.000/7.006 (17.780/17.795)

   b. Replace fluid-end sections with bores that are worn more than 0.010 in. oversized. The procedure for replacing faulty sections is described in "Changing Fluid-End Assembly" (Page 5-15).

   c. If the fluid end is machined to accept thin-wall packing sleeves, replace the sleeve rather than the entire fluid-end section. For this procedure, refer to "Replaceable Packing Sleeves" (Page 5-19).

2. Check the threads of the fluid-end sections for cracks. Replace faulty sections following the procedure outlined in "Changing Fluid-End Assembly" (Page 5-15).

3. Separate the two pieces of the packing nut assembly and inspect the threads for damage. Clean and lubricate the threads before threading the two components back together.
4. If only the expendables are being replaced (header, packing ring, female adapter, packing lube seal and O-ring), inspect the seal carrier and the spacer that will be reused. Remove any burrs or nicks with a file or emery cloth. Make certain all the lubricating oil ports and seal grooves in the seal carrier are clean and free of cement or other pumping material. Discard and replace carriers and/or spacer rings that are severely corroded or damaged. Inspect the carrier for fatigue cracks that may occur with long-term service. Check to make sure the spacer ring is not bent.

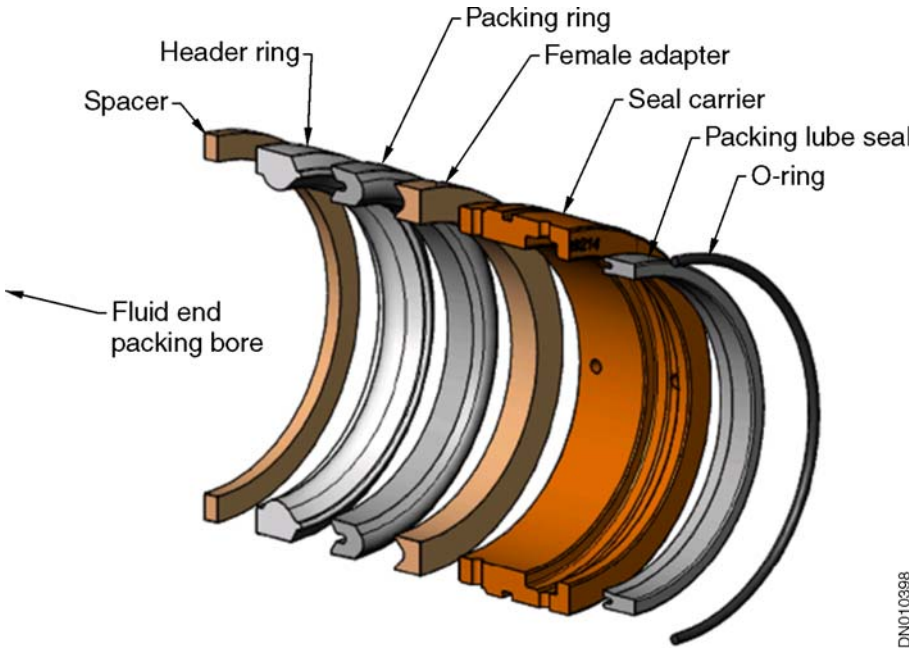


Figure 5.11—CDI Plunger Packing Arrangement

5. Lightly oil the outside of the carrier. Install the O-ring in the groove on the OD of the carrier. Do not roll the ring as it slides over the outside of the carrier. Snap a packing lube seal into the groove in the ID. The lube seal is installed with the lip toward the lube ports in the carrier.
6. Lightly oil the spacer ring and install into the packing bore with either side out.
7. Lightly oil the header ring and install it into the packing bore with the flat side facing the already installed spacer ring.
8. Lightly oil the packing ring and install it with the open end of the “vee” toward the header ring.
9. Lightly oil the female adapter and install it into the packing bore with the open cupped end toward the installed packing ring.

10. Install the seal carrier with the lube ports (holes) ahead of the O-ring.
11. Thread the packing nut assembly completely together. Ensure that the ends of the packing nut assembly and the fluid end are clean where they come in contact. Put the packing nut assembly in place on the fluid end and begin running the assembly out, making sure to line up the pin slot on the packing nut sleeve with the groove pin installed in the fluid-end foot.
12. Once the packing nut assembly is contacting the seal carrier and the fluid-end foot, seat the packing by tightening the packing nut with a packing wrench until snug, approximately a 30-lb pull on a 15-in. packing wrench.
13. Loosen the packing nut until it loses contact with the seal carrier then re-tighten the packing nut until it just contacts the seal carrier to allow installation of the plunger.
14. Lubricate the threads of the plunger tie bolt and thread the hex end into the pushrod retainer. Torque the plunger tie bolt to 350 ft-lb using a plunger tie bolt socket wrench and wrench support (half-moon).
15. Insert the correct size plunger centering guide into the front of the fluid end. Clean and lubricate the plunger and insert it in through the plunger centering guide, tapered-end first.
16. Thread the tie rod half of the plunger installation tool (machine gun bar, piccolo bar, swiss cheese bar, bar with holes in it) onto the plunger tie bolt. Install the plunger half of the plunger installation tool (top hat, cylinder with holes on either end) onto the tie rod half of the plunger installation tool.
17. Push the plunger in through the packing by sticking a packing wrench or appropriately shaped bar into the plunger installation tool tie rod half and pry forward against the plunger half of the installation tool. Repeat this process until the plunger is all the way through the packing assembly, then remove both pieces of the plunger installation tool (leave the centering guide in place).
18. Turn the drive shaft of the pump to bring the pushrod adapter up against the plunger. Install the plunger nose and lubricated seal onto the plunger tie bolt and torque the plunger nose to 250 ft-lb using a plunger nose wrench and wrench support (half moon).
19. Remove the plunger centering guide.

Note	If a plunger centering guide is not used, the plunger nose needs to be snugged to approximately 30 ft-lb. Then the plungers need to be cycled back and forth at least once before the noses are torqued to 250 ft-lb. This step is necessary to center the plunger on the push rod adapter.

20. Repeat Steps 3 through 19 for the remaining fluid-end sections.
21. Inspect the front cylinder head cover gaskets and spacer rings for damage and replace if necessary. Install the covers with the lubricated gaskets and rings in place on the covers.
22. Inspect the threads of cylinder head cover retainers for cracks. Lubricate and install the retainers over the cylinder head covers. To tighten the retainers, hit all the lugs of the retainers clockwise

repeatedly until a sharp ringing is heard and the hammer strike results in an immediate bounce. Then hit the lugs a few more times to make sure they are very tight.

Note	Tightness of cylinder head cover retainers is absolutely necessary to maintain the structural integrity of the fluid end sections. Failure to tighten (preload) the cylinder head cover retainers sufficiently will result in premature failure of the fluid end in the form of failed threads or fatigue cracks. If there is any doubt that the cylinder head cover retainers are sufficiently tight, tighten them more.

Tie-bolts and Discharge Passage Seals

Disassembly

The following instructions are used for disassembling the top and bottom tie-bolt configuration.

1. Remove the fluid end by following the disassembly steps under, “Changing Fluid-End Assembly” (**Page 5-15**).
2. Position the fluid end upright on the foot (cylinder head facing up) and remove the bottom tie-bolt.

Note	Spacers and seals are compressed if the top tie-bolt is removed first.

3. Remove the top tie-bolt.
4. Remove the four nuts from the discharge flanges. Remove the flanges, flange seals, and spacers.
5. Separate the sections, and remove the spacers and seals.

Assembly

1. Clean the seal bores of the sections not discarded and check them for fluid cutting. If the shoulder that backs up the fluid seal is eroded, replace that fluid-end section.
2. Plug unused stud holes with grease to help prevent rust.
3. Assemble the fluid-end sections with the spacers and new seals.
4. Install the discharge flanges with short spacers and new seals. Coat the threads of the discharge flange studs with thread lubricant and tighten the discharge flange nuts to the proper torque specification (see torque requirements, **Table 5.3**, **Page 5-21**).
5. Coat the threads of the top tie-bolt with thread lubricant, install the tie-bolt, and torque it to specification (see torque requirements, **Table 5.3**, **Page 5-21**).
6. Coat the threads of the bottom tie-bolt with thread lubricant, install it, and torque it to specification (see torque requirements, **Table 5.3**, **Page 5-21**).
7. Install the fluid end using the assembly steps in the following section, “Changing Fluid-End Assembly” (**Page 5-15**).

Changing Fluid-End Assembly

Disassembly

1. Disconnect the plunger lube supply and return hoses from the fluid end.
2. Remove the cylinder-head covers by hammering the lugs of the cylinder-head cover retainers counterclockwise.
3. Use a plunger nose wrench supported by a wrench support to remove the plunger noses and seals. Insert the round end of a packing bar into the pushrod adapters to prevent the pushrod assembly from turning.
4. With the packing bar still in the pushrod adapter, remove the plunger tie-bolts using a plunger tie-bolt socket wrench and wrench support.
5. Move the plungers into the fluid end by turning the power-end input shaft with a strap wrench.
6. Support the fluid end using chains and an overhead crane. Remove the 12 internal wrenching nuts holding the fluid end to the spacer and remove the fluid end.

Assembly

1. If a stud has been galled, pry the spacer assembly off and remove the stud with a pipe wrench. Check the threads in the power end. Re-tap or drill, tap, and helicoil damaged threads. A maximum of three helicoils can be used between all 12 fluid-end mounting holes (refer to **Figure 5.12**).

Note	For additional information, see Specification D00248012.

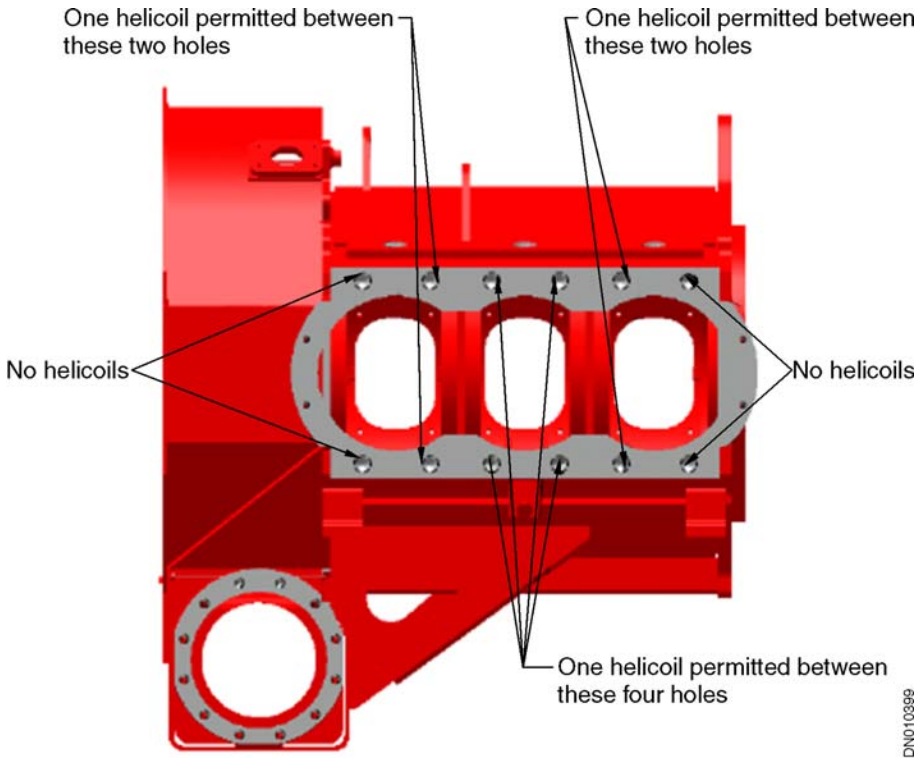


Figure 5.12—Drawing showing proper use of helicoils for the power end

2. After applying thread lubricant to the threads, install a new stud with a stud driver and torque to specification (see **Table 5.3**, **Page 5-21**).
3. If the spacer assembly was removed, clean the sealing surfaces thoroughly, apply a thin continuous bead of RTV silicone around the attaching studs on the power-end sealing face, and reinstall the spacer.
4. Using the chain and hoist, fit the fluid end on the spacer. Apply the correct lubricant to the threads of the studs and install the 12 nuts (and washers if required). Use the locknut wrench and the extension or a hydraulic wrench and reaction arm to torque the nuts (see torque requirements, **Table 5.3**, **Page 5-21**).

5. Reconnect the plunger lube oil supply and return hoses.
6. Be sure to install the correct size push-rod nose adapters when changing from one diameter plunger to another. Install the push-rod nose adapters onto the ends of the push-rod nose retainers.
7. Finish the fluid-end installation by completing the steps outlined in the section, “Pressure Packing and Plungers Assembly” (**Page 5-10**).

Discharge Flanges

Maintenance/Repair Procedure

1. Remove the nut from the top tie-bolt.
2. Remove the two nuts securing the bottom of the discharge flange.
3. Remove the flange and seals, and the seal spacer.
4. Clean the seal bores. Check the bores for fluid cutting. If the shoulder that backs up the seal has been eroded, replace the fluid-end section using the procedure in, “Changing Fluid-End Assembly” (**Page 5-15**).
5. Install a new seal assembly (two seals and the spacer). Reinstall the flange.
6. Coat the threads of the studs with thread lubricant and install the two nuts on the studs. Torque the nuts with a calibrated torque wrench or hydraulic wrench to specification (see torque requirements, **Table 5.3**, **Page 5-21**).
7. Coat the thread of the top tie-bolt with thread lubricant, and install the nut onto the top tie-bolt. Torque the nut to specification (see torque requirements, **Table 5.3**, **Page 5-21**).

Important **Use a box-end wrench as a backup. Do NOT use a pipe wrench as a backup. A pipe wrench will damage the surface of the bolt and may cause a stress fissure, which could crack.**

Replaceable Packing Sleeves

Some HT-400™ pump fluid ends are machined to accept a replaceable thin-wall packing sleeve and a two-piece packing nut. Resleeving fluid ends that sustain packing bore wear with this method is more economical than replacing the section.

Sleeve Removal Procedure

1. Use an oxyacetylene torch to heat a 3-in. (7.62-cm) strip from “front to rear” on the inside diameter of the sleeve. Heat the strip until it is red hot (use an Oxweld® 90 heating tip or equivalent).

Caution	**Heat the sleeve, but do NOT cut it.**

2. Rapidly quench the sleeve with water. At the same time, use a metal bar to knock the sleeve out of the bore.

Note	If the sleeve is difficult to remove, you may need two strips heated 180° apart.

3. Check the bore for burrs and clean out all debris, rust, etc. Polish with crocus cloth or something similar, and ensure that the sealing area for the O-ring is clean and smooth.

Sleeve Installation Procedure

1. Install an O-ring on the new sleeve.
2. Lightly lubricate the sleeve and packing bore with oil. Do not put oil on the front taper of the sleeve.
3. Pass the sleeve through the spacer frame, and start it into the bore.
4. Place the tool into the sleeve, small end first.
5. Put the rod into the fluid end, round end first.
6. Install the lugs on the rod. Use an O-ring to secure the lugs in place (on some sizes, the lug retainer may be used to help hold the lugs).
7. Push the rod with the lugs back into the tool and hold the lugs in place, 180° apart.
8. Place the top guide over the rod and into the cylinder-head threads.
9. Slide the ram over the rod.
10. Thread the nut onto the rod to hold the ram centered on the plate.
11. Stroke the pump to pull the sleeve into the bore.
12. When the ram reaches the end of the stroke, bleed off pressure and destroke the ram piston by turning the nut.

13. Continue stroking the pump/ram until the rear of the sleeve is flush with or slightly below the face of the fluid-end bore.
14. Remove all tools.
15. Drill a 3/16-in. (4.7625-cm) [0.187-in. (0.475-cm) pipe] diameter lube hole through the sleeve. Use the fluid-end lube hole and a pipe collar as a guide to match the drill.
16. If using a recirculating lube system, or if an air bleed hole is necessary, drill a second hole using the same method through one of the top ports.
17. De-burr the hole(s), and clean out all drill cuttings.
18. Repack and reassemble the fluid end.

Important **Ensure that the weep hole is not plugged. If the O-ring on the sleeve is cut, fluid will come from the weep hole, indicating that the sleeve must be removed and a new O-ring installed.**

Fastener Torque Requirements

Table 5.3—Pump Fastener Torque Values*
(Torque Table from Specification 316.00100, Rev. H)

Fastener	Thread Diameter		Copper-based	Moly-based	Oil	Copper-based	Moly-based	Oil
			Torque					
	in.	n	(ft-lb)	(ft-lb)	(ft-lb)	(N-m)	(N-m)	(N-m)
Fluid-end attaching stud into power end (all)	1.000	14	183	200	350	249	271	475
Nut to fluid-end attaching stud (not more than 1/2 turn of nut after snug to 75 ft-lb)	1.000	14	750	830	1432	1017	1126	1941
Top tie-bolt	1.375	12	1374	1500	2640	1862	2034	3579
Bottom tie-bolt	0.750	16	184	200	348	249	271	472
Discharge flange stud to fluid end	1.000	14	183	200	349	248	271	474
Nut to discharge flange stud	1.000	14	403	440	770	547	597	1044
Pushrod tie-bolt to crosshead	1.000	14	288	314	550	391	426	746
Pushrod retainer to pushrod tie-bolt	1.000	14	236	257	450	320	349	610
Plunger tie-bolt to pushrod retainer	1.000	14	183	200	350	249	271	475
Plunger tie-bolt to pushrod retainer	1.000	14	131	143	250	178	194	339
Connecting rod cap bolt	0.750	10	119	130	220	162	176	298
Gear support flange	0.500	13	46	50	84	63	68	114
Gear support thrust plate	0.500	13	56	60	101	75	82	137
Grizzly™ pump gear case bolt and nut	0.625	11	162	175	296	219	238	401
Grizzly™ pump gear case bolt only	0.625	11	143	155	262	194	210	355
Suction header stud	0.625	11	92	100	168	125	135	228
Suction header nut	0.625	11	139	150	253	188	203	343
Allison transmission nut	2.000	16	730	800	1430	990	1085	1938
Grizzly™ pump input flange	0.500	13	70	75	127	95	102	172

*Torque values will vary depending on the thread lubricant used

Section
6

Standard Fluid-End Parts

Introduction

This section provides parts lists for various HT-400™ pump fluid-end assemblies/subassemblies.

Suction Valve Subassembly

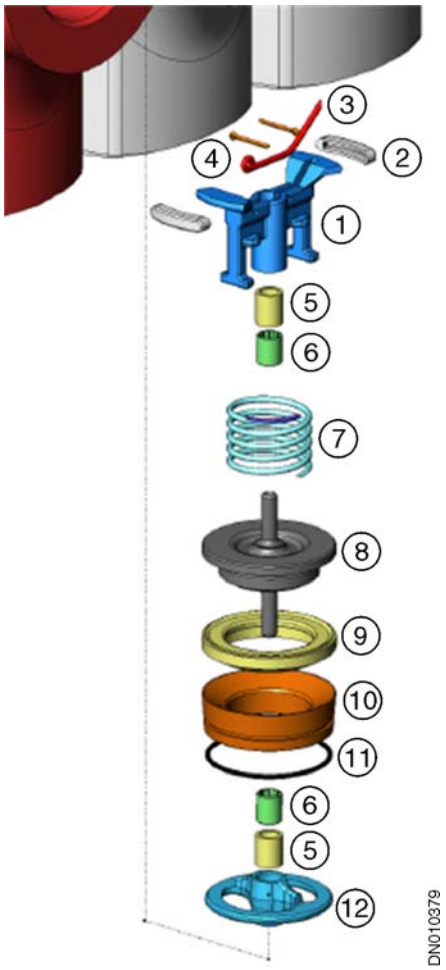


Table 6.1—3-3/8- and 4.0-inch (No. 3) Suction Valve Subassemblies

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100058419	316.22977	3	Retainer, Stop and Spring, HT400, No. 3 Suction Valve, Mach. Cast.
2	100002972	316.25233	6	Boot, Suction and Stop, HT-400™, No. 3, 4 and 5 Frac
3	100002841	316.2125	3	Spring, Lock, Suction Stop, No. 3, HT400
4	100002079	70.35717	6	Pin, Cotter, 1/8 x 1 1/2 Inch, HT-400™
5	100002868	316.22005	6	Liner, Two Piece Bushing, Valve Guide, HT400, No.4 Frac, Brass

Table 6.1—3-3/8- and 4.0-inch (No. 3) Suction Valve Subassemblies (Continued)

Loc	SAP Part No.	Legacy No.	Qty	Description
6	100002867	316.22004	6	Insert, Two Piece Bushing, Valve Guide, Special, HT-400™, No 4 Frac
7	100002837	316.2108	6	Spring, Valve, HT400, No. 3, 3.38 and 4 Inch, 36 lb/in
8	100002824	316.21007	6	Valve, HT400, 3.38, 4.0 In, Frac
9	101333083	316.21048	6	Insert, Valve, HT400, No. 3 Frac, Urethane, Acid/Frac Service (Yellow)
9	100002823	316.21006	6	Insert, Valve, HT400, No. 3 Frac, Urethane, Standard Service (Brown)
10	100002825	316.21008	6	Seat Valve, HT400, No. 3 Frac, Tapered
11	100000968	8.34037	6	O-ring, 90 Duro, 4 x 3 3/4 x 1/8, 568-240
12	100002838	316.21096	6	Retainer, Guide Bushing, HT400, 3.38, 4.0 Inch, Tapered Seat Bore

Table 6.2—4-1/2-inch (No. 4) Suction Valve Subassemblies

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100058432	316.23034	3	Retainer, Stop and Spring, HT400, No. 4 Suction Valve, Mach. Cast.
2	100002972	316.25233	6	Boot, Suction and Stop, HT-400™, No. 3, 4 and 5 Frac
3	100007270	316.22252	3	Spring, Lock, Suction Stop, No. 4, HT400
5	100002868	316.22005	6	Liner, Two Piece Bushing, Valve Guide, HT400, No.4 Frac, Brass
6	100002867	316.22004	6	Insert, Two Piece Bushing, Valve Guide, Special, HT-400™, No 4 Frac
7	100002936	316.2308	6	Spring, Valve, HT400, No. 4, 4.5 Inch, 25 lb/in
8	100002875	316.22048	6	Valve, HT400, 4.5 inch, Frac
9	101333104	316.22046	6	Insert, Valve, HT400, No. 4 Frac, Urethane, Acid/Frac Service (Yellow)
9	100002876	316.22049	6	Insert, Valve, HT400, No. 4 Frac, Urethane, Standard Service (Brown)
10	100002874	316.22047	6	Seat Valve, HT400, No. 4 Frac, Tapered
11	100000970	8.34041	6	O-ring, 90 Duro, 4 1/2 x 4 1/4 x 1/8, 568-244
12	100002955	316.23953	6	Retainer, Guide Bushing, HT400, No. 4, Tapered Seat Bore

Table 6.3—5.0- and 6.0-inch (No. 5) Suction Valve Subassemblies

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100058542	316.25840	3	Retainer, Stop and Spring, HT400, No. 5 Suction Valve, Mach. Cast.
2	100002972	316.25233	6	Boot, Suction and Stop, HT-400™, No. 3, 4 and 5 Frac
3	100002882	316.22253	3	Spring, Lock, Suction Stop, No. 5, HT400
5	100002870	316.22007	6	Liner, Two Piece Bushing, Valve Guide, HT400, No.5 Frac, Brass
6	100002869	316.22006	6	Insert, Two Piece Bushing, Valve Guide, Special, HT-400™, No 5 Frac
7	100058597	316.27259	6	Spring, Valve, HT400, No. 5, Conical, Stainless, 50 lb/in
8	100002960	316.24027	6	Valve, HT400, No. 5, 5.0 and 6.0 inch, Frac
9	101349952	316.24026	6	Insert, Valve, HT400, No. 5 Frac, Urethane, Acid/Frac Service (Yellow)
9	100002961	316.24037	6	Insert, Valve, HT400, No. 5 Frac, Urethane, Standard Service (Brown)
10	100002957	316.24024	6	Seat Valve, HT400, No. 5 Frac, Tapered
11	100000974	8.34045	6	O-ring, 90 Duro, 5 3/16 x 5 x 3/32, 568-159
12	100002962	316.24043	6	Retainer, Guide Bushing, HT400, No. 5, Tapered Seat Bore

Discharge Valve Subassembly

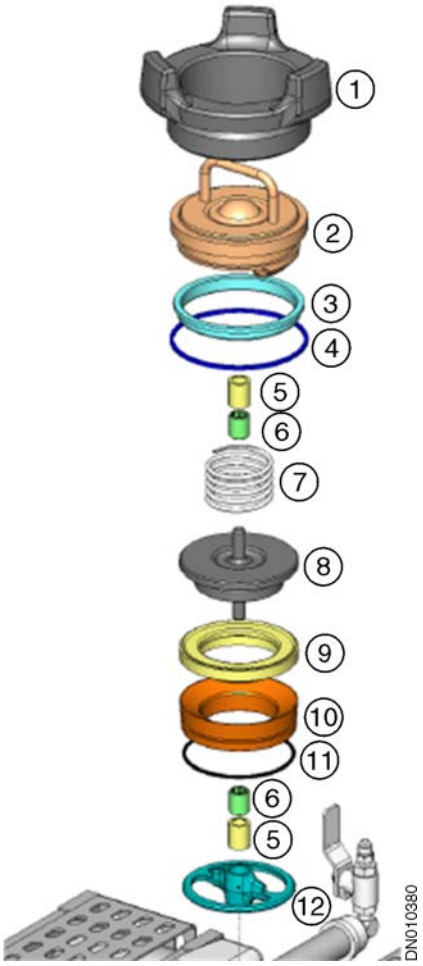


Table 6.4—3-3/8-inch Fluid-End Discharge Valve Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100008186	316.2102	3	Retainer, Cover, HT-400™, 3.38 in.
2	100002836	316.2107	3	Cover, Discharge, Double Guided Valve, HT-400™, 3.38 in.
3	100002830	316.21052	3	Gasket, Discharge Valve & Cylinder Head Cover, 3.38 in., HT-400™
4	100002829	316.21051	3	Ring, Spacer, Discharge Valve & Cylinder Head Cover, 3.38 in., HT-400™
5	100002868	316.22005	6	Liner, Two Piece Bushing, Valve Guide, HT400, No.4 Frac, Brass

Table 6.4—3-3/8-inch Fluid-End Discharge Valve Subassembly (Continued)

Loc	SAP Part No.	Legacy No.	Qty	Description
6	100002867	316.22004	6	Insert, Two Piece Bushing, Valve Guide, Special, HT-400™, No 4 Frac
7	100002837	316.2108	3	Spring, Valve, HT400, No. 3, 3.38 and 4 Inch, 36 lb/in
8	100002824	316.21007	3	Valve, HT400, 3.38, 4.0 In, Frac
9	101333083	316.21048	3	Insert, Valve, HT400, No. 3 Frac, Urethane, Acid/Frac Service (Yellow)
9	100002823	316.21006	3	Insert, Valve, HT400, No. 3 Frac, Urethane, Standard Service (Brown)
10	100002825	316.21008	3	Seat Valve, HT400, No. 3 Frac, Tapered
11	100000968	8.34037	3	O-ring, 90 Duro, 4 x 3 3/4 x 1/8, 568-240
12	100002838	316.21096	3	Retainer, Guide Bushing, HT400, 3.38, 4.0 Inch, Tapered Seat Bore

Table 6.5—4-inch Fluid-End Discharge Valve Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100007820	316.2202	3	Retainer, Cover, HT-400™, 4.0 in.
2	100002938	316.23091	3	Cover, Discharge, Double Guided Valve, HT-400™, 4.0 and 4.5 in.
3	100002878	316.22052	3	Gasket, Discharge Valve & Cylinder Head Cover, No. 4, HT-400™
4	100002877	316.22051	3	Ring, Spacer, Discharge Valve & Cylinder Head Cover, No.4, HT-400™
5	100002868	316.22005	6	Liner, Two Piece Bushing, Valve Guide, HT400, No.4 Frac, Brass
6	100002867	316.22004	6	Insert, Two Piece Bushing, Valve Guide, Special, HT-400™, No 4 Frac
7	100002837	316.2108	3	Spring, Valve, HT400, No. 3, 3.38 and 4 Inch, 36 lb/in
8	100002824	316.21007	3	Valve, HT400, 3.38, 4.0 In, Frac
9	101333083	316.21048	3	Insert, Valve, HT400, No. 3 Frac, Urethane, Acid/Frac Service (Yellow)
9	100002823	316.21006	3	Insert, Valve, HT400, No. 3 Frac, Urethane, Standard Service (Brown)
10	100002825	316.21008	3	Seat Valve, HT400, No. 3 Frac, Tapered
11	100000968	8.34037	3	O-ring, 90 Duro, 4 x 3 3/4 x 1/8, 568-240
12	100002838	316.21096	3	Retainer, Guide Bushing, HT400, 3.38, 4.0 Inch, Tapered Seat Bore

Table 6.6—4-1/2-inch Fluid-End Discharge Valve Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100007820	316.2202	3	Retainer, Cover, HT-400™, 4.0 in.
2	100002938	316.23091	3	Cover, Discharge, Double Guided Valve, HT-400™, 4.0 and 4.5 in.
3	100002878	316.22052	3	Gasket, Discharge Valve & Cylinder Head Cover, No. 4, HT-400™
4	100002877	316.22051	3	Ring, Spacer, Discharge Valve & Cylinder Head Cover, No.4, HT-400™
5	100002868	316.22005	6	Liner, Two Piece Bushing, Valve Guide, HT400, No.4 Frac, Brass
6	100002867	316.22004	6	Insert, Two Piece Bushing, Valve Guide, Special, HT-400™, No 4 Frac
7	100002936	316.2308	3	Spring, Valve, HT400, No. 4, 4.5 Inch, 25 lb/in
8	100002875	316.22048	3	Valve, HT400, 4.5 inch, Frac
9	101333104	316.22046	3	Insert, Valve, HT400, No. 4 Frac, Urethane, Acid/Frac Service (Yellow)
9	100002876	316.22049	3	Insert, Valve, HT400, No. 4 Frac, Urethane, Standard Service (Brown)
10	100002874	316.22047	3	Seat Valve, HT400, No. 4 Frac, Tapered
11	100000970	8.34041	3	O-ring, 90 Duro, 4 1/2 x 4 1/4 x 1/8, 568-244
12	100002955	316.23953	3	Retainer, Guide Bushing, HT400, No. 4, Tapered Seat Bore

Table 6.7—5.0- and 6.0-inch Fluid-End Discharge Valve Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100058508	316.2502	3	Retainer, Cover, HT-400™, 5.75 in.
2	100058471	316.24044	3	Cover, Discharge, Double Guided Valve, HT-400™, 5.0 and 6.0 in.
3	100011734	316.25052	3	Gasket, Discharge Valve & Cylinder Head Cover, No. 5, HT-400™
4	100011733	316.25051	3	Ring, Spacer, Cylinder Head Cover, No.5, HT-400™
5	100002870	316.22007	6	Liner, Two Piece Bushing, Valve Guide, HT400, No.5 Frac, Brass
6	100002869	316.22006	6	Insert, Two Piece Bushing, Valve Guide, Special, HT-400™, No 5 Frac
7	100058597	316.27259	3	Spring, Valve, HT400, No. 5, Conical, Stainless, 50 lb/in
8	100002960	316.24027	3	Valve, HT400, No. 5, 5.0 and 6.0 inch, Frac
9	101349952	316.24026	3	Insert, Valve, HT400, No. 5 Frac, Urethane, Acid/Frac Service (Yellow)
9	100002961	316.24037	3	Insert, Valve, HT400, No. 5 Frac, Urethane, Standard Service (Brown)
10	100002957	316.24024	3	Seat Valve, HT400, No. 5 Frac, Tapered

Table 6.7—5.0- and 6.0-inch Fluid-End Discharge Valve Subassembly

11	100000974	8.34045	3	O-ring, 90 Duro, 5-in. x 4 3/4-in. x 1/8-in., 568-248
12	100002962	316.24043	3	Retainer, Guide Bushing, HT400, No. 5, Tapered Seat Bore

Plunger/Cylinder Head Cover Subassembly

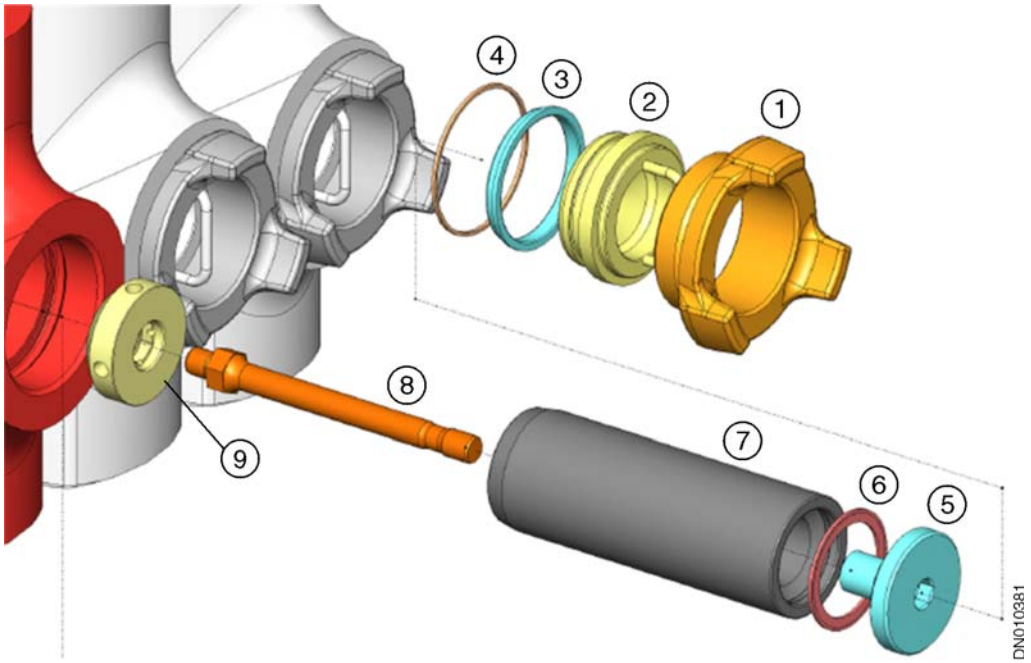


Table 6.8—3 3/8-inch Fluid-End Plunger/Cylinder Head Cover Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100008186	316.2102	6	Retainer, Cover, HT-400™, 3.38 in
1	100011711	316.22606	3	Retainer, Protective Cylinder Head Cover, 4.0 in
2	100002836	316.2107	3	Cover, Cylinder Head, HT-400™, 3.38 in
2	100002902	316.22605	3	Cover, Protective Cylinder Head, 4.0 in
3	100002830	316.21052	6	Gasket, 3 Discharge Valve & Cylinder Head Cover, 3 3/8 in
4	100002829	316.21051	6	Ring, Spacer, #3 Discharge Valve & Cylinder Head Cover, 3 3/8
5	100002843	316.2131	3	Nose, Plunger, HT-400™, 3 3/8 in.
6	100002842	316.2130	3	Seal, Plunger Nose Assembly, HT-400™, 3 3/8 in
7	100009641	316.21026	3	Plunger, 3 3/8 in., Hard Surface, L-Spacer, HT-400™
8	100002827	316.21028	3	Tie Rod, Plunger, HT-400™, 3.38, 4.0, 4.5 in
9	100002831	316.21059	3	Adapter, Pushrod, HT-400™, 3 3/8 in, Two Piece Nose

Table 6.9—4-inch Fluid-End Plunger/Cylinder Head Cover Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100008186	316.2102	6	Retainer, Cover, HT-400™, 3.38 in
1	100011711	316.22606	3	Retainer, Protective Cylinder Head Cover, 4.0 in
2	100002836	316.2107	3	Cover, Cylinder Head, HT-400™, 3.38 in
2	100002902	316.22605	3	Cover, Protective Cylinder Head, 4.0 in
3	100002830	316.21052	6	Gasket, 3 Discharge Valve & Cylinder Head Cover, 3 3/8 in
4	100002829	316.21051	6	Ring, Spacer, #3 Discharge Valve & Cylinder Head Cover, 3 3/8
5	100002885	316.2231	3	Nose, Plunger, HT-400™, 4.0 in.
6	100002884	316.2230	3	Seal, Plunger Nose Assembly, HT-400™, 4.0
7	100002883	316.22294	3	Plunger, 4.0 In., Hard Surface, L-Spacer, HT-400™
8	100002827	316.21028	3	Tie Rod, Plunger, HT-400™, 3.38, 4.0, 4.5 in
9	100011706	316.22302	3	Adapter, Pushrod, HT-400™, 4.0 in, Two Piece Nose

Table 6.10—4 1/2-inch Fluid-End Plunger/Cylinder Head Cover Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100007820	316.2202	6	Retainer, Cover HT-400™, 4.5 in
1	100007823	316.23639	3	Retainer, Protective Cylinder Head Cover, 4.5 in
2	100009530	316.2207	3	Cover, Cylinder Head, HT-400™, 4.5 in, Bar Stock
2	100002952	316.23638	3	Cover, Protective Cylinder Head, 4.5 in
3	100002878	316.22052	6	Gasket, 4 Discharge Valve & Cylinder Head Cover, 4 1/2
4	100002877	316.22051	6	Ring, Spacer, #4 Discharge Valve & Cylinder Head Cover, 4 1/2
5	100002941	316.2331	3	Nose, Plunger, HT-400™, 4.5, 5.0, 6.0 in.
6	100002940	316.2330	3	Seal, Plunger Nose Assembly, HT-400™, 4.5
7	100002937	316.23085	3	Plunger, 4.5 In., Hard Surface, L-Spacer, HT-400™
8	100002827	316.21028	3	Tie Rod, Plunger, HT-400™, 3.38, 4.0, 4.5 in
9	100011721	316.23089	3	Adapter, Pushrod, HT-400™, 4.5 in, Two Piece Nose

Table 6.11—5-inch Fluid-End Plunger/Cylinder Head Cover Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100058508	316.2502	6	Retainer, Cover, HT-400™, 5.75 in
1	100058490	316.24615	3	Retainer, Protective Cylinder Head Cover, 5 in
2	100058475	316.2407	3	Cover, Cylinder Head, HT-400™, 5.0 in
2	100011728	316.24614	3	Cover, Protective Cylinder Head, 5.0 in
3	100011734	316.25052	6	Gasket, 5 Discharge Valve & Cylinder Head Cover, 5 in
4	100011733	316.25051	6	Ring, Spacer, #5 Discharge Valve & Cylinder Head Cover, 5 in
5	100002941	316.2331	3	Nose, Plunger, HT-400™, 4.5, 5.0, 6.0 in.
6	100002940	316.2330	3	Seal, Plunger Nose Assembly, HT-400™, 4.5
7	100011726	316.24296	3	Plunger, 5.0 In., Hard Surface, L-Spacer, HT-400™
8	100002970	316.25165	3	Tie Rod, Plunger, HT-400™, 6.0 in
9	100011727	316.24336	3	Adapter, Pushrod, HT-400™, 5.0 in, Two Piece Nose

Table 6.12—6-inch Fluid-End Plunger/Cylinder Head Cover Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100058510	316.2506	6	Retainer, Cover, HT-400™, 6.0 in
1	100058618	316.27614	3	Retainer, Protective Cylinder Head Cover, 6 in
2	100008190	316.2507	3	Cover, Cylinder Head, HT-400™, 6.0 in
2	100058617	316.27613	3	Cover, Protective Cylinder Head, 6.0 in
3	100058512	316.25074	6	Gasket, 6 Discharge Valve & Cylinder Head Cover, 6 in
4	100058511	316.25073	6	Ring, Spacer, #6 Discharge Valve & Cylinder Head Cover, 6 in
5	100002941	316.2331	3	Nose, Plunger, HT-400™, 4.5, 5.0, 6.0 in.
6	100002940	316.2330	3	Seal, Plunger Nose Assembly, HT-400™, 4.5
7	100058514	316.25162	3	Plunger, 6.0 In., Hard Surface, L-Spacer, HT-400™
8	100002970	316.25165	3	Tie Rod, Plunger, HT-400™, 6.0 in
9	100058517	316.25172	3	Adapter, Pushrod, HT-400™, 6.0 in, Two Piece Nose

Packing Nut and Packing Subassembly

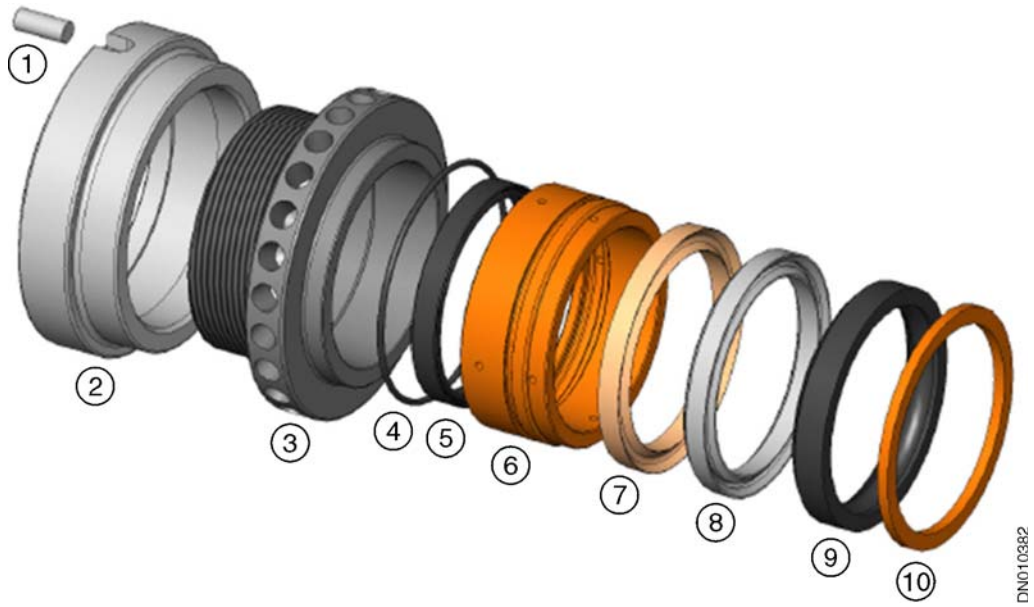


Table 6.13—3-3/8-inch Packing Nut

Loc	SAP Part No.	Qty	Description
1	100002081	3	Pin, Groove, ½-in x 1 ¼-in, Type 5
2	100002846	3	Sleeve, Wiper Gland, 3.375 Inch
3	100002845	3	Nut, Packing Adjustment, 3.375 Inch

Table 6.14—3-3/8-inch CDI Packing

Loc	SAP Part No.	Qty	Description
4	101377627	3	Seal, Packing Lube, 3.375, WS-Seal, CDI
5	100002011	3	O-Ring, 90 Duro, 4 3/8 x 4 1/8 X 1/8 568-243
6	101377626	3	Carrier, Seal, 3.375, CDI
7	101377624	3	Adapter, Female, 3.375, PEEK, CDI
8	101377623	3	Packing, 3.375, CDI, WSP1, PTFE
9	101377622	3	Header Ring, 3.375, HNBR, CDI
10	101377620	3	Spacer, 3.375, Fluid End, CDI

Table 6.15—3-3/8-inch Acid Service Packing (8140)

Loc	SAP Part No.	Qty	Description
4	101408135	3	Seal, Packing Lube, Z20, 3-3/8 x 3-7/8 x 9/16 Zurcon UCUP, Double Lip FE
5	100000969	3	O-Ring, 90 Duro, 4 3/8 x 4 1/8 X 1/8 568-243
6	101389194	3	Carrier, Seal, 3.375, HT-400™, 2004
7	100002852	3	Ring, Backup, Packing, HT-400™ 3.38 in, 2004
8	100002854	3	Packing Set, 3 3/8 x 4 3/8 x 0.50 Stock HT, 3 rings, Hard, Acid Service
9	100058346	3	Header Ring, 3 3/8 x 4 3/8 Packing, Polyurethane, HT-400™ FE
10	100002852	3	Adapter, Header Ring, 3 3/8 x 4/3/8, HT-400™, FE

Table 6.16—4.0-inch Packing Nut

Loc	SAP Part No.	Qty	Description
1	100002081	3	Pin, Groove, ½-in x 1 ¼-in, Type 5
2	101328357	3	Sleeve, Wiper Gland, HCLE, 4.0 Inch
3	101328001	3	Nut, Packing Adjustment, HCLE, 4.0 Inch

Table 6.17— 4.0-inch CDI Packing

Loc	SAP Part No.	Qty	Description
4	101377657	3	Seal, Packing Lube, 4.000, WS-Seal, CDI
5	100002016	3	O-Ring, 90 Duro, 5 x 4 3/4 X 1/8 568-248
6	101377656	3	Carrier, Seal, 4.000, CDI
7	101377652	3	Adapter, Female, 4.000, PEEK, CDI
8	101377641	3	Packing, 4.000, CDI, WSP1, PTFE
9	101377640	3	Header Ring, 4.000, HNBR, CDI
10	101377638	3	Spacer, 4.000, Fluid End, CDI

Table 6.18—4.0-inch Acid Service Packing (8140)

Loc	SAP Part No.	Qty	Description
4	100058388	3	Seal, Packing Lube, Z20, 4 x 4 1/2 x 9/16 Zurcon UCUP, Double Lip FE
5	100000974	3	O-Ring, 90 Duro, 5 x 4 3/4 X 1/8 568-248
6	101389213	3	Carrier, Seal, 4.0, HT-400™, 2004
7	101389224	3	Ring, Backup, Packing, HT-400™ 4.0 in, 2004
8	100002899	3	Packing Set, 4 x 5 x 0.50 Stock HT, 3 rings, Hard, Acid Service
9	100002897	3	Header Ring, 4 x 5 Packing, Polyurethane, HT-400™ FE
10	100002896	3	Adapter, Header Ring, 4 x 5, HT-400™, FE

Table 6.19—4.5-inch Packing Nut

Loc	SAP Part No.	Qty	Description
1	100002081	3	Pin, Groove, ½-in x 1 ¼-in, Type 5
2	101328357	3	Sleeve, Wiper Gland, HCLE, 4.0 Inch
3	101330209	3	Nut, Packing Adjustment, HCLE, 4.5 Inch

Table 6.20—4.5-inch CDI Packing

Loc	SAP Part No.	Qty	Description
4	101377665	3	Seal, Packing Lube, 4.50, WS-Seal, CDI
5	100002019	3	O-Ring, 90 Duro, 5 1/2 x 5 1/4 x 1/8 568-252
6	101377664	3	Carrier, Seal, 4.50, CDI
7	101377663	3	Adapter, Female, 4.500, PEEK, CDI
8	101377661	3	Packing, 4.50, CDI WSP1, PTFE
9	101377660	3	Header Ring, 4.50, HNBR, CDI
10	101377659	3	Spacer, 4.50 in., Fluid End, CDI

Table 6.21—4.5-inch Acid Service Packing (8140)

Loc	SAP Part No.	Qty	Description
4	101252286	3	Seal, Packing Lube, Z20, 4 1/2 x 5 x 9/16 Zurcon UCUP, Double Lip FE
5	100000977	3	O-Ring, 90 Duro, 5 1/2 x 5 1/4 X 1/8 568-252
6	101389214	3	Carrier, Seal, 4.5, HT-400™, 2004
7	101389225	3	Ring, Backup, Packing, HT-400™ 4.5 in, 2004
8	100002951	3	Packing Set, 4 1/2x 5 1/2 x 0.50 Stock HT, 3 rings, Hard, Acid Service
9	100002949	3	Header Ring, 4 1/2 x 5 1/2 Packing, Polyurethane, HT-400™ FE
10	100002948	3	Adapter, Header Ring, 4 1/2 x 5 1/2, HT-400™, FE

Table 6.22—5.0-inch Packing Nut

Loc	SAP Part No.	Qty	Description
1	100027239	3	Pin, Groove, 3/8-in x 1 ¼-in, Type 5
2	101438001	3	Sleeve, Wiper Gland, HCLE, 5.0 Inch
3	101438000	3	Nut, Packing Adjustment, HCLE, 5.0 Inch

Table 6.23—5.0-inch CDI Packing

Loc	SAP Part No.	Qty	Description
4	101377674	3	Seal, Packing Lube, 5.0, WS-Seal, CDI
5	101377672	3	O-Ring, 90 Duro, 6 x 5 3/4 x 1/8, 568-256
6	100002022	3	Carrier, Seal, 5.0, CDI
7	101377671	3	Adapter, Female, 5.00, PEEK, CDI
8	101377669	3	Packing, 5.0, CDI WSP1, PTFE
9	101377668	3	Header Ring, 5.0, HNBR, CDI
10	101377667	3	Spacer, 5.0 in., Fluid End, CDI

Table 6.24—5.0-inch Acid Service Packing (8140)

Loc	SAP Part No.	Qty	Description
4	101408161	3	Seal, Packing Lube, Z20, 5 x 5 1/2 x 9/16 Zurcon UCUP, Double Lip FE
5	100000980	3	O-Ring, 90 Duro, 6 x 5 3/4 X 1/8 568-256
6	101389216	3	Carrier, Seal, 5.0, HT-400™, 2004
7	101389226	3	Ring, Backup, Packing, HT-400™ 5.0 in, 2004
8	100002967	3	Packing Set, 5 x 6 x 0.50 Stock HT, 3 rings, Hard, Acid Service
9	100058486	3	Header Ring, 5 x 6 Packing, Polyurethane, HT-400™ FE
10	100002966	3	Adapter, Header Ring, 5 x 6, HT-400™, FE

Table 6.25—6.0-inch Packing Nut

Loc	SAP Part No.	Qty	Description
1	100027239	3	Pin, Groove, 3/8-in x 1 ¼-in, Type 5
2	101330379	3	Sleeve, Wiper Gland, HCLE, 6.0 Inch
3	101330259	3	Nut, Packing Adjustment, HCLE, 6.0 Inch

Table 6.26—6.0-inch CDI Packing

Loc	SAP Part No.	Qty	Description
4	101377686	3	Seal, Packing Lube, 6.0, WS-Seal, CDI
5	100007763	3	O-Ring, 90 Duro, 7 x 6 3/4 x 1/8, 568-261
6	101377685	3	Carrier, Seal, 6.0, CDI
7	101377684	3	Adapter, Female, 6.00, PEEK, CDI
8	101377683	3	Packing, 6.0, CDI WSP1, PTFE
9	101377682	3	Header Ring, 6.0, HNBR, CDI
10	101377679	3	Spacer, 6.0 in., Fluid End, CDI

Table 6.27—6.0-inch Acid Service Packing (8140)

Loc	SAP Part No.	Qty	Description
4	101408181	3	Seal, Packing Lube, Z20, 6 x 6 1/2 x 9/16 Zurcon UCUP, Double Lip FE
5	100013726	3	O-Ring, 90 Duro, 7 x 6 3/4 X 1/8 568-261
6	101389217	3	Carrier, Seal, 6.0, HT-400™, 2004
7	101389227	3	Ring, Backup, Packing, HT-400™ 6.0 in, 2004
8	100002997	3	Packing Set, 6 x 7 x 0.50 Stock HT, 3 rings, Hard, Acid Service
9	100058613	3	Header Ring, 6 x 7 Packing, Polyurethane, HT-400™ FE
10	100002996	3	Adapter, Header Ring, 6 x 7, HT-400™, FE

Straight Discharge Flange Subassembly

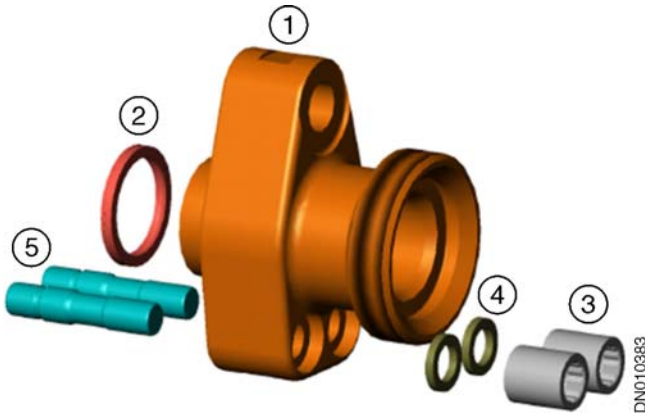


Table 6.28—3 3/8-inch Fluid-End Straight Discharge Flange

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100058317	316.21013	1	Flange, Discharge, HT-400™ Pump, 3-3/8 Inch, 20,000 PSI, Straight
2	100002801	315.27117	1	Seal, Discharge Passage, 2.5 OD
3	100002811	316.11621	2	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
4	100002798	315.11183	2	Washer, Flat, Worm Housing, Head, 1 In.
5	100002926	316.23013	2	Stud, HT-400™, Fluid End To Thick Discharge Flange

Table 6.29—4.0-inch Fluid-End Straight Discharge Flange

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100002992	316.27482	1	Flange, Discharge, HT-400™ Pump, 4.0 - 6.0 Inch, Straight
2	100002975	316.2547	1	Seal, Discharge Passage, HT-400™, 3.375 O.D.
3	100002811	316.11621	2	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
4	100002798	315.11183	2	Washer, Flat, Worm Housing, Head, 1 In.
5				Flange Secured by Fluid End Tie Bolts

Table 6.30—4 1/2-, 5.0-, and 6.0-inch Fluid-End Straight Discharge Flange

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100002992	316.27482	1	Flange, Discharge, HT-400™ Pump, 4.0 - 6.0 Inch, Straight
2	100002975	316.2547	1	Seal, Discharge Passage, HT-400™, 3.375 O.D.
3	100002811	316.11621	2	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
4				No Washers Used
5	100002926	316.23013	2	Stud, HT-400™, Fluid End To Thick Discharge Flange

Curved Discharge Flange Subassembly

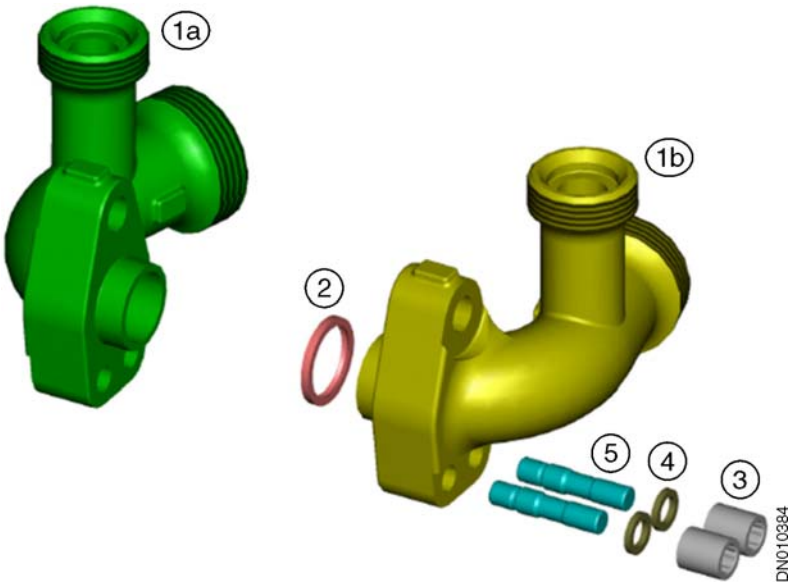


Table 6.31—3 3/8-inch Fluid-End Curved Discharge Flange

Loc	SAP Part No.	Legacy No.	Qty	Description
1a	100009881	316.21676	1	Flange, Discharge, HT-400™, 3-3/8 Inch, 20,000 PSI, Curved, RH
1b	100009882	316.21677	1	Flange, Discharge, HT-400™, 3-3/8 Inch, 20,000 PSI, Curved, LH
2	100002801	315.27117	1	Seal, Discharge Passage, 2.5 OD
3	100002811	316.11621	2	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
4	100002798	315.11183	2	Washer, Flat, Worm Housing, Head, 1 In.
5	100002926	316.23013	2	Stud, HT-400™, Fluid End To Thick Discharge Flange

Table 6.32—4.0-inch Fluid-End Curved Discharge Flange

Loc	SAP Part No.	Legacy No.	Qty	Description
1a	100002930	316.23019	1	Flange, Discharge, HT-400™, 4.0 - 6.0 Inch, Curved Right-Hand
1b	100002929	316.23017	1	Flange, Discharge, HT-400™, 4.0 - 6.0 Inch, Curved Left-Hand
2	100002975	316.2547	1	Seal, Discharge Passage, HT-400™, 3.375 O.D.
3	100002811	316.11621	2	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
4	100002798	315.11183	2	Washer, Flat, Worm Housing, Head, 1 In.
5				Flange Secured by Fluid End Tie Bolts

Table 6.33—4 1/2-, 5.0-, and 6.0-inch Fluid-End Curved Discharge Flange

Loc	SAP Part No.	Legacy No.	Qty	Description
1a	100002930	316.23019	1	Flange, Discharge, HT-400™, 4.0 - 6.0 Inch, Curved Right-Hand
1b	100002929	316.23017	1	Flange, Discharge, HT-400™, 4.0 - 6.0 Inch, Curved Left-Hand
2	100002975	316.2547	1	Seal, Discharge Passage, HT-400™, 3.375 O.D.
3	100002811	316.11621	2	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
4				No Washers Used
5	100002926	316.23013	2	Stud, HT-400™, Fluid End To Thick Discharge Flange

Blank Discharge Flange Subassembly

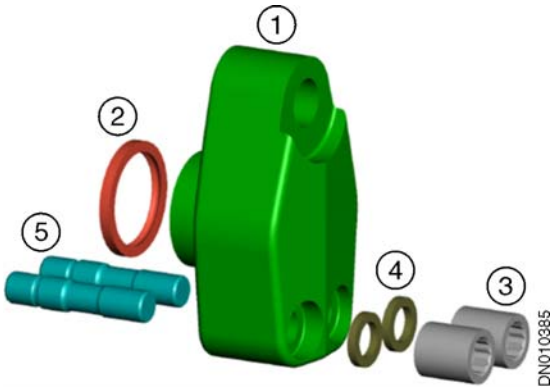


Table 6.34—3 3/8-inch Fluid-End Blank Discharge Flange (Thin)

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100002858	316.21673	1	Flange, Discharge, HT-400™, 3.38 In., Blank, Thin (Uses Short Top Tie Bolt: 100002893)
2	100002801	315.27117	1	Seal, Discharge Passage, 2.5 OD
3	100002811	316.11621	2	Nut, 1-14 NF, Internal Wrenching, 1.03 Total Length
4	100002798	315.11183	2	Washer, Flat, Worm Housing, Head, 1 In.
5	100009362	316.23012	2	Stud, HT-400™, Fluid End To Thin Discharge Flange

Table 6.35—3 3/8-inch Fluid-End Blank Discharge Flange (Thick)

Loc	SAP Part No.	Legacy No.	Qty	Description
1	101325320		1	Flange, Discharge, HT-400™, 3.38 In., Blank, Thick (Uses Standard Top Tie Bolt)
2	100002801	315.27117	1	Seal, Discharge Passage, 2.5 OD
3	100002811	316.11621	2	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
4	100002798	315.11183	2	Washer, Flat, Worm Housing, Head, 1 In.
5	100002926	316.23013	2	Stud, HT-400™, Fluid End To Thick Discharge Flange

Table 6.36—4.0-inch Fluid-End Blank Discharge Flange

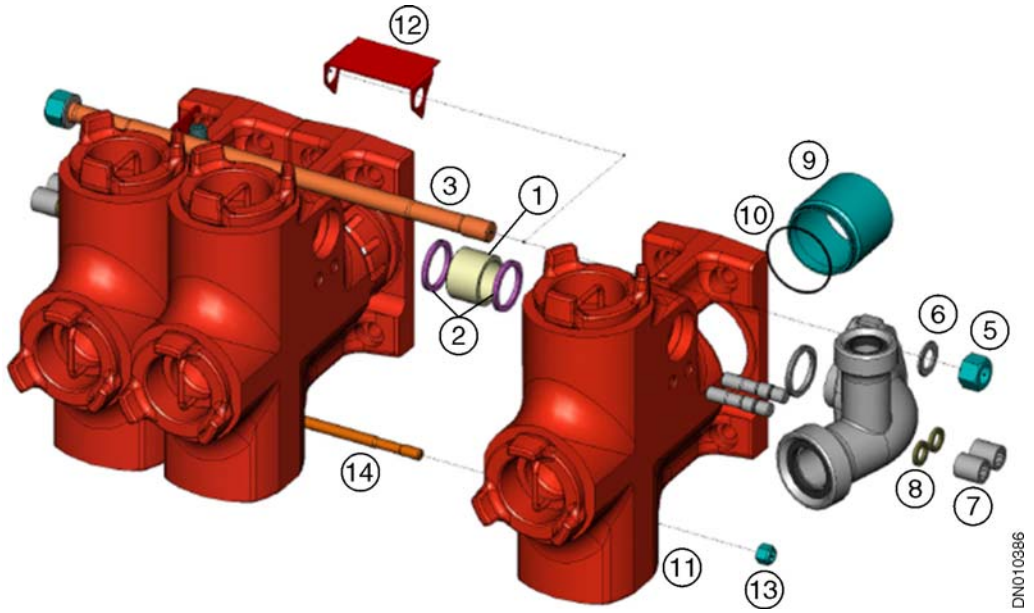
Loc	SAP Part No.	Legacy No.	Qty	Description
1	100007821	316.22980	1	Flange, Discharge, HT-400™, 4.0, 4.5, 5.0, 6.0 Inch , Blank, Thick
2	100002975	316.2547	1	Seal, Discharge Passage, HT-400™, 3.375 O.D.
3	100002811	316.11621	2	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
4	100002798	315.11183	2	Washer, Flat, Worm Housing, Head, 1 In.
5				Flange Secured by Fluid End Tie Bolts

Table 6.37—4 1/2-, 5.0-, and 6.0-inch Fluid-End Blank Discharge Flange

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100007821	316.22980	1	Flange, Discharge, HT-400™, 4.0, 4.5, 5.0, 6.0 Inch , Blank, Thick
2	100002975	316.2547	1	Seal, Discharge Passage, HT-400™, 3.375 O.D.
3	100002811	316.11621	2	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
4				No Washers Used
5	100002926	316.23013	2	Stud, HT-400™, Fluid End To Thick Discharge Flange

Fluid-End Section Subassembly

3-3/8-, 4 1/2-, 5.0-, and 6.0-inch Fluid Ends



4.0-inch Fluid Ends (Three Top Tie-Bolts)

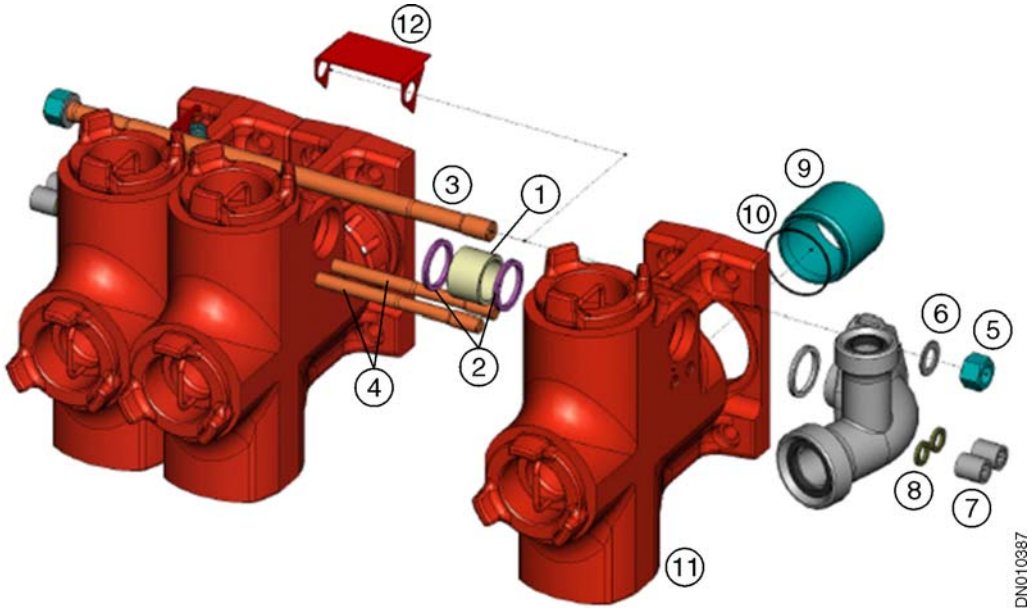


Table 6.38—3 3/8-inch Fluid End

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100002850	316.2145	2	Spacer, Inner, Discharge Passage Seal, HT-400™, 3.375 in FE
2	100002801	315.27117	6	Seal, Discharge Passage, HT-400™, 2.5 in. O.D.
3	100002993	316.27488	1	Bolt, Tie, 1.375-12 UNF x 32.4 in., Top, Fluid End, HT-400™, TC
5	100002976	316.25501	2	Nut, Top Tie Bolt, HT-400™, TC
6	100002894	316.22493	2	Washer, Hardened, 2.31 O.D. x 1.43 I.D., For Top Tie Bolt,
7	100002811	316.11621	4	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
8	100002798	315.11183	4	Washer, Flat, Worm Housing, Head, 1 In.
9	100007819	316.21981	3	Sleeve, Packing, HT400, 3.38 In.
10	100007621	8.34038	3	O-Ring, 90 Duro, 4 1/8 X 3 7/8 X 1/8, 568-241
11a	100002866	316.21951	3	Fluid End Section, HT-400™ Pump, 3.38 Inch, Not Sleeved
11b	101455172		3	Fluid End Section, HT-400™ Pump, 3.38 Inch, With Packing Sleeve
12	100058621	316.27927	1	Tag, Part Number, Fluid End, HT-400™
13	100001860	70.32760	2	Nut, Elastic, Stop, 3/4-in., 16NF
14	100002925	316.23011	1	Bolt, Bottom, Tie, HT400, Type Certified

Table 6.39—4.0-inch Fluid End

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100002974	316.2545	2	Spacer, Inner, Discharge Passage Seal, HT-400™, 5.75 in.
2	100002975	316.2547	6	Seal, Discharge Passage, HT-400™, 3.375 in. O.D.
3	100002993	316.27488	1	Bolt, Tie, 1.375-12 UNF x 32.4 in., Top, Fluid End, HT-400™, TC
4	100002994	316.27489	2	Bolt, Tie, Fluid End, HT-400™, 1 in. Dia, Three Top Tie Bolt FE, TC
5	100002976	316.25501	2	Nut, Top Tie Bolt, HT-400™, TC
6	100002894	316.22493	2	Washer, Hardened, 2.31 O.D. x 1.43 I.D., For Top Tie Bolt,
7	100002811	316.11621	4	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
8	100002798	315.11183	4	Washer, Flat, Worm Housing, Head, 1 In.
9	100002914	316.22981	3	Sleeve, Packing, HT400, 4.0 In.
10	100000972	8.34043	3	O-Ring, 90 Duro, 4 3/4 X 4 1/2 X 1/8, 568-246
11a	100002915	316.22982	3	Fluid End Section, HT-400™ Pump, 4.00 Inch, Not Sleeved
11b	101455173		3	Fluid End Section, HT-400™ Pump, 4.00 Inch, With Packing Sleeve
12	100058621	316.27927	1	Tag, Part Number, Fluid End, HT-400™

Table 6.40—4 1/2-inch Fluid End

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100002974	316.2545	2	Spacer, Inner, Discharge Passage Seal, HT-400™, 5.75 in.
2	100002975	316.2547	6	Seal, Discharge Passage, HT-400™, 3.375 in. O.D.
3	100002993	316.27488	1	Bolt, Tie, 1.375-12 UNF x 32.4 in., Top, Fluid End, HT-400™, TC
5	100002976	316.25501	2	Nut, Top Tie Bolt, HT-400™, TC
6	100002894	316.22493	2	Washer, Hardened, 2.31 O.D. x 1.43 I.D., For Top Tie Bolt,
7	100002811	316.11621	4	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
8				Washer Not Used In This Application
9	100002956	316.23981	3	Sleeve, Packing, HT400, 4.5 In.
10	100000975	8.34047	3	O-Ring, 90 Duro, 5 1/4 X 5 X 1/8, 568-250
11a	100002954	316.23951	3	Fluid End Section, HT-400™ Pump, 4.5 Inch, Not Sleeved
11b	101455174		3	Fluid End Section, HT-400™ Pump, 4.5 Inch, With Packing Sleeve
12	100058621	316.27927	1	Tag, Part Number, Fluid End, HT-400™
13	100001860	70.32760	2	Nut, Elastic, Stop, 3/4-in., 16NF
14	100002925	316.23011	1	Bolt, Bottom, Tie, HT400, Type Certified

Table 6.41—5.0-inch Fluid End

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100002974	316.2545	2	Spacer, Inner, Discharge Passage Seal, HT-400™, 5.75 in.
2	100002975	316.2547	6	Seal, Discharge Passage, HT-400™, 3.375 in. O.D.
3	100002993	316.27488	1	Bolt, Tie, 1.375-12 UNF x 32.4 in., Top, Fluid End, HT-400™, TC
5	100002976	316.25501	2	Nut, Top Tie Bolt, HT-400™, TC
6	100002894	316.22493	2	Washer, Hardened, 2.31 O.D. x 1.43 I.D., For Top Tie Bolt,
7	100002811	316.11621	4	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
8				Washer Not Used In This Application
9	100002969	316.24981	3	Sleeve, Packing, HT400, 5.0 In.
10	100000979	8.34051	3	O-Ring, 90 Duro, 5 3/4 X 5 1/2 X 1/8, 568-254
11a	100058502	316.24951	3	Fluid End Section, HT-400™ Pump, 5.0 Inch, Not Sleeved
11b	101455175		3	Fluid End Section, HT-400™ Pump, 5.0 Inch, With Packing Sleeve

Table 6.41—5.0-inch Fluid End

12	100058621	316.27927	1	Tag, Part Number, Fluid End, HT-400™
13	100001860	70.32760	2	Nut, Elastic, Stop, 3/4-in., 16NF
14	100002925	316.23011	1	Bolt, Bottom, Tie, HT400, Type Certified

Table 6.42—6.0-inch Fluid End

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100002974	316.2545	2	Spacer, Inner, Discharge Passage Seal, HT-400™, 5.75 in.
2	100002975	316.2547	6	Seal, Discharge Passage, HT-400™, 3.375 in. O.D.
3	100002993	316.27488	1	Bolt, Tie, 1.375-12 UNF x 32.4 in., Top, Fluid End, HT-400™, TC
5	100002976	316.25501	2	Nut, Top Tie Bolt, HT-400™, TC
6	100002894	316.22493	2	Washer, Hardened, 2.31 O.D. x 1.43 I.D., For Top Tie Bolt,
7	100002811	316.11621	4	Nut, 1-14 NF, Internal Wrenching, 1.03 TL
8				Washer Not Used In This Application
9	100002998	316.27981	3	Sleeve, Packing, HT400, 6.0 In.
10	100000983	8.34057	3	O-Ring, 90 Duro, 6 3/4 X 6 1/2 X 1/8, 568-260
11a	100058622	316.27951	3	Fluid End Section, HT-400™ Pump, 6.0 Inch, Not Sleeved
11b	101455176		3	Fluid End Section, HT-400™ Pump, 6.0 Inch, With Packing Sleeve
12	100058621	316.27927	1	Tag, Part Number, Fluid End, HT-400™
13	100001860	70.32760	2	Nut, Elastic, Stop, 3/4-in., 16NF
14	100002925	316.23011	1	Bolt, Bottom, Tie, HT400, Type Certified

Plunger Lube Pump Assembly

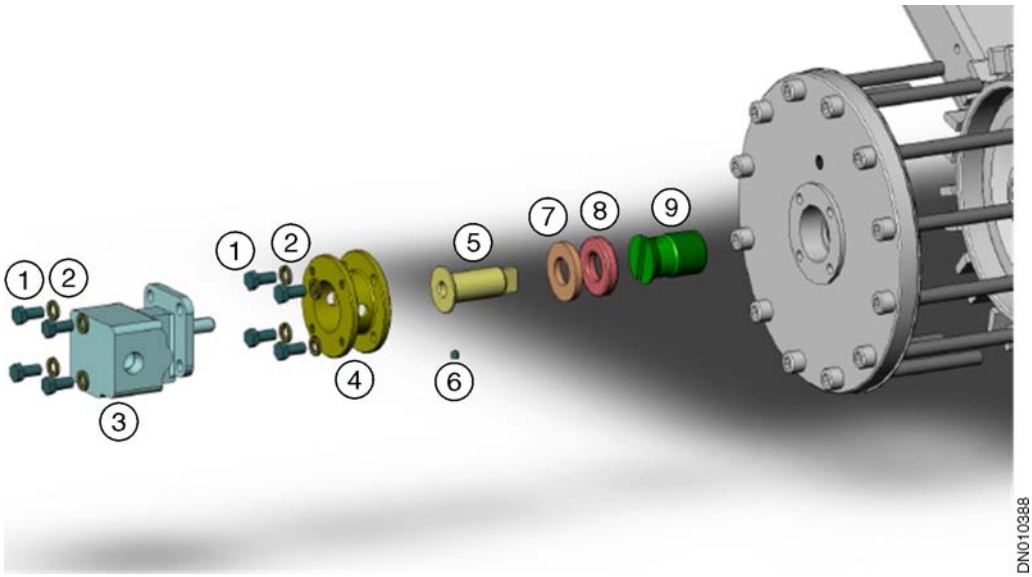
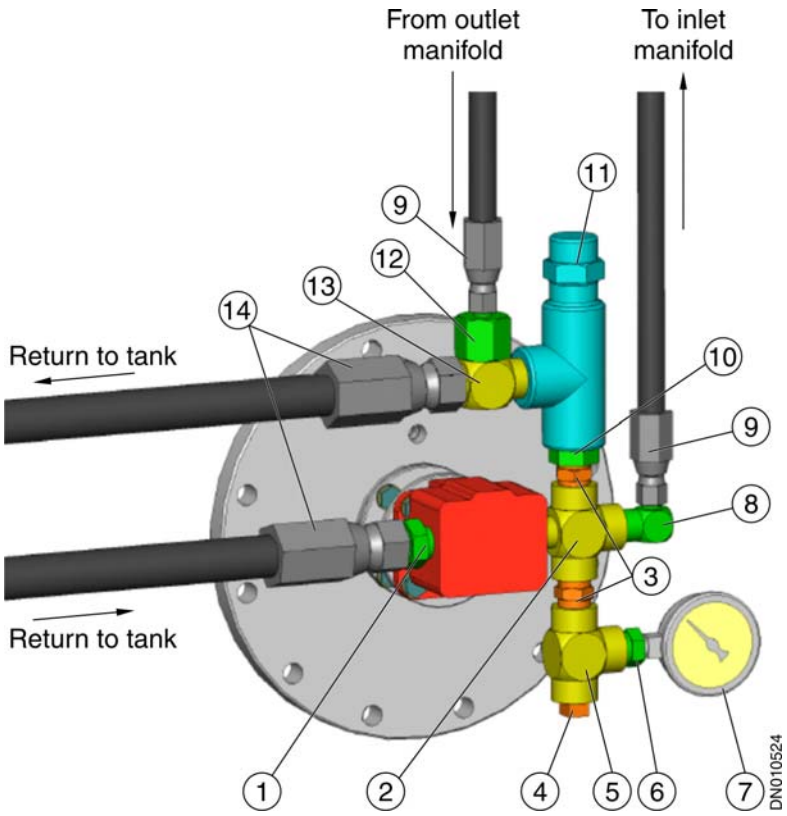


Table 6.43—Plunger Lube Pump Subassembly

Loc	SAP Part No.	Legacy No.	Qty	Description
1	100029874	70.58806	8	Washer, Flat, 3/8-in. WI, Pl
2	13431	70.43839	8	Screw, Hex Socket, 3/8-in. 16NC x 1 1/4-in., Unbrako/ Loc-Wel
3	100003003	317.54010	1	Pump, Gear, Recirculating Plunger Lubrication, HT-400™ Pump
4	100058711	317.51020	1	Adapter, Pump To Thrust Plate, Plunger Lube, HQ
5	100011749	317.51065	1	Adapter, HQ, Lube Pump, Plunger Lube
6	100028805	70.44781	1	1/4-in. x 1/4-in. 20NC Set Screw
7	100011751	317.51067	1	Seal, Lip, 1.000 Id X 2.000 Od X 0.250 Width
8	100011750	317.51066	1	Bearing, Ball, Radial, 1.0 Id X 2.0 Od X 0.375 Thick, Open
9	100011748	317.51064	1	Adapter, HQ, Worm Shaft, Plunger Lube

Recirculating Plunger Lube Pump Plumbing



The configuration shown is for a right-hand pump case. For a left-hand pump case, the recirculating pump is rotated 180° and the plumbing is a mirror image.

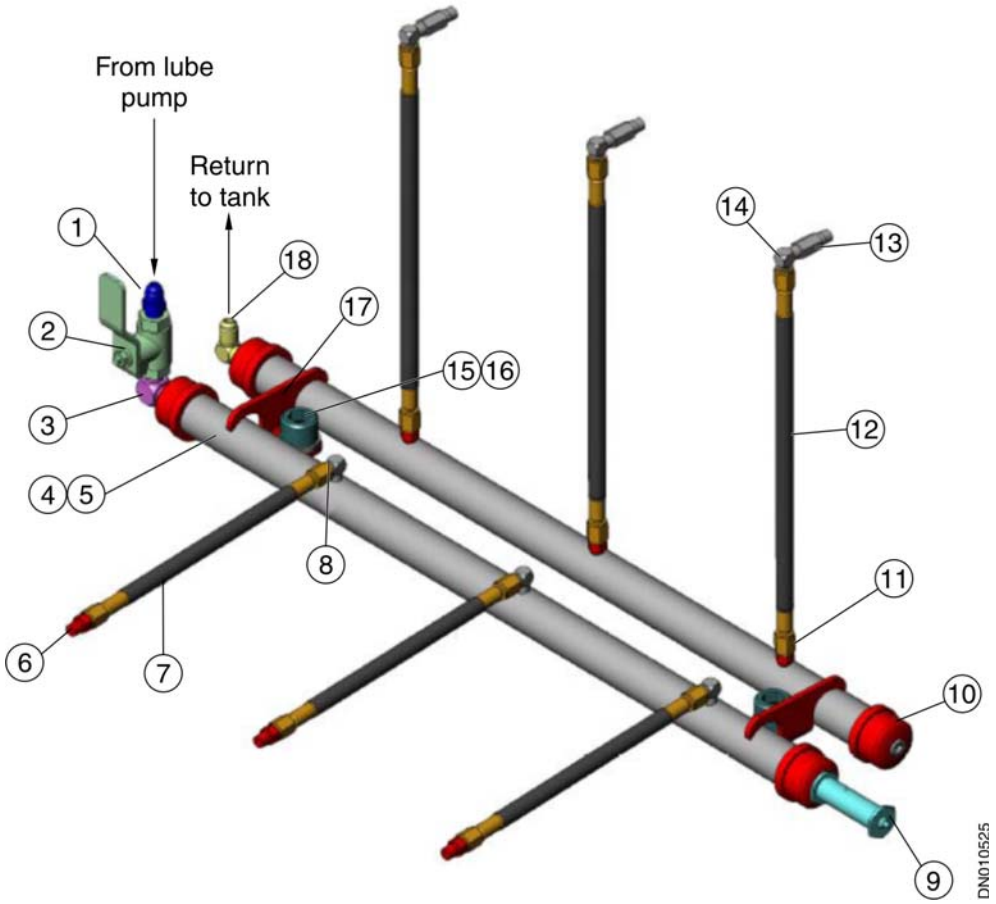
Table 6.44—Recirculating Plunger Lube Pump Plumbing

Loc	SAP Part No.	Qty	Description
1	100025600	1	Adapter, Hose, Straight, 1 1/16-12 JIC Male x 1/2-14 MPT, Stl
2	100035164	1	Adapter, Hose, Cross, 1/2-14 MPT x 1/2 -14 FPT x 12 -14 FPT, Aeroquip
3	100016860	2	Nipple, Standard, 1/2 X AT, Blackwall, A120
4	101139835	1	Pipe Plug - 1/2 NPT, Sq Head, Steel
5	100033152	1	Adapter, Hose, Cross, Tee, 1/2-14 FPT
6	100001210	1	Bushing, Hexagon, 1/2 x 1/4, Steel

Table 6.44—Recirculating Plunger Lube Pump Plumbing (Continued)

Loc	SAP Part No.	Qty	Description
7	100025044	1	Gauge, Pressure, 0-60 psi, 2 1/2 in., 1/4 NPT
8	100025646	1	Adapter, Hose, Elbow, 9/16-18 JIC Male x 1/2-14 MPT, Steel
9	100033606	2	Fitting, Hose, Straight, 3/8 NOM Hose x 9/16 JIC Swivel Female, Brass
10	100016518	1	Bushing, Hexagon, 3/4 x 1/2, Steel
11	100015300	1	Valve, Relief, Brown and Sharp, 3/4, Preset at 45#
12	100031214	1	Adapter, Hose, Straight, 1 1/16-12 JIC Female x 9/16-18 JIC Male
13	100031598	1	Adptr, Hose, Tee, 1 1/16-12 JIC M x 3/4-14 MPT x 1 1/16-12 JIC M, Stl
14	100035892	2	Fitting, Hose, Straight, 1 1/16-12 JIC Swivel Female x 3/4 NOM Hose, Brs

Recirculating Plunger Lube Fluid-End Manifold Plumbing



Component orientation and hose length scale are altered for improved viewing

Table 6.45—Recirculating Plunger Lube Fluid-End Manifold Plumbing

Loc	SAP Part No.	Qty.	Description
1	100025596	1	Adapter, Hose, Straight, 9/16-18 JIC Male x 1/4-18 NPT Male, Steel
2	100000596	1	Valve, Ball, 1/4, 600 PSI, FPT, Bronze Body, 316 Ball & Stem, Tefl Seats & Seals
3	100033761	1	Adapter, Hose, 90 Degree 1/4-18 MPT x 1/4-18 MPT, Aero
4	101376366	2	Assembly, Manifold, Plunger, Lubrication, FE, Triplex, WSP

Table 6.45—Recirculating Plunger Lube Fluid-End Manifold Plumbing (Continued)

Loc	SAP Part No.	Qty.	Description
5	100032911	2	Tag, Identification, Hydraulic Tubing, Stnls Stl, 0.31 Wide x 14.3
6	100025591	6	Adapter, Hose, Straight, 7/16-20 JIC Male x 1/8-27 MPT, Steel
7	101374860	3	Line, Upper, Oil, Plunger Lubricator, WSP
9	100002681	1	Valve, Safety, 1/4, Brass, 150 psi Pressure Relief Setting
10	100027497	1	Plug, Pipe, 1/4 18 NPTF, Steel Countersunk Hex, Headless
12	101374914	3	Line, Lower, Oil, Plunger Lubricator, WSP
13	100000592	3	Valve, Check, 1/8, Female Inlet, Male Outlet, With 70 Duro O-Ring
14	100025604	6	Adapter, Hose, Elbow, 7/16-20 JIC Male x 1/8-27 MPT, Steel
15	100028293	2	Screw, Hex Socket, 3/4-10 NC x 1 1/4
16	100029925	2	Washer, Lock, 3/4, Steel, PL
17	101391751	2	Bracket, Plunger Lubrication Manifold, WSP
18	100015025	1	Adapter, Hose, Elbow, 9/16-18 JIC Male x 1/4-18 MPT, Steel

Section
7

HCLE Fluid-End Repair Procedures

Introduction

This section covers the following HCLE fluid-end repair procedures:

1. Changing valves and valve seats
2. Changing plunger packing
3. Changing fluid-end assemblies
4. Replacing section assemblies
5. Replacing packing sleeves

Warning **Before doing any work on fluid ends that are installed on a pumping unit, flush any hazardous materials out of the fluid end and then turn the pump driving engine off. Bleed off pressure from the pump and disconnect the pump from supply hoses and discharge lines. Lock and tag out power switches used to start and run the pump. Failure to this may result in serious injury or death.**

Warning **Most fluid end repair and maintenance requires cycling the plungers. The only approved method for turning the pump drive-shaft at the time of this publication is with a strap wrench.**

Changing Valves and Valve Seats

Disassembly

1. Remove the discharge cover retainer using a bar and hammer. The tool being used in **Figure 7.1** is a guide-bushing-removing punch (PN 100002984).



Figure 7.1—Removing the discharge cover retainer

2. Pull the discharge covers using the appropriate procedure below (either “a” or “b” as applies).

   a. **If the threads on the discharge cover handles are NOT damaged**, install either: (a) the J-slot discharge valve seat removing tool, or (b) a 1 3/8-in. 12 NF nut onto the handle. Pull the discharge covers by removing the discharge cover retainers (**Figure 7.2**).

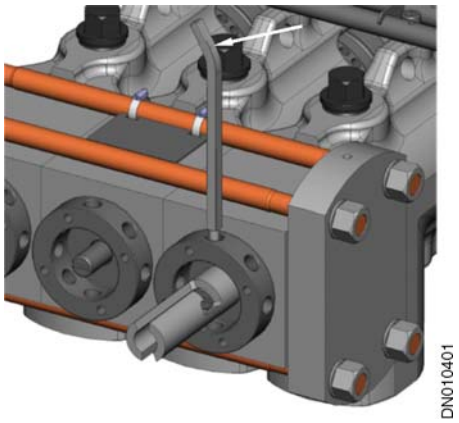


Figure 7.2—Removing the discharge covers

b. **If the threads on the discharge cover handles are damaged**, remove the discharge cover retainers. Then remove the discharge covers by alternately hitting the handle top-and-bottom or side-to-side with a shop hammer until the cover becomes free. Another method is to install a cheater pipe on the cover handle and pry up-and-down repeatedly until the cover becomes loose (**Figure 7.3**).

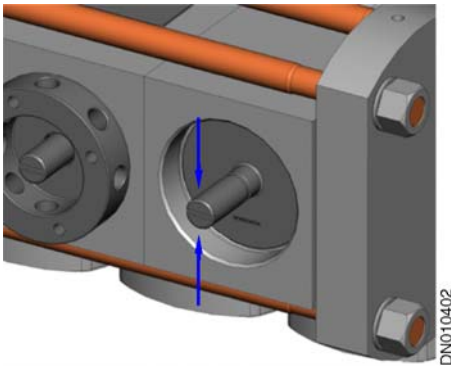


Figure 7.3—Removing the discharge covers

Note — Once the discharge covers become loose, they will be pushed out by the discharge valve spring. Do not allow any of the components to fall from the fluid end and become damaged.

3. Remove the discharge cages, discharge valve springs, and discharge valves (**Figure 7.4**).

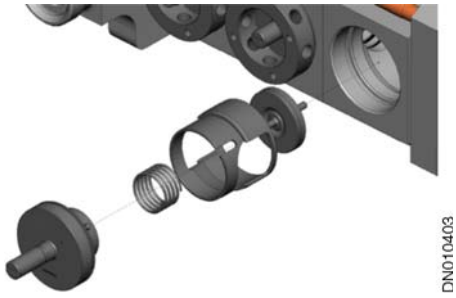


Figure 7.4—Remove discharge cages, valve springs, and valves

4. To remove the discharge valve seats, use either of the following two methods:

   a. **If using the extended discharge valve seat puller**: Install the extended puller over the valve guide spokes (you may have to cycle the plunger back to get sufficient clearance). Turn the extended puller clockwise, then pull back to engage the tool. Cycle the plunger forward to contact the extended puller and then continue cycling the plunger forward until the seat and tool are pushed out, freeing the discharge seat (**Figure 7.5**).

   Repeat for the remaining sections.

   b. **If using the slide hammer**: With the j-slot tool attached to the slide hammer, install the j-slot over the valve guide spokes and rotate the tool clock-wise. Then pull back to engage the j-slot on the valve guide spokes. Pull back on the slide hammer rod to keep the j-slot engaged, then slide the handle back, hitting the stop repeatedly until the seat is freed. Remove the valve seat from the fluid end and then from the tool.

   Repeat for the remaining sections.

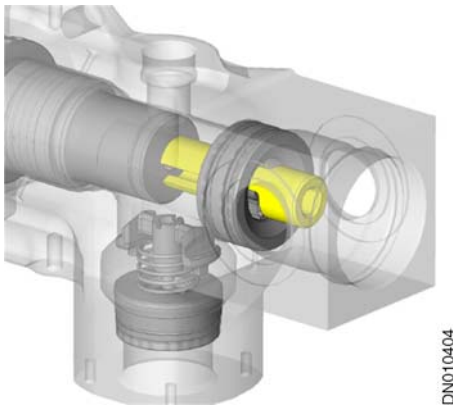


Figure 7.5—Remove discharge valve seats using the valve seat puller

5. Remove the top access covers (**Figure 7.6**).

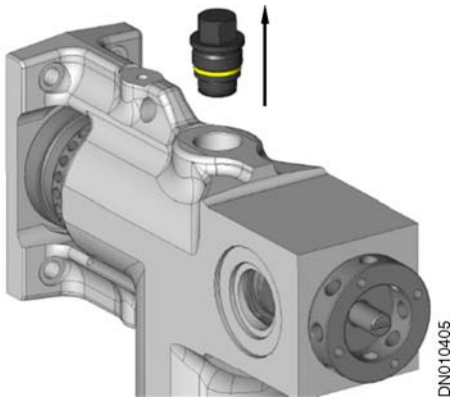


Figure 7.6—Remove top access covers

6. Insert the suction spring retainer tool through the top access port (you may need to cycle the plunger back to gain clearance). Engage the pins at the end of the tool into the slots in the top of the spring retainer as pictured in **Figure 7.7**.

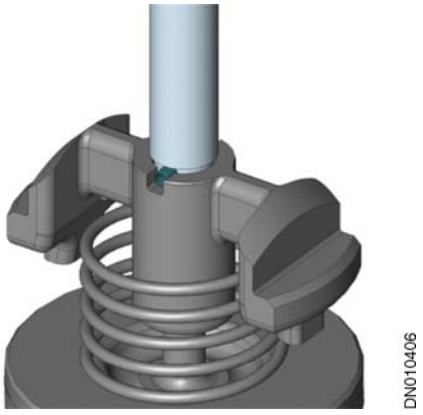


Figure 7.7—Insert the suction spring retainer tool

7. Push down on the tool to compress the suction spring slightly (**Figure 7.8**), then rotate the tool handle either direction to disengage the spring retainer. Remove the spring retainer through the discharge bore and repeat for the remaining sections.

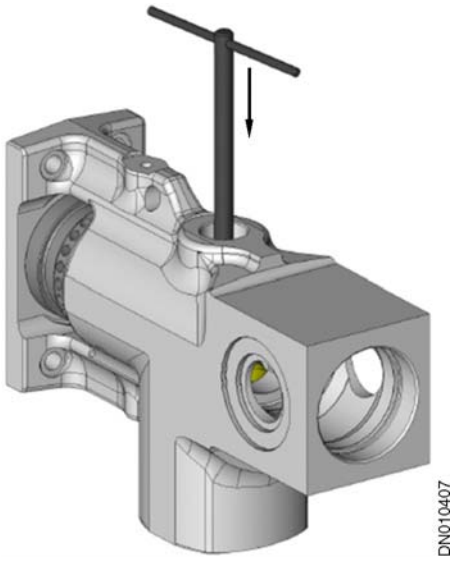


Figure 7.8—Push down on the tool

8. Remove the suction springs and the suction valves through the discharge bores (**Figure 7.9**). To remove the suction valves, tilt the valve onto its side. Hold onto the outside edge of the valve, tilt it forward slightly, and remove it from the valve pot. The clearance is tight, but it will fit. Repeat for the remaining sections.

   Note — The suction valve seat removal method described below can be done while the fluid end is still attached to the pumping unit with the suction header on.

   An alternative method for removing the suction valve seats is to remove the suction header from the pump, and drive the seats out.

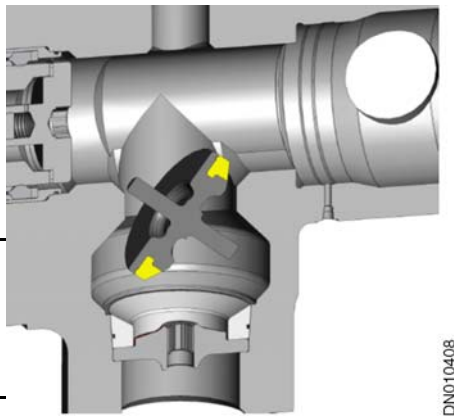


Figure 7.9—Remove the suction springs and the suction valves

9. To remove the suction valve seats using a jaw puller, first place the correct size pulling jaw assembly into the fluid end (**Figure 7.10**).

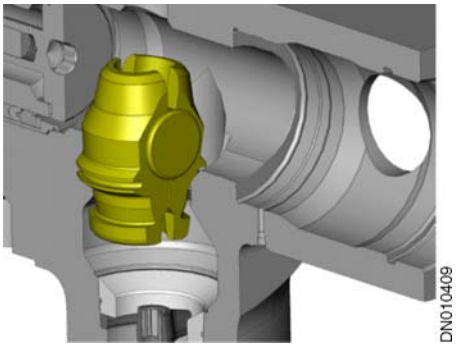


Figure 7.10—Removing the suction valve seats using a jaw puller

10. Place the closed jaws over the valve guide spokes. Rotate the jaws back and forth to make sure they are over the spokes (**Figure 7.11**).

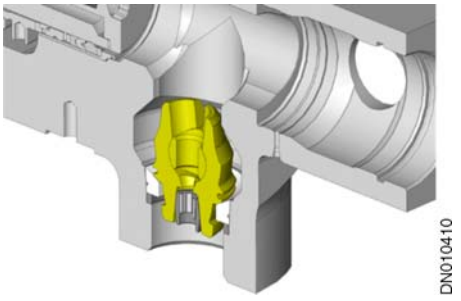


Figure 7.11—Place the closed jaws over the valve guide spokes

11. Insert the pulling retainer into the fluid end through the discharge bore, and the threaded rod through the top access hole (**Figure 7.12**).

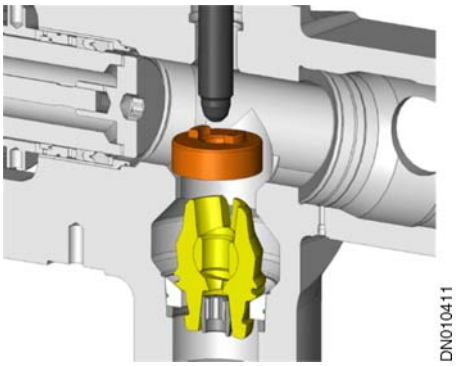


Figure 7.12—Insert the pulling retainer and the threaded rod

12. Thread the retainer onto the threaded puller rod and move the retainer up the rod as much as space will allow (**Figure 7.13**).

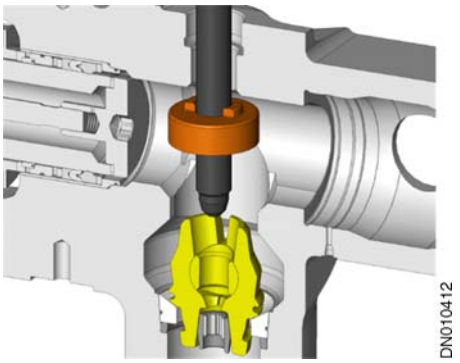


Figure 7.13—Thread the retainer onto the threaded puller rod

13. Screw the threaded rod into the puller jaw assembly. As the nose of the rod contacts the puller jaws, the jaws will open up until they contact the inner diameter of the valve seat (**Figure 7.14**). Make sure the retainer is not contacting the puller jaws at this point. Tighten the threaded rod with the socket and rod wrench.

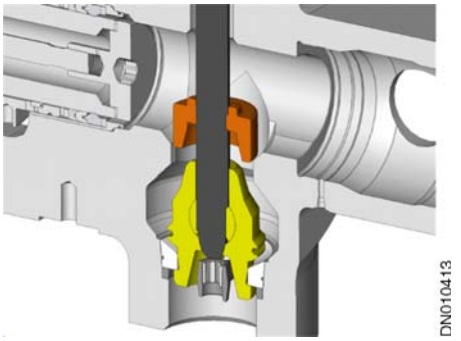


Figure 7.14—Screw the threaded rod into the puller jaw assembly

14. Thread the retainer down the threaded rod onto the puller (Figure 7.15).

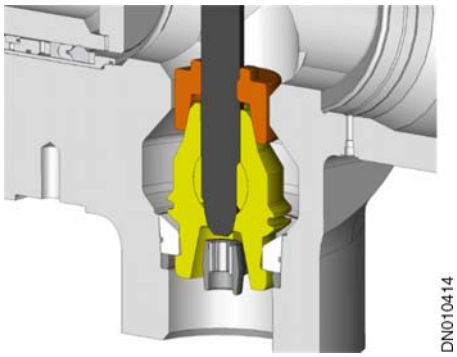


Figure 7.15—Thread the retainer down the threaded rod onto the puller

15. Place puller socket tube over the threaded puller rod and engage the slots on the dogs of the retainer (Figure 7.16).

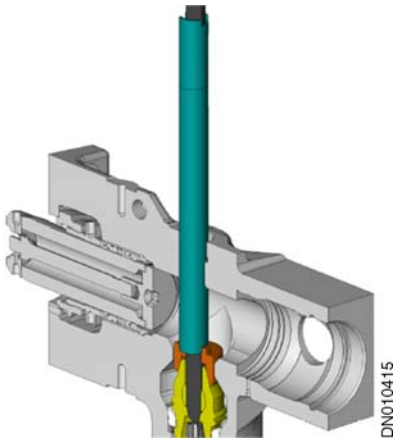


Figure 7.16—Place puller socket tube over the threaded puller rod

16. Tighten the retainer by placing the socket and rod wrench onto the socket tube and turning clockwise (Figure 7.17).

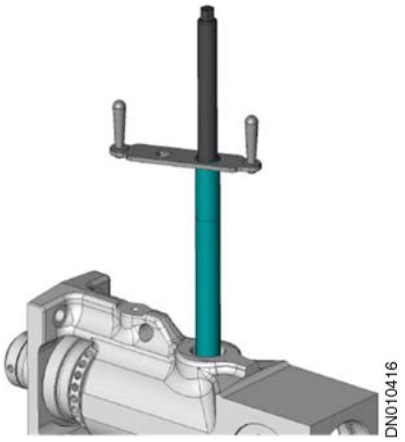


Figure 7.17—Tighten the retainer

17. After removing the socket tube from over the threaded puller rod, grasp the threaded rod and try to shake it; it should be snug. When the puller is properly install the threaded rod will be centered in the access hole as shown in **Figure 7.18**.



Figure 7.18—Puller should be centered

18. When installing the puller cylinder, first slide the spacer over the treaded rod to give the cylinder a flat elevated surface to push against. Then slide the cylinder over the threaded rod and screw the puller nut down until it contacts the compressed cylinder (**Figure 7.19**).
19. Hook up the hydraulic connections from the cylinder to the pump. Apply hydraulic pressure to the cylinder and remove the seat. There will be a loud pop when the seat is freed.
20. Once the seat is freed, remove the cylinder assembly, loosen the puller retainer with the socket tube, remove the threaded rod from the pulling jaw assembly, and remove the threaded rod and puller retainer from the fluid end.
21. Separate the pulling jaw assembly from the valve seat and remove them both from the fluid end. Finally remove the valve guide retainer from the bottom of the valve pot.



Figure 7.19—Slide the cylinder over the threaded rod and screw the puller nut down until it contacts the compressed cylinder

Repeat these steps for the remaining fluid end sections.

Changing Valves and Valve Seats

Inspection Procedures

Inspect the valves and valve seat parts (refer to **Figure 7.20**).

- **Valve seats**—If there are signs of washing or cutting, and/or if the valve seating indentation is greater than 0.020 in. (0.51 mm), replace the valve seat (or flip the seat if it is a discharge seat with an unused surface on the alternate side).
- **Valve inserts**—If there is wear on the valve insert that might prevent complete sealing, replace the insert.
- **Valves**—If there are signs of washing or cutting, or if there are cracks or material missing, replace the valves.



Figure 7.20—Inspect valve seats, inserts, and guide inserts

- **Valve guide inserts**—If missing or heavily worn, replace the insert. If the liner is damaged, replace the insert.
- **Other parts**—If a part shows signs of wear or breakage, replace it.

Reassembly Procedure

1. Clean the suction valve pocket area thoroughly (**Figure 7.21**). Ensure that there is no proppant or debris in the bottom of the valve pocket that would prevent the seat from installing completely. Ensure that there are no scratches or marks in the valve seat bore that will damage the valve seat and O-ring seal during installation.
2. Inspect the valve guide retainers and guide inserts. Replace as necessary.

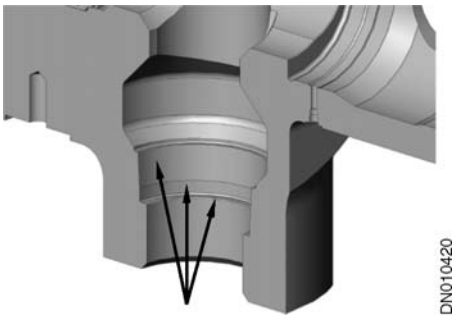


Figure 7.21—Inspect the suction valve pocket area

3. Lubricate the valve guide bushing/inserts and install the assembled retainers in the fluid end with the guide bushing insert offset upward (**Figure 7.22**).
4. Clean the outer diameter of the valve seat. Install and lubricate a new O-ring on the suction valve seat and install it into the suction valve seat bore with the valve face-up.



Figure 7.22—Install assembled retainers in the fluid end with guide bushing insert offset up

5. Install the bottom half of the correct size valve seat driving tool into the fluid end and onto the suction valve seat (**Figure 7.23**).

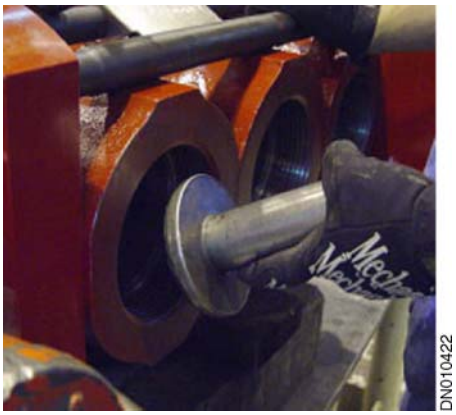


Figure 7.23—Installing the bottom half of the valve seat driving tool

6. Inset the upper half of the valve seat driving tool through the upper access hole and drive the suction valve seat into the seat bore with a shop hammer (**Figure 7.24**). When the seat is seated, the tool will rebound. Final seating will occur when the fluid end is pressured to 3,000 to 5,000 psi (20 700 to 34 000 kPa).



Figure 7.24—Drive the suction valve seat into the seat bore

7. Inspect the valves and inserts and replace as necessary. Lubricate the sealing surface and install the valve onto the suction valve seat (**Figure 7.25**).



Figure 7.25—Installing the valve onto the suction valve seat

8. Install the suction valve spring onto the suction valve (**Figure 7.26**). The suction valve spring for all HCLE fluid ends is a 25-lb/in. cylindrical spring.



Figure 7.26—Installing the suction valve spring onto the suction valve

9. Inspect the suction spring retainer and bushing and replace as necessary. The insert should be offset toward the bottom of the retainer (see **Figure 7.27**). Install the retainer into the fluid end over the previously installed suction spring.

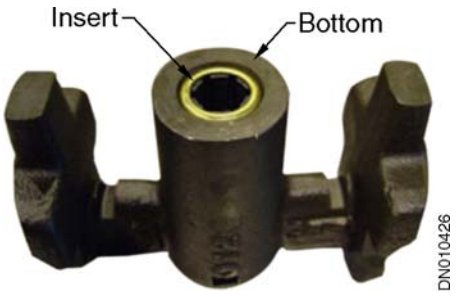


Figure 7.27—Insert should be offset toward the bottom of the retainer

10. To complete the suction spring retainer installation, insert the suction spring retainer tool through the access port and engage the slots in the top of the retainer with the pins in the end of the tool. Press down on the tool to compress the suction spring, and rotate the tool until the handle is inline with the plunger bore (see **Figure 7.28**).
11. To ensure that the retainer is completely locked in place, without pressing down, try to rotate the tool. If the retainer is locked in, it will not move and the tool will be centered in the access port.

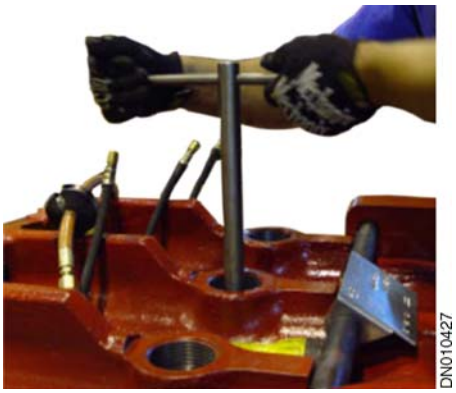


Figure 7.28—Rotate the tool until the handle is inline with the plunger bore

12. Clean the discharge bore thoroughly. Remove all proppant and debris and inspect the sealing and mating surfaces for scratches or burs that may damage the seals.
13. Inspect the discharge valve seat and seals, and replace as necessary.
14. Lubricate the discharge valve seat seals and install the valve seat into the discharge bore.

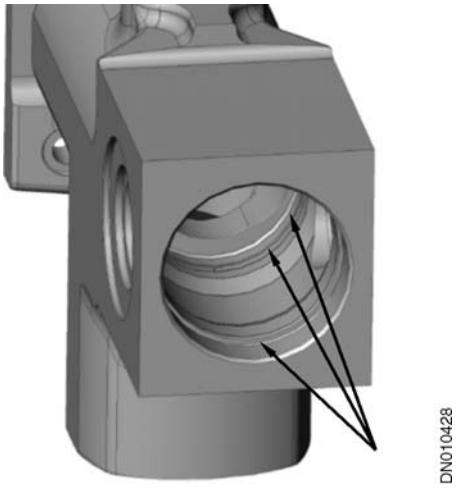


Figure 7.29—Clean and inspect the sealing and mating surfaces of the discharge bore

15. Using the proper size valve seat installation tool, drive the seat into the seat bore (**Figure 7.30**). Be careful that the seat remains aligned with the bore as it is driven in. Once the seat is seated completely, the tool will rebound after being struck with the hammer.



Figure 7.30—Driving the seat into the seat bore

16. Lubricate the face of the valve insert and the valve stems and install them onto the discharge seat in the fluid end (Figure 7.31).



Figure 7.31—Lubricate the face of the valve insert and the valve stems before installing

17. Install the discharge cage as follows:

Important **While holding the discharge cover in one hand, install the discharge cage over the back of the cover, engaging the pin in the cover into the locating slot in the cage (the way it will be installed in the pump).**

Orient the two parts together until the openings in the cage are horizontal. Note the orientation of the slot on the front of the cover handle. Once the cover is installed, this is how the slot will be oriented to ensure that the openings in the cage line up with the discharge passage through the fluid-end sections and discharge flange(s). Almost all covers will be installed with the slot in the handle horizontal (as shown in Figure 7.32).



Figure 7.32—Most covers will be installed with the slot in the handle horizontal

18. Install the discharge cage into the discharge bore of the fluid end with the openings (windows) horizontal and the notch facing outward.

19. Install the discharge spring over the valve stem.

Note	Both 5- and 6-inch HCLE fluid ends use conical discharge springs. When installing these springs, make sure the small end points toward the plunger (**Figure 7.33**).

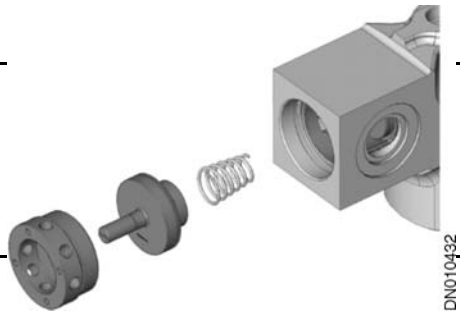


Figure 7.33—5- and 6-in. HCLE conical spring installation

20. Inspect the discharge cover and seal, and replace as necessary. Lubricate the discharge cover seal and install the discharge cover and retainer, making sure to engage the alignment pin in the slot in the discharge cage. Also make sure the valve stem goes into the valve insert in the cover.

21. While pushing the discharge cover in against the discharge valve spring, turn the discharge cover retainer in. Make sure that while the retainer is being turned, the discharge cover doesn't change orientation (watch the slot on the front of the handle). When the retainer contacts the cover, tap the cover into the fluid end with a shop hammer to engage the seal into the seal bore.

22. To tighten the retainer, insert a suitable sized bar and hit it with a shop hammer (**Figure 7.34**). As mentioned earlier, the guide bushing removing punch works well for this.

23. Inspect the seal and threads of the access cover plug. Replace as necessary. Clean the threads and the access cover seal bore in the fluid-end section. Lubricate the seal and threads of the plug and install it into the fluid end (**Figure 7.35**).

    Depending on when the access plug was made, it may be necessary to tap it down with a shop hammer to get the seal into the seal bore and allow the threads to start. Tighten the plug with a wrench and hammer.



Figure 7.34—Tightening the retainer

Repeat these steps as necessary for the remaining fluid-end sections.

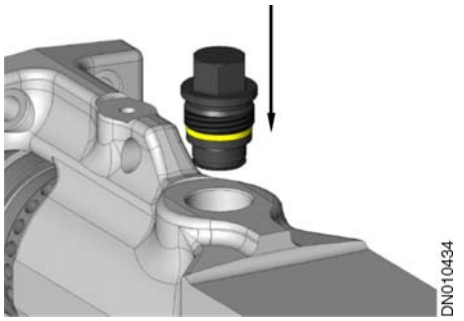


Figure 7.35—Install the access cover plug

Changing Plunger Packing

Disassembly

1. Remove the discharge valve assembly (see disassembly procedure, Steps 1–4 (Page 7-2).
2. To avoid loosening the push rod retainer or the push rod tie-bolt, insert the round end of a packing bar into the push rod adapter and hold in place while another person removes the plunger nose using a plunger nose wrench and wrench support. As the plunger nose is rotated the packing bar may rotate until it contacts the spacer (Figure 7.36). Repeat this step for the remaining plungers.

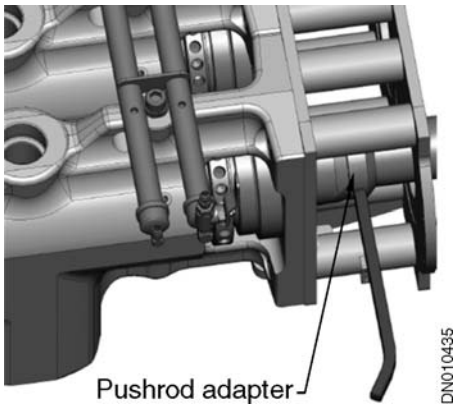


Figure 7.36—Avoid loosening the push rod retainer or the push rod tie-bolt

Note — If the plunger nose is extremely difficult to loosen, remove the packing bar from the pushrod adapter. When the plunger nose wrench is turned, the pushrod tie-bolt or the push rod retainer will loosen. When the assembly feels loose, reinsert the packing bar into the push rod adapter and continue turning to remove the plunger nose. Make sure to torque the push rod tie-bolt and retainer back to specification if this procedure is used.

3. Cycle the pump one crankshaft revolution to push the plungers out to top dead center (TDC).
4. Using a plunger removal tool, cycle the pump to push the plunger out of the packing. Remove the plunger from the fluid end. Repeat this step for the remaining plungers.
5. Loosen and remove the plunger tie-bolts using the plunger tie-bolt socket wrench.
6. Fully compress the packing nut assemblies and remove them from the fluid end.
7. Knock the packing assembly out the back of the fluid end using a wood handle or bar.

Important — If you are planning to reuse the brass rings, be careful not to damage them during removal.

Changing Plunger Packing

Inspection Procedure

Inspect the following plunger packing components as follows:

- **Packing, header ring, and plunger lube seal**—If the packing was leaking or there is visible wear, replace the part.
- **Spacer and carrier**—If there are scratches or excessive wear, replace the part. Small burs can be polished out with emery cloth.
- **Packing bore**—Inspect the packing bore by measuring the diameter where the packing ring makes contact. If there is a groove or dip worn into the bore (mainly at the bottom of the bore) and the packing has been leaking, replace the packing sleeve.
- **Plunger**—Check the plunger for scratches or scoring that could damage or prematurely wear the packing and lube seal. Replace part if necessary.

Reassembly Procedure

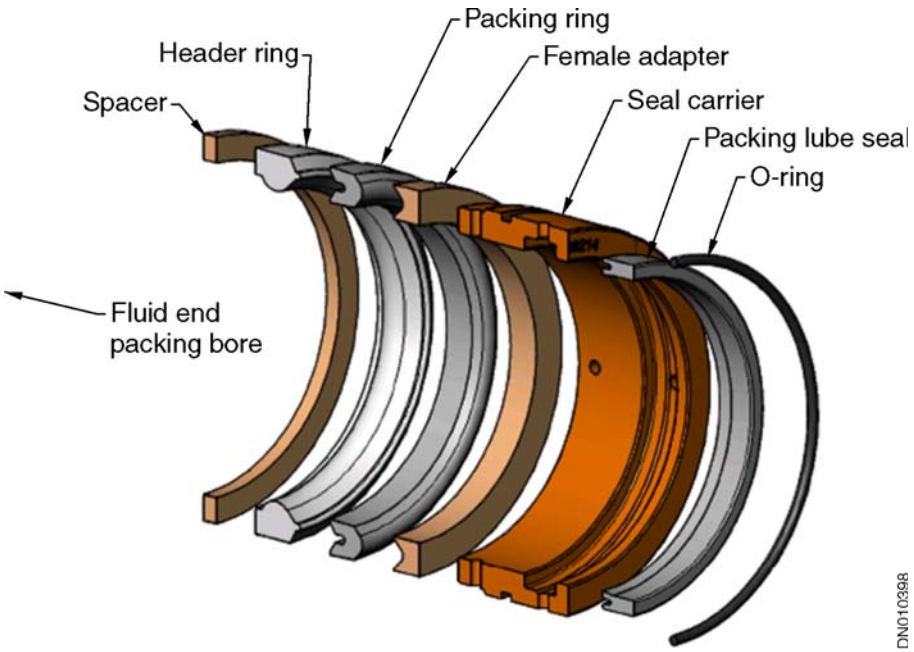


Figure 7.37—CDI packing

1. Thoroughly clean the packing bore. Any proppant and/or proppant fines (dust) left in the packing bore will result in premature packing and packing bore failure.

2. Lubricate and install the spacer into the packing bore (**Figure 7.38**).

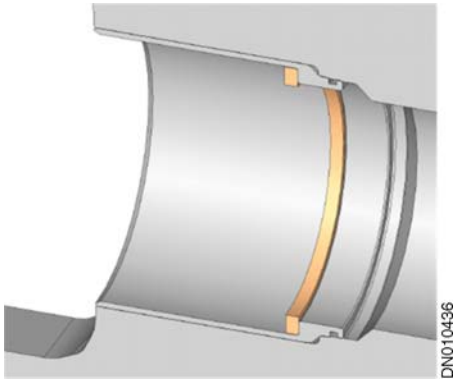


Figure 7.38—Install the spacer into the packing bore

3. Thoroughly lubricate the header and install it into the packing bore, flat-face first (rib facing out). Using the packing inserting tool from the front of the fluid end, pull the ring tight up against the spacer ring (**Figure 7.39**).

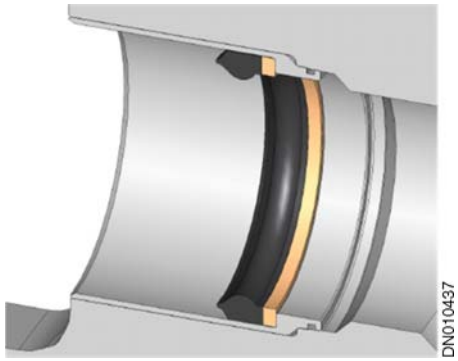


Figure 7.39—Install the header into the packing bore

4. Thoroughly lubricate the packing ring and install it, nose facing out. Seat the packing ring with the packing installation tool (**Figure 7.40**).

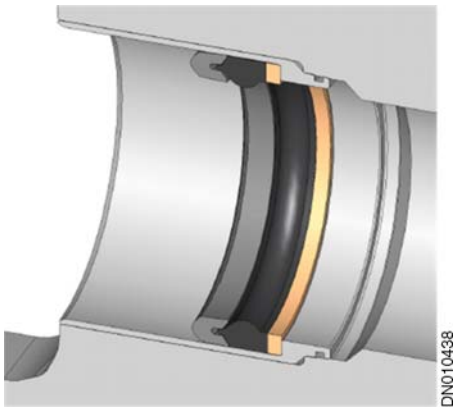


Figure 7.40—Install and seat the packing ring

5. Lubricate the female adapter and install it into the fluid end, curved-side facing in, to mesh with the curved nose of the packing ring. Seat this ring the same as the previous rings (**Figure 7.41**).
6. Install a new lube seal in the seal carrier. Ensure that the open end of the lube seal is facing the lube port in the carrier.
7. Install a new O-ring on the outside of the seal carrier.

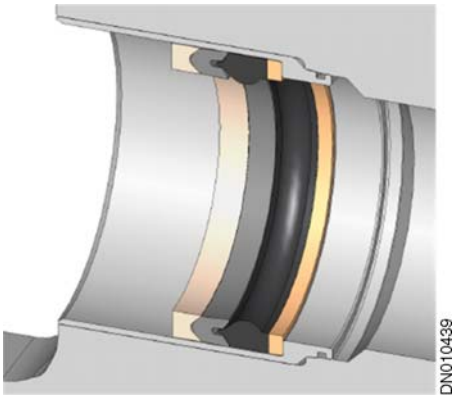


Figure 7.41—Install the female adapter into the fluid end

8. Lubricate the seal carrier and install it, lube-port end first (**Figure 7.42**).
9. Lubricate the threads of the packing nut and wiper gland sleeve and thread the two together.

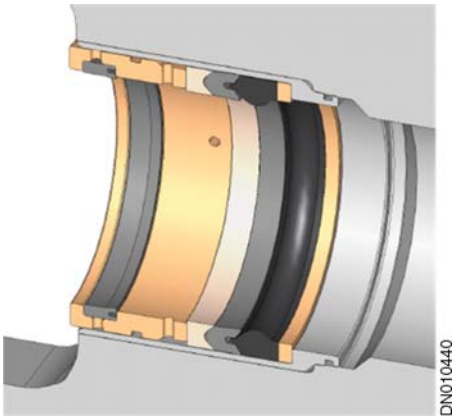


Figure 7.42—Install the seal carrier

10. Install the packing nut and wiper sleeve. Make sure the groove in the wiper sleeve engages the groove pin in the fluid end, then expand the packing nut (**Figure 7.43**).

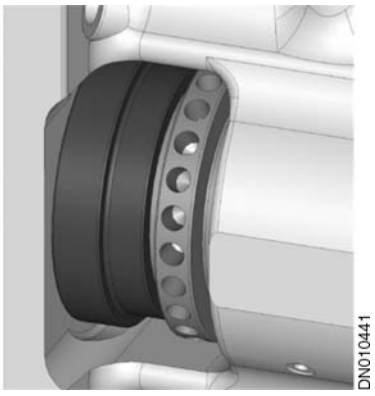


Figure 7.43—Install the packing nut and wiper sleeve

11. When the packing nut contacts the seal carrier, seat the packing by tightening it to approximately 40 ft-lb (30-lb pull on a 15-inch packing bar), then back off the nut until it just loses contact with the carrier to enable plunger installation.

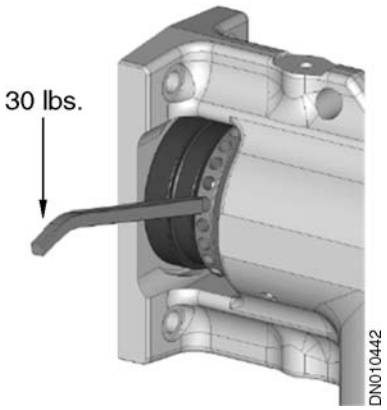


Figure 7.44—Seat the packing

12. Lubricate the threads on the plunger tie-bolt and install it into the pushrod retainer. Torque the plunger tie-bolt to 300–400 ft-lb (**Figure 7.45**).

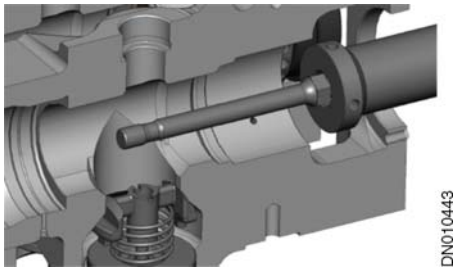


Figure 7.45—Install the plunger tie-bolt into the pushrod retainer

13. Install the plunger centering guide into the discharge bore and bring the push rod to top dead center (all the way forward) (**Figure 7.46**).
14. Clean and lubricate the plunger and install it into the plunger centering guide, tapered-end first, until it contacts the packing.
15. Install the plunger inserting bar pushrod half through the plunger and thread it onto the plunger tie-bolt. Install the plunger inserting bar plunger half over the pushrod half and push it against the plunger (**Figure 7.47**).

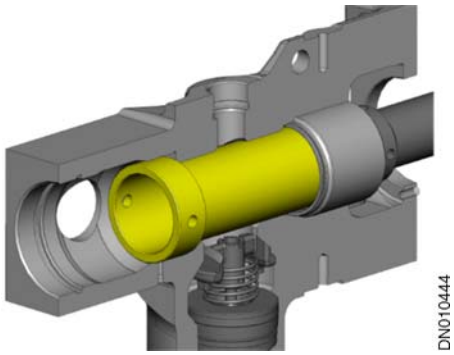


Figure 7.46—Install the plunger centering guide into the discharge bore

Note

The inserting bar plunger half “top-hat” for standard fluid ends is too short for complete plunger installation, and a spacer will need to be made to install the plunger completely in an HCLE fluid end. The standard inserting bar plunger “top-hat” is also too wide to fit into a 4-in. plunger centering guide.

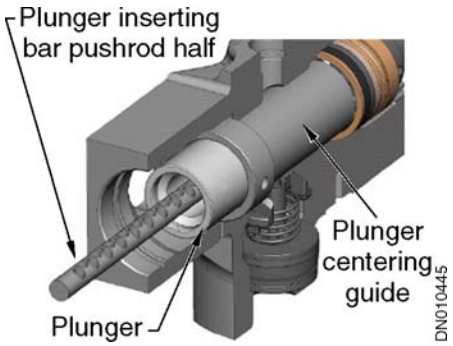


Figure 7.47—Install the plunger inserting bar pushrod

16. Drive the plunger through the packing by prying the plunger inserting bar plunger half forward (**Figure 7.48**).
17. When the plunger contacts the pushrod adapter or has gone as far as the tool will allow, remove the tools.

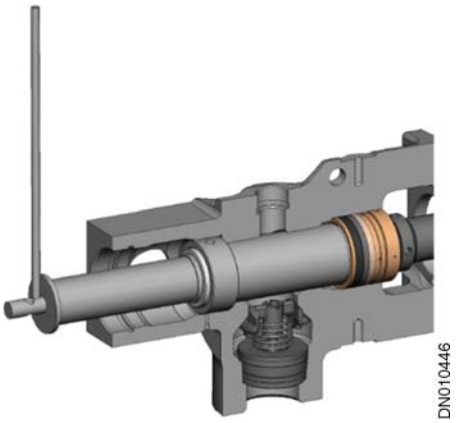


Figure 7.48—Drive the plunger through the packing

18. Lubricate both sides of the plunger nose seal assembly and install the plunger nose and plunger nose seal assembly onto the plunger (plunger centering guide still in place) (**Figure 7.49**).

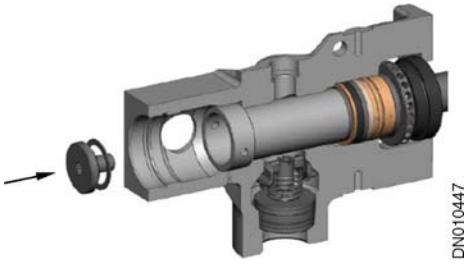


Figure 7.49—Install the plunger nose seal assembly

Note — If a plunger centering guide was not used or if the plunger did not come into contact with the pushrod adapter during installation, it will be necessary to center the plunger using the roll method (see below).

Roll method for centering plungers—Snug the plunger noses (about 30 ft-lb). Then cycle the pump at least once to center the plungers on the pushrod adapter.

19. Torque the plunger nose to 200–300 ft-lb.
20. Remove the plunger centering guide if one was used.
21. Tighten packing with a 30-lb pull on a 15-inch packing bar. When the pump has run and the packing becomes completely seated, further adjustment may be required (Figure 7.50).

Note	Before running the pump, check to make sure the plunger lube supply valve is open and that there is a sufficient volume of clean packing oil in the supply reservoir.

22. Finish by reinstalling the discharge valve assembly. See the reassembly procedure (beginning on Page 7-9).

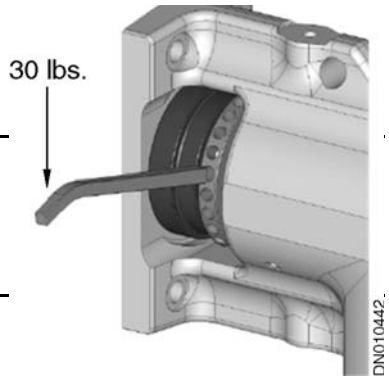


Figure 7.50—Tighten the packing

Changing Fluid-End Assembly

Removal Procedure

1. Remove the discharge valve assembly. See the disassembly procedure, Steps 1–4 (on Page 7-2).
2. To avoid loosening the push rod retainer or the push rod tie-bolt, insert a packing bar into the push rod adapter and hold while another person removes the plunger nose using a plunger nose wrench and wrench support. As the plunger nose is rotated, the packing bar may rotate until it contacts the spacer.

   Repeat this step for the remaining plungers.

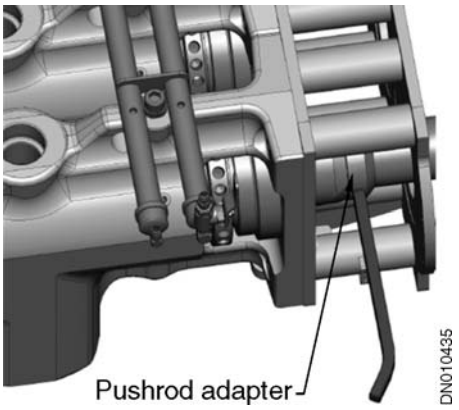


Figure 7.51—Insert a packing bar into the pushrod adapter to prevent loosening the pushrod retainer or pushrod tie bolt

Note

If the plunger nose is extremely difficult to loosen, remove the packing bar from the pushrod adapter. When the plunger nose wrench is turned, the pushrod tie-bolt or the push rod retainer will loosen. When the assembly feels loose, reinsert the packing bar into the push rod adapter and continue turning to remove the plunger nose. Make sure to torque the push rod tie-bolt and retainer back to specification if this procedure is used.

3. **For 4.5-, 5-, and 6.0-inch fluid ends**: With the plunger noses off, remove the plunger tie-bolts using the plunger tie-bolt wrench and wrench support.
4. Cycle the pump one crankshaft revolution to push the plungers out to top dead center (TDC).
5. **For 4.0-inch fluid ends**: With the plunger noses off, cycle the pump to push the plungers out to TDC. Remove the plungers with the 3 3/8-inch plunger removal tool (5-in. piece of 2 × .125-in. angle iron), then remove the plunger tie bolts using the plunger tie-bolt wrench and wrench support (Figure 7.52).
6. Disconnect the discharge iron from the discharge flange(s), disconnect the plunger lube line(s), remove the fluid catch tray underneath the fluid end (if so equipped), and disconnect the pressure transducer wiring (if so equipped).
7. Support the fluid end with appropriate lifting chains. Remove the slack from the chains using an overhead hoist rated for at least 5,000 lb.

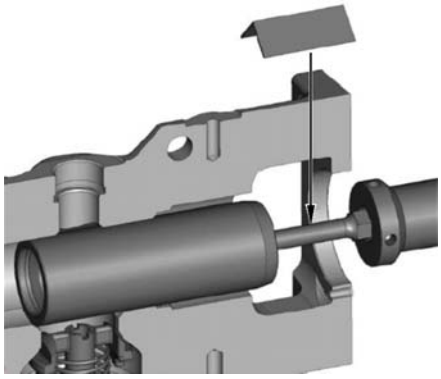


Figure 7.52—For 4.0-inch fluid ends

8. Remove the bottom fluid-end attaching nuts, followed by the top attaching nuts.
9. Carefully slide the fluid assembly off the attaching studs.

Installation Procedure

1. Check the condition of the fluid-end attaching studs. Replace or tighten as needed. If one or more studs show signs of failure, replace all of them.
2. Ensure that the pushrod adapters are correctly sized for the size pump being installed.
3. Clean the mating faces of the spacer and fluid-end assembly.
4. Install the fluid-end assembly over the fluid-end attaching studs.
5. Lubricate the threads of the attaching studs with molybdenum thread lubricant and install the attaching nuts onto all the studs.
6. Torque the attaching nuts to 640 ft-lb.

7. Reattach discharge lines, plunger lube line, the fluid catch tray, and anything else removed to facilitate removing the fluid-end assembly.
8. To finish the installation of the fluid-end assembly, see the plunger packing reassembly procedure, Steps 12–20 (on **Page 7-16**).

Replacing Section Assemblies

Disassembly Procedure

1. Begin by following the steps outlined in the fluid-end assembly removal procedure (Page 7-21).
2. Remove the plunger lube lines and lube manifold from the fluid-end assembly.
3. Place the fluid-end assembly on the ground or on a heavy workbench on the foot of the assembly with the discharge covers facing up (Figure 7.53).
4. Support both discharge flanges and remove the tie-bolt nuts and washers from one side in a crisscross pattern.
5. Remove the tie-bolts and remaining nuts and washers.
6. Remove the discharge flanges, seal plates, and seals.
7. Separate the fluid-end sections and remove the seals and seal plates between the sections.

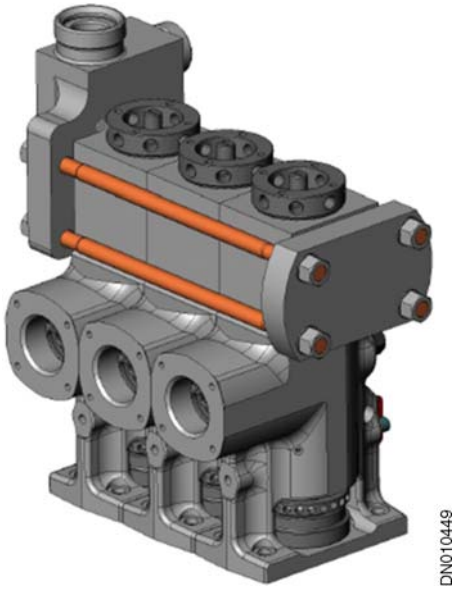


Figure 7.53—Placement of the fluid-end assembly

Assembly Procedure

1. Clean the fluid-end discharge seal bores thoroughly. Remove any rough spots on the sealing face with emory cloth.
2. Lubricate the discharge seal bores, discharge seals, and discharge seal plates with grease. Install the seals into the seal bores. The brass ring on the seals needs to face out to contact the seal plate positioned between the two seals (Figure 7.54).
3. Position the sections together with the seals and seal plates between them.
4. Install the discharge flanges onto the fluid assembly in the same way that the fluid sections were joined (seal plate sandwiched between two seals). Hold the discharge flanges in position with an overhead hoist.

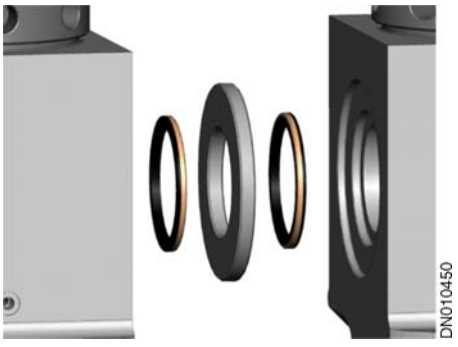


Figure 7.54—Install seals into seal bores

5. Lubricate the threads of the tie-bolts and install one nut and washer on each one.
6. Install the tie-bolts through the discharge flanges and install the remaining nuts and washers. Make sure the thread engagement on each of the tie-bolts is equal on both sides (Figure 7.55).
7. Using a crisscross pattern, tighten all four tie-bolts to the torque specifications (refer to Table 7.1).

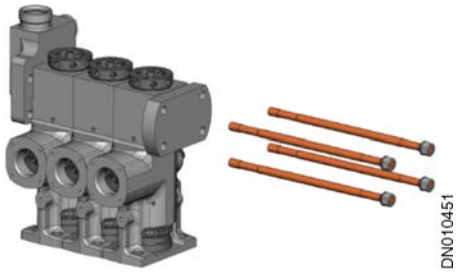


Figure 7.55—Install the tie-bolts through the discharge flanges

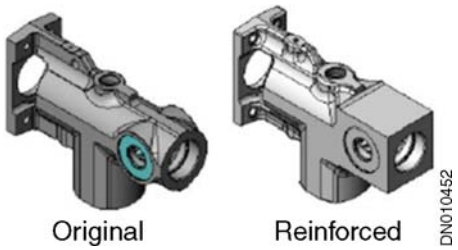


Table 7.1—Tie-Bolt Torque Specifications for HCLE Fluid Ends

Size (in.)	Original HCLE Torque (ft-lb)	Reinforced HCLE Torque (ft-lb)
4	700–750	1,500
4.5	600–650	1,500
5	—	1,500
6	400–450	1,500

8. Install the plunger lube lines and lube manifold on the fluid-end assembly.
9. Finish by following the steps outlined in the fluid-end assembly installation procedure (on Page 7-22).

Replacing Packing Sleeves

Disassembly Procedure

1. Follow Steps 1–7 outlined in the plunger packing disassembly procedure (Page 7-15) to remove the plunger packing.
2. Follow Steps 6–9 outlined in fluid-end assembly removal procedure (Page 7-21) to remove the fluid-end assembly from the spacer and power end.
3. Use an Oxy-Fuel torch to heat a 3-inch strip on the packing sleeve. Heat the strip until it is a medium red.

Caution **Do not cut or overheat the sleeve, as it will damage the packing sleeve bore.**

4. Quench the sleeve with water while another person knocks the sleeve out the back of the fluid end with a metal bar and hammer.
5. If the previous two steps do not free the sleeve from the fluid end, heat two 3-inch strips directly across from one another and repeat the quench hammer procedure.
6. Once the sleeve is removed, clean the sleeve bore and polish out any burs that may damage the O-ring seal during installation.

Assembly Procedure

1. Install a new O-ring on the new packing sleeve.
2. Lubricate the sleeve bore and packing sleeve.
3. Assemble the sleeve puller end as shown in Figure 7.56 outside the fluid end. Ensure that the adapter is bottomed out on the threaded rod before tightening the retainer down using the puller socket tube.
4. Start the packing sleeve into the packing bore followed by the sleeve puller assembly.

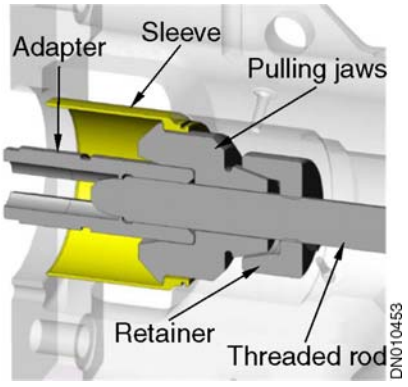


Figure 7.56—Assemble the sleeve puller end

5. At the front of the pump, install the puller guide over the threaded puller rod followed by the hydraulic cylinder (ram). Secure the assembly with the puller nut. Make sure the sleeve is lined up correctly with the sleeve bore and tighten the puller nut to hold the assembly in place (**Figure 7.57**).
6. Hook up the hydraulic hose(s) and pump to the hydraulic cylinder, and pull the sleeve into the seal bore. The back of the sleeve will be flush with the back of the fluid end when completely installed. It may be necessary to cycle the cylinder to get the sleeve installed completely (fully extend the cylinder, pulling the sleeve into the sleeve bore, then compress the cylinder, retighten the puller nut, and extend the cylinder again).
7. Release the pressure from the cylinder and disassemble the puller assembly from the fluid end.

Repeat this process on the remaining fluid-end sections as necessary.

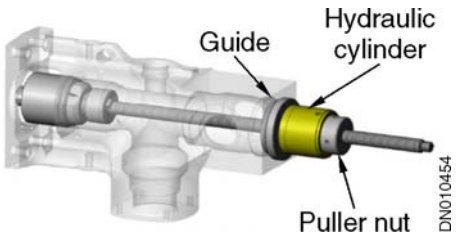


Figure 7.57—Install the puller guide over the threaded puller rod followed by the hydraulic cylinder

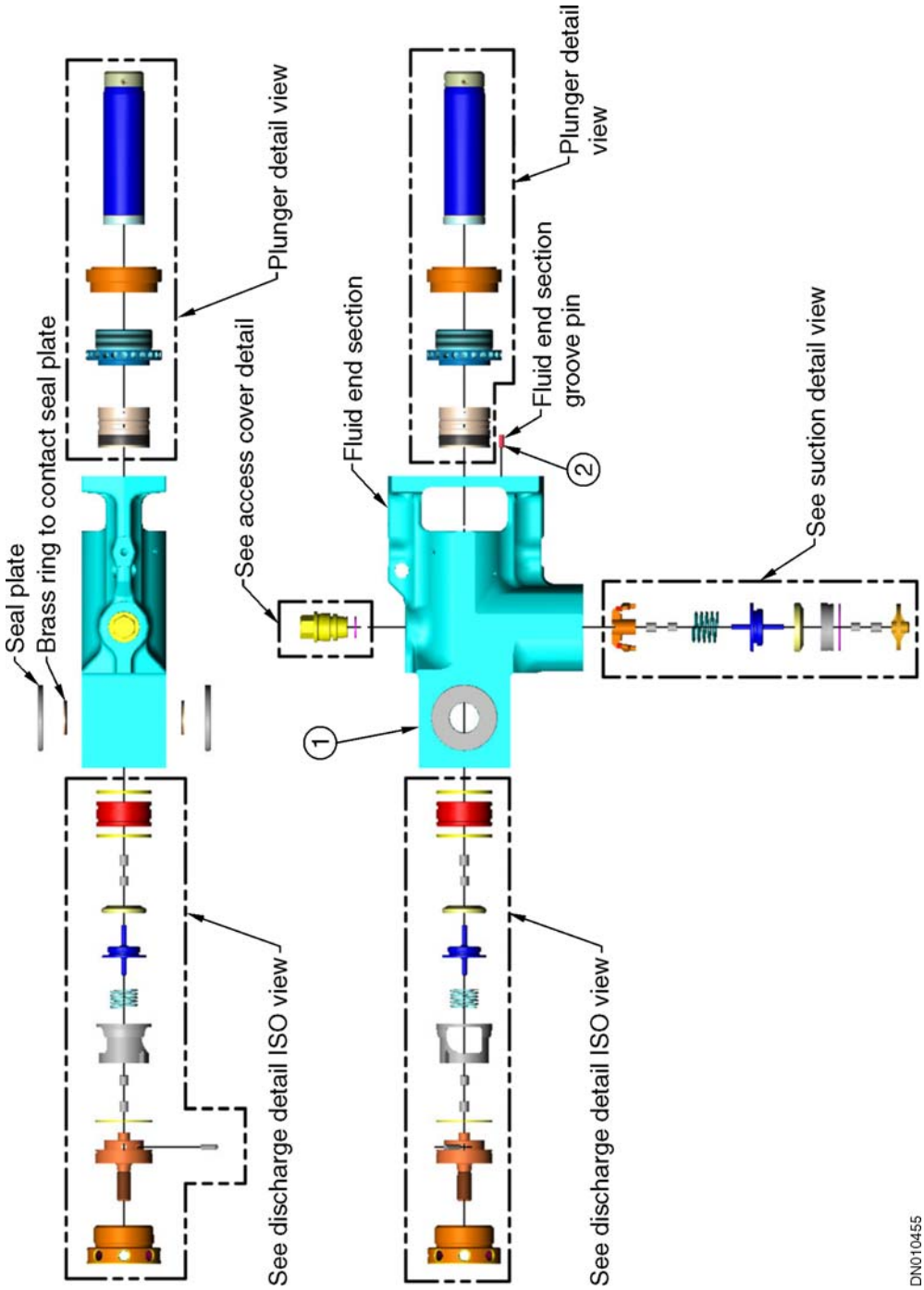
Section
8

HCLE Fluid-End Parts

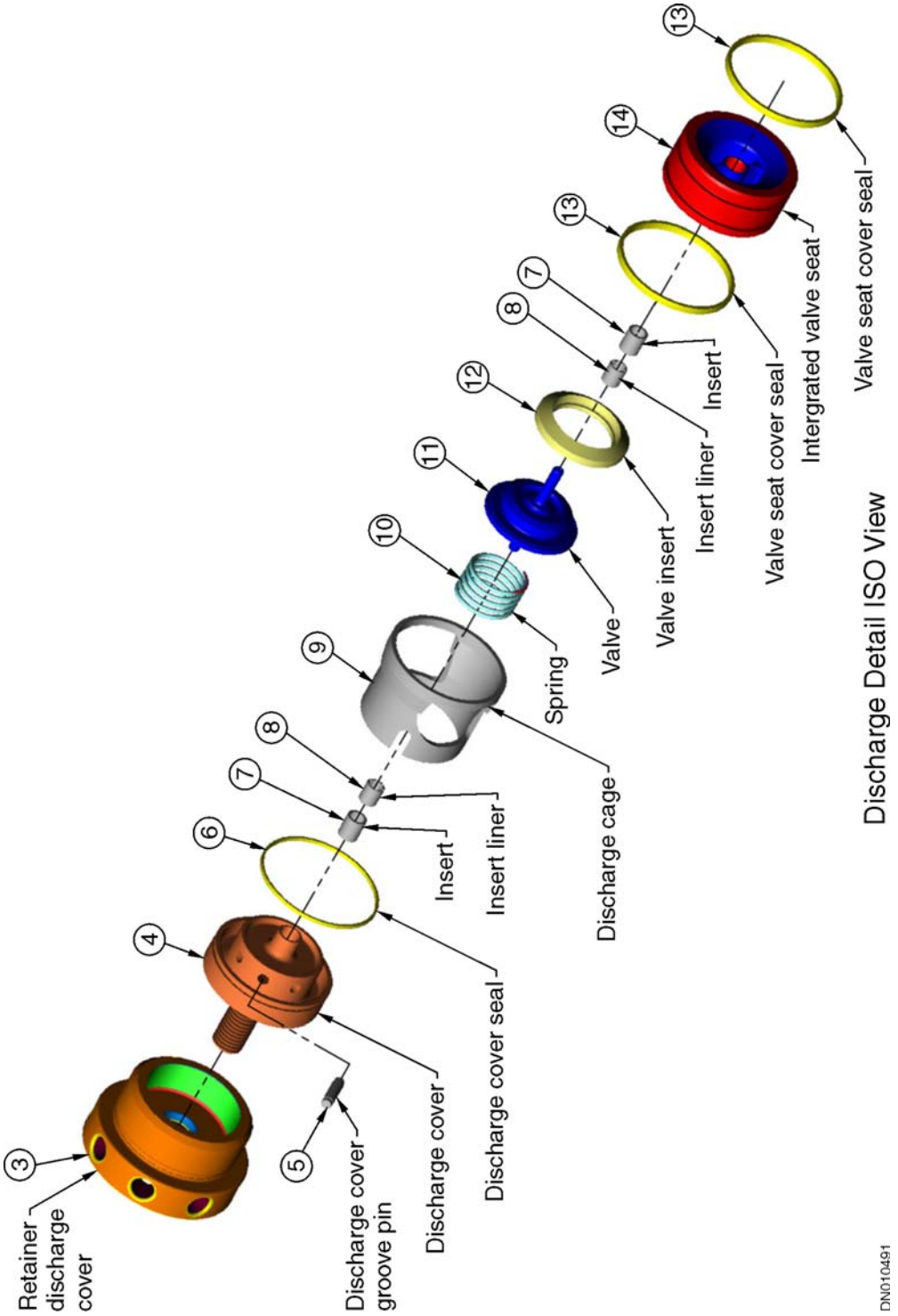
Introduction

This section provides HCLE fluid-end diagrams and part number lists.

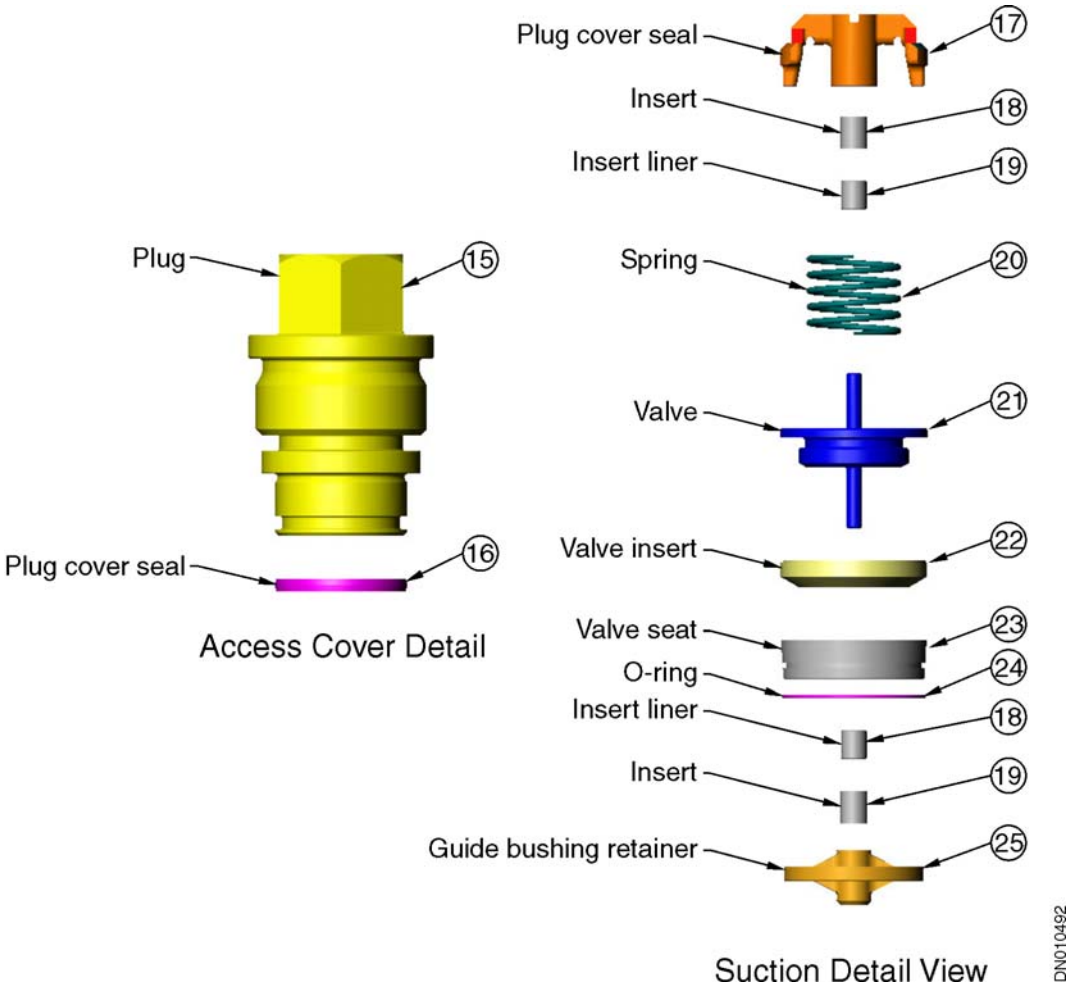
Fluid-End Overview



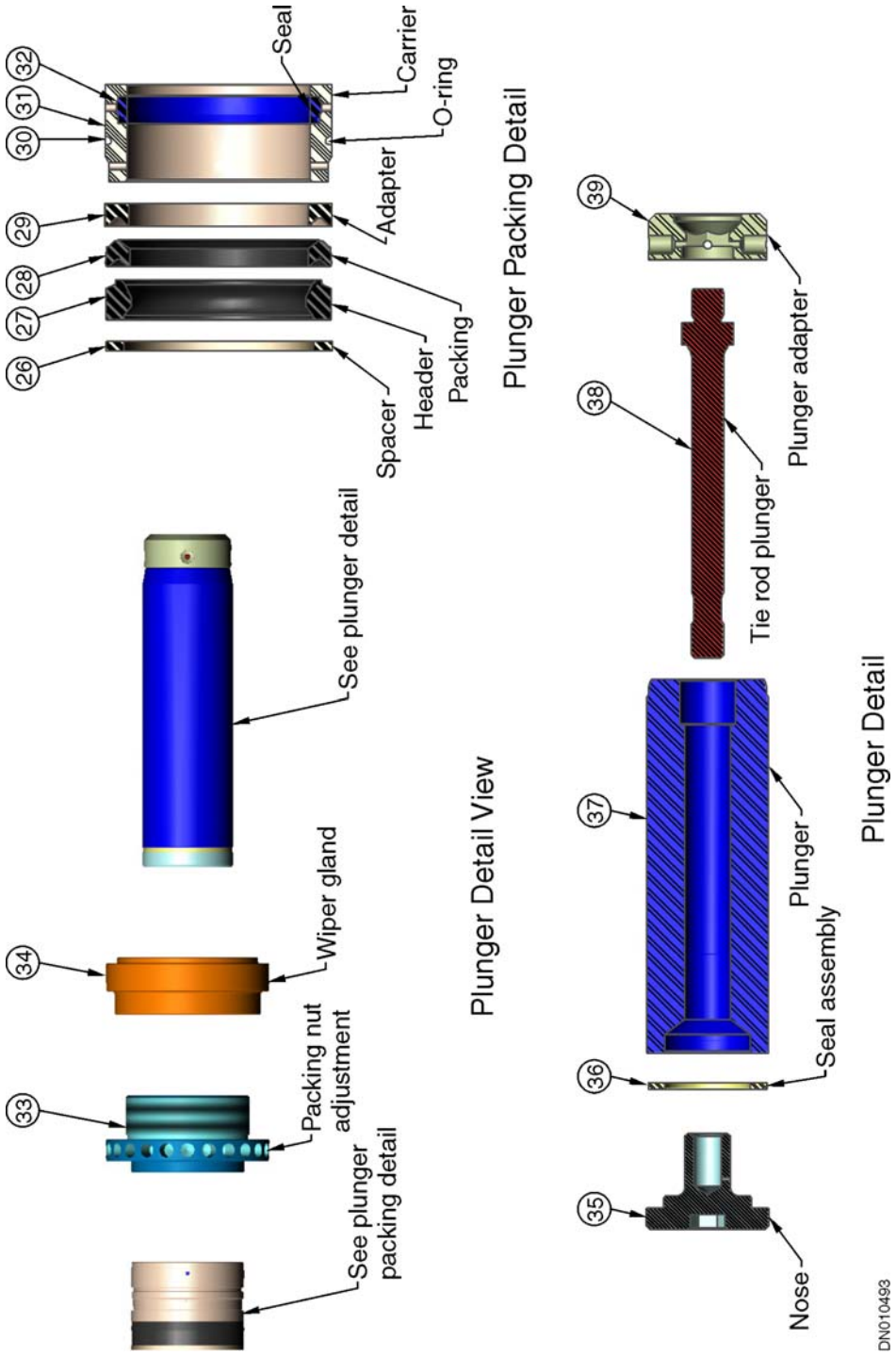
Discharge Detail (ISO View)



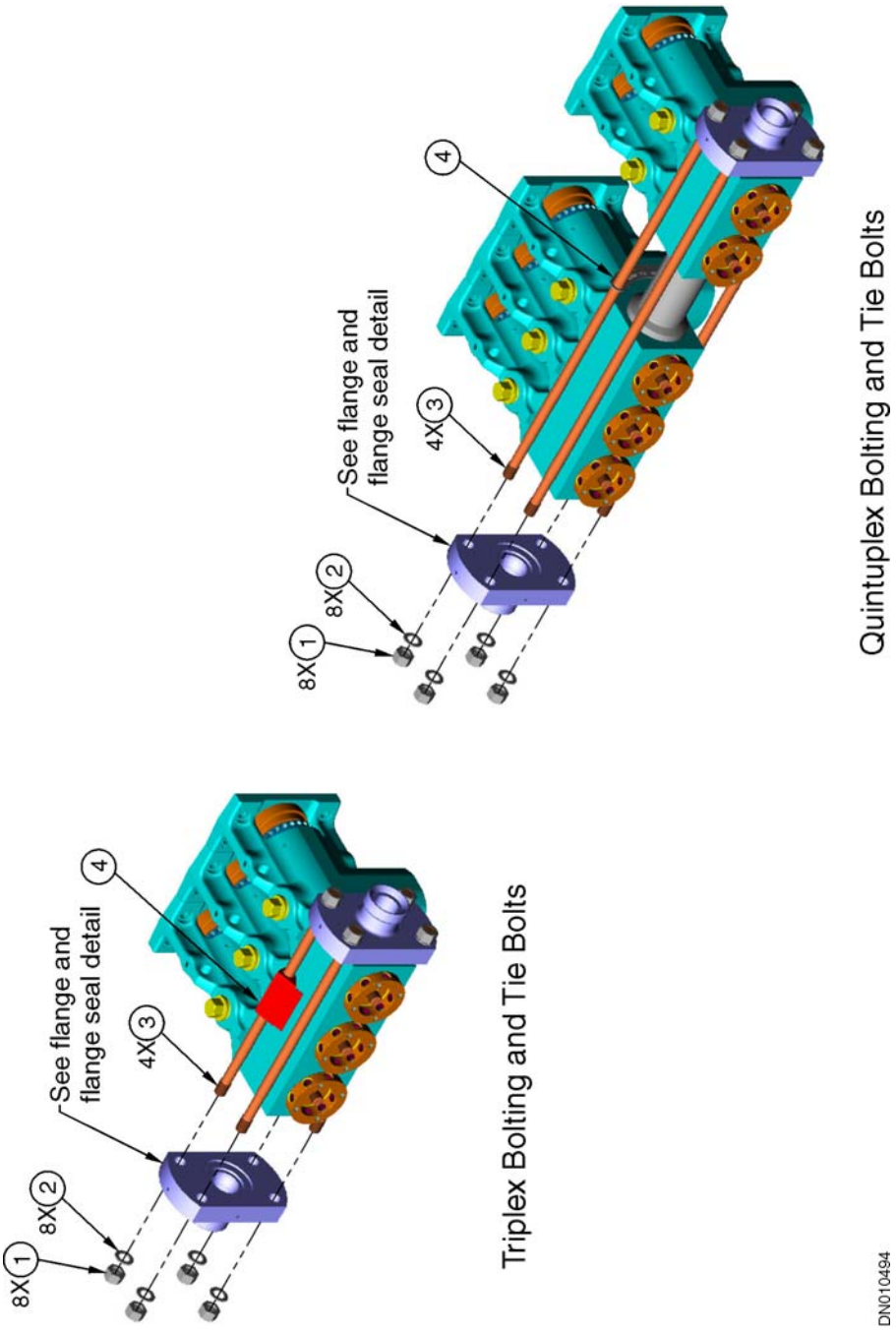
Access Cover/Suction Details



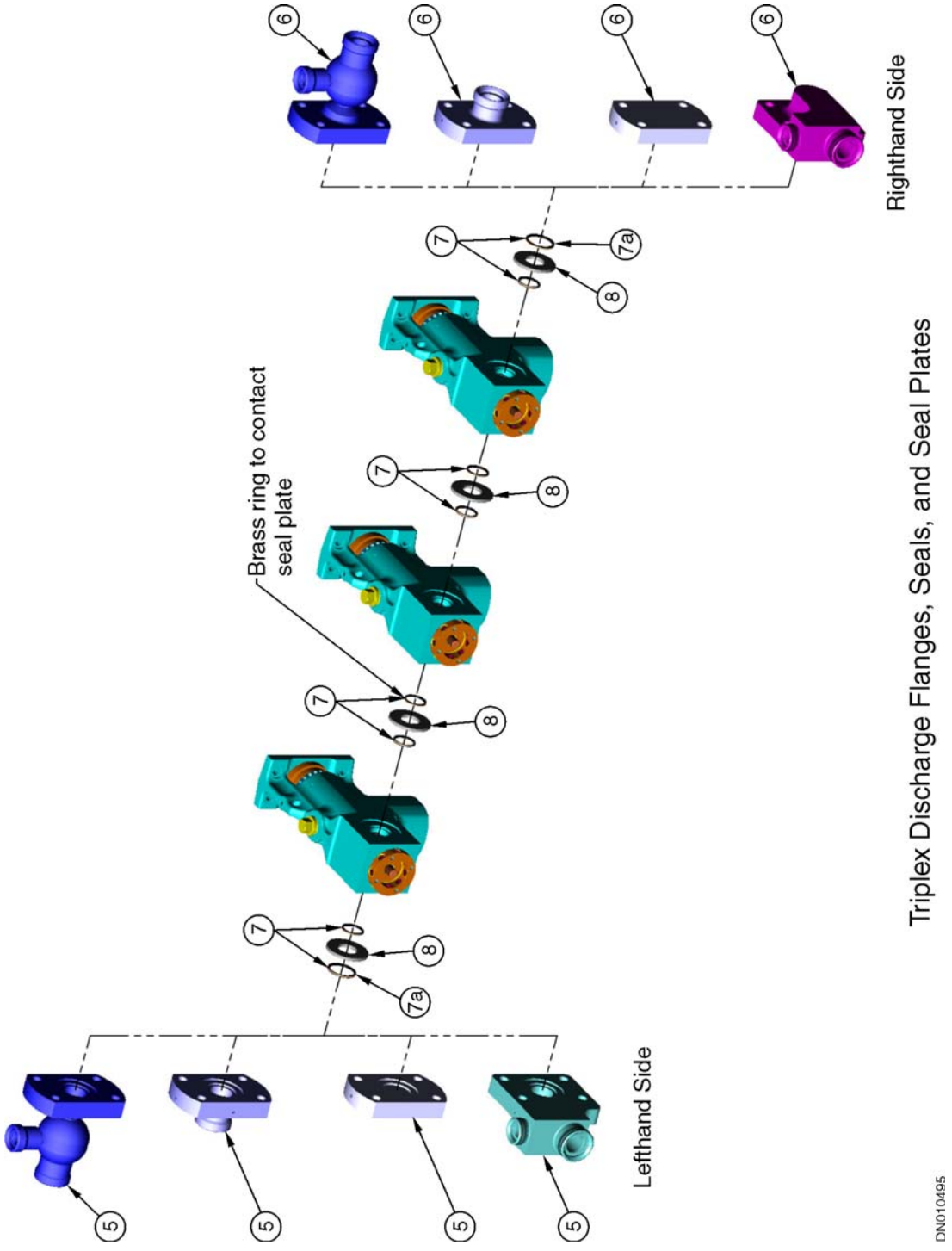
Plunger Detail



Bolting and Tie-Bolts (Triplex and Quintuplex)



Triplex Discharge Flanges, Seals, and Seal Plates



Quintuplex Discharge Flanges, Seals, and Seal Plates

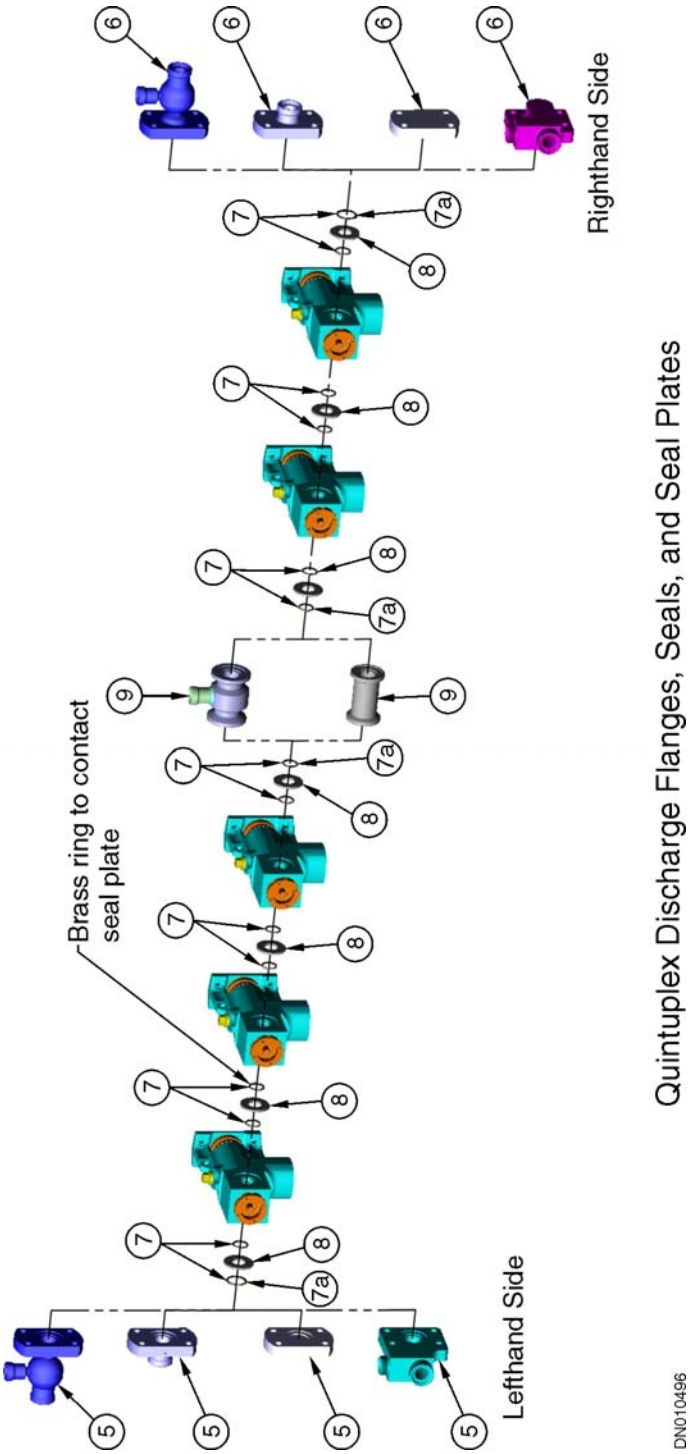


Table 8.1—HCLE Fluid-End, Single-Section Assembly

Find No.	Description	Qty.	4.0 in.	4.5 in.	5.0 in.	6.0 in.	Notes
Fluid-End Section							
1	Fluid-end section	1	101414414	101414412	101441714	101414413	Γ
1†	Fluid-end section	1	N/A	101476487	N/A	N/A	Γ
2	Fluid-end section groove pin	1	100002081	100002081	100002081	100002081	Γ
Discharge							
3	Retainer discharge cover	1	101327491	101229388	101229388	101229388	Γ
4	Discharge cover	1	101327844	101228808	101450115	101450115	Γ
5	Discharge cover groove pin	1	101303165	101303165	101448347	101448347	Γ
6	Discharge cover seal	1	101424202	101425718	101427748	101427748	Γ, Δ
7	Insert	2	100002867	100002867	100002869	100002869	Δ, Θ
8	Insert liner	2	100002868	100002868	100002870	100002870	Δ, Θ
9	Discharge cage	1	101327879	101229192	101430559	101430559	Γ, Δ
10	Spring	1	100002837	100002936	100058597	100058597	Δ
11	Valve	1	100002824	101354936	100002960	100002960	Δ
12	Valve insert	1	101333083	101333104	101349952	101349952	Δ
13	Valve seat cover seals	2	101424205	101425640	101426649	101426649	Γ, Δ
13†	Valve seat cover seals	2	N/A	101473483	N/A	N/A	Γ, Δ
13‡	Valve seat cover seals	2	101439486	101481071	101439913	101439913	Γ, Δ
14	Integrated valve seat	1	101402944	101416765	101416766	101416766	Γ, Δ
14†	Integrated valve seat	1	N/A	101475252	N/A	N/A	Γ, Δ
14‡	Integrated valve seat	1	101440202	101483244	101441257	101441257	Γ, Δ
Access *Access Cover*							
15	Plug	1	101415893	101415893	101415893	101415893	Γ
16	Cover seal	1	101424201	101424201	101424201	101424201	Γ, Δ
Suction							
17	Stop retainer/guide spring	1	101327609	100003045	100003045	100003045	Θ
18	Insert	2	100002867	100002869	100002869	100002869	Θ
19	Insert liner	2	100002868	100002870	100002870	100002870	Θ
20	Spring	1	100002936	100002936	100002936	100002936	Δ, Θ
21	Valve	1	101354936	100002960	100002960	100002960	Δ, Θ
22	Valve insert	1	101333104	101349952	101349952	101349952	Δ, Θ
23	Valve seat	1	100002874	100002957	100002957	100002957	Δ, Θ
24	O-ring	1	100000970	100000974	100000974	100000974	Δ, Θ
25	Guide bushing retainer	1	101328144	101355505	101355505	101355505	Θ

Table 8.1—HCLE Fluid-End, Single-Section Assembly (Continued)

Find No.	Description	Qty.	4.0 in.	4.5 in.	5.0 in.	6.0 in.	Notes
Plunger *Plunger Packing*							
26	Spacer	1	101377638	101377659	101377667	101377679	Δ, Θ
27	Header	1	101377640	101377660	101377668	101377682	Δ, Θ
28	Packing	1	101377641	101377661	101377669	101377683	Δ, Θ
29	Adapter	1	101377652	101377663	101377671	101377684	Δ, Θ
30	O-ring	1	100002016	100002019	101377672	100007763	Δ, Θ
31	Carrier	1	101377656	101377664	100002022	101377685	Δ, Θ
32	Seal	1	101377657	101377665	101377674	101377686	Δ, Θ
Plunger Adjustment							
33	Packing nut adjustment	1	101328001	101330209	101438000	101330259	Θ
34	Wiper gland	1	101328357	101328357	101438001	101330379	Θ
Plunger							
35	Nose	1	100002885	100002941	100002941	100002941	Θ
36	Seal assembly	1	100002884	100002940	100002940	100002940	Δ, Θ
37	Plunger	1	100002883	100002937	100011726	100058514	Δ, Θ
38	Tie rod plunger	1	100002827	100002827	100002970	100002970	Θ
39	Plunger adapter	1	100011706	100011721	100011727	100058517	Θ

Notes:

† - Parts used specifically for 4.5-in. HCLE fluid ends with reversible discharge seats.

‡ - Parts used specifically for HCLE fluid ends where discharge valve seals are installed into the fluid end.

Γ - Parts unique to the HCLE fluid end

Δ - Consumable parts

Θ - Parts common to both HCLE and standard fluid ends

Table 8.2—HCLE Fluid-End Triplex Assembly

Find No.	Description	Qty.	4.0 in.	Qty.	4.5 in.	Qty.	5.0 in.	Qty.	6.0 in.
Bolting & Tie-Bolts									
1	Nut	8	100002976	8	100002976	8	100002976	8	100002976
2	Washer	8	100002894	8	100002894	8	100002894	8	100002894
3	Tie-bolt	4	100002993	4	100002993	4	100002993	4	100002993
Fluid-End Tag									
4	Tag	1	101441221	1	101441221	1	101441221	1	101441221
Left-Hand Discharge									
5	Straight		101427491		101427491		101427491		101427491
	Blank		101419211		101419211		101419211		101419211
	Straight w/ riser		101419210		101419210		101419210		101419210
	Left-hand, right-angle chunk flange		101419209		101419209		101419209		101419209
Right-Hand Discharge									
6	Straight		101427491		101427491		101427491		101427491
	Blank		101419211		101419211		101419211		101419211
	Straight w/ riser		101419210		101419210		101419210		101419210
	Right-hand, right-angle chunk flange		101419208		101419208		101419208		101419208
Seals & Seal Plates									
7	Discharge Seal	6	101412377	8	101412378	8	101412378	8	101412378
7a	Flange seal 4-in. only	2	101412378						
8	Seal Plates	4	101413044	4	101413045	4	101413045	4	101413045
Packing Lube									
Installation plunger lube kit	Triplex recirculation manifold lube system		101363113		101363113		101363113		101363113

Table 8.3—HCLE Fluid End Quinuplex Assembly

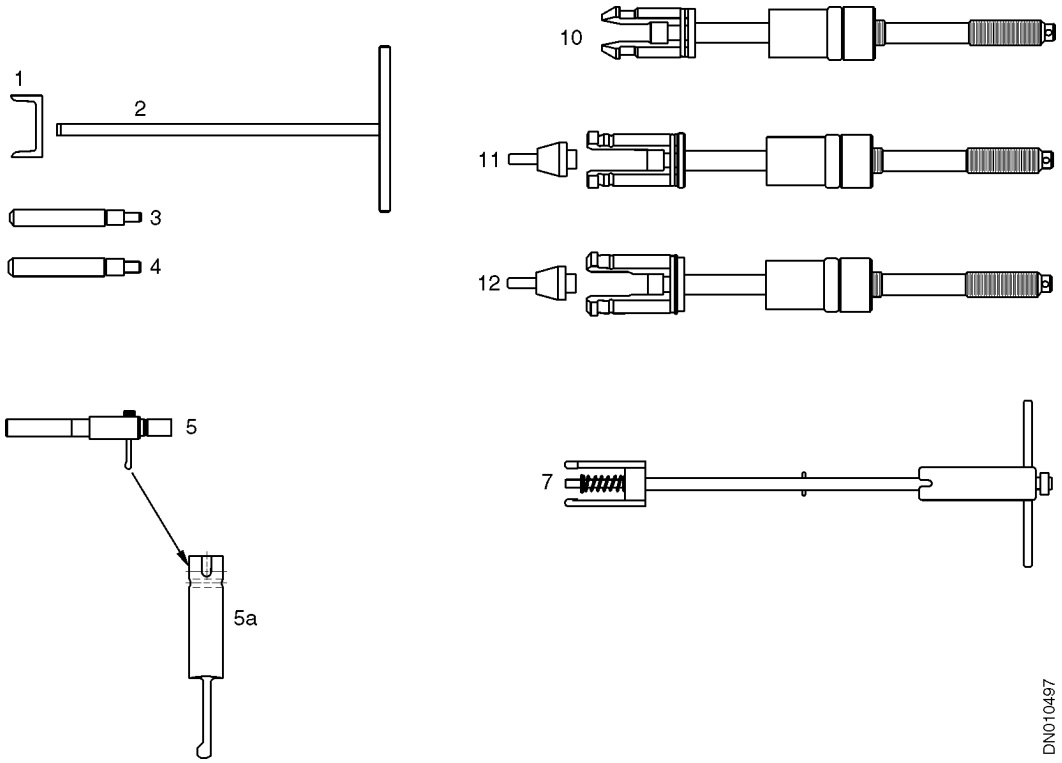
Find Numbers	Description	Qty.	4.0 inch	Qty.	4.5 inch	Qty.	5.0 inch	Qty.	6.0 inch
Bolting & Tie-Bolts									
1	Nut	8	100002976	8	100002976	8	100002976	8	100002976
2	Washer	8	100002894	8	100002894	8	100002894	8	100002894
3	Tie-bolt	4	100002993	4	100002993	4	100002993	4	100002993
Fluid End Tag									
4	Tag	1	101303439	1	101303439	1	101303439	1	101303439
Left Hand Discharge									
5	Straight		101427491		101427491		101427491		101427491
	Blank		101419211		101419211		101419211		101419211
	Straight w/ riser		101419210		101419210		101419210		101419210
	Left-hand, right-angle chunk flange		101419209		101419209		101419209		101419209
Right Hand Discharge									
6	Straight		101427491		101427491		101427491		101427491
	Blank		101419211		101419211		101419211		101419211
	Straight w/ riser		101419210		101419210		101419210		101419210
	Right-hand, right-angle chunk flange		101419208		101419208		101419208		101419208
Seals & Seal Plates									
7	Discharge seal	10	101412377	14	101412378	14	101412378	14	101412378
7a	Flange seal 4-in. only	4	101412378						
8	Seal plates	7	101413044	7	101413045	7	101413045	7	101413045
Center Flange									
9	Spacer		101418816		101418816		101418816		101418816
	Spacer w/ pressure port		101420748		101420748		101420748		101420748
Packing Lube									
Installation plunger lube kit	Quinuplex recirculation manifold lube system		101366706		101366706		101366706		101366706

Section
9

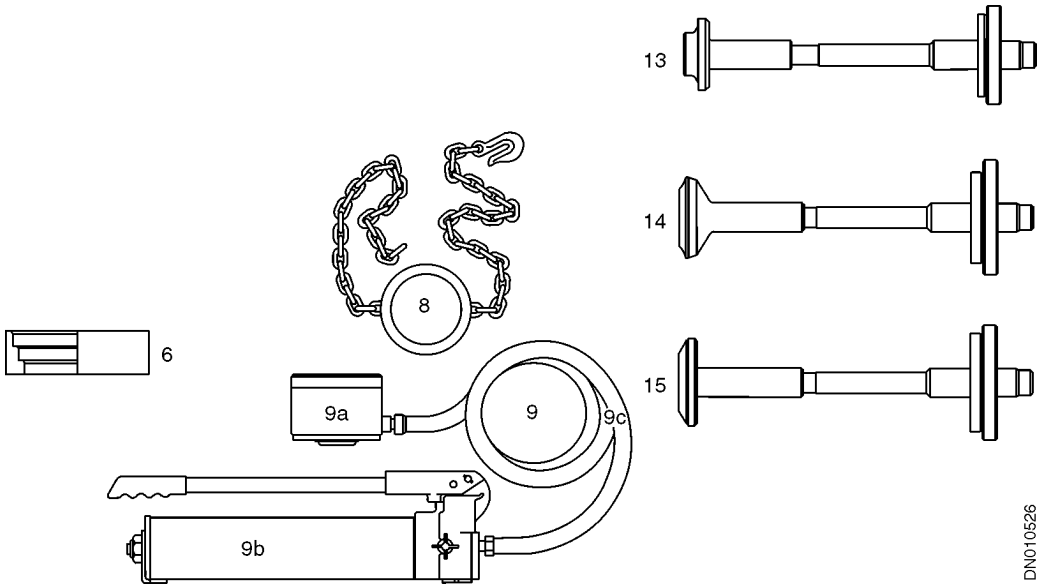
Pump Tools

Fluid-End Tools

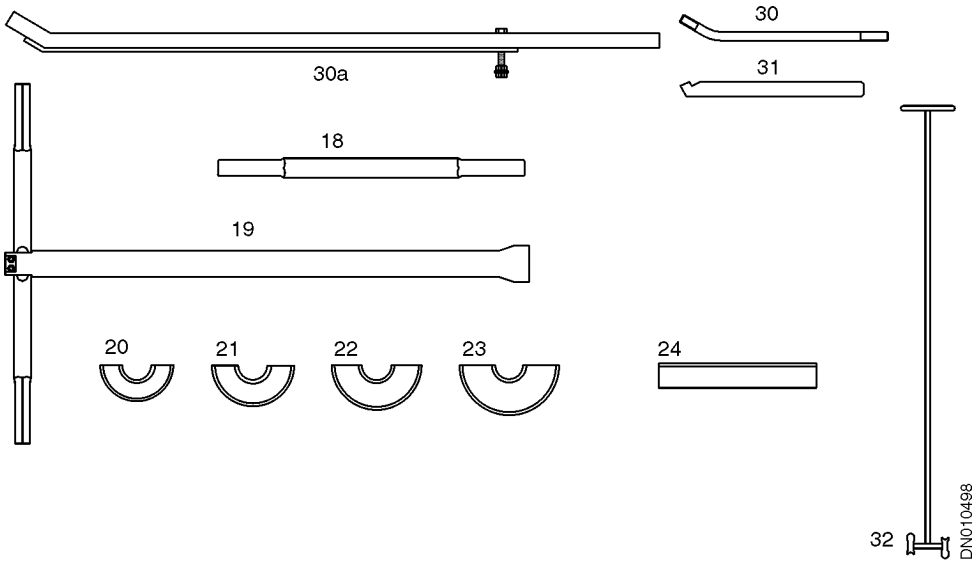
For Removing and Replacing Valves



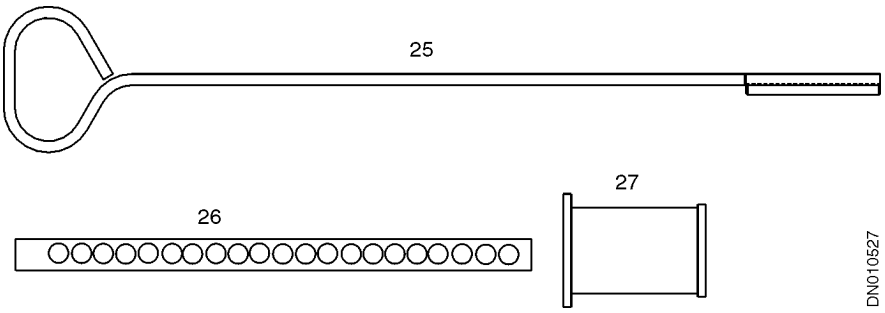
For Removing and Replacing Valve Seats



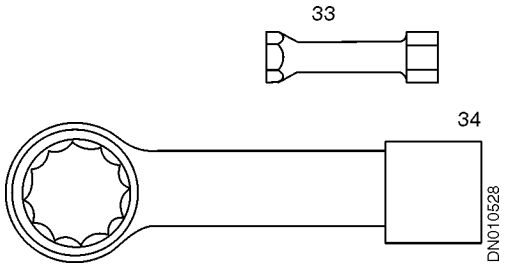
For Removing and Replacing Packing



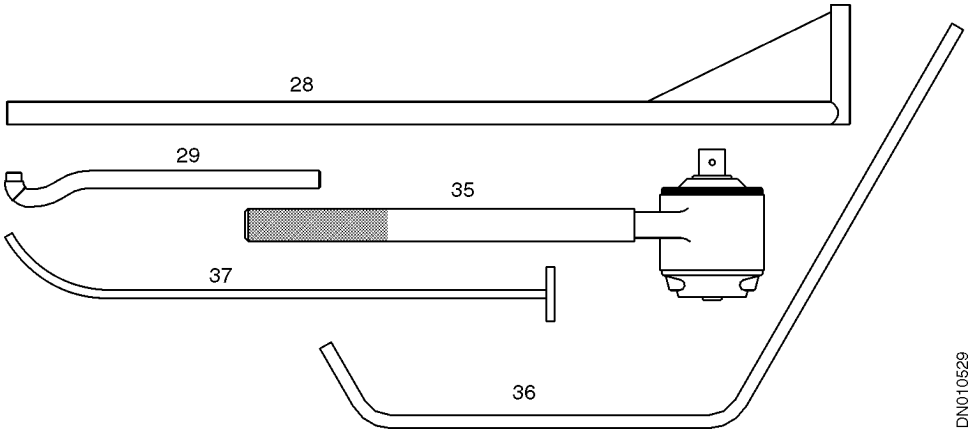
For Removing and Replacing Plungers



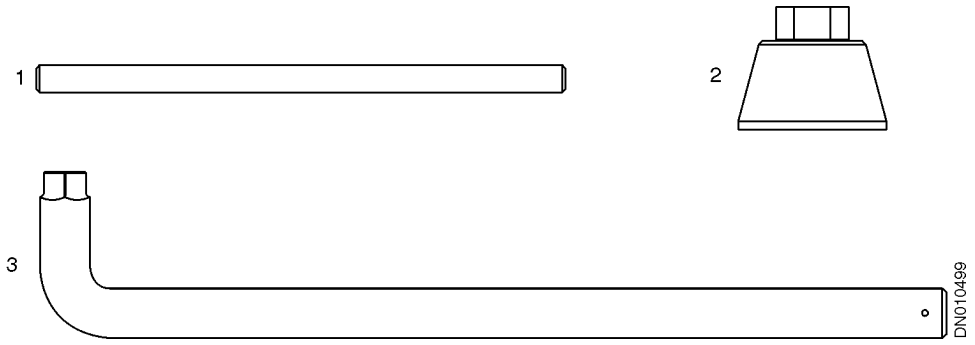
For Removing and Replacing Discharge Flanges



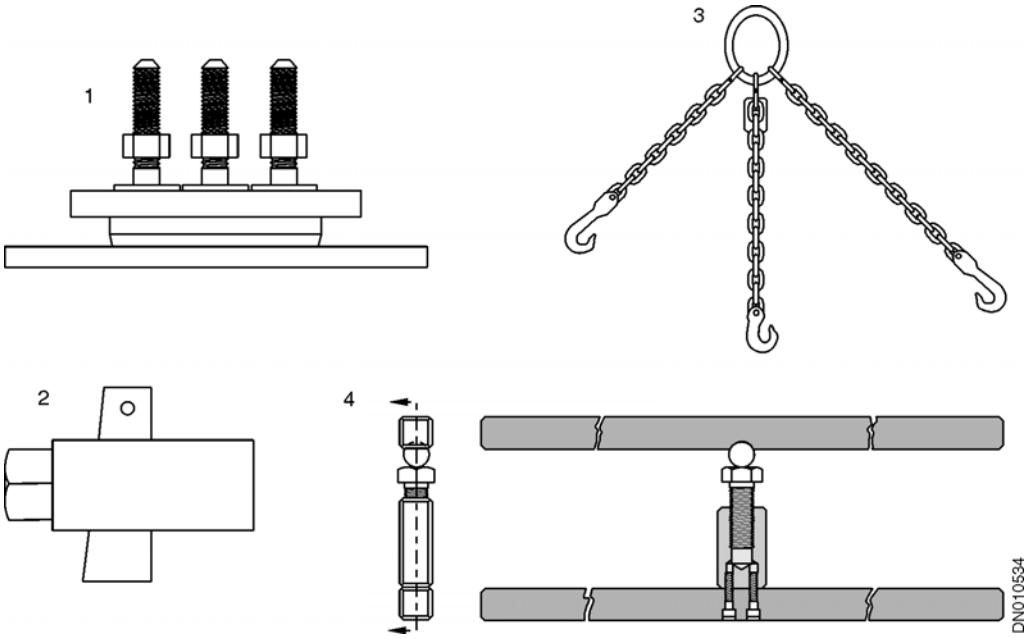
For Removing and Replacing Fluid-End Assembly



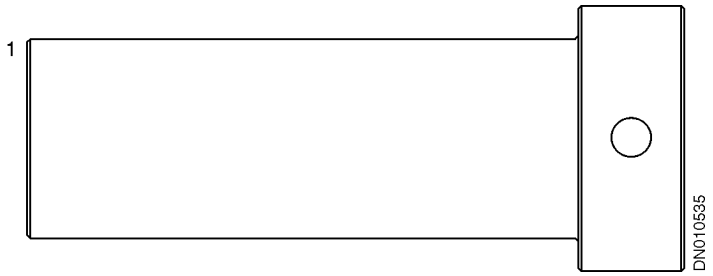
Spacer Tools



Power-End Tools

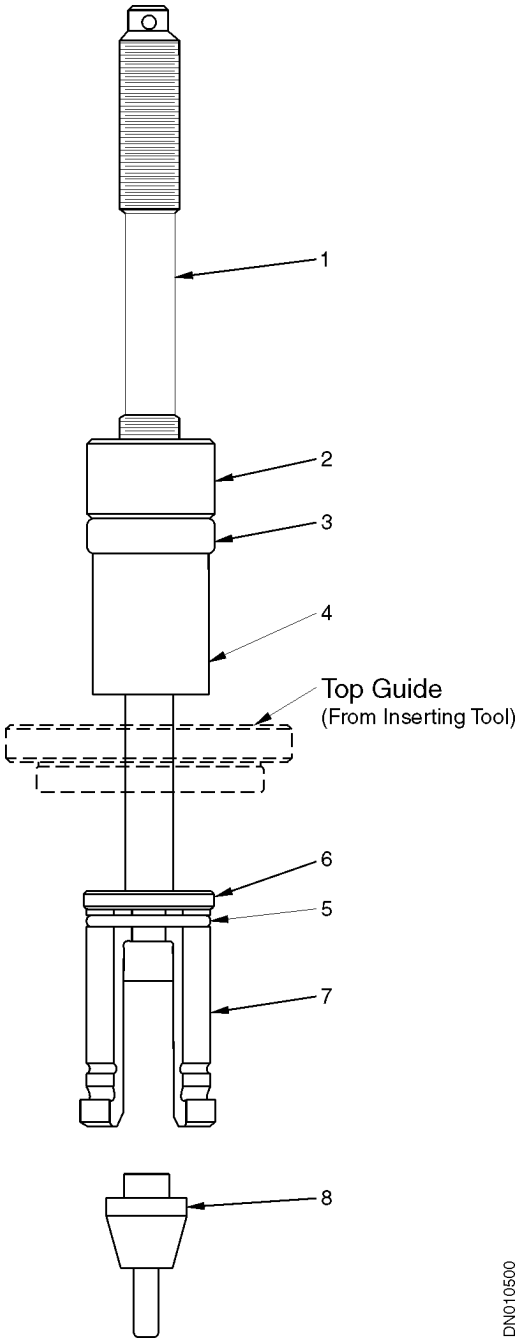


Plunger Alignment Tool



Seat Pulling/Inserting Tools

Seat Pulling Tool



Seat Inserting Tool

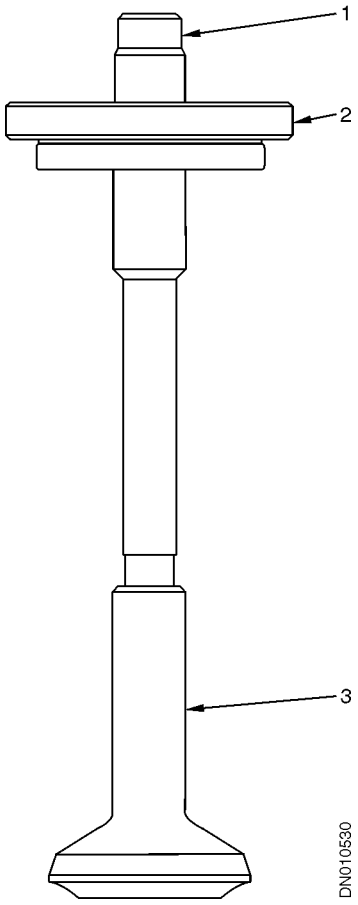


Table 9.1—Fluid-End Tools

Loc	Part No.	Qty	Description	Fluid-End Size (in.)				
				3 3/8	4	4 1/2	5	6
Remove and Replace Valve Tools *Basic Tools Used on All Valve Types*								
1	100002989	1	Adapter, stop and spring installation tool	•	•		•	•
2	100002983	1	Wrench, tee, stop and spring retainer	•	•	•	•	•
3	100002910	1	Punch, guide bushing removing[1]	•	•	•		
4	100002984	1	Punch, guide bushing removing[2]				•	•
Additional Tools Used on Frac Valves								
5	100009621	1	Insert installing tool	•	•	•	•	•
5A	100002887	1	Insert installing tool, tab valve	•	•	•	•	•
6	100058373	1	Removal tool adapter, valve seat	•	•	•	•	•
Remove and Replace Frac Valve Seat Tools *Basic Tools Used on All Valve Seat Types*								
7	100002865	1	Seal-removing tool, valve seat	•	•	•	•	•
8	100003076	1	Guard-safety chain, hydraulic ram	•	•	•	•	•
9	100007829	1	Ram/pump assembly	•	•	•	•	•
9A	100003074	1	Ram, assy, valve seat puller[3]	•	•	•	•	•
9B	100027563	1	Pump, hydraulic, hand	•	•	•	•	•
9C	100025575	1	Hose assembly, 2-WB, 3/8 in. NPT	•	•	•	•	•
Additional Tools Used on Frac Valve Seats								
10*	100002861	1	Puller assembly, valve seat No. 3	•	•			
11*	100011714	1	Puller assembly, valve seat No. 4 frac			•		
12*	100058410	1	Puller assembly, valve seat No. 5 frac				•	•
13*	100002856	1	Inserting tool, valve seat No. 3	•	•			
14*	100011709	1	Inserting tool, valve seat No. 4			•		
15*	100058533	1	Inserting tool, valve seat No. 5 frac				•	•
Remove and Replace Plunger Tools								
18	100007818	1	Wrench, nose plug	•	•	•	•	•
19	100002978	1	Wrench, socket, plunger tie-bolt nut	•	•	•	•	•
20	100002822	1	Support, wrench, 3 3/8 in.	•	•			
21	100002871	1	Support, wrench, 4 and 4 1/2 in.			•		
22	100058468	1	Support, wrench, 5 in.				•	

Table 9.1—Fluid-End Tools (Continued)

Loc	Part No.	Qty	Description	Fluid-End Size (in.)				
				3 3/8	4	4 1/2	5	6
Remove and Replace Plunger Tools (continued)								
23	100058620	1	Support, wrench, 6 in.					•
24	100002826	1	Plunger-removing tool, 3 3/8 in.	•	•			
25	100002979	1	Plunger-removing tool, 4 1/2 in. to 6 in.			•	•	•
26	100002803	1	Inserting tool, tie rod half	•	•	•	•	•
27	100002802	1	**Inserting tool, plunger half**	•	•	•	•	•
Remove and Replace Fluid-End Assembly Tools								
28	100002981	1	Extension, lock nut wrench	•	•	•	•	•
29	100002980	1	Wrench, locknut	•	•	•	•	•
Remove and Replace Wiper and Pressure Packing								
30	100002977	1	Wrench, packing nut adjusting	•	•	•	•	•
30A	100058527	1	Wrench, packing, constant torque	•	•	•	•	•
31	100002985	1	Drive, packing nut adjusting	•	•	•	•	•
32	100002864	1	Packing inserting tool	•	•	•	•	•
Removing and Replacing Discharge Flanges								
33	100011745	1	Drive, nut, 3-in. outboard flange		•	•	•	•
34	100030687	1	Wrench, socket, 2-in. flats	•	•	•	•	•
35	100011742	1	Wrench, torque multiplier, 2,200 ft/lb	•	•	•	•	•
Draining Fluid-End Assembly								
36	100058293	1	Drain tool, valve	•	•	•	•	•
37	100058297	1	Drain tool, Y suction header	•	•	•	•	•

Table 9.2—Spacer, Power-End, and Plunger Alignment Tools

Loc	Part No.	Qty	Description	Spacer Type				
				L-4	L-3	L-2	L-1	
Spacer Tools								
1	100058374	1	Bar, L-spacer		•	•	•	
2	100002835		Wiper tool, pushrod, L-spacer, discharge	•	•	•		
3	100002982		Wrench, locknut, for L-spacer	•	•	•	•	
Loc	**Part No.**	**Qty**	**Description**	**Power End Type**				
					R-H	L-H		
Power-End Tools								
1	100058365	1	Inserting tool assembly, worm seal		•	•		
2	100058242		Stud driver		•	•		
3	100008187		Chain-lifting		•	•		
4	316.1197		Crosshead aligning jack		•	•		
Plunger Alignment Tool								
1	100058347	1	Guide, centering, plunger, 3 3/8 x 4 3/8 in.					
	100058395		Guide, centering, plunger, 4 in. x 5 in.					
	100058445		Guide, centering, plunger, 4 1/2 x 5 1/2 in.					
	100058487		Guide, centering, plunger, 5 in. x 6 in.					
	100058614		Guide, centering, plunger, 6 in. x 7 in.					

Suction Valve Seat Puller

Figure 9.1 correlates to items found in **Table 9.3** on the following page.

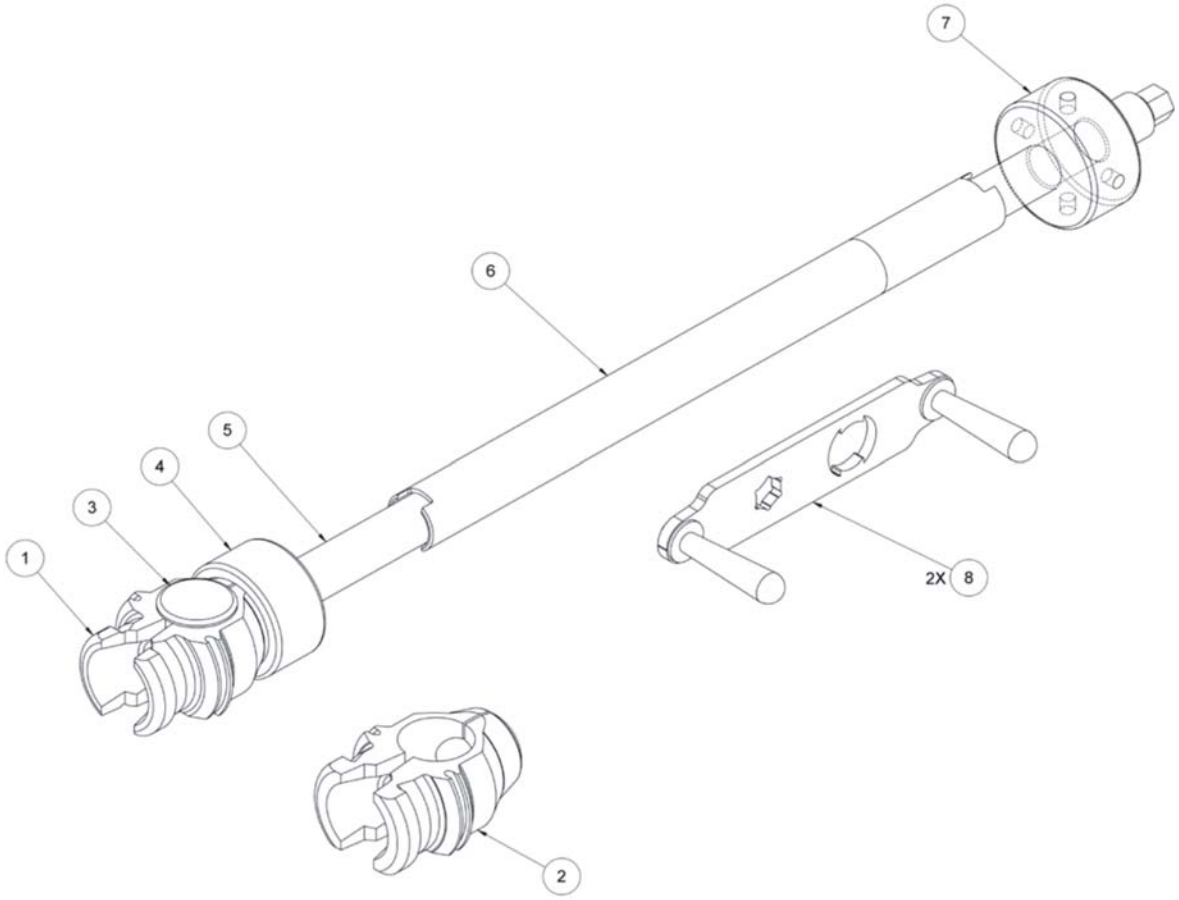


Figure 9.1—Additional tools used on frac valve seats (fluid end) (see Table 9.3)

Table 9.3—Additional Tools Used on Frac Valve Seats

	Loc	Part No.	Qty	Description	Fluid End Size (in.)					
					3 3/8	4	4 1/2	5	6	
Pulling Jaws	*	101616082	1	Jaw, puller, valve seat, suction, No. 3, STD FE	•	•				Standard HT-400™ fluid end
	1	101417882	1	Jaw, puller, valve seat, suction, No. 4, HCLE			•			
	2	101417883	1	Jaw, puller, valve seat, suction, No. 5, HCLE				•	•	
	*	101616082	1	Jaw, puller, valve seat, suction, No. 3, STD FE	N/A					HCLE fluid end
	1	101417882	1	Jaw, puller, valve seat, suction, No. 4, HCLE	"	•				
	2	101417883	1	Jaw, puller, valve seat, suction, No. 5, HCLE	"		•	•	•	
	2	101417883	1	Jaw, puller, valve seat, suction, No. 5, HCLE	N/A	N/A	•			HT-2000 fluid end
	*	101616747	1	Jaw, puller, valve seat, suction, No. 6, HT-2000 FE	"	"		•		
	*	101617261	1	Jaw, puller, valve seat, suction, No. 7, HT-2000 FE	"	"			•	
Pulling Tools	*	101585241	2	Ring, retaining, external, 5100-262, 2.625 dia shaft						
	3	101418323	1	Pin, puller, valve seat, suction, HCLE						
	4	101412455	1	Retainer, tool, pulling, sleeve, plunger packing						
	5	101417988	1	Rod, threaded, 1-1/2-6 ACME, 42-in. long						
	6	101418553	1	Socket, puller, 24-in., HCLE						
	7	100011713	1	Nut, puller, valve seat puller						
	8	101428371	2	Wrench, socket and rod						
	*	101210936	1	Spacer						
Hyd. Rams	*	101426089	1	Cylinder, 60-ton, center hole, 10,000-psi						
	*	100059105	1	Ram assembly, hydraulic, high capacity, valve seat puller, HT-2000 fluid end						
	*	101426090	1	Pump, hydraulic						
	*	101426091	1	Hose assembly, hydraulic						

*Note: Parts not shown in drawing

HCLE Fluid-End Tools

Part No.	Description
101361466	Assembly puller seat discharge HT-400™ fluid ends. This assembly includes the following parts: 100002811—Nut, 1-14 NF, internal wrenching, 1.03 thread length 100002976—Nut, top tie bolt, HT400, type certified 101329031—Discharge valve seat puller, HSCLE, 4.0-, 4.5-, and 6.0-in. fluid end 101353932—Rod, Valve seat puller,4 in , 4 1/2-in. and 6-in. HSCLE fluid ends 101361465—Puller seat discharge HT-400™ fluid ends 101374733—Extended discharge valve seat puller, HSCLE, 4.0-, 4.5-, 6.0-in. fluid end
101372024	4.0-in, HSCLE suction spring retainer installation/removal tool
101356242	Adaptor seat puller tapered No. 3 and 4 HT-400™ , HSCLE and fluid ends
101436148	Guide, plunger centering, 4.0-in., HCLE
101456760	Guide, plunger centering, 4.5-in., HCLE
101456982	Guide, plunger centering, 5.0-in., HCLE
101457023	Guide, plunger centering, 6.0-in., HCLE
100011739	Guide, top, valve seat inserting tool, HT400 fluid end, 5.0- and 6.0-in.
101403243	Jaw, tool, pulling, sleeve, plunger packing, 4.0-in., fluid end, WSP
101421505	Jaw, tool, pulling, sleeve, plunger packing, 4.5-in., fluid end, WSP
101298384	Jaw, tool, pulling, sleeve, plunger packing, 5.0-in., fluid end, WSP
101421506	Jaw, tool, pulling, sleeve, plunger packing, 6.0-in., fluid end, WSP
101435099	Kit, fluid end maintenance tools, 4.0-, 4.5-, 5.0-, 6.0-in. HCLE
101413376	Kit, hand puller, suction valve
100026270	Mallet, rubber, #7
100011713	Nut, puller, valve seat puller, 4-in. and 4 1/2-in. HT-400™ fluid end
101412455	Retainer, tool, pulling, sleeve, plunger packing, fluid end, WSP
101417988	Rod, threaded, 1-1/2-6 ACME, 42-in. long, double taper x 1-in. hex, HCLE
101418553	Socket, puller, 24-in., HCLE
101437472	Support, seat, hammering plunger, 4.0-in., HCLE fluid end
101457208	Support, seat, hammering plunger, 4.5-, 5.0-, and 6.0-in., HCLE fluid end
101420318	Tool, plunger removal, 4-in., WSP
100002977	Wrench, packing nut adjusting, 5 3/4 HT-400™ fluid end
101428371	Wrench, socket and rod