



# **OPERATION MANUAL**

## **TwinForce™ Series Waterblast Unit**

# Protect Workers and Equipment with the Jetstream® **Visual Safety System\***

Yellow	Green	Blue	Orange
10,000 PSI	15,000 PSI	20,000 PSI	40,000 PSI
690 Bar	1,034 Bar	1,379 Bar	2,758 Bar

**Be sure operators are using the right equipment.**  
New color coded parts and accessories clearly show water-blast components in use are correctly and safely suited to current pump pressures with the Visual Safety System.



- Easy to use and implement
- Easy to see at a distance
- Helps keep workers safe
- Helps prevent equipment damage



\*Complies with WJTA visual safety system color guidelines

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# WARRANTY

**Limited Warranty.** Each Waterblast Unit, Bareshaft Pump, and Fluid End manufactured by Jetstream is warranted against defects in material and workmanship for a period of 12 months or 1,000 hours, provided it is used in a normal and reasonable manner and in accordance with all operating instructions. If sold to an end user, the applicable warranty period commences from the date of delivery to the end user. If used for rental purposes, the applicable warranty period commences from the date of delivery to the party holding the equipment available for rent. This limited warranty may be enforced by any subsequent transferee during the warranty period. This limited warranty is the sole and exclusive warranty given by Jetstream.

**Exclusive Remedy.** Should any warranted product fail during the warranty period, Jetstream will cause to be repaired or replaced, as Jetstream may elect, any part or parts of such Waterblast Unit, Bareshaft Pump, or Fluid End that the examination discloses in Jetstream's sole judgment to be defective in material or factory workmanship. Repairs or replacements are to be made at Jetstream in Houston, Jetstream FS Solutions Rental Center, the customer's location, or at other locations approved by Jetstream. Labor is furnished only when the unit or part is returned to the factory or when travel and expenses are paid by the purchaser. Freight, travel and expenses incurred in connection with repair or warranty are excluded from this warranty and shall be paid by the purchaser. The foregoing remedies shall be the sole and exclusive remedies of any party making a valid warranty claim.

The Jetstream Limited Warranty shall NOT apply to (and Jetstream shall NOT be responsible for):

1. Major components or trade accessories that have a separate warranty from their original manufacturer, such as, but not limited to: diesel engines, electric motors, electronic soft starter and/or across the line starter panels, axles, PTO's, clutch packs, high pressure gauges, high pressure hoses, flex lances, etc.
2. Normal adjustments and maintenance services.
3. Normal wear parts such as, but not limited to: oil, clutches, belts, filters, packing, cartridges, univalves, face seals, diffusers, gland nut bushings, plungers, nozzles, rupture disks, etc.
4. Failures resulting from the machine being operated in a manner or for a purpose not recommended by Jetstream including failures or malfunctions resulting from corrosion, misapplication, overpressurization, inadequate pump suction conditions, improper water quality, improper maintenance, or misuse.
5. Repairs, modifications or alterations which in Jetstream's sole judgment, have adversely affected the machine's stability, operation or reliability as originally designed and manufactured.
6. Items subject to misuse, negligence, accident or improper maintenance.

**\*NOTE\*** The use of any part other than ones approved by Jetstream may invalidate this warranty. Jetstream reserves the right to determine, in its sole discretion, if the use of non-approved parts invalidates the warranty. Nothing contained in this warranty shall make Jetstream liable for loss, injury, or damage of any kind to any person or entity resulting from any defect or failure in the machine or part.

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This warranty is in lieu of all other obligations or liabilities, contractual and otherwise, on the part of Jetstream. For the avoidance of doubt, Jetstream shall not be liable for any indirect, special, incidental or consequential damages, including, but not limited to, loss of use or lost profits. Jetstream makes no representation that the unit has the capacity to perform any functions other than as contained in Jetstream's written literature, catalogs or specifications accompanying delivery of the machine. No person or affiliated company representative is authorized to alter the terms of this warranty, to give any other warranties or to assume any other liability on behalf of Jetstream in connection with the sale, servicing or repair of any machine manufactured by Jetstream. Any legal action based hereon must be commenced within eighteen (18) months of the event or facts giving rise to such action.

Jetstream reserves the right to make design changes or improvements in its products without imposing any obligation upon itself to change or improve previously manufactured products.

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# WATERBLAST SAFETY

## Recognizing Safety Information

One of Jetstream's ongoing endeavors is to minimize or eliminate the risk of injury to the product user. Jetstream has taken every effort to alert the user to potential safety risks through the use of cautionary statements within the operator manual and safety decals (Figure 1) on its products. Be sure to take the time to identify and understand these notifications wherever they may be.

Always follow recommended precautions and safe operating practices.

## Understanding Signal Words

 This is the safety-alert symbol. When you see this symbol on your unit or in this manual, be alert to the potential for personal injury. The safety-alert symbol is often used in conjunction with signal words.

A signal word – DANGER, WARNING, or CAUTION – is used with the safety-alert symbol. DANGER identifies the most serious hazards.

This symbol and these signal words appear on the unit and in this manual. Read and understand the following definitions of the signal words before operating or working on the unit.

### **DANGER**

Danger is used to indicate the presence of a hazard which WILL cause severe physical injury or death if proper precautions are not taken.

### **WARNING**

Warning is used to indicate the presence of a hazard which MAY cause serious physical injury or death, and can result in serious property damage if proper precautions are not taken.

### **CAUTION**

Caution is used to indicate the presence of a hazard which MAY cause some physical injury or property damage if proper precautions are not taken.

## **ATTENTION**

Attention indicates installation, operation, or maintenance information which is important but is not considered a hazard.

## Waterblast Safety Manual




A safety manual is shipped with each unit. It provides guidelines and instructions for maintaining a safe work environment while using and maintaining waterblast equipment.

All operators and maintenance personnel should read and understand the content of this manual to help maintain a safe work environment.

## **ATTENTION**

*The Waterblast safety manual should be kept with the unit at all times*

Contact Jetstream for additional copies of the safety manual.

 **WARNING:** Breathing diesel engine exhaust exposes you to chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

- Always start and operate the engine in a well-ventilated area.
- If in an enclosed area, vent the exhaust to the outside.
- Do not modify or tamper with the exhaust system.
- Do not idle the engine except as necessary.

For more information go to [www.P65warnings.ca.gov/diesel](http://www.P65warnings.ca.gov/diesel).

## Understanding Safety Decals

The following illustrations show common locations for safety decals. Decals and their locations may vary for different units. Always be familiar with the location and content of all safety decals on any Jetstream unit.

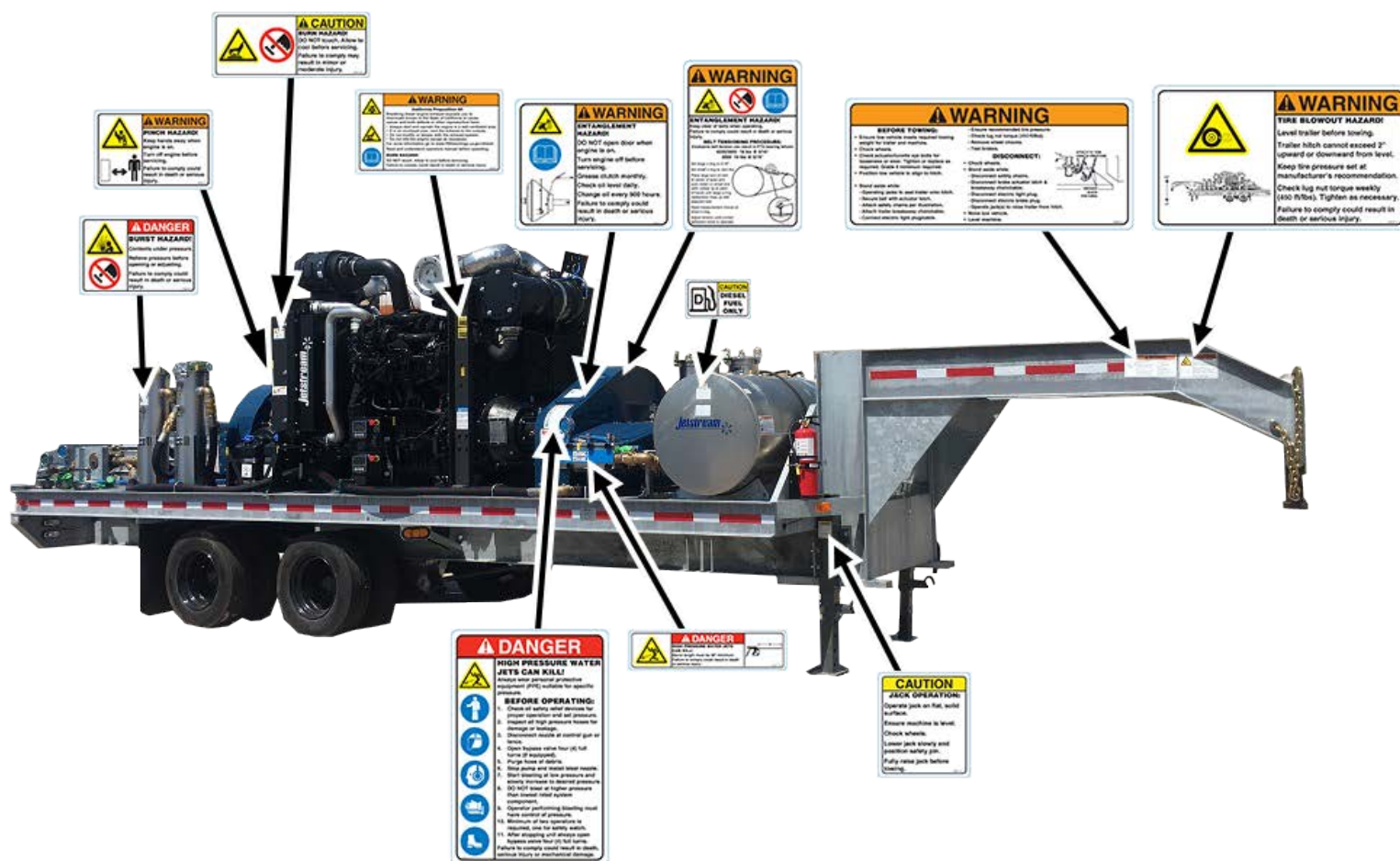


Figure 1: Example of Safety Decals



## General Safety Precautions

### Read Instructions

Read and follow all the manufacturer's instructions prior to using any waterblast product. Contact the manufacturer if unsure of any details.

Further instructions for safe operation are located in the Jetstream Safety Manual. Read this manual before operating the equipment.

### Inspect Equipment

Inspect the condition of all components prior to use. Do not use any item that is in suspect condition. If unsure about the condition of a component, ask a supervisor or maintenance personnel for instructions. Use only components that are marked with a recommended operating pressure. Never exceed the operating pressure of the weakest component in the system.

### Check Pressure Ratings



All components in the system must be properly rated for the intended operating pressure. Refer to the Safety Manual for more information on pressure ratings.

Figure 2: Pressure Rating Markings

### Rupture Discs

Installation of two rupture discs is necessary to protect the pump and operators.

- Rupture disc ratings: one at 120% of operating pressure, one at 140% of operating pressure



Figure 3: Rupture Discs

### Check Connections

Check the condition of the connection threads prior to making any high pressure connection. For 15,000 psi (1000 bar) and lower pressures use at least four wraps of Teflon tape on male pipe (NPT) threads for sealing purposes. Do not allow any tape to overlap the end of the fitting. Tape fragments may enter the system's water stream and clog the nozzle's orifices. Apply a coat of anti-seize compound over the Teflon sealant to prevent "galling" or seizing of threads. For "Jetstream® 20K"; "type M"; "MP (20K)" & HP (40K)" connections use anti-seize compound on the threads and the male cone.

### Tighten Connections

Properly tighten all high pressure connections. Hand-tighten pipe (NPT) fittings and then wrevolutions. Do not exceed two revolutions on NPT threaded connections.

Use caution when using a pipe wrench. Pipe wrenches can cause deep scoring leading to weakened components.

Refer to the Technical sections in the 15K, 20K and 40K catalogs or at the following web page for more information and torque specifications for the various fittings used on these units.

<https://waterblast.com/new-catalogs>

### Use Two Operators

Use at least two operators when waterblasting. The primary operator handling the cleaning device must maintain control of the water discharge at all times. The secondary operator controlling the waterblast unit must be positioned a safe distance of at least 12 ft. (3.7 m) from the blast operation.



Figure 4: Primary and Secondary Equipment Operators



## Purge the System

Before attaching a nozzle to the control gun or tube cleaning lance, operate the pump at low speed to purge dirt and debris from the system. Dirt and debris can clog nozzle orifice(s) and cause excessive system pressures.



Figure 5: Purging the System

## Test the System

With the nozzle installed, operate the pump at low speed (low pressure) to test the system. Should system repairs or adjustments be necessary, stop the pump and relieve all pressure before performing any required repairs or adjustments.

## Slowly Increase Pressure

Visually inspect all fittings for leaks at 1000 psi (69 bar), and then again once the system reaches full pressure. Do not use your hand to find leaks. If leaks are evident, turn the system off and relieve the pressure. Remove the leaking fitting, clean and inspect. If the fitting looks undamaged, re-install the fitting. If the leak persists, the fitting must be replaced. Leaking fittings can cause fitting damage and very dangerous injection wounds.

With the system operating properly, slowly increase pump speed until operating pressure is reached.

## Use the Minimum Pressure Required

Do not exceed the operating pressure of the system's lowest pressure-rated component. Use of lower pressure-rated components in a system should be avoided if possible. Components with a lower pressure rating can be overlooked and explode if vigilance is not maintained. Keep equipment pressure rating and warning tags intact.

## Be Prepared

If equipment malfunctions or a malfunction is suspected, immediately stop the cleaning activity and relieve the pressure in the system before attempting any repair. Always follow manufacturer's repair instructions.

## Performing Maintenance or Repairs

Because of the hazards involved with water blasting, maintenance or repairs may only be performed by service personnel that are properly trained to maintain this equipment. Training is available through Jetstream® and can be requested from the Jetstream website ([www.waterblast.com](http://www.waterblast.com)) or FS Solutions rental centers.

Following repairs or maintenance, operate the system at low pressure to test the system. Adjust the pressure slowly during operation.

## Freezing Conditions

After shutting down in freezing conditions, even for brief periods, drain the water from all components. Prior to starting the equipment after a freeze, the operation of all equipment components must be checked carefully to ensure they are not frozen, or cracked, and are still in safe operating condition.

Refer to "Winterizing the Unit" on page 36 for details.

## Store Components Properly

Properly store components to protect from damage when not in use. Ensure all warning tags and markers remain intact for the next usage.

## Long Term Storage

Refer to Appendix B: LONG TERM STORAGE PROCEDURE.

## Trailer Safety

### Tires and Rims

An inflated tire and rim can be very dangerous if improperly used, serviced or maintained. To avoid serious injury, never attempt to re-inflate a tire which has been run flat or seriously under-inflated without first breaking down the tire and wheel assembly for inspection. Do not attempt to add air to tires or replace tires or wheels without first taking precautions to protect persons and property. For details, see the regulations of the Occupational Safety and Health Administration (OSHA).

### Avoid Unit Instability

Park the trailer or skid on hard, level ground. Use the trailer jack to level the trailer. Use wheel chocks to secure the trailer in place.



Figure 6: Wheel Chocks

### Check Lighting

Before towing the trailer, verify that all lighting and reflectors are in proper working order. Repair any damaged lights or reflectors.

## Check Brake Systems

The Jetstream trailer is equipped with electric brakes. Before towing the trailer, verify that the trailer brakes are working properly.

### Breakaway System

Jetstream trailers are equipped with break-away brake systems to stop the trailer should it become disconnected from the tow vehicle while being towed. Verify the systems are operating properly before towing the trailer.

Install the breakaway cable on the tow vehicle before travel.

### Trailer Hitch

Inspect the trailer hitch before travel. Ensure the hitch is not damaged. If the hitch is adjustable, adjust the hitch to keep the trailer level during travel. The torsion axles do not distribute the load so it is extremely important to tow the trailer level to maintain even tire loads. When installing on the tow vehicle, ensure the hitch is properly locked onto the hitch ball.



Figure 7: Trailer Hitch Assembly.

### Safety Chains

Safety chains keep the trailer connected to the tow vehicle in the event of a hitch failure. Connect the trailer's safety chains to the tow vehicle before towing the trailer.



## COMPONENT IDENTIFICATION

Before operating the unit it is necessary to fully understand each component and how it functions. Following is a brief description of the main components of the TwinForce unit.

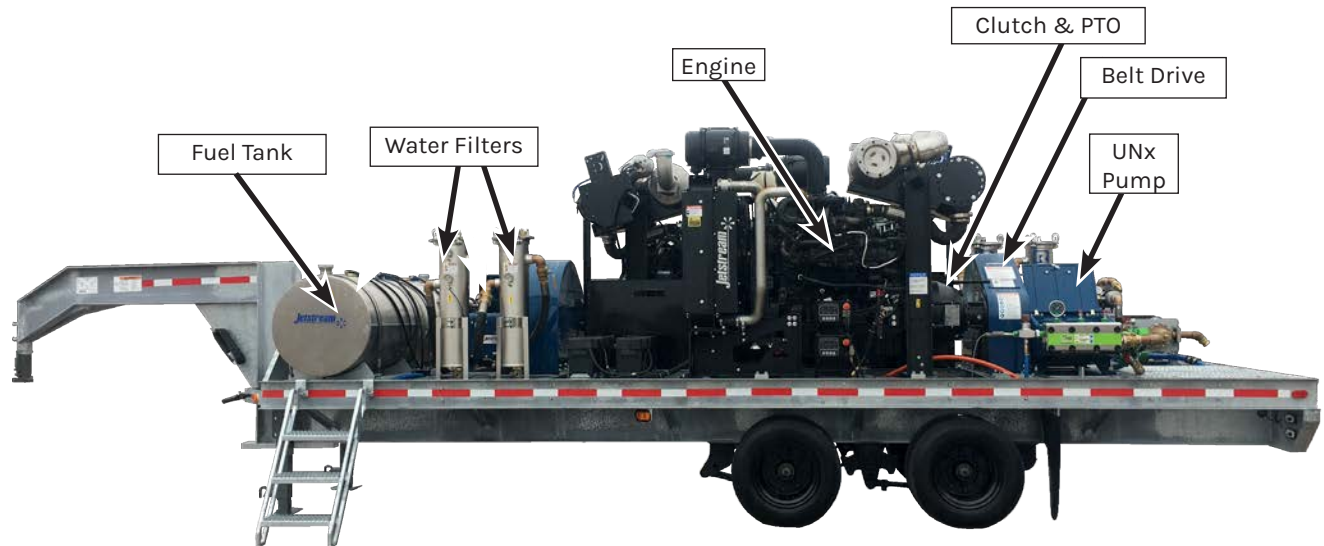


Figure 8: TwinForce Series Waterblast Unit

### Engine

The engine is the source of power to drive the pump. Available engine options provide a power range of 325-400 HP (243-298 kW) in single unit configuration or 650-800 HP (485-597 kW) in dual unit configuration.

### Clutch and PTO

The clutch, through use of a lever on top, provides the means to engage and disengage the clutch. When engaged, power is transmitted from the engine to the pump via the power take off (PTO) and belt drive. The PTO contains a shaft that rotates on bearings

### Belt Drive

The belt drive is driven by the PTO. A pulley is mounted on the PTO shaft and, when engaged, drives the other pulley to operate the pump.

### UNx™ Pump

The UNx pump uses the power from the engine

to pressurize the source water into high pressure output. The pump is separated into two sections, the power end and the fluid end.

The power end contains the components that drive the pump. It is also referred to as the “crank end” because it contains a crankshaft.

The fluid end contains the components that determine the output pressure of the pump. The operator may change the output pressure and flow of the pump by changing the components in the fluid end. The fluid end is also referred to as the “wet” end as this is where the water travels in and out of the pump.

Refer to the pressure specific catalogs (15K, 20K and 40K) for detailed exploded views and component part numbers for the fluid and power ends. The catalogs are available at the following website:

<https://waterblast.com/new-catalogs>

### Inlet Water Filtration

Each pump has an associated dual water filtration package. Inlet water travels from the

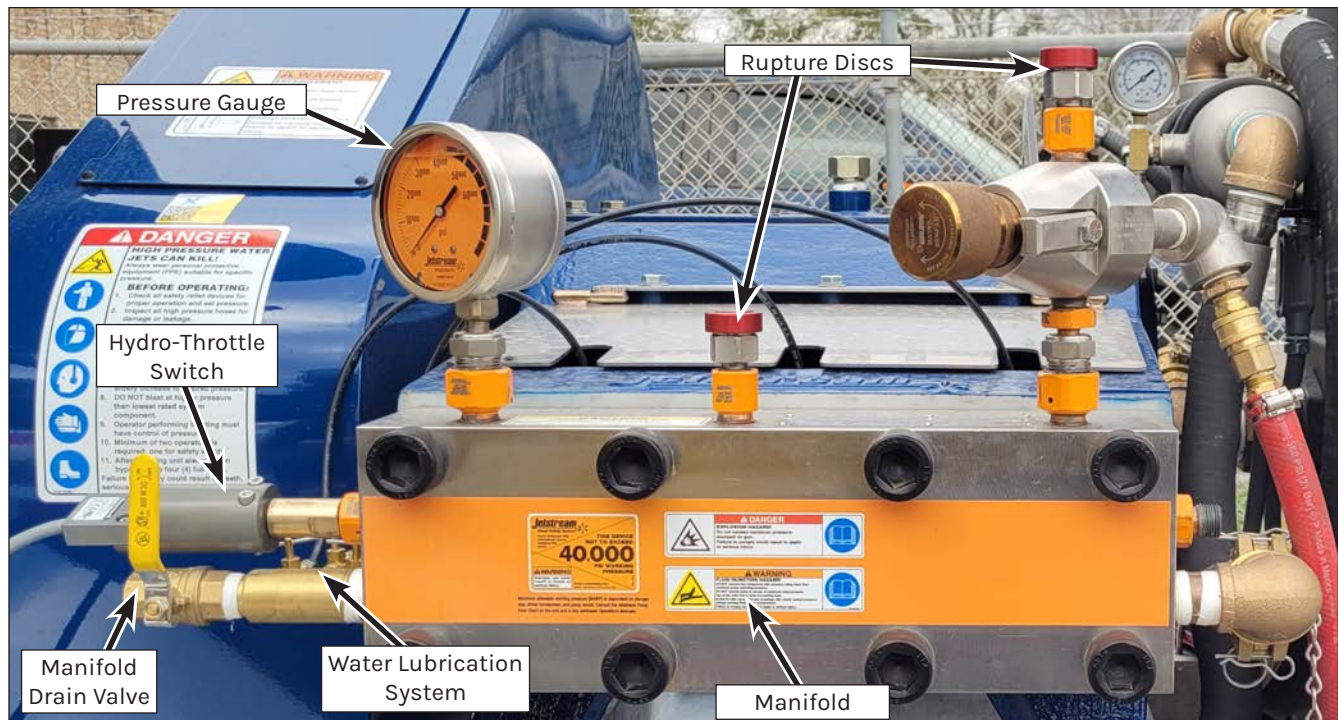


Figure 9: Pump Components

charge pump into the first filter and then the second filter in line. A ball valve is fitted to the inlet side of the filter after the charge pump. This is used when the associated pump will not be used, but there is water supply due to use of the opposite triplex pump.



Figure 10: Water Filter Housings

## Manifold

The manifold houses many of the components that make up the fluid end of the pump including the uni-valves. The three uni-valves each consist of a suction and discharge valve combined into one assembly. The valves convert low pressure water to high pressure water.

## Manifold Drain Valve

The manifold drain valve allows the manifold to be flushed of contaminants prior to pump usage. It is also used to purge air during operation start up.

## Water Lubrication System

The water lubrication system provides water to the packing in the pump. The water lubricates and cools for optimum operation of the pump. The system includes a manifold and three water lines. Needle valves are present on manifolds that are pressure fed (all 40K units). The needle valves control the amount of flow to each stuffing box and must be properly adjusted during operation. Manifolds that are not pressure fed have a fixed flow. Refer to “Charge Pump (40K Units)” on page 13 for more information on pressure fed manifolds.

## Pressure Gauge

The liquid filled pressure gauge allows the operator controlling the pump to monitor the pressure of the system.



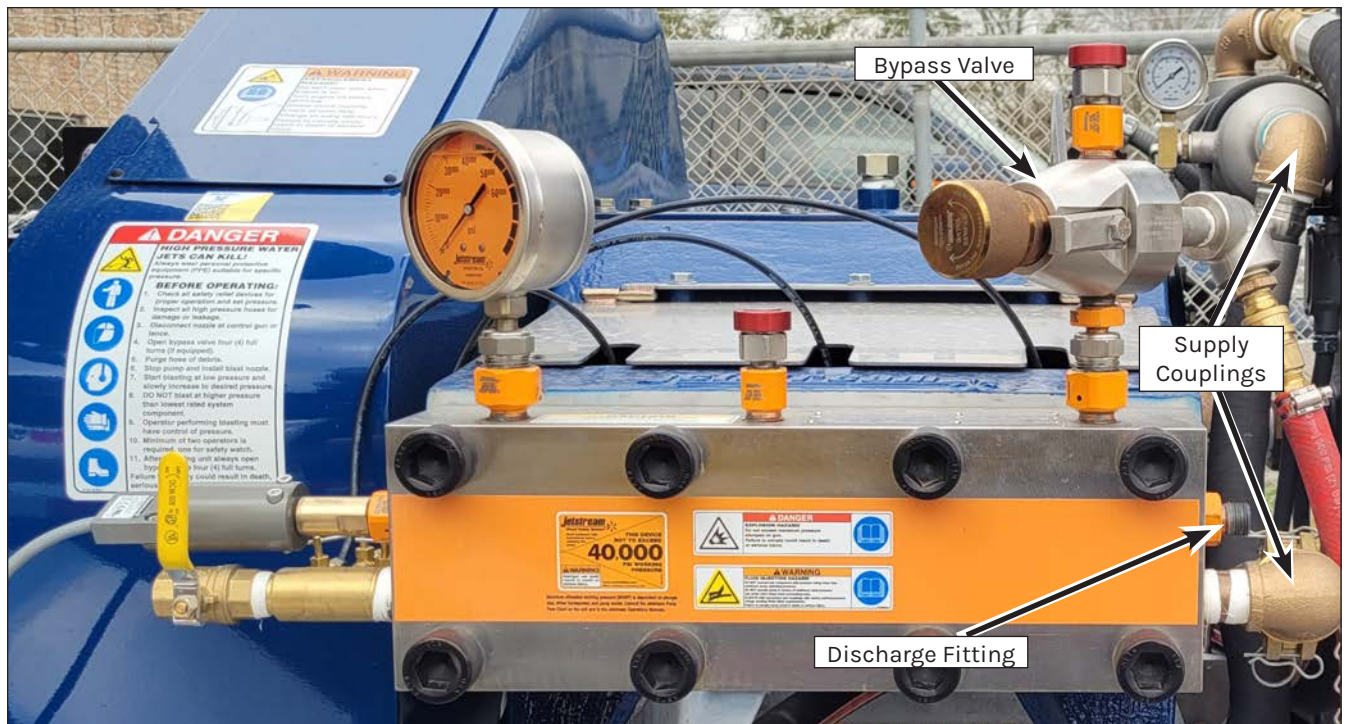


Figure 11: Pump Components (continued)

## Hydro-Throttle Switch (Optional)

The hydro-throttle switch senses the pressure within the pump and allows the engine to idle when the operator is not blasting.

Refer to “Using the Hydro-Throttle (Dump System Only)” on page 31.

## Rupture Discs

Two rupture discs are used in the system. The rupture discs provide protection from excess pressure in the system. If system pressure were to exceed the rated pressure of the discs, the discs would burst. If a disc bursts, water will flow through the ruptured disc to provide relief for the system and protect components from excess pressure. Check the discs before operating the pump. Keep a supply of rupture discs on hand for use. If a rupture disc should burst, there is no way to build pressure until the disc is replaced. Use only genuine Jet-stream rupture discs properly rated for the intended operating pressure.

## Bypass Valve

The bypass valve controls the pump pressure by bleeding off excess water and diffusing it to

low pressure. Turning the knob allows the operator to adjust pressure during operation and relieve pressure when not waterblasting.

The bypass valve controls pressure by allowing water to bypass through the valve. A discharge hose is attached to the bypass valve. The hose extends to the other side of the unit where it is attached to a drain elbow. Water that bypasses the valve will drain from the bypass drain throughout operation.

The proper use of the bypass valve is to install the correct size nozzle in the system so that the bypass valve can be closed during operation. A combination of plunger size, engine rpm, and nozzle will allow the bypass valve to close at almost all flow rates.

**Note:** For units employing a shut in system, a regulator valve is substituted for a bypass valve.

## Regulator Valve (Not Shown)

For shut-in systems (where no low pressure water dumps from the gun), the bypass valve is replaced with a regulator valve. The regulator maintains constant system pressure

when operating one or more shut-in devices. When a gun or other device is disengaged, the regulator automatically adjusts to shift the excess flow to a low pressure outlet while maintaining system pressure. Because shut-in systems maintain constant system pressure, the hydro-throttle does not function in these applications.

## Discharge Fitting

The discharge fitting allows the connection of a high pressure hose. High pressure water exits from this fitting. On 15K manifolds, a quick disconnect is recommended to prevent galling of pipe threads and damage to the manifold.

## Supply Couplings

The supply couplings provide a quick method for attaching the supply hose to the manifold.

## Control Panels

Twin Force units come equipped with a total of 4 control panels. The associated panels are either marked with a “1” or a “2” (Figure 12). Two control panels are able to control and monitor a single engine, although only one of each pair is able to start with key. The “Near Side” Panel has the key and toggle switches, and the “Far Side” panel does not have the key and switches. These panels are linked together, but any parameter that is manually changed in one of the pair, will need to be also set in the alternate control panel. Detail on accessing menus and parameters can be found in the control panel manuals that come with the unit.

Each end of the tether cable connecting two panels for control of the same engine is identified as “Near Side” or “Far Side”. This designates which panel that particular end should connect to.

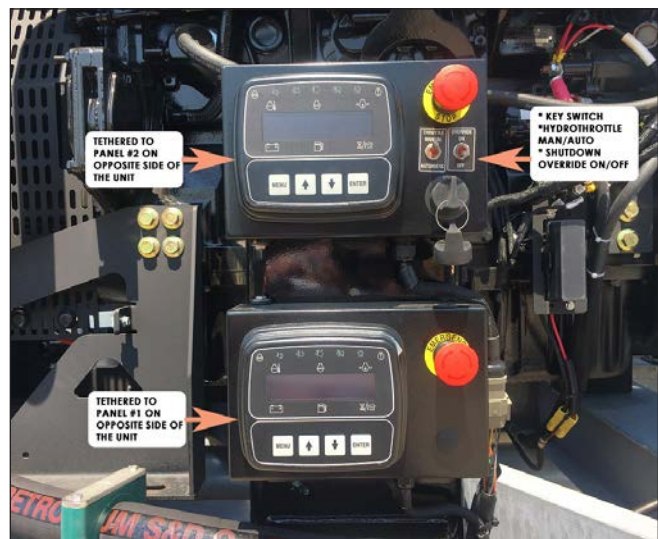


Figure 12: Control Panels



## Water Inlet

The inlet water connection (Figure 13) is a 2" Camlok Nipple. The inlet regulator is adjustable and pressure to the fluid end should not exceed 75 psi.

## Bypass Drain

The bypass drain is connected to the bypass valve. Water will drain from the hose onto the ground during pump operation as explained in "Secondary Filter (40K Units)" on page 11. This hose can be plumbed to an alternate drain or tank for collection if required. If bypass drain water needs to be routed to a different location, contact Jetstream engineering for assistance.



## CAUTION

*If a bypass discharge hose is used, the hose must be properly sized to prevent excessive backpressure. Excess backpressure can cause vibration and pulsation in the system leading to damaged system components.*

## Secondary Filter (40K Units)

A secondary filter (Figure 14) is mounted on top of the pump for use when operating at "40K". The filter is not connected during 15K or 20K operation.

A pressure gauge is mounted on the filter to monitor pressure in the filter.

A differential pressure switch is mounted in the filter circuit to monitor proper flow through the filter. If the filter becomes plugged and flow is insufficient, the switch will cause the engine to shut off. "Emergency Stop" will be displayed on the control panel.

A drain valve is located on the filter cover that allows the operator to purge air from the filter at startup.



Figure 13: Water Inlet



Figure 14: Secondary Filter

## Fuel System

The unit houses two 125 gallon fuel tanks (Figure 15) with mechanical float valve gauges. Fuel sender mounting flange is standard option. The tanks are used SEPARATELY and each has to be filled separately for use with its associated engine.

The fuel tank caps are vented and lockable. Keys are supplied with original shipment of the unit.

## Batteries

Two 12 volt lead acid batteries wired in parallel (12V) are located in between the belt drive and the fuel tank (Figure 16). The batteries and connections are contained in two rain proof containers.



Figure 15: Fuel Tanks

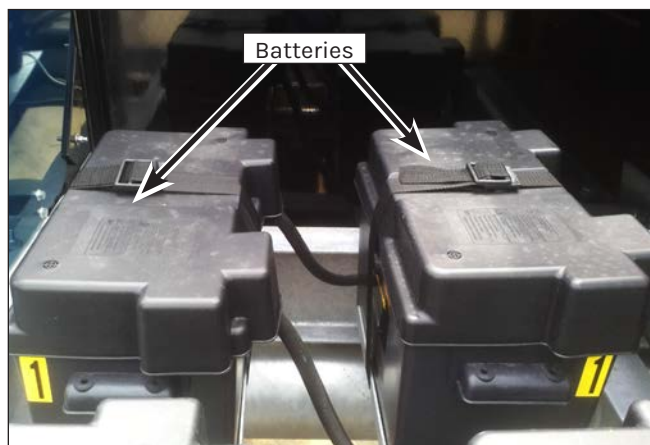


Figure 16: Batteries



## Charge Pump (40K Units)

A charge pump (Figure 17) is mounted on the underside of the unit. A belt pulley, driven by the belt drive, spins the pump. The charge pump is required to provide 40 - 50 psi (2.8 - 3.4 Bar) of water through the secondary filter on 40K equipped units. Other fluid end pressure ranges do not require secondary filtering so the plumbing must be re-routed to bypass the secondary filter.

### **CAUTION**

*Do not operate the engine without water in the system. Damage to the charge pump will occur.*



Figure 17: Charge Pump

## Fluid End and Unit Identification

A plate (Figure 18) is attached to all fluid end manifolds. The plate is stamped with the fluid end model number. In addition, the plate is stamped with plunger size and output pressure related to that plunger size. Refer to this plate before operating the pump.

Two plates are attached to the trailer or skid near the bottom of the pump (Figure 19).

A serial number plate displays the model and serial number of the unit. Always refer to this serial number when contacting Jetstream for parts or service.

An emissions plate displays the emissions certification as well as the date of manufacture and the vehicle identification number (VIN).



Figure 18: Fluid End Rating Plate

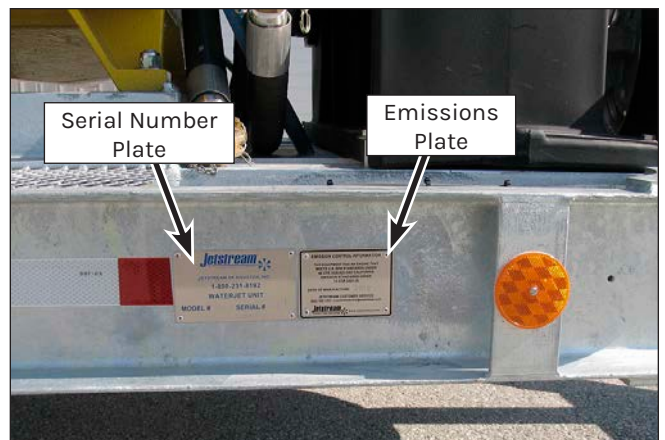


Figure 19: Serial Number and Emissions Plates



# TRAILER UNITS

Twin Force unit components are mounted to a deck over gooseneck trailer. GVWR and Axle information & VIN can be found on the tongue, on the inside or outside face of the member.

## Trailer Components

### Fire Extinguisher (Optional)

A multi-purpose dry chemical fire extinguisher (Figure 20) is located ahead of the fuel tank on the trailer for emergencies.

### Spare Tire (Optional)

A spare tire (Figure 20) is available in the event of a blowout. Always keep the spare properly pressurized to the sidewall rating.

### Jack Stand

The jack stands (Figure 21) support the trailer when not being towed and can be used to level the unit. Use the hand crank to adjust tongue height up or down. The support capacity of the jack stands is 12,000 lb. (5443 kg),

### Adjustable Ball Hitch

The adjustable height hitch (Figure 21) is available with a 2 5/16 in. ball, lunette ring or bulldog style attachments. The hitch can be adjusted up or down to keep the trailer level when towing.

### **DANGER**

*The trailer must be level during towing to prevent abnormal tire wear, dangerous tire overload or failure.*

### Safety Chains

Hook the safety chains (Figure 21) to the tow vehicle before towing the trailer. The chains keep the trailer with the tow vehicle in the event of a hitch failure.

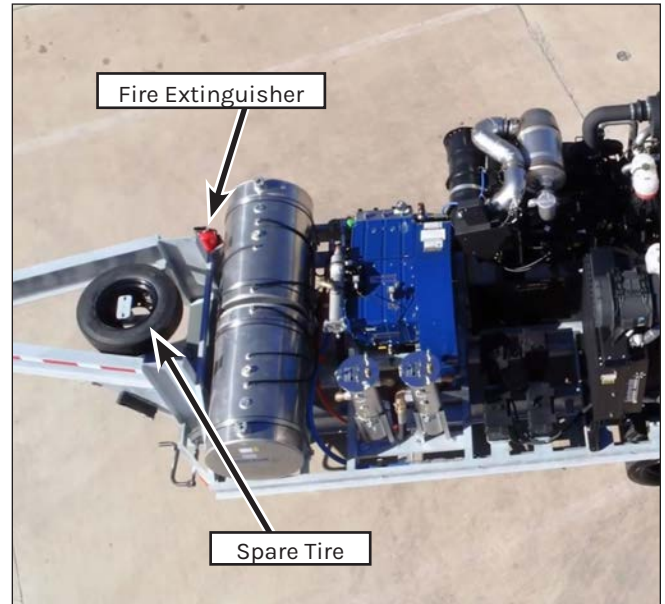


Figure 20: Fire Extinguisher and Spare Tire.

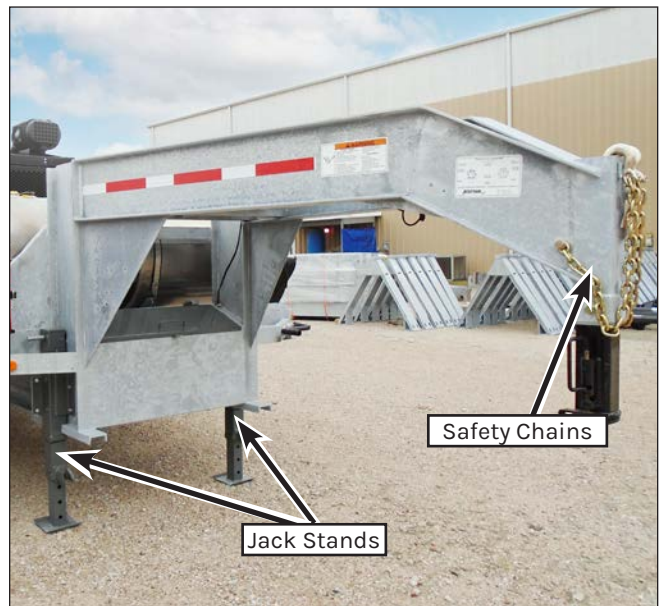


Figure 21: Jack Stand and Safety Chains.

## Electrical Connector

The 7-pin electrical connector (Figure 22) connects the tow vehicle's electrical system (lighting, charging, braking) to the trailer.

**Note:** The center pin on the electrical connector is not used.

## Ground Cable (Optional)

Attach the grounding cable (Figure 23) to the structure being cleaned to prevent sparks created by static electricity.

## Document Holder (Optional)

A document holder (Figure 23) is mounted in the tongue area as a means to store the trailer registration required for legal transport or job specific papers.



Figure 22: Electrical Connector.

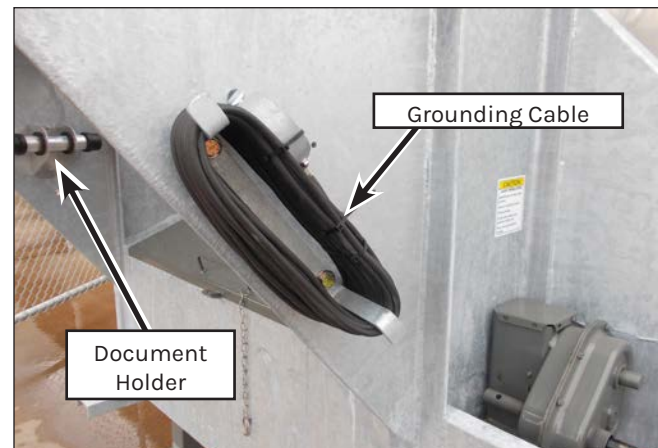


Figure 23: Grounding Cable and Document Holder.



## Lighting And Reflectors

### Front and Side Lights and Reflectors

The trailer is equipped with two front clearance lights (Figure 24) to show the trailer's width. The lights will illuminate when the tow vehicle has its lights turned on.

The two side marker lights and reflectors show the trailer's presence and length. The lights will illuminate when the tow vehicle has its lights turned on.

### Rear Lights and Reflectors

The trailer is equipped with a row of rear markers lights (Figure 25) required for trailers over 80 in. (203 cm) wide. The lights will illuminate when the tow vehicle has its lights turned on.

The two rear tail lights will illuminate when the tow vehicle has its lights turned on. The turn signals and brake lights illuminate when the tow vehicle uses a turn signal or depresses the brake pedal.



Figure 24: Front and Side Lighting.

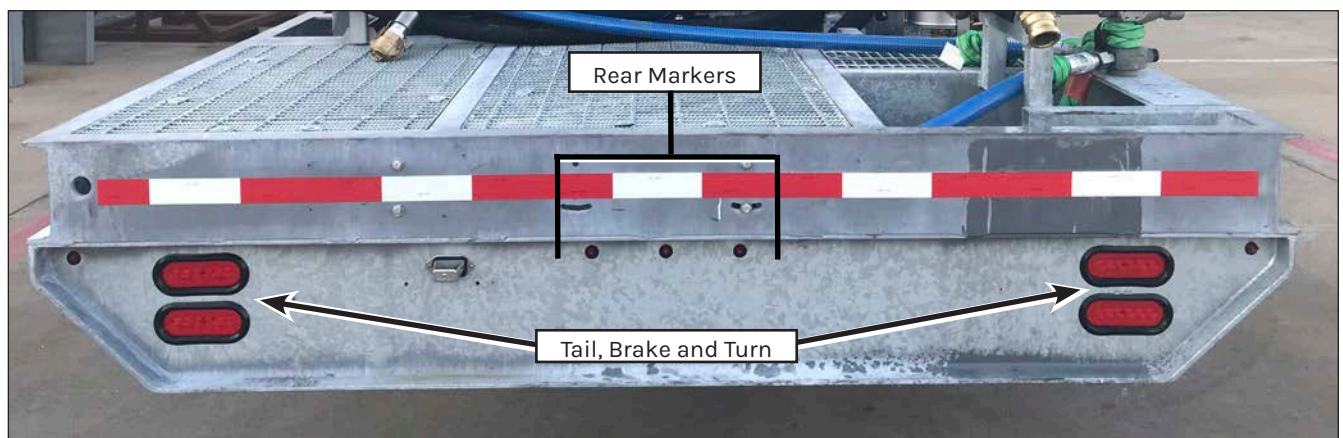


Figure 25: Rear Lighting.

## Trailer Breakaway System

The trailer is equipped with a breakaway system in the event that the trailer should come unhitched from the tow vehicle. If this occurs, the breakaway system will apply the trailer brakes to bring the trailer to a stop.

The breakaway system includes a battery (Figure 26) and a breakaway switch (Figure 27). Both components are located in the tongue area.

In the event of a separation, the lanyard (Figure 27) would be pulled from the breakaway switch which closes a set of contacts. Voltage from the breakaway system battery is sent through the closed contacts in the switch to the brake magnets in the drum brakes. The magnet actuates the brakes to stop the trailer.

The battery is connected to the tow vehicle charging system, if properly wired, to provide charging when being towed. Check the battery for proper voltage before towing.

Refer to the connector wiring decal located on the side of the tongue.

### Activating the System

1. When attaching the trailer to the tow vehicle, attach the loose end of the lanyard to the tow vehicle hitch.
2. Ensure the trailer electrical connector is properly connected.

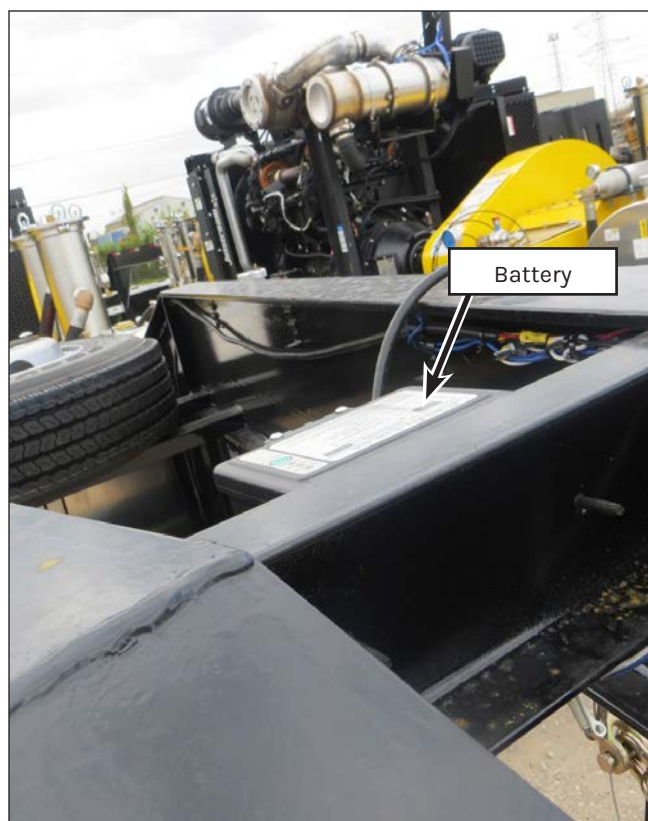


Figure 26: Breakaway System Battery

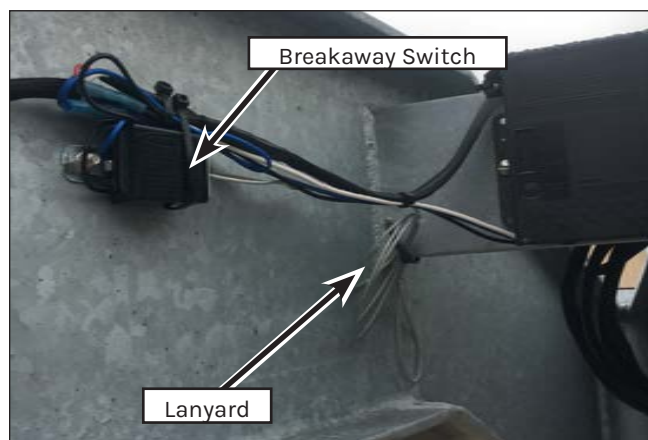


Figure 27: Breakaway Switch and Lanyard..



## CONTROL PANEL

Twin Force units come equipped with a total of 4 control panels. The associated panels are either marked with a “1” or a “2” (Figure 28). Two control panels are able to control and monitor a single engine, although only one of each pair is able to start with key. The “Near Side” Panel has the key and toggle switches, and the “Far Side” panel does not have the key and switches. These panels are linked together, but any parameter that is manually changed in one of the pair, will need to be also set in the alternate control panel. Detail on accessing menus and parameters can be found in the control panel manuals that come with the unit.

**Shutdown Override:** When switched to the ON position, the override switch will ignore the low water level sensor and/or the differential pressure switch (secondary filter) and the engine will run without water at the filters. When switched to the OFF position, the unit will not start without water supplied to its associated filters. If no water is present, the panel will display “Emergency Stop”.



### ATTENTION

*Do not operate the unit in override mode. The override feature is typically used for engine service.*

**Throttle Mode:** When the switch is in the Automatic position, the engine will switch from the predefined minimum speed to the set operating speed as demand from the pump changes.

When in the Manual position, the throttle up and throttle down buttons must be used to change engine speed.

For additional information, see the control panel operations manual supplied with the unit.

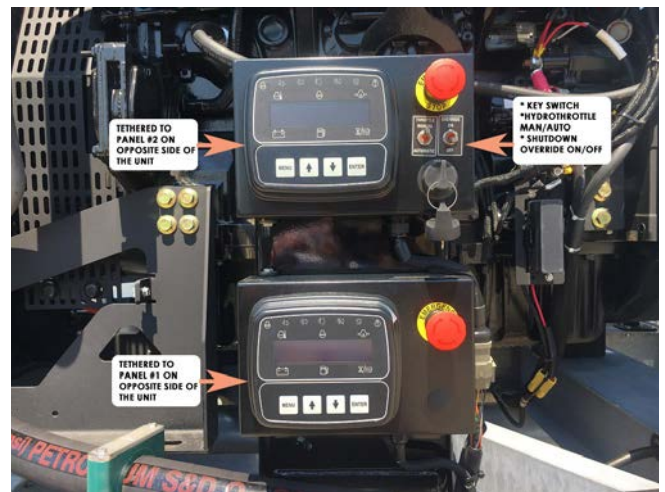


Figure 28: Main Control Panels

## Jetstream Connections

Each end of the tether cable connecting two panels for control of the same engine is identified as “Near Side” or “Far Side” (Figure 29). This designates which panel that particular end should connect to.



Figure 29: Jetstream Wiring Connections.

## Jetstream 3000/3600/4200 Bareshaft Pump Installation Guidelines

**NOTE:** This following pages contain installation guidelines for all of Jetstream's bareshaft pumps. The TwinForce Series unit currently is only designed for use with 4200 and 5200 Series pumps.

### Models

The Jetstream UNx bareshaft pump is available in three horsepower ranges and three pressure ranges – 15,000 psi, 20,000 psi, or 40,000 psi and can be supplied with an optional geardrive. The geardrive is available in four different gear ratios to support diesel engine or electric motor input speeds. Both styles can be supplied left hand drive or right hand drive (as viewed from FE) and the geardrive model's input shaft can also be clocked to five different locations. The geardrive unit requires inline drive with flexible coupling<sup>\*\*\*</sup>. The standard unit can be inline or belt driven via pulleys exerting a side load on the crankshaft. All Jetstream powerends have a preferred rotation direction (top of crankshaft towards the fluid end) that is marked on the casting. However reverse rotation operation is allowed with the addition of optional reverse rotation oil scrapers. The geardrive requires a clockwise input rotation direction.

3000 series 150 hp max    600 rpm max

3600 series 175 hp max    550 rpm max

4200 series 325 hp max    518 rpm max

### Water Supply

The 15K and 20K versions can be gravity fed (water level 3' minimum above the manifold suction inlet). The 40K version requires 40 psi minimum supply pressure at full pump speed to operate. All fluid ends have a maximum inlet supply pressure of 75 psi.<sup>\*\*\*\*</sup>

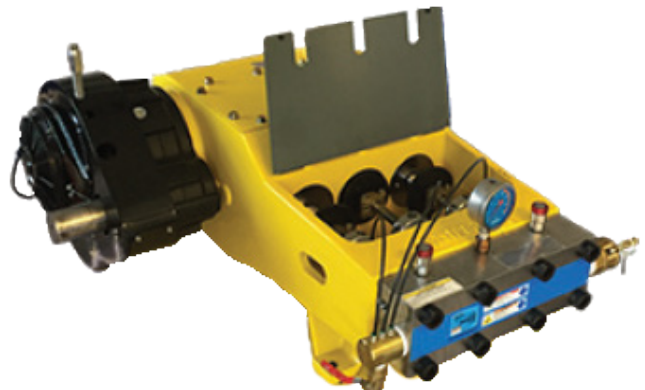
The supply water should be clean and cold. The

maximum allowed inlet water temperature is 125°F. Ideally the water should be filtered to 25 micron (3 micron for 40K) and 40-80°F for maximum packing life. Severly reduced packing life will be encountered with warmer water. The inlet supply hose should be 3" ID if gravity fed and 2" ID if pressure fed. Jetstream recommends oilfield suction hose as it has proven to be durable with a relatively small bend radius. The hose should be as short and straight as possible with no additional fittings (elbows) - especially important with gravity fed setup. If bends are required it is best to bend the hose without the use of elbows.

The plunger packing is lubricated with the supply water and is not adjustable on normal gravity fed 15K/20K systems. On 40K and pressure fed systems, the lube harness needs to be equipped with needle valves to allow adjustment of the lube water flow. The cooling water should exit the rear of the gland nuts with a steady stream (more than a drip) but not enough to be splashed onto the pony rod during operation.

### Pulsation

Positive displacement pumps create pulsation in the high pressure discharge line. For this reason, it is extremely important to utilize flexible hoses (ie rubber, thermoplastic) in lieu of rigid piping to minimize water hammer and vibration. If rigid piping is necessary, it should not be installed at the pump discharge. A 25' or 50' section of hose should be installed at the pump discharge. This length can be coiled



and hung for space savings. A high pressure pulsation damper may be beneficial in some cases. Short on/off cycles at high pressure will create the largest spikes of pressure and require care to dampen. Flow controls or other means to slow the abrupt change of pressure will smooth these pulsations.

### Lubrication

The powerend is lubricated via 80W90 gear oil in the sump of the housing. The journal bearings, crossheads, and connecting rod bushings are supplied oil via gravity from a collection trough above the crossheads. The powerend has a level requirement to ensure oil lubricates the crank-shaft tapered roller bearings and stays in contact with the crank-shaft. Front to back level specification is 7° and side to side level is 10°. Both a low oil level shutdown and a high oil temperature shutdown are available as options.

The powerend oil has a recommended maximum temperature of 190°F and can be comfortably run in most environments. Extremely hot or cold environments (i.e. Middle East, Canada) may require oil cooler or synthetic oil. Contact Jetstream Engineering for assistance.

---

## Jetstream 5200 Bareshaft Pump Installation Guidelines

All of the previous requirements for the 4200 are the same for 5200 except as noted below:

5200 series 400 hp max 518 rpm max

### Water Supply

The 5200 pump cannot be gravity fed and requires 40-50 psi suction water pressure at full pump speed to operate. As such, it is supplied with lube water flow control valves mounted on a manifold in the rod box area. All fluid ends have a maximum inlet supply pressure of 75 psi.\*\*\*

### Rod Box

The 5200 pump is supplied with a keyed locking rod box that is enclosed from the elements.

### Side Bypass

The 5200 pump has been developed in conjunction with a side mounted bypass to reduce clutter on the top of the Fluid End and to provide a means of attaching accessories to the bypass without flow restrictions such as a hydrothrottle.





## Technical Notes

\*\*\* Driver selection and coupling selection requires engineering analysis of torsional loads and vibrations (TVA). Jetstream can supply the mass-elastic data for the pump but it is customer's responsibility to perform TVA of the system. Coupling failure, engine damage, and powerend damage can result from incorrect coupling selection.

\*\*\*\*All pumps have a minimum inlet pressure necessary to prevent cavitation.

Additionally, Jetstream (and many other) pumps have a maximum allowable inlet pressure. Excessive inlet pressure will not affect the operation or life of the fluid end, but can negatively affect the power end.

The connecting rods are equipped with plain bearings where they contact the crankshaft. These bearings require lubrication to survive. When the crankshaft rotates and pulls the crosshead backwards through the suction stroke, the force between the connecting rod journal bearing and the crankshaft decreases greatly. This reduction in force and the rotation of the crankshaft causes oil to be drawn into the small space between the connecting rod journal bearing and the crankshaft. As there is no oil pump in the 3000/3600/4200/5200 series, this is the only mechanism that lubricates the journal bearings.

High pressure on the plungers during the suction stroke can prevent oil from being drawn into the space between the connecting rod journal bearing and the crankshaft. The lack of lubrication can cause journal bearings to fail in only a few hours. This problem is worse with large plungers, high inlet pressure, and low speeds.

Following Jetstream's maximum allowable fluid end inlet pressure of 75 psi and minimum pump speeds of 200 rpm for the 3000, 183 rpm for the 3600, and 173 rpm for the 4200 and 5200 series will prevent this type of failure.



## OPERATION

This section describes the operation of the TwinForce™ Series unit.

### Preparing the Unit

1. Remove All Shipping Protection
2. (For trailer and skid units) The exhaust stack rain cap (Figure 30) will be tie-wrapped shut for transport. Remove the tie wrap and tags from the engine exhaust stack.



#### **CAUTION**

*When mounting skid units on a trailer or truck, orient the rain cap so the flapper on the exhaust stack opens to the rear. If not oriented properly it will allow rain to enter the exhaust when traveling and the turbo will be damaged from spinning backwards without lubrication.*

3. Remove all on board packages.
4. Inspect the unit and report any damage to your Jetstream representative.
5. Remove the pump wrench from the rod box (Figure 31).



#### **ATTENTION**

*For shipping and safety concerns, the unit is transported with very little fuel or no fuel. Add fuel to the fuel tank before starting the unit.*

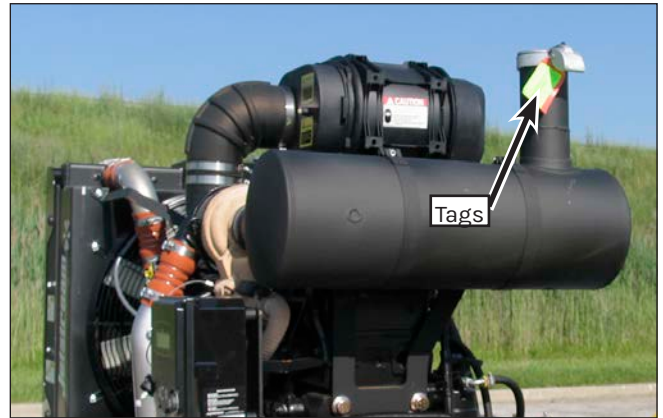


Figure 30: Typical Exhaust Stack.

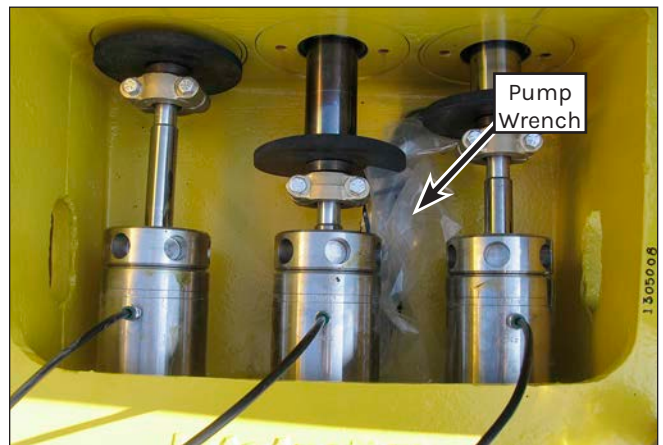


Figure 31: Pump Wrench Removal.

## Recommended Equipment

Jetstream equips the waterblast units with the components they recommend for safe operation. Those components include:

- Pressure Gauge
- Two Rupture Disc Assemblies
- Bypass Valve or Regulator Valve
- Discharge Quick Disconnect Coupling.



### **ATTENTION**

*Installation of two rupture discs is required by Jetstream for warranty coverage on this pump. One rupture disc must be rated at 120% of the fluid end stamped pressure rating. The other disc must be rated at 140% of the fluid end stamped pressure rating.*

*Keep a supply of rupture discs on hand for operation at different pressures and for replacement in the event of a rupture.*



### **WARNING**

*Do not operate the engine without water in the system. Damage to the charge pump will occur.*



### **ATTENTION**

*A quick disconnect coupling is an important means of protecting the manifold from wear at the high pressure discharge hose connection port. If the internal threads on the manifold become worn or damaged the cost to repair them is far greater than replacing a coupling. The manifold would need to be shipped back to Jetstream for repair or replacement.*

## Hose and Water Supply Requirements

- The water supply hose inside diameter must be large enough to supply 150% of the unit's maximum flow requirements.
- The inside diameter of the high pressure discharge hose will be determined by the necessary length of hose and the amount of flow passing through the hose length. Contact your Jetstream representative for proper hose sizing.
- Supply pressure must be no greater than 35 psi (2.4 bar) coming into the regulator. If the pressure exceeds 35 psi, install a pressure regulator large enough to meet flow requirements. Regulators are available from Jetstream.

## Start-up Preparation

**NOTE:** These steps may be completed on one engine and pump at a time.

1. Park the trailer (or place the skid) on a hard, level surface.
2. For trailer mounted units, level the trailer using the jack stand.
3. Check the engine fluid levels. Refer to the engine manual for more information.
4. Check the fuel level.
5. Check the oil level in the pump.
6. Check the oil level in the PTO.
7. Inspect the filter bags. Inspect the secondary filter cartridge if operating at 40K.
8. Check the tightness of the gland nuts on each stuffing box.
9. Check the belt tension.
10. Inspect all equipment. Ensure that every piece of equipment in the pressure circuit is properly rated for the intended operating pressure. Replace any component that is not properly rated.
11. Connect the supply hose and verify the drain valve is closed.

12. Install the discharge hose onto the fitting on the manifold along with a hose safety check.



### **WARNING**

*Anytime the system has been opened, the system must be purged.*

*When the high pressure hose is first connected to the unit or when extra hose lengths are added to the hose string, the hose must be purged of all dirt and debris. Do not connect the control gun or tool to the high pressure hose until the hose has been purged of dirt and debris with water flow from the pump. Failure to purge debris inside a hose may result in clogging of the cleaning nozzle and excess pressure in the system.*

6. Start the engine by rotating the key switch to the RUN position. Wait for the “Engine Ready to Start” message to appear on the panel.
7. After the message appears, rotate the key switch to the START position. The engine will begin to crank. As soon as the engine starts, release the key switch. The key switch will return to the RUN position and the engine will continue to run.
8. Observe the control panel display for engine data.
9. Engage the clutch by firmly pulling or pushing the lever towards the engine. Only engage the clutch with the engine at idle speed (Figure 32).

## **Starting the Unit**

1. Verify the clutch is disengaged (clutch lever pulled toward pump). Disengage, if necessary. Disengage the clutch only when the engine is at idle speed.
2. Open the bypass valve by turning the knob fully counter-clockwise until the O-ring is visible (where the knob enters the valve body) or four full turns counter-clockwise from the closed position. This allows the engine to start without a load from the pump.
3. On 6000 series pump, open the air side of the pulsation dampener and close it again to reset the diaphragm before operation.



### **ATTENTION**

*Refer to the engine's Operation and Maintenance Manual before starting, operating or repairing the engine.*

4. Move the override switch on the control panel to the OFF position. This provides low water level and pressure switch shutdown protection. If the control panel displays “Low Water”, the pressure to the inlet is low.
5. Move the throttle switch to the MANUAL position.

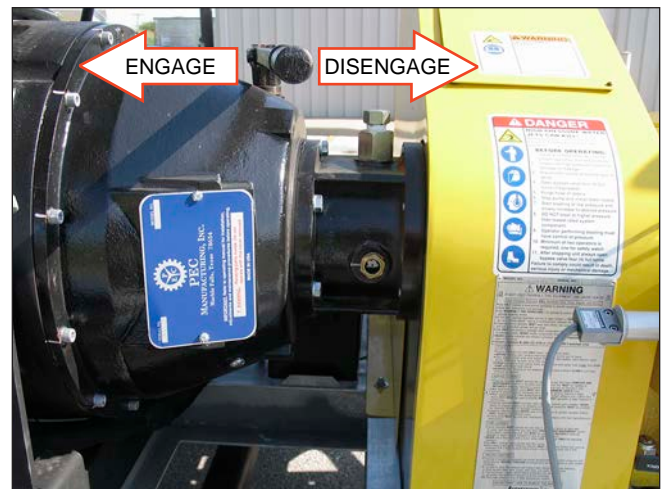


Figure 32: Clutch Engagement.

## Flushing the System

With the engine at idle, warming to operating temperature, flush the system of any debris. Flushing the system prevents any debris from clogging the cleaning nozzles and valves which will cause excessive pressure in the system. Nozzles must be removed from all equipment during flushing.

1. If operating at 40K, first open the bleed valve (Figure 33) and allow any air to purge from the secondary filter. Once a steady flow of water exits the filter, close the valve.
2. Open the manifold drain valve. Allow water to drain from the valve for approximately 5-10 seconds. (Figure 34).

### **WARNING**

*Two operators are required to flush the discharge hose and equipment. One operator must be stationed at the unit and the other at the discharge device.*

3. Hold the discharge hose stationary (Figure 35).
4. With the manifold free of debris, the engine at normal operating temperature (160°F (71°C) - 185°F (85°C)) and at idle speed, engage the clutch.
5. Turn the bypass valve clockwise just enough to obtain a generous flow of water through the discharge hose. Allow the hose to flush for about 30 seconds.

**Note:** A substantial amount of thrust may occur at the discharge end while flushing.

6. Decrease flow to the hose by fully opening (counter-clockwise) the bypass valve. Some water will continue to flow from the hose.
7. With the engine at idle speed, shift the transmission to Neutral.
8. Connect the control gun (or other equipment being used) to the discharge hose.
9. With the hose secure and equipment controlled by another operator, engage

the clutch.

10. Turn the bypass valve clockwise to increase flow through the discharge device(s). Allow the control gun to flush for about 30 seconds.

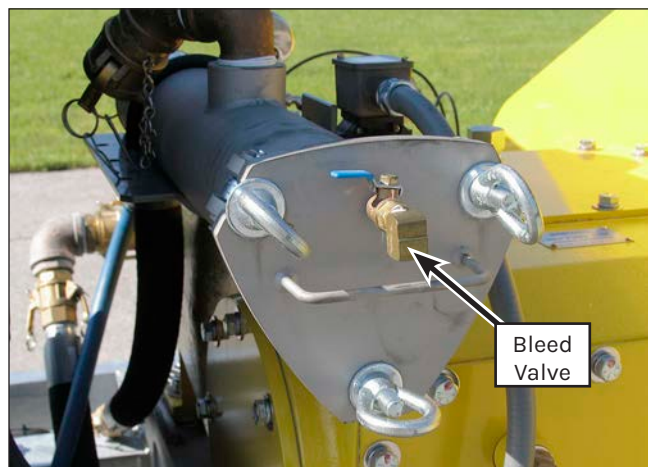


Figure 33: Secondary Filter Bleed Valve.

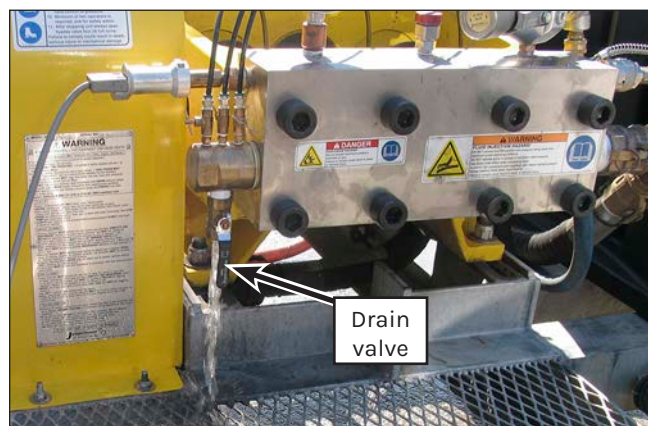


Figure 34: Flushing the Manifold.



Figure 35: Flushing the Discharge Hose.



11. Reduce the discharge flow by fully opening the bypass valve.
12. With the engine at idle speed, disengage the clutch.
13. The nozzles can now be installed on the discharge device(s).
14. Before waterblasting, adjust the lubrication line needle valves, if equipped. Refer to “Checking the Water Lubrication System”, below.

## Checking the Water Lubrication System

1. Lift the rod box cover to view the water lubrication system.

### **WARNING**

*There are moving parts inside the rod box that can cause serious injury. Use extreme caution. Keep all tools out of the rod box while the pump is running.*

2. Look into the rod box and verify that lubrication water is flowing from the back of the gland nut at the plunger/gland nut intersection. The flow should be a small stream but should not splash onto the pony rods. (Figure 36).
3. Next, check the stuffing box temperature by very carefully placing your finger tips on the top of the stuffing box. The temperature should be cool to warm but still cool enough that you can keep your fingers on it for 10 seconds.

If there is no water flow, or the temperature is too hot, or if steam is visible, the needle valves need to be adjusted.

4. Adjust the needle valves (Figure 37) (needle valves are only included on pressure fed setups. Gravity fed units will not utilize needle valves) to increase the water flow. Excessive splashing may occur, which could cause water to be drawn into the power end, contaminating the oil. Adjust the needle valves to prevent excessive lubrication water flow. Re-check the lubrication water flow periodically during operation.

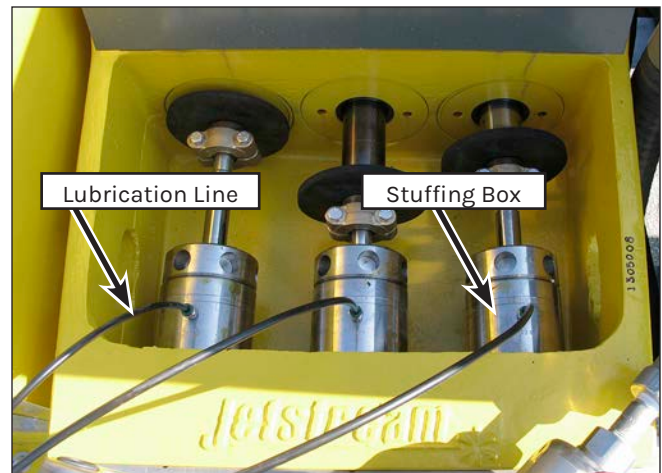


Figure 36: Checking Lubrication.

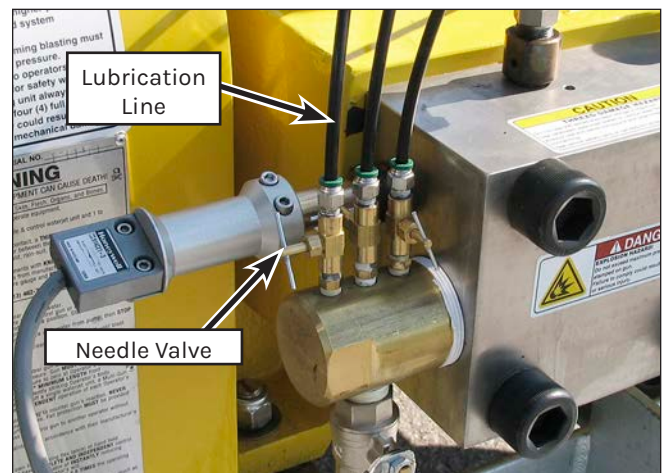


Figure 37: Needle Valve Adjustment (40K).



Figure 38: 5200 Series Water Lubrication System.

5. Once properly adjusted, system pressure can be raised for waterblasting.
6. 5200 pump differences: The plumbing arrangement is slightly different on the 5200 power end. It is located in the rod box and the adjustable flow controls are integrated into the elbow fittings (Figure 32).

## Raising System Pressure

### **WARNING**

Before building pressure, contain the high pressure discharge hose. Failure to contain and control the high pressure water can result in death or serious injury. The water is considered “contained” if it is allowed to discharge from the system through a “manned” control gun or a “manned” lance inserted in a tube. Control guns can produce a tremendous amount of reverse thrust based on flow and pressure.

Discharge must be in an enclosed space where no one can get injected and the end of the hose is restrained from moving.

Never use open lengths of high pressure hose for anything but purging at low pump speed.

Install whip checks at all hose connections.

### **CAUTION**

When operating in cold temperatures, allow ample time for the pump oil to warm before raising system pressure.

### **ATTENTION**

If new packing was installed or if operating the pump for the first time, the pump packing must be broken in properly. Refer to “Breaking In New Packing” for instructions.

1. With both engines running and transmissions in gear, raise the engine speed of either engine to 1400 rpm, followed the second engine, by pressing the throttle up button (Figure 39) on the control panel(s).
2. Both bypass valves on each fluid end (If equipped) should be completely closed. Pressure control will be made at the rear of the trailer from the single bypass device in which both output hoses from the

pump fluid ends are entering. Slowly turn the bypass valve clockwise to start closing the bypass and build pressure.

3. Slowly increase pressure by increasing engine rpm by 300 rpm on each engine at a time until the intended operating pressure and flow is obtained. Optimal engine speed for operation is between 1400-2100 rpm. The control panel prevents the unit from exceeding the maximum rpm allowed by the pump. Both engines should run at the same speed.

### **ATTENTION**

Always blast with the bypass valve fully closed. This will ensure the most efficient operation with all water being utilized. If less water volume is required, reduce the engine rpm to control the flow amount. If bypassing flow is necessary, the bypass valve cartridge and the bypass valve diffuser will wear and these parts may need replacing regularly. Bypassing water also wastes water and wastes fuel as this is lost horsepower.

### **WARNING**

Do not operate the pump under a load at engine speeds below 1400 rpm. This will lug the engine and cause excessive vibration leading to engine damage and cracked brackets, guards and fittings.

### **ATTENTION**

Slight variation in the consistency of pressure fluctuations may be noticed at the outlet pressure gauge as the pump synchronization moves in and out of phase. This should not be confused with large intermittent drops and recovery of the pressure at the gauge, which could be a sign of blown packing and/or other operational issues with the equipment.



Figure 39: Throttle Controls.

## Breaking in New Packing



### **ATTENTION**

*This procedure is only applicable for 15K and 20K molded packing. It is not required for plastic packing.*

*New packing must be broken in to prevent damage and ensure optimal performance. Break-in should occur in three to four pressure increases over a 5 minute period.*

1. Adjust the engine speed to 1400 rpm.
2. Adjust the discharge pressure to 3,000 psi (200 bar) by slowly closing the bypass valve (all dump valves closed).
3. When the coolant temperature reaches 120° F (49° C), increase engine speed to 2100 rpm.
4. Continue to bring the discharge pressure up to full operating pressure in about three equal steps while operating 1 minute for each step.

Check the lubrication water and carefully feel the stuffing boxes for excess temperatures. Stuffing boxes and gland nuts should only be slightly warm to the touch when the pump is running at the rated operating pressure. Hot stuffing boxes and gland nuts may be caused by insufficient water lubrication or tight fitting packing. If insufficient lubrication water flow cannot be corrected by readjusting the needle valves, stop the pump and correct the problem.

## Using the Hydro-Throttle (Dump System Only)

The hydro-throttle allows the operator to set an operating speed for the engine to cycle between as the control gun (or other device) dumps pressure. This prevents the pump operator from manually adjusting the engine speed during cycling. The engine will cycle from low idle to the set speed as dictated by pump pressure.



To set the hydro-throttle:

1. Start with the switch in the MANUAL position.
2. Raise engine rpm to the desired operating engine speed and then move the switch to the AUTOMATIC position. The control panel will record this rpm into memory. As the discharge device is cycled between operating pressure and dumping (zero pressure), the control panel will cycle the engine between low idle and the operating rpm that was set by the operator. If the switch is moved back to MANUAL, the operator must reset the top threshold or raise and lower engine speed manually using the up/down buttons.



## Monitoring Weep Holes

Weep holes are manufactured into the manifold to alert the operator when seals have failed. If a seal fails, the water will leak from its associated leakage hole.

There are two types of weep holes, the high pressure face seal weep holes that are rectangular slots (Figure 40) and the low pressure uni-valve seal weep holes that are round. There are three of each type located along the top of the manifold.



### ATTENTION

*On 20K manifolds, the rectangular weep holes also communicates with the top pressure ports. If water is observed at the rectangular weep holes, first check the corresponding 20K port connection. The 20K seal pill may need repositioning or replacing.*

If water is leaking from one of the rectangular weep holes, the seal that seals the uni-valve to the stuffing box has failed. On 15K and 20K manifolds, the O-ring (Figure 41) on the valve makes that seal. On 40K manifolds, there is no O-ring on the valve to seal the manifold. The stuffing box contains a face seal to seal this connection.

If water is leaking from the round weep holes (Figure 40), the outer O-rings (Figure 42) on the valves have failed.

**Note:** The larger O-ring will leak to the rectangular weep hole.

Monitor the manifold for leakage during operation. If leakage occurs, immediately replace all of the seals on the leaking valve.



### WARNING

*If leaks are allowed to continue, expensive damage to the valves or manifold block could occur.*

Inspect the valve seats during seal replacement and lap the valves if necessary. Refer to “Valve Lapping” for instructions.

Monitor the manifold for leakage during operation. If leakage occurs, immediately replace all of the seals on the leaking valve.

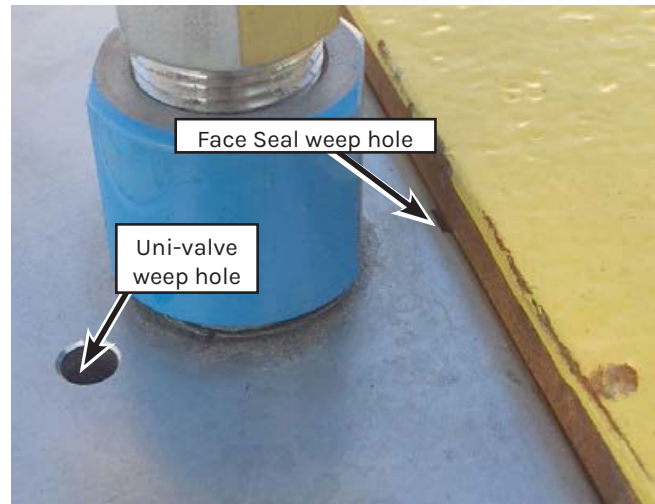


Figure 40: Weep Holes



Figure 41: Uni-valve to Stuffing Box Seals.

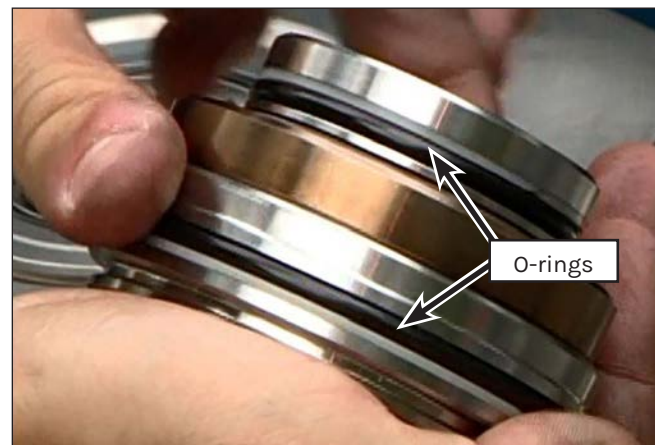


Figure 42: Outer O-rings.



## Pressure Controls

When the combined output of both pumps is required, the pressure controls at the rear of the trailer are used (Figure 43). There is a bypass pressure control for both 15K Max and 20K Max pressure that allow pressure control for the flow incoming from two hoses. Typically when one pressure control is not used, it will be plugged at the 3 ports on the WYE fitting.

When 40K is required, the output flow from the pump nearest the tongue of the trailer will travel to and pass thru the rear pump, and the combined flow will exit the rear pump. A single bypass valve fixed to either fluid end will control the pressure. If a bypass valve is on both fluid ends, one should be completely closed.

15K and 20K water travels through 20K hard pipe and hose (Blue) while 40K water travels through separately plumbed 40K hard pipe and hose (Orange).

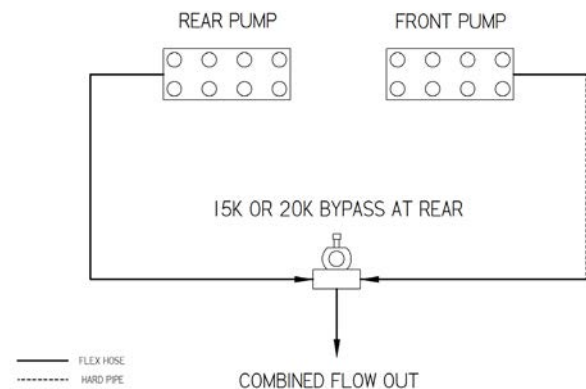


Figure 43: Pressure Controls

## Stopping the Unit

1. Open the bypass valve by turning counter-clockwise four full turns to relieve the system pressure. Monitor the gauge to ensure system pressure is at zero.
2. Decrease the engine speed to idle and disengage the clutch by pulling the lever towards the pump.
3. Allow the engine to operate for 4-5 minutes before stopping. This allows the engine turbocharger to properly cool. When the temperature shown on the control panel decreases to approximately 176°F (80°C), it is safe to turn off the engine.

### **WARNING**

*Do not idle the engine for more than 5 minutes.*

4. Turn the key switch to the OFF position.



# MAINTENANCE

## Unit Maintenance

**Note:** Refer to the OEM manual for maintenance intervals and service instructions for the engine.

### Daily

1. **Check the Unit for Fluid Leaks** - Repair any leakage points found on the unit.
2. **Check Engine Oil Level** - Add oil as necessary.
3. **Check Coolant Level** - Add coolant as necessary.
4. **Inspect Water Filter Bags** - Inspect the water filter bags and replace as necessary. Refer to “Filter Inspection” on page 42.
5. **Check Power End Oil Level** - Add oil as necessary. Refer to “Checking Power End Oil Level” on page 72 for instructions.
6. **Check Gland Nut Torque** - Ensure the gland nuts are properly tightened for operation. Refer to “Checking Gland Nut Torque” on page 53 for instructions.
7. **Adjust Water Lubrication System** - Ensure the water is properly adjusted on pressure fed manifolds equipped with needle valves. Refer to “Checking the Water Lubrication System” on page 29.
8. **Inspect Rupture Discs** - Ensure the rupture discs are installed and inspect for damage. Refer to “Rupture Disc Inspection” on page 54. Verify extra replacement discs are on hand in case of a rupture.
9. **Secondary Filter** - Monitor the pressure on the secondary filter pressure gauge. The filter pressure must be monitored during operation to determine filter condition. Refer to “Secondary Filter (40k Operation Only)” on page 42 and “Filter Cartridge Replacement” on page 43 for more information.

### 50 Hours

1. **Check Pump Drive Belt Tension** - Ensure the belts are properly tensioned per the tension decal under the belt cover. Refer to “Checking Belt Tension” on page 74.
2. **Uni-Valve Inspection** - Inspect the seals for damage and the valve seats for deposits, jetting or other damage. Refer to “Valve Inspection” on page 70.
3. **Inspect Clutch Breather** - Remove the breather and inspect for dirt and debris. Clean or replace as necessary.
4. **Inspect Pump Breather** - Remove the breather and inspect for dirt and debris. Clean or replace as necessary.

### 100 Hours

1. **Initial Power End Oil Change** - After the first 100 hours of operation on a new unit, change the power end oil. Refer to “Changing the Power End Oil” on page 73.
2. **Inspect Batteries** - Inspect the batteries and ensure the terminals are tight and protected with a coat of petroleum jelly. Clean the tops of each battery. Remove the cell caps and check the electrolyte level in each cell. If the levels are low, add distilled water so the fluid is well above the battery plates.
3. **Initial Engine Oil Change** - Refer to the engine manual.
4. **Initial Stuffing Box Lubrication Check** - Remove stuffing boxes, clean powerframe bore, lubricate with anti-seize or petroleum jelly, and replace stuffing boxes.

### 500 Hours

1. **Regular Power End Oil Change** - Change the power end oil. Refer to “Changing the Power End Oil” on page 73.
2. **PTO Oil Change** - Change the oil in the PTO. Refer to “Changing PTO Oil” on page 74.

3. **Belt Inspection** - Inspect the belts for cracks, damage, glazing or any other defect. Replace as necessary. Replace the belts as a set and adjust the new belts as outlined in “Adjusting Belt Tension” on page 75.
4. **Regular Stuffing Box Lubrication Check**  
- Remove stuffing boxes, clean power-frame bore, lubricate with anti-seize or petroleum jelly, and replace stuffing boxes.

## Winterizing The Unit

Severe damage can result if the waterblast unit is not protected from freezing conditions. The stuffing boxes hold water that can freeze causing damage to the stuffing boxes, uni-valves, plungers and manifold. To prevent freezing drain the water from all hoses, charge pump and tanks, and add anti-freeze to the stuffing boxes.

If the unit is to be idle for any period of time that would allow freezing in the pump or piping, utilize the following procedure:

1. Drain the water from the tank.
2. Disconnect the water supply suction line and high pressure discharge hose from the manifold.
3. Drain the manifold of water and close the drain.
4. Assemble pipe fittings into a funnel assembly as shown in (Figure 44).
5. Install the assembly on the suction side of the manifold.
6. Pour a glycol based anti-freeze solution into the funnel as shown in (Figure 45). Approximately 0.5 gal. (2 L) of anti-freeze is required.
7. Place the override switch in the ON position to bypass the low water shutdown.
8. Before starting the engine, check the area in the path of the discharge fitting on the manifold. Ensure the area is clear. Anti-freeze will be discharged from the discharge fitting during this procedure.



Figure 44: Funnel Assembly Installation.



Figure 45: Adding Anti-Freeze.



Figure 46: Draining the Anti-Freeze.

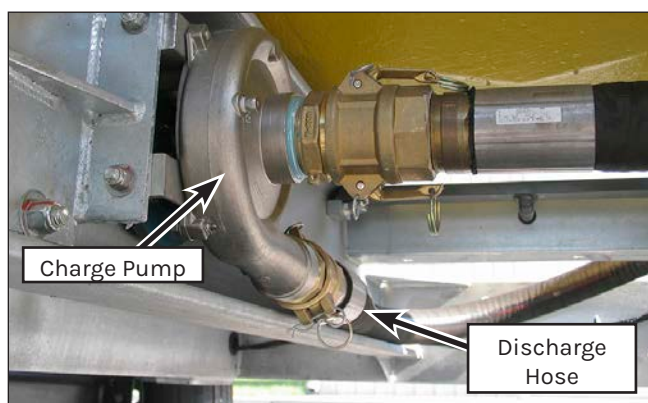


Figure 47: Draining the Charge Pump.



9. Start the engine.
10. With the engine idling, gently feather the clutch by applying light pressure to the clutch handle in the engagement direction. Watch the plungers move back and forth slowly until anti-freeze is discharged from the manifold port as shown in (Figure 46).
11. Once anti-freeze has been discharged from the discharge port, disengage the clutch and shut off the engine.
12. Remove the funnel assembly from the suction port and reconnect the suction hose.
13. Disconnect the water lubrication lines from the stuffing boxes and drain the lines.
14. (Charge pump-equipped units) Disconnect the discharge hose (Figure 47) on the charge pump. Drain the water from the hose and reconnect.
15. Rinse the anti-freeze completely off of the unit.
16. Ensure the supply water piping system is protected against freezing.

## Trailer Maintenance

The Jetstream Waterblast trailer requires regular inspection and maintenance to provide safe performance and long life.

### Tires

All tires supplied with Jetstream waterblast trailers are of heavy-duty construction. Replacement tires must meet these original equipment specifications:

Unit Type	Tire Size	Load Capacity @ Rated Pressure
ALL	215/75R17.5HC, H	4550 lb (2063 kg) @ 123 PSI

#### **WARNING**

*Tire installations that do not meet or exceed these specifications may cause tire failure resulting in loss of trailer control and/or bodily injury.*

Check tire pressure every 3 months and before travel. Proper tire pressure is stated on the sidewall.

Inspect tire wear every 6 months or 3000 miles (4828 km). Refer to the following chart to diagnose tire wear. Repair as necessary to correct abnormal wear.

### Wheel Bearings

Periodically fill the hub with a high quality hypoid gear oil to the level indicated on the clear plastic oil cap. The oil can be filled through the rubber plug hole in the cap. Oil should be replaced every 12 months or 12,000 miles.

See complete maintenance guide at [DexterAxle.com](http://DexterAxle.com) within the 9-15K Axle Complete Service Manual

#### **WARNING**

*Failure to grease or properly seal wheel bearings could lead to bearing failure resulting in wheel loss and/or bodily injury.*






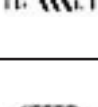
Wear Pattern		Possible Cause	Remedy
	Center Wear	Over-inflation	Adjust air pressure to correct specification
	Edge Wear	Under-inflation	Adjust air pressure to correct specification
	Outside Wear	Bent axle/spindle	May need to replace axle beam
	Inside Wear	Overloading or loss of camber	Ensure the trailer is not overloaded
	Inside & Outside Wear	Incorrect alignment when inside and outside on opposite tires	Align axles
	Flat Spots	Wheel locking/tire skidding	Adjust brake shoes. Reduce gain on brake controller. Avoid sudden or hard stops.

Figure 48: Tire Wear and Possible Cause.

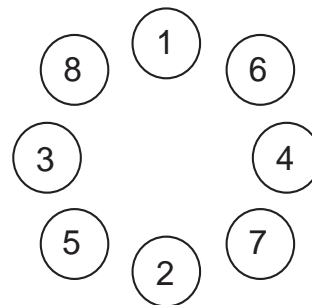


Figure 49: Lug Nut Torque Pattern.

### Lug Nuts

All wheel lug nuts supplied with Jetstream Waterblast Trailer Units utilize a M22-1.5 thread. Replacement lug nuts must match the wheel studs supplied with the unit.

Check the torque on the lug nuts every 500 miles (800 km). Proper torque is 450 ft-lbs.(612 N/m). Tighten Lug Nuts in sequence (Figure 49).

## Axles

Dexter leaf spring axles are installed in an underslung configuration and each has a gross axle weight rating of 15,000lb (6804 kg)

If a problem with an axle is suspect, contact your Jetstream representative.

## Trailer Breakaway System

### System Check

1. Disconnect the trailer connector from the tow vehicle.
2. Open the battery case (Figure 50) and check the battery voltage using a voltmeter. The battery should be approximately 12V. If less than 12V, charge the battery. Note the voltage before proceeding to the next step.
3. Pull the lanyard from the breakaway switch and listen for the engagement of the brakes. Recheck the battery voltage. The voltage should be 1 or more volts lower than the previous measurement if the brakes are working. If the brakes could not be heard or if there was no change in voltage proceed to the next step.
4. If the battery is properly charged, the switch must be checked. With the lanyard pin pulled from the switch, check for continuity of the switch by probing the two wires with a continuity check function on a digital multi-meter. If there is no continuity, replace the switch.
5. If there is continuity, a wiring problem is likely the cause. Inspect the wiring for poor connections or broken wire and repair. Refer to the Connector Wiring Decal (Figure 51).

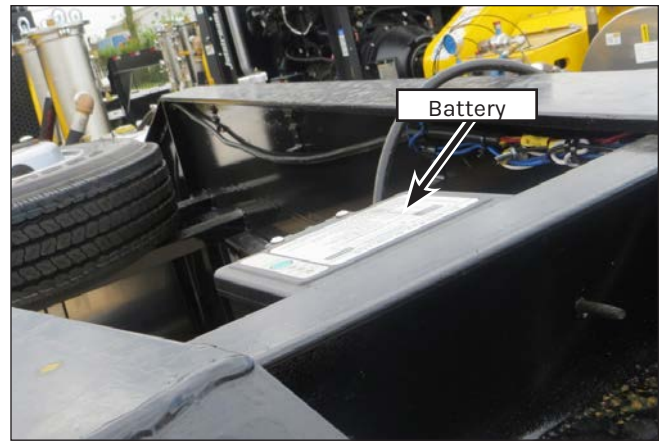


Figure 50: Breakaway System Kit Location.

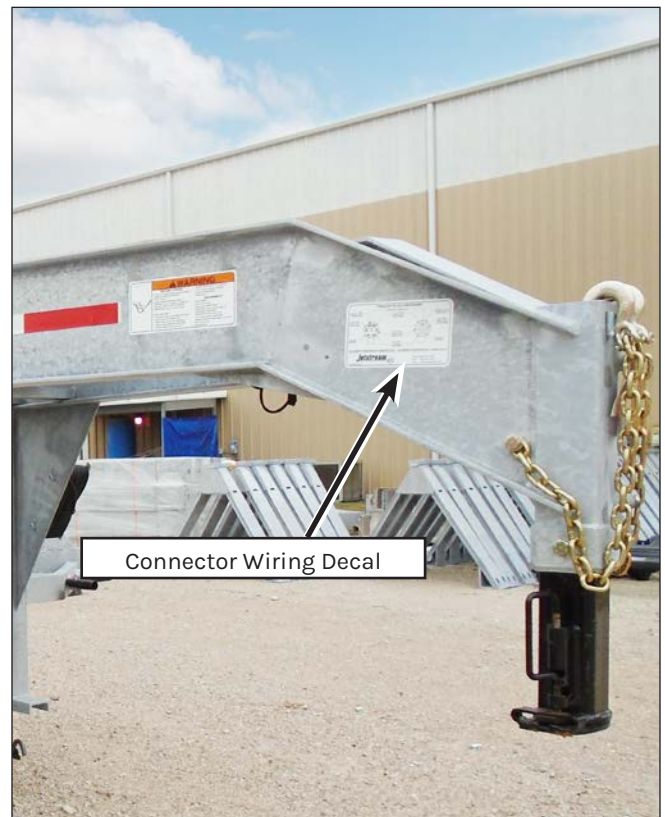


Figure 51: Connector Wiring Decal.





# WATER AND FILTRATION

## Water Quality Requirements

The quality of water that is supplied to your Jetstream pump can have a direct impact on performance. Items like dissolved solids and pH values out of the allowable range can, either by themselves, or together with other properties of the water, lead to premature failure (such as cracking) of pump components and related accessories.

Suspended gasses (tiny bubbles) in the water can also lead to premature component failure. These gases can sometimes be detected visually by inspecting the water in the inlet tank for tiny bubbles or a milky appearance.

As part of the installation and or operating procedures of this pump, an expert that specializes in water quality must perform a water quality test. If your water is found to exceed any of the allowable measurements in the chart below, consult a specialist in water purification and conditioning.

Recommended water quality levels:

Substance	Maximum Allowed (mg/L)
Silica	1.0
Calcium	0.5
Magnesium	0.5
Iron	0.1
Manganese	0.1
Chloride	5.0
Sulfate	25.0
Nitrate	25.0
Carbon Dioxide	0
Total Dissolved Solids	50.0
pH	6.8 - 7.5
Specific Conductivity	50 micro-mhos/cm

**Note:** Boiler water additives with either ammonia or amines are not allowed.

**Note:** If water that has been treated by either reverse osmosis or deionization is to be used in your pump, it is important that it does not have a total dissolved solids (TDS) reading of less than 0.5 ppm. Water with a TDS reading of 0.5 ppm or less has been known to attack carbide components such as plungers and back-up rings.

## Filter Inspection

1. Loosen the 3 eye bolts (Figure 52) securing the filter housing cover and swing the lid open.
2. Lift the filter bags (Figure 53) from the filter housing and inspect for debris. Replace as necessary.



### **ATTENTION**

*Filter bags are not washable. Any attempt to wash or flush a bag for reuse could damage the bag. This may allow debris past the filter and into the valves causing damage.*

## Secondary Filter (40K Operation Only)

The secondary filter, or polishing filter, is used for 40K operation only. When operating at 40K, monitor the filter pressure gauge (Figure 54) for an indication of filter condition. During normal operation, the pressure gauge should be within the 30 to 40 psi (2 to 2.75 bar) range. When differential pressure inside the filter housing between the clean side and the dirty side drops approximately 7 to 10 psi (0.48 to 0.69 bar), the pressure switch on the filter housing will trip and the engine will shut off to protect the unit from damage. Replace the dirty filter cartridge if this occurs.



### **ATTENTION**

*Extended operation with a dirty filter will lead to filter failure and allow debris to reach the valves causing damage to the valves.*

*It is important to know the condition of your filter cartridge. Standard units come with a pressure gauge on the filter. In order to monitor the condition of the filter it is important to note the engine operating speed and housing pressure when the filter is first changed. Refer to "Filter Cartridge Replacement" on page 43 for more information.*

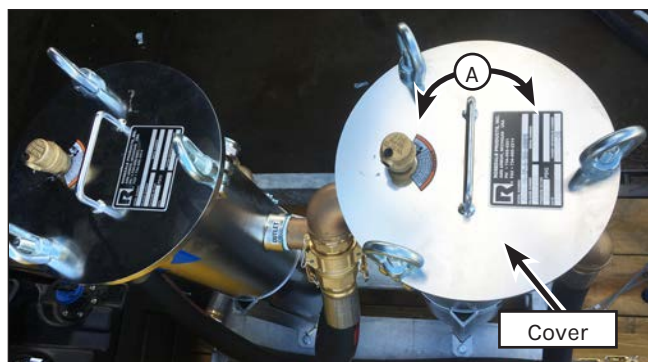


Figure 52: Filter Housing Cover

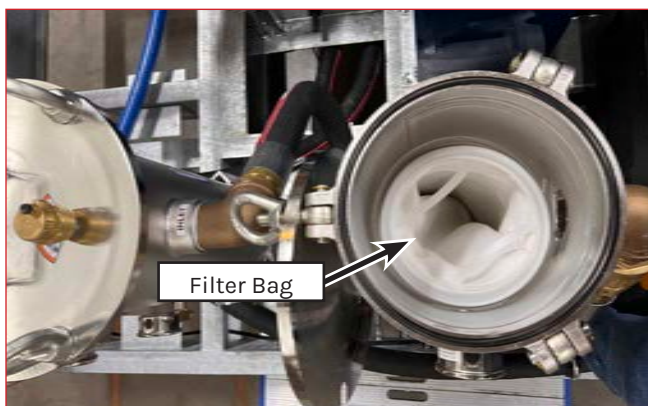


Figure 53: Filter Bag Removal.

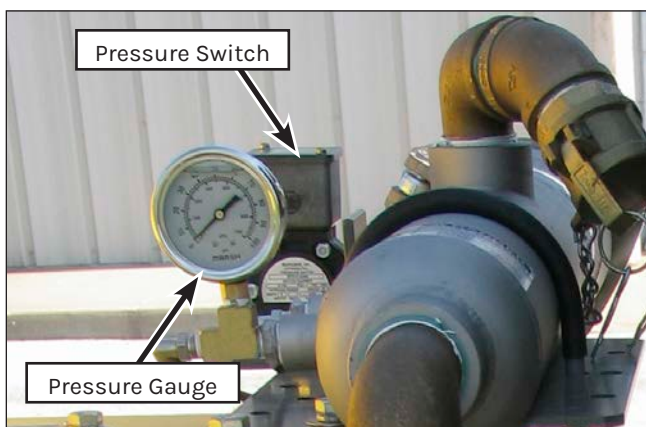


Figure 54: Secondary Filter Assembly.

## Filter Cartridge Replacement

1. Relieve pressure from the housing using the bleed valve then loosen the three eye-nuts (Figure 55) on the filter cover.
2. Slowly open the cover and capture the spring (Figure 56) and spring keeper.
3. Remove the filter cartridge.
4. Install the new filter cartridge onto the guide rod. Ensure the guide rod is correctly seated into the bottom of the housing.
5. Inspect the O-ring and install a new one if necessary.
6. Place the spring keeper and spring into place on the end of the filter cartridge.
7. Move the filter cover into position and tighten the eye-nuts.
8. Prepare the pump for operation and start the unit. Start a typical blast operation and record the following:
  - Engine rpm
  - Gauge pressure on the secondary filter
9. Save this record for monitoring the status of the secondary filter. Monitor the pressure gauge as more hours of operation are accumulated on the filter cartridge. When the pressure on the filter gauge has dropped approximately 7 to 10 psi (0.48 to 0.69 bar) (with the unit operating at the same rpm as earlier recorded), the filter must be replaced.

## Switch Adjustment

The differential pressure switch will shut down the unit when the pressure drop across the filter is approximately 7 to 10 psi (0.48 to 0.69 bar). If the switch doesn't close within the 7 to 10 psi (0.48 to 0.69 bar) range, it may need to be adjusted. Contact Jetstream for switch adjustment instructions.

## Uni-Valve Life

The uni-valve seats can be damaged by dirty water. It is important to change filters regularly to improve pump performance and prolong valve life. (Nozzles and bypass cartridges are also adversely affected by dirty water).

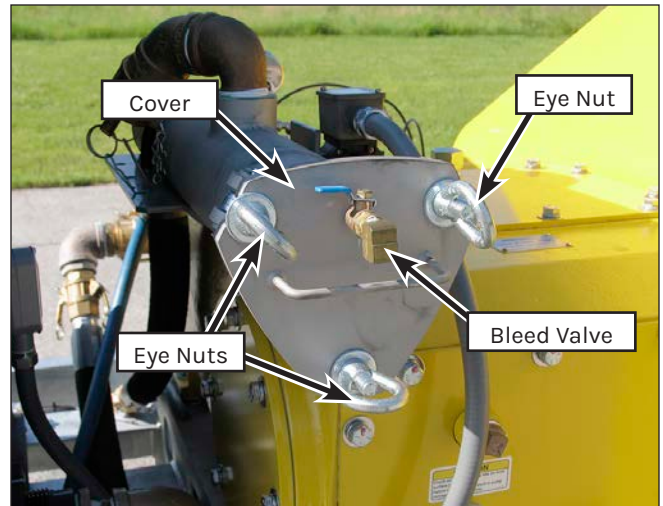


Figure 55: Filter Cover.

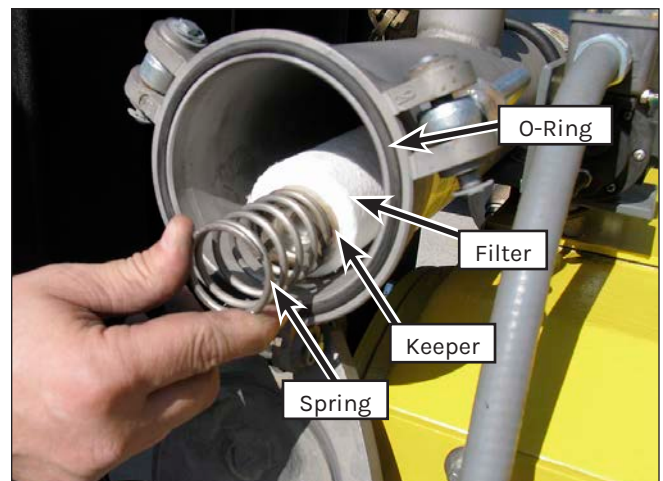


Figure 56: Cartridge Removal.

Inspect uni-valve seats regularly to monitor condition and lap the valve seats when necessary. Refer to "Valve Lapping" on page 70 for lapping instructions.





## PRESSURE CONVERSION

The versatility of the Jetstream waterblast units allows operators to modify the pump to change to different operating pressure ranges when necessary.

There are three ranges of pressure and are usually referred to as 15K, 20K, and 40K. These are abbreviated names to easily denote the maximum operating pressure.

- The 15K fluid end can operate up to 15,000 psi (1034 bar).
- The 20K fluid end can operate up to 20,000 psi (1379 bar).
- The 40K fluid end can operate up to 40,000 psi (2758 bar).

When converting a fluid end to a different pressure, it is necessary to exchange the stuffing boxes and manifold with the proper components for the new operating pressure.

### **WARNING**

When switching to higher operating pressures, it is necessary that all equipment be properly pressure rated. Refer to the Jetstream Safety Manual for specific guidelines for hoses, fittings, etc.

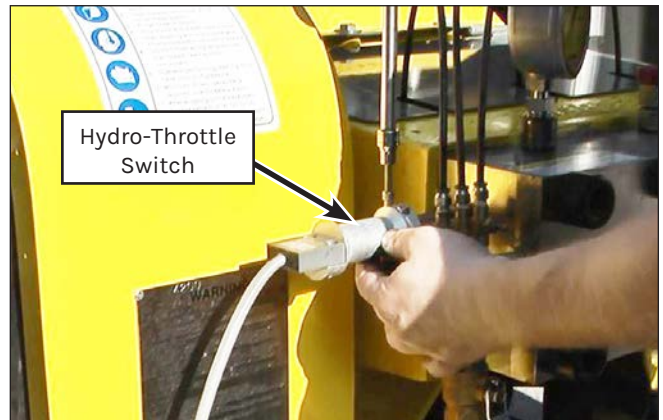


Figure 57: Hydro-throttle Switch.

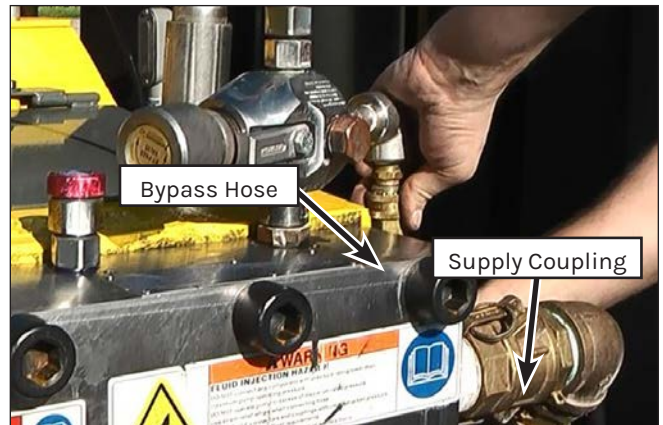


Figure 58: Line Removal.

## Converting a Pump

Use the following procedure to convert a pump to a different pressure.

1. Relieve pressure from the pump, shut off the engine and disengage the clutch.
2. Turn off the water supply, drain the water tank.
3. Remove the two bolts that secure the hydro-throttle switch aluminum housing (Figure 57) to the brass cartridge in the manifold. Remove the switch and housing and set aside.
4. Disconnect the bypass drain hose and the supply coupling from the manifold (Figure 58).
5. Open the rod box cover and disconnect the lubrication lines from the stuffing box fittings (Figure 59).

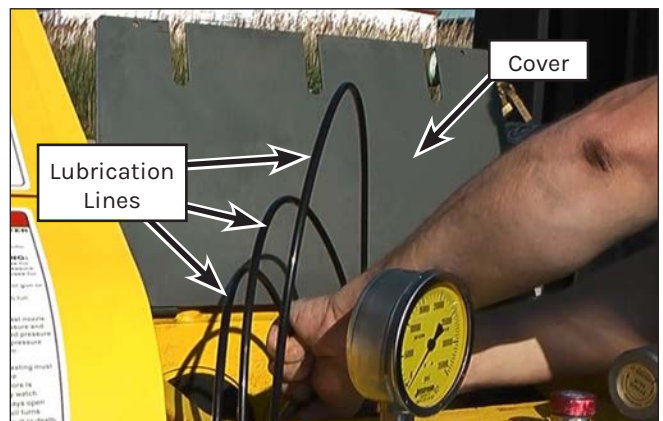


Figure 59: Disconnecting Lubrication Lines.

6. Remove the cotter pin (Figure 60) from the hinge rod and remove the rod.
7. Remove the top manifold bolts (Figure 61) at each corner.

**Note:** The pump wrench can be used with a hammer to remove the manifold bolts.

8. Install manifold mounting studs (Figure 62) into the two open holes to allow for easier installation of the new manifold.

**Note:** Manifold mounting studs can be purchased from Jetstream. (p/n 54261)

9. Continue removing the remaining manifold bolts.

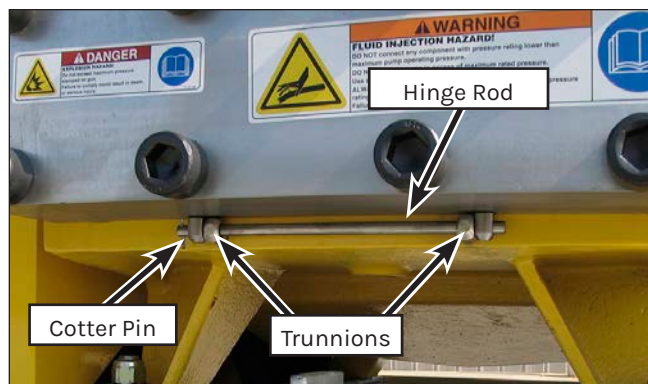


Figure 60: Hinge Rod, Trunnions, and Cotter Pin.

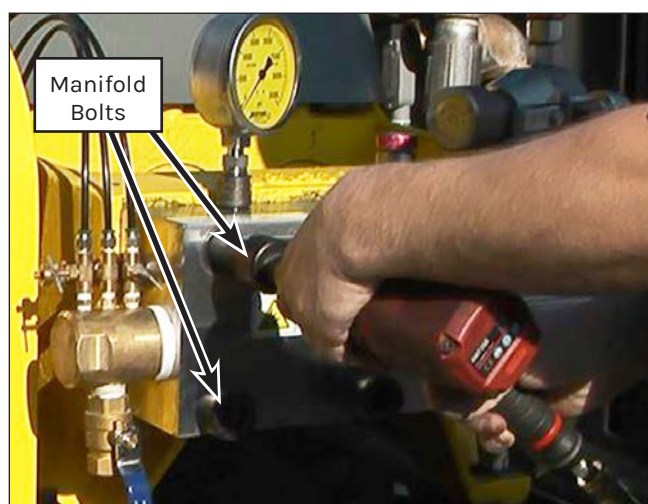


Figure 61: Manifold Bolt Removal.

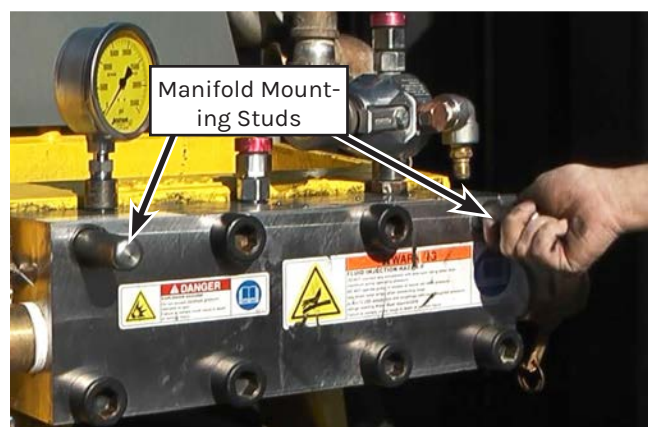


Figure 62: Manifold Mounting Stud Installation.

10. Once all of the bolts are removed, lift the manifold off the pump (Figure 63).

**CAUTION**

*Use two people to lift the manifold. The Manifold is heavy and failure to use two people may cause serious injury.*

**Note:** The weight of the manifold is approximately:

- 3000 Series: 90 lb. (41 kg)
- 3600/4200 Series: 165 lb. (75 kg)

11. Remove the water lubrication fitting (Figure 64) from each stuffing box.
12. Remove the two bolts that secure each plunger coupling (Figure 65) to the plungers and remove the three couplings.

**Note:** The coupling halves are matched and must be kept together.



Figure 63: Manifold Removal.

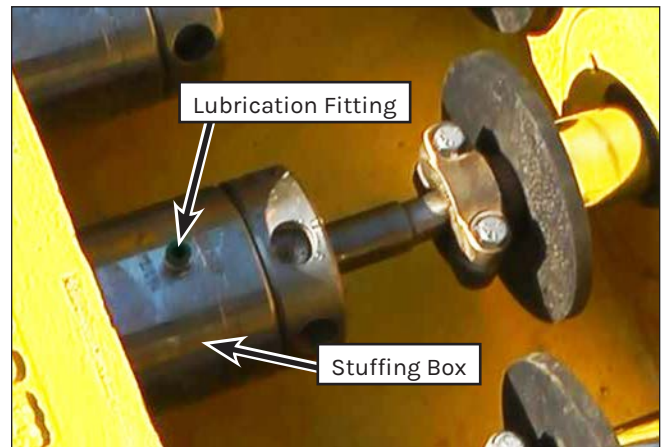


Figure 64: Lubrication Fittings.

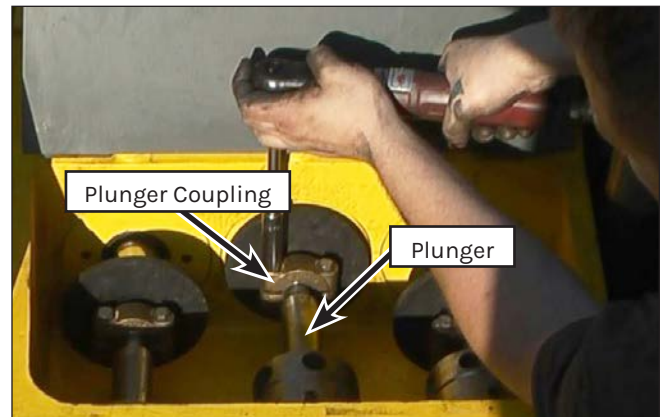


Figure 65: Plunger Coupling Removal.



13. Pull each stuffing box from the pump case (Figure 66).
14. Clean the stuffing box bore thoroughly and apply petroleum jelly or Anti-Seize to the bores.



### **ATTENTION**

*Apply petroleum jelly or Anti-Seize to each stuffing box bore when installing stuffing boxes to help prevent corrosion and extend pump life.*

15. Install the new stuffing boxes into the pump case. Orient the stuffing boxes so the flat face on the outer diameter matches the flat face in each case bore.
16. Extend the plunger from each stuffing box until it mates with the opposing crosshead pony rods. Install the plunger coupling (Figure 67) on each plunger and secure with the two bolts. Tighten the bolts to 20 ft.-lb.(27 N·m).
17. Ensure the gland nuts are tight. Use the pump wrench and a 5 lb. (2 kg) hammer to tighten the gland nuts to approximately 250 ft.-lb.(338 N·m) (Figure 68). Hit the wrench about three times using moderate power. This should supply sufficient torque on the nut.



Figure 66: Stuffing Box Removal.

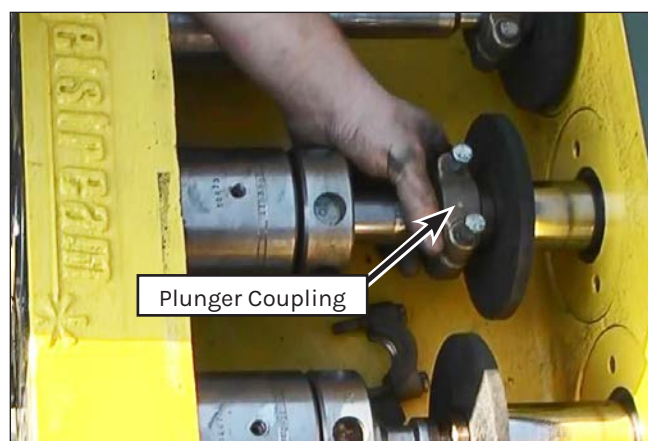


Figure 67: Plunger Coupling Installation.



Figure 68: Tightening the Gland Nuts.



18. Apply Teflon tape to the threads of the lubrication line fittings (Figure 69). Install the fittings onto the stuffing boxes.
19. Apply a light coating of petroleum jelly or Anti-Seize to the mounting face of the power end. This will greatly reduce the buildup of corrosion.
20. Lift the new manifold onto the manifold mounting studs (Figure 70).

### **CAUTION**

*Use two people to lift the manifold. The Manifold is heavy and failure to use two people may cause serious injury.*

21. Install and adjust the trunnion rod as follows:

#### **Manifold Trunnion Adjustment**

The trunnions in the manifold must be adjusted such that the hinge rod supports the manifold to allow the capscrews to be screwed in or out by hand. The manifold holes need to be centered over the tapped holes in the powerframe (or adapter plate). This configuration will put the hinge rod in a substantial bind and it will be bent down slightly at the ends since it will be supporting the weight of the manifold block. This centered position of the manifold will also ensure proper operation of the valves and seals at all pressures.

- a. Slide the manifold away from the powerframe (or adapter plate) a few inches (Figure 71, A). This will allow room to adjust the threaded trunnions in the bottom of the manifold.
- b. Screw both manifold trunnions (Figure 71, B) in completely and then back them out approximately 2-1/2 turns. Slide the manifold back against the powerframe (or adapter plate).

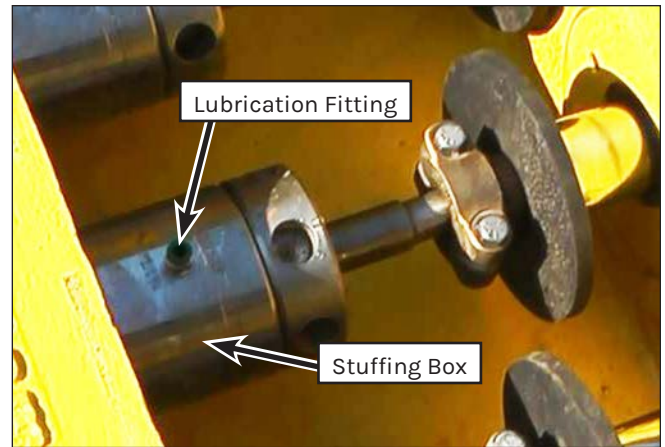


Figure 69: Lubrication Line Fittings.



Figure 70: Lift the New Manifold onto the Mounting Studs.

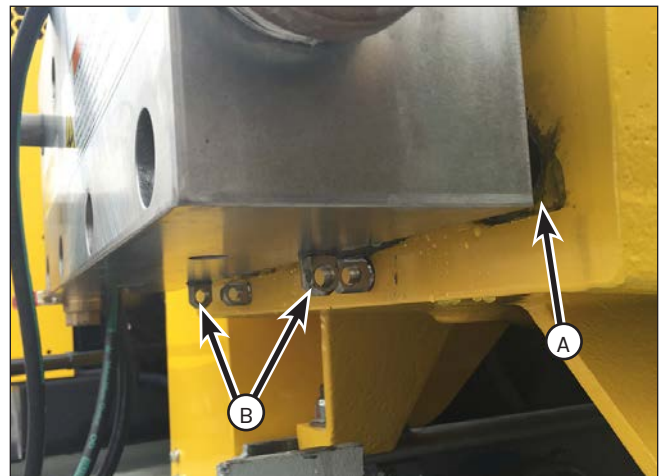


Figure 71: Manifold in Adjustment Position.

- c. To install the hinge rod (Figure 72), it will be necessary to either lift the manifold or use a screwdriver to flex the rod while simultaneously tapping the end with a hammer to get the rod through the second set of trunnions. Check for correct alignment and free rotation of the manifold bolts.

### CAUTION

*Use two people to lift the manifold. The Manifold is heavy and failure to use two people may cause serious injury.*

- d. Repeat as necessary making half turn adjustments to both trunnions up or down until the manifold bolts thread in and out easily.

22. Install the manifold bolts (Figure 73) in the open holes and hand-tighten.
23. Remove the manifold mounting studs (Figure 73).
24. Install the remaining two bolts. Tighten all of the bolts in a crisscross sequence (Figure 74). Proper torque is 350 ft.-lb. (470 N·m).



Figure 72: Hinge Rod Installation.

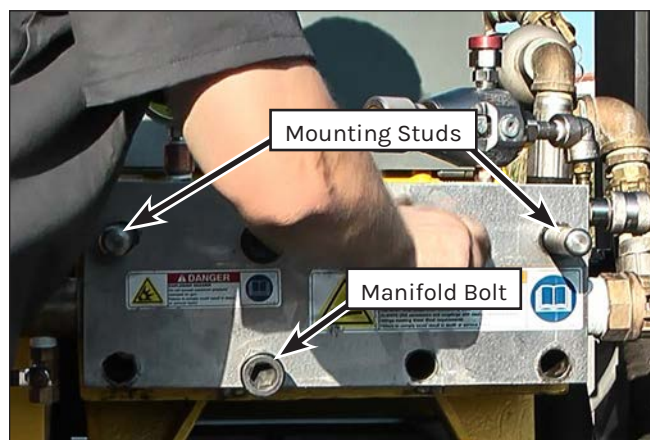


Figure 73: New Manifold Installation.



Figure 74: Tightening Sequence.

25. Connect the water lubrication lines (Figure 75) to the fittings on the stuffing boxes.
26. Connect the supply coupling (Figure 76) and the bypass hose to the manifold.
27. Place the hydro-throttle switch and housing (Figure 77) into position and install the two bolts that secure it.



## **ATTENTION**

*If converting to a 40K fluid end, the secondary filter must be plumbed for operation. Refer to “40K Hose Connections”.*

*When converting to 40K, a charge pump is required to force the water through the secondary filter. If the 40K manifold is not pressurized, the univalves will be damaged. If your unit is not equipped with a charge pump, it cannot be converted to a 40K fluid end. Units equipped with a charge pump are plumbed so that the charge pump feeds the manifold at all times with the clutch engaged. The charge pump is belt driven by the PTO.*

28. Verify all connections, glands and bolts were properly tightened.
29. Ensure the water lubrication system is properly adjusted, if equipped, before waterblasting. Refer to “Checking the Water Lubrication System” on page 29 for instructions.
30. If new packing was installed, break in the packing as outlined in “Breaking in New Packing” on page 31.

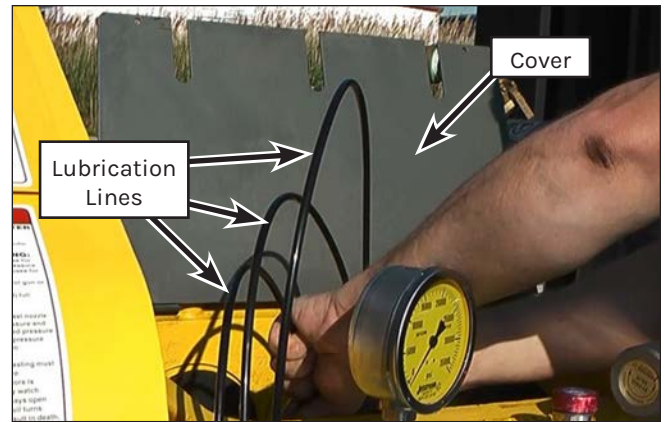


Figure 75: Connecting the Water Lubrication Lines.

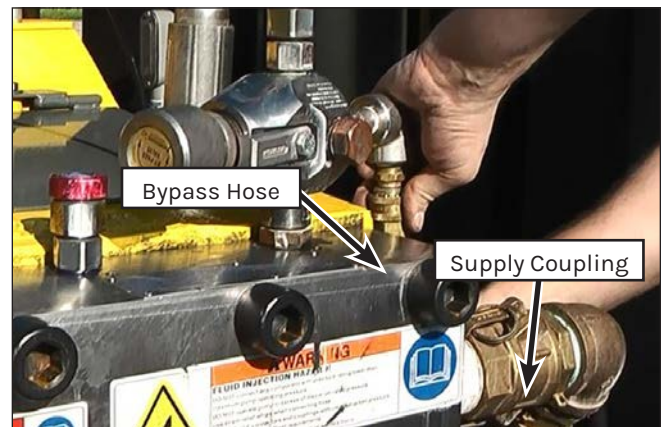


Figure 76: Connecting Bypass Hose and Supply Coupling.

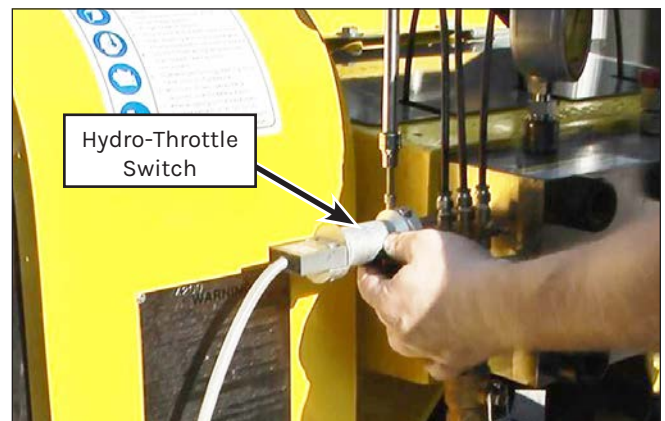


Figure 77: Hydro-Throttle Switch and Housing Installation.



## 40K Hose Connections

1. Remove the supply hose (Figure 78) (supply from charge pump) from the suction elbow fitting on the 15K/20K manifold.
2. Install the 40K manifold as outlined earlier in this chapter.
3. Remove the plug from the filter outlet hose (Figure 79). Connect the hose to the elbow on the 40K manifold.
4. Remove the cap from the secondary filter inlet coupling (Figure 79).
5. Install the charge pump supply hose on the secondary filter inlet coupling.

*\* When converting to 40K, the front and rear pumps will be tied together. Flow from the first pump will enter the manifold of the second pump, and the combined flow will leave the second pump. (see schematic, Figure 79)*

### CAUTION

When flushing the system before operation, purge the secondary filter of air. Failure to do so could cause pump cavitation and damage. Use the bleed valve (Figure 80) on the filter to purge the air from the filter.

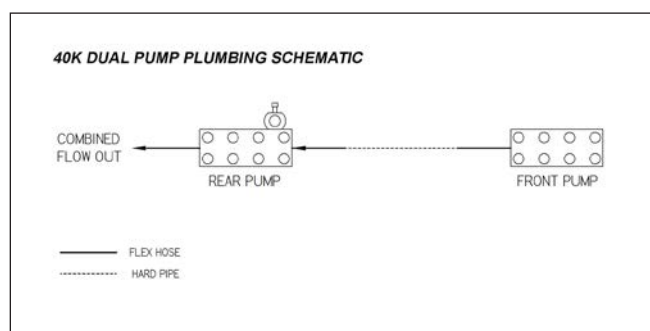
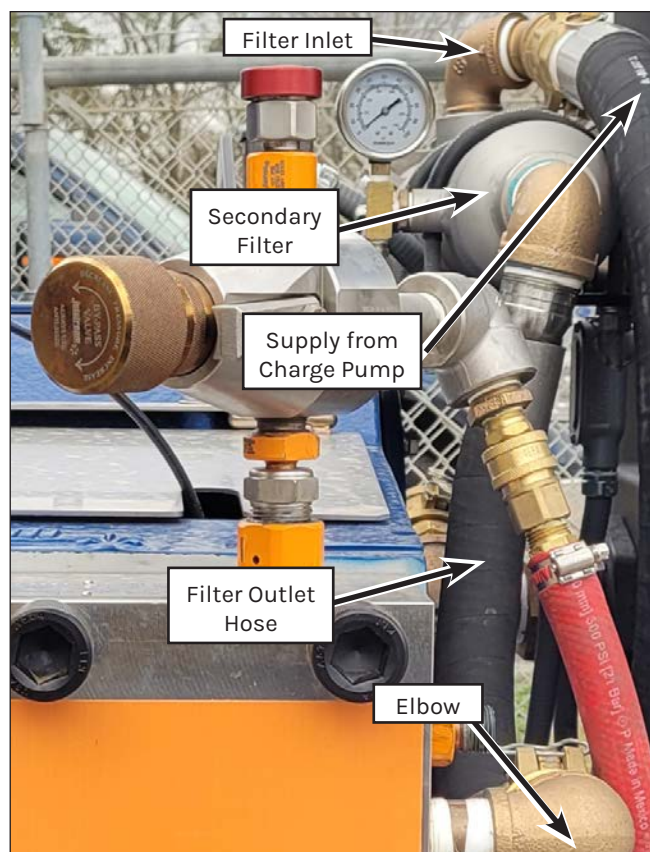


Figure 79: Plumbing.

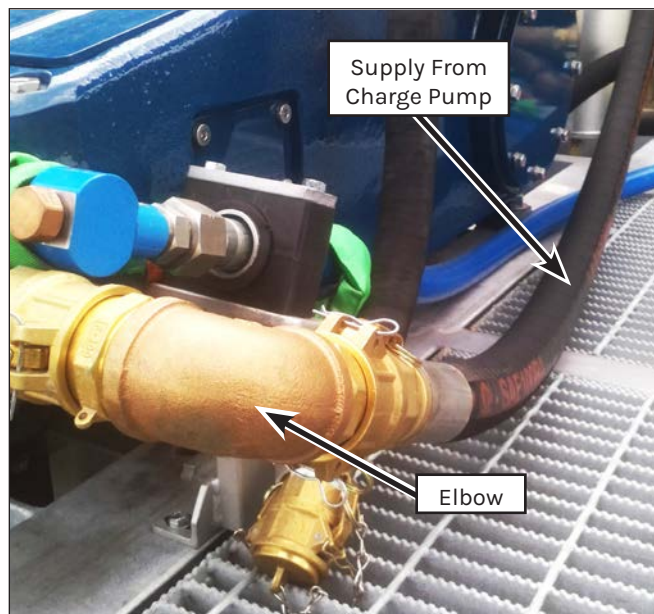


Figure 78: Supply Hose from Charge Pump.

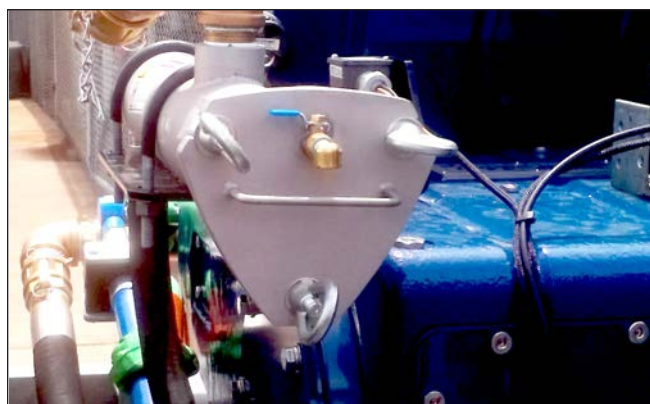


Figure 80: Secondary Filter Bleed Valve.



# SERVICE

## Fluid End

### Checking Manifold Bolt Torque

Verify the head bolts are properly tightened. Check the bolt torque in a crisscross sequence starting with the center bolts (Figure 81). Proper torque is 350 ft.-lb. (470 N·m) which can be achieved with a few hammer strikes on the pump wrench.

#### Checking Gland Nut Torque

1. Open the rod box cover.
2. Place the long end of the pump wrench in one of the gland nut holes.
3. Use a 5 lb. (2 kg) hammer to hit the wrench in the direction (Figure 82) to tighten the gland nuts. Hit the wrench about three times using moderate force. This will supply sufficient torque on the nut.
4. Repeat for the remaining nuts.
5. Close the rod box cover.



### ATTENTION

*It is helpful to mark gland nuts once they are confirmed to be operating correctly. A permanent marker can be used to mark a line across the top of the gland nut and stuffing box. This will allow easy visual confirmation that the gland nuts are properly torqued.*



Figure 81: Tightening Sequence.



Figure 82: Tightening the Gland Nut.

## Rupture Disc Inspection

1. Use an adjustable wrench to remove the cap (Figure 83) from the rupture disc assembly.
2. Remove the rupture disc from the base and inspect.
3. Verify a disc is installed and has not been damaged. Replace as necessary.



### **ATTENTION**

Installation of rupture discs with a burst pressure no greater than 1.4 times the working pressure is required by Jetstream for warranty coverage on this pump.



4. Install the upper housing back onto the assembly.
5. Repeat for the remaining rupture disc.

## Packing Replacement

### **Removal**

1. Relieve pressure from the pump, shut off the engine and disengage the clutch.
2. Turn off the water supply and drain the water tank.
3. Open the rod box cover.
4. Disconnect the water lubrication lines, if equipped.
5. Position the plunger to be serviced so that it is at bottom dead center (pony rod is fully retracted towards crankshaft). Pull the drive belts to rotate the pump (Figure 85)



### **WARNING**

Use caution when rotating the pump as this can be a pinch hazard.

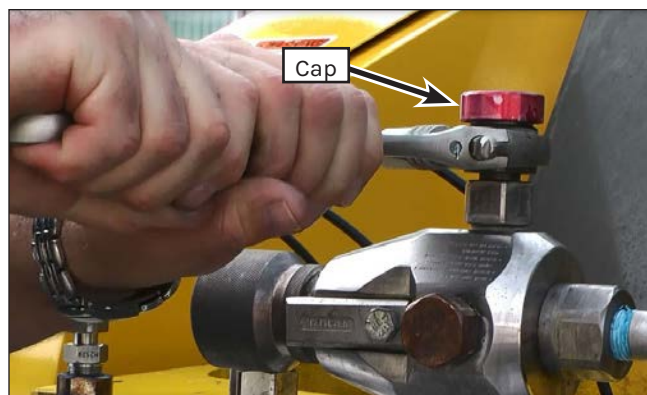


Figure 83: Housing/Cap Removal (15K Manifold Shown).

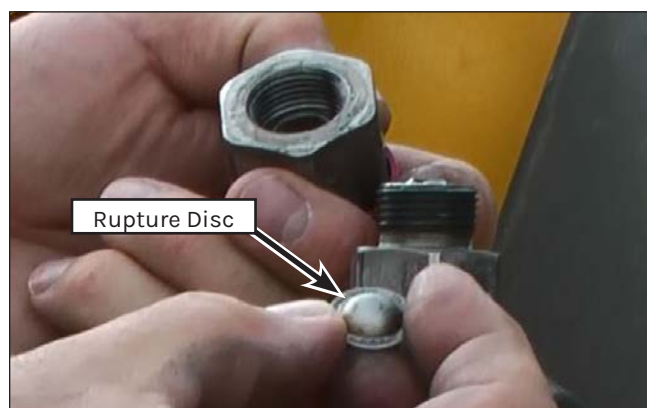


Figure 84: Disc Removal.



Figure 85: Rotating the Belt Drive.

6. Insert the rounded end of the pump wrench (Figure 86) into one of the holes in the gland nut and tap the top of the wrench sharply with a heavy hammer to loosen. When loose, unscrew the gland nut from the stuffing box by hand.
7. Remove the two bolts that secure the plunger coupling (Figure 87) to the plunger and remove the coupling. Push the plunger into the stuffing box for clearance.
8. Remove the gland nut and plunger from the stuffing box. It may require effort to wiggle the packing out by moving the plunger from side to side and up and down.
9. Remove the packing set (Figure 88).

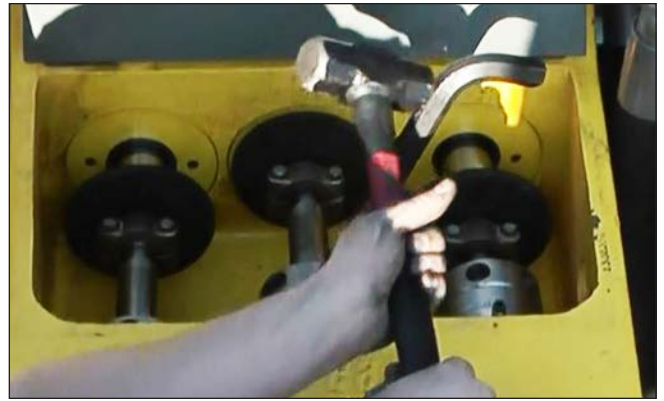


Figure 86: Loosening the Gland Nut.

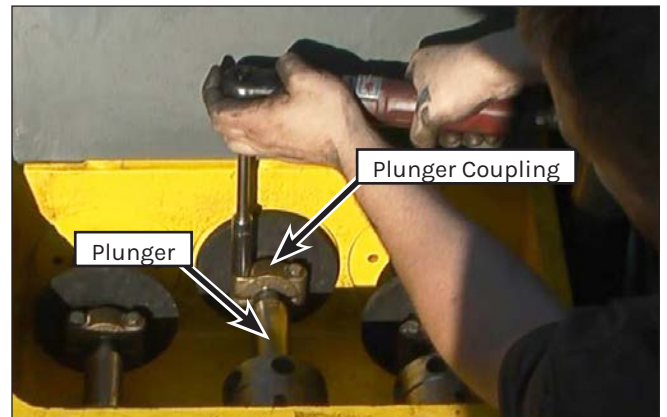


Figure 87: Plunger Coupling Removal.

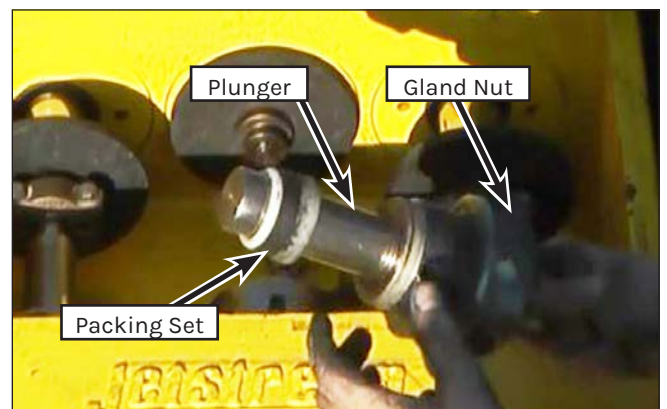


Figure 88: Packing removal.

10. Remove the plunger and guide bushing (Figure 89) from the gland nut and inspect.

**Note:** The guide bushing may be stuck and require some force to remove. Use a tool in the cutout (Figure 90) to push the bushing out. Use caution to avoid damaging the gland nut.



Figure 89: Guide Bushing Removal (15K/20K Gland Nuts).

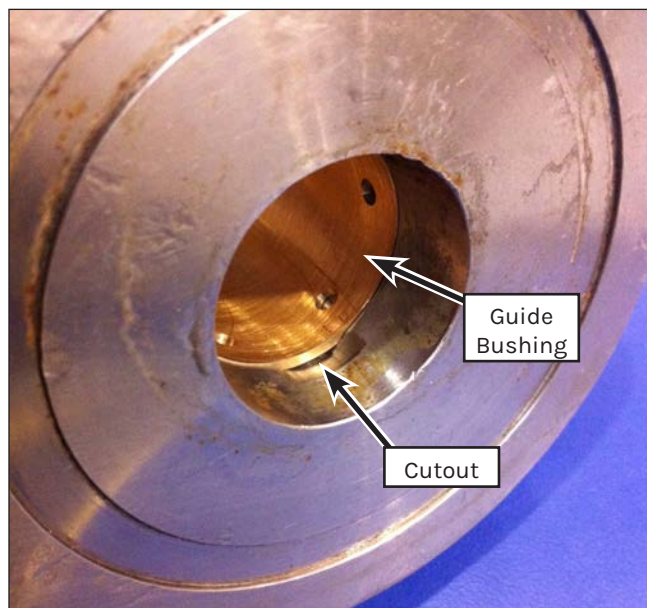


Figure 90: Stuck Bushing.



**Note:** On 40K fluid ends, the brass sleeve (Figure 91) inside the stuffing box does not need to be removed unless the plunger shows evidence of rubbing on the sleeve.

- 11. Remove the O-ring (Figure 92) from the gland nut.
- 12. Repeat the previous steps for the remaining stuffing boxes if packing is to be replaced.

**Inspection**

- 1. Inspect the plunger for scratched or deep scores. Discard damaged plungers.
- 2. On 40K units, measure the diameter of the guide bushing (Figure 93, A). If the diameter exceeds the Dimension A specification listed in the “40K Guide Bushing Replacement Table” below, replace the bushing. If the bushing shows scoring or if the edge is chipped, replace the bushing.

40K Guide Bushing Replacement Diameter		
Fluid End	Plunger Size	Dimension A
3040	# 5	0.533 in. (13.54 mm)
3640	# 6	0.603 in. (15.32 mm)
4240	# 7	0.673 in. (17.09 mm)
4240	# 8	0.733 in. (18.62 mm)

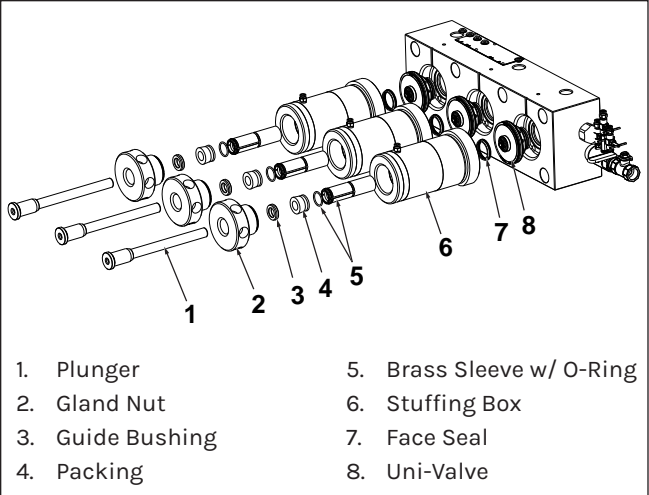


Figure 91: 15K/20K Fluid End (Some Components Not Shown).

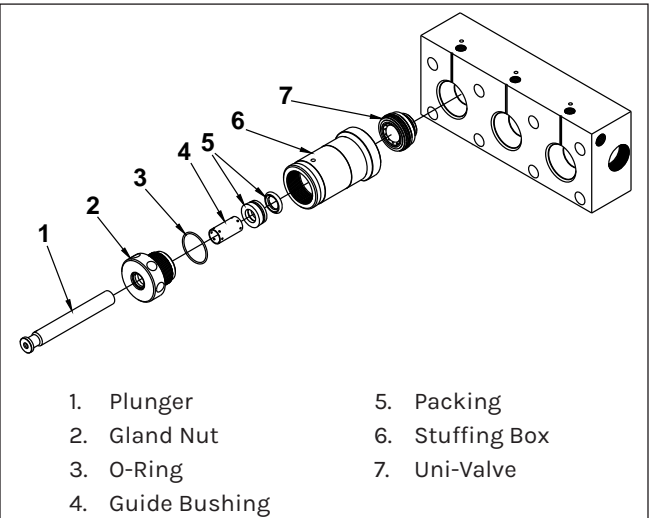


Figure 92: 40K Fluid End (Some Components Not Shown).

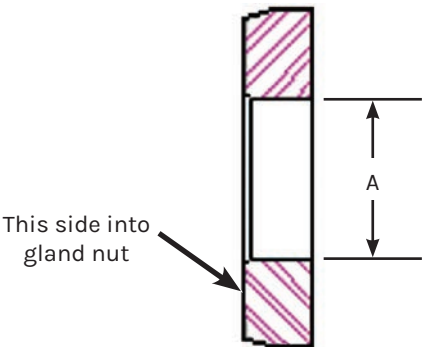


Figure 93: Guide Bushing Check (40K Only).

### Installation

1. Install a new O-ring (Figure 94) onto the gland nut.
2. Install the guide bushing (Figure 94) and plunger into the gland nut.
3. Place the new packing and guide bushing onto the plunger. Orient the packing as shown in (Figure 91) for 15K/20K and (Figure 92) for 40K.
4. Lubricate the gland nut with anti-seize compound. Apply the compound to the threads and on the small face that contacts the inside of the stuffing box (Figure 95). Place the assembly into the stuffing box. Hand-tighten the gland.



Figure 94: Guide Bushing Installation.

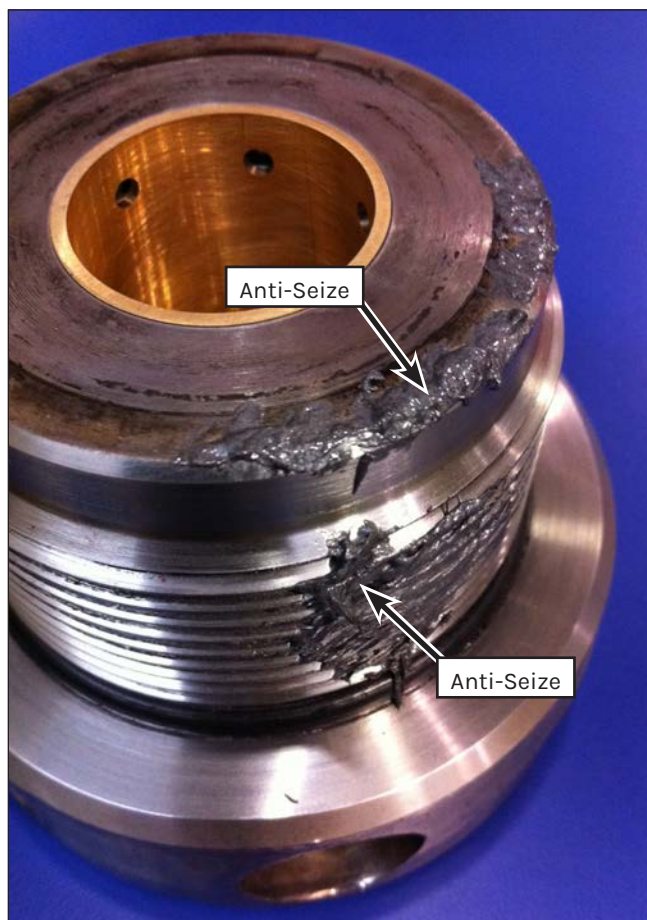


Figure 95: Applying Anti-Seize.

5. Pull the plunger (Figure 96) back to meet the crosshead pony rod. If the packing is too tight to move the plunger by hand, the pump can be rotated by hand (via the belts) to move the pony rod to meet the plunger.
6. Place the plunger coupling into position and install the coupling bolts (Figure 97). Tighten the bolts to 20 ft.-lb.(27 N·m).
7. Use the pump wrench and a 5 lb. (2 kg) hammer to tighten the gland nuts to approximately 250 ft.-lb.(338 N·m). Hit the wrench about three times using moderate force (Figure 98). This will supply sufficient torque on the nut.
8. Repeat the previous steps for the remaining stuffing boxes.
9. Connect the water lubrication lines and close the rod box cover.
10. It is necessary to break-in new packing properly to ensure optimal performance and a proper seal. Refer to “Breaking in New Packing” on page 31 for the proper break-in procedure.

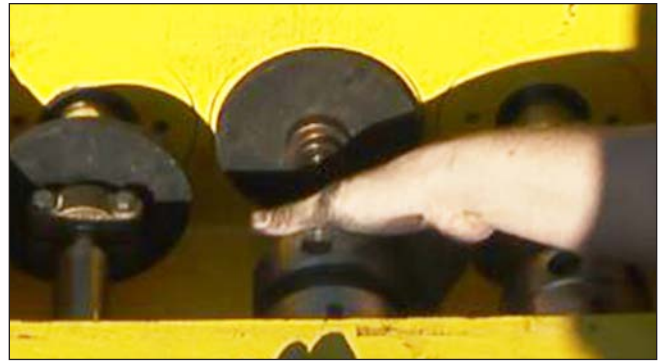


Figure 96: Gland Installation.

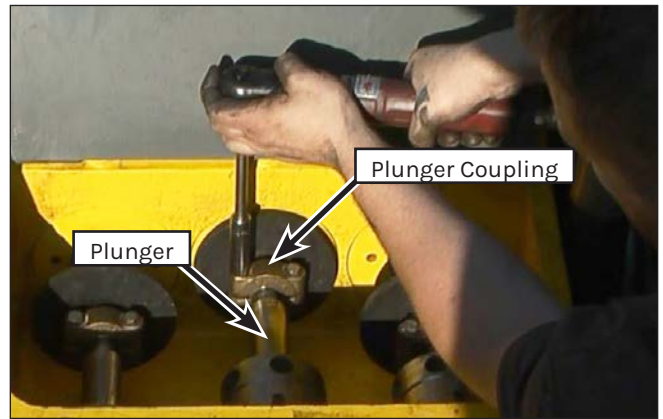


Figure 97: Plunger Coupling Installation.



Figure 98: Tightening the Gland.



## Uni-Valve Service

### Removal

1. Relieve pressure from the pump, shut off the engine and disengage the clutch.
2. Turn off the water supply and drain the water tank.
3. Disconnect the bypass drain hose and the supply coupling from the manifold (Figure 99).
4. Open the rod box cover (Figure 100) and disconnect the lubrication lines from the stuffing box fittings.
5. Remove the manifold bolts (Figure 101). Ensure the hinge rod (Figure 102) is installed before removing the bolts.

### WARNING

If the hinge rod is missing, the manifold can fall and cause serious injury.

**Note:** The pump wrench can be used with a hammer to remove the manifold bolts.



Figure 99: Line Removal.

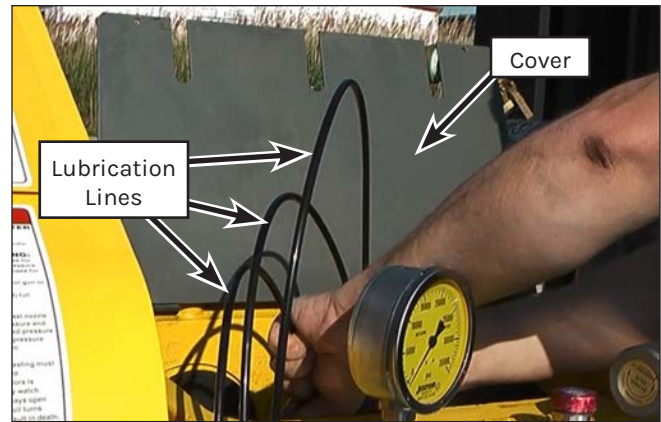


Figure 100: Disconnecting the Lubrication Lines.

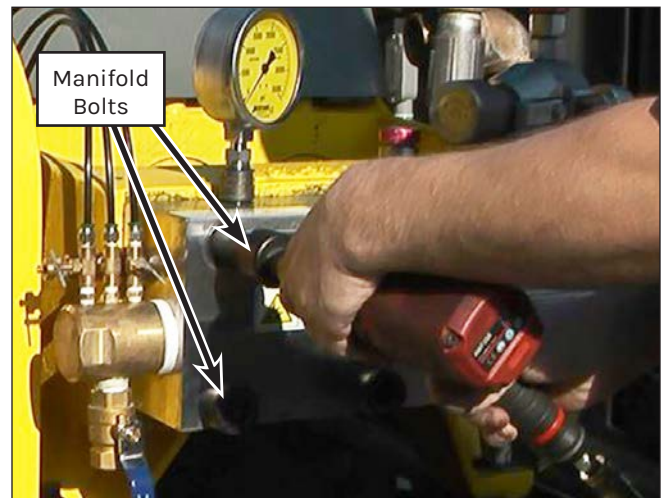


Figure 101: Removing the Manifold Bolts.



Figure 102: Hinge Rod and Trunnions.



6. Slowly swing the manifold downward to the manifold support rest. The weight of the manifold is approximately:
  - 3600/4200 Series: 165 lb. (75 kg)
  - 3000 Series: 90 lb. (41 kg)
7. Use two small pry bars (Jetstream p/n 70179) to pry the valve out of the manifold as shown in (Figure 103).
8. Remove the remaining valves. Refer to the topics on valve service later in this chapter for disassembly and maintenance instructions.

### **CAUTION**

*Jetstream uni-valves must be lapped regularly to minimize damage to the seating surfaces and maximize valve life. Service intervals depend on many variables including water quality, filter maintenance, and hourly usage. Refer to "Valve Lapping" on page 70 for instructions.*

## 40K Face Seal Replacement

Because the valves on 40K manifolds do not have exterior O-rings that seal the manifold to the pump frame, the stuffing boxes contain a face seal to seal the two surfaces. Perform the following to replace.

1. Press slightly behind the face seal using your finger and gently pull the seal out (Figure 104).

### **CAUTION**

*Do not use hard metal tools such as screwdrivers or picks to remove the face seal. Doing so may cause damage to the stuffing box and sealing surface to the point where the box must be discarded.*

2. Wipe the seal retaining area and inspect.
3. Apply O-ring lubricant to the entire area of the new seal.
4. With the sealing lip facing away from the stuffing box, press the new seal into place by hand until seated.
5. Ensure the seal stays in place until the manifold is in place and tightened.

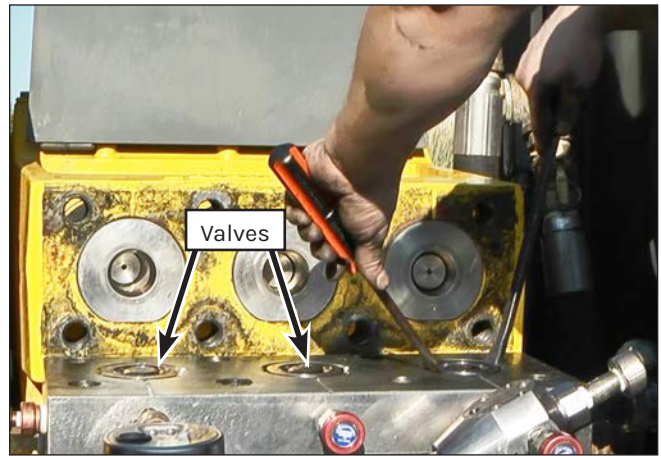


Figure 103: Valve Removal.

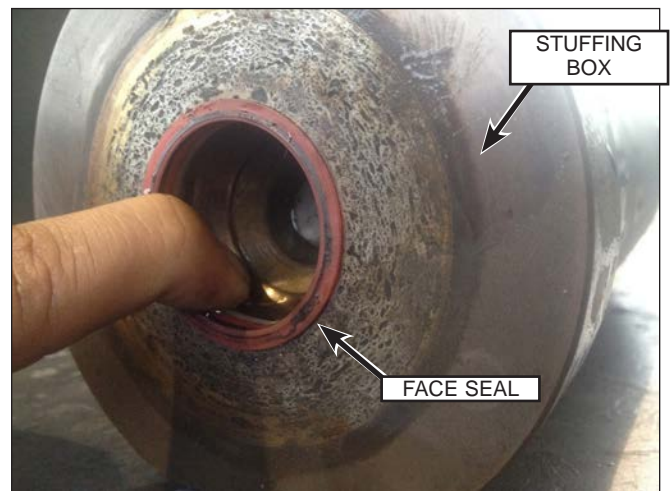


Figure 104: Face Seal Removed.

## Installation

1. Place the valve into position on the manifold. Using the palms of your hands, press the valve into the manifold as shown in (Figure 105).
2. Install the remaining valves.
3. Swing the manifold upward to install the bolts.
4. Install the manifold bolts and tighten in a crisscross sequence starting with the center bolts (Figure 106). Proper torque is 350 ft.-lb. (470 N·m).
5. Connect the water lubrication lines (Figure 107) to the stuffing boxes and close the rod box cover.
6. Connect the supply coupling (Figure 108) and the bypass hose to the manifold.

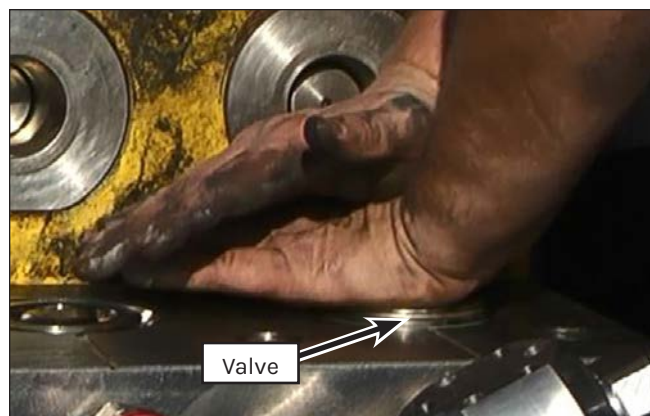


Figure 105: Installing the Valves.



Figure 106: Tightening Sequence.

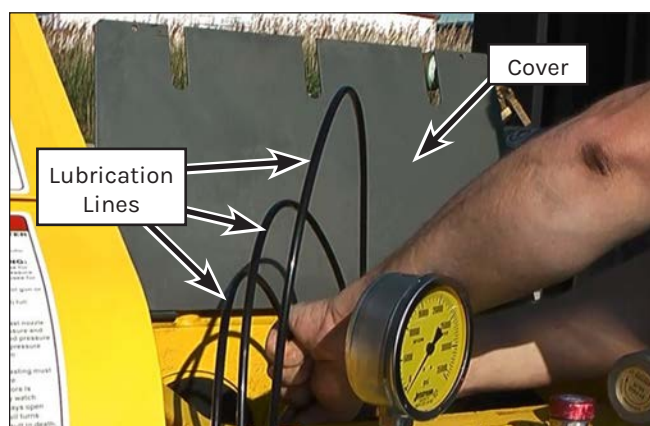


Figure 107: Connecting the Water Lubrication Lines.

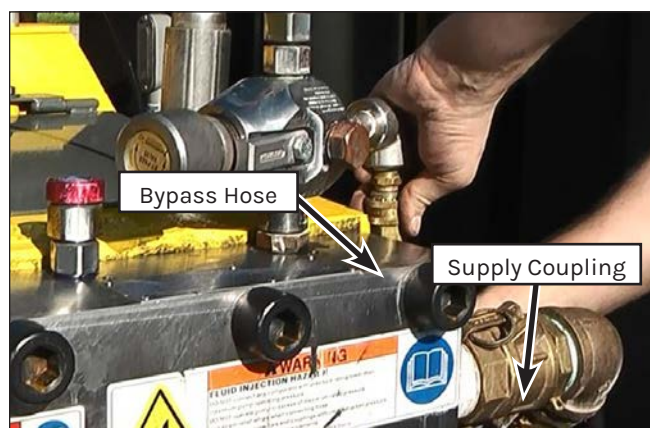


Figure 108: Hose Connections.

## 15K, 20K Uni-Valve Service

### Disassembly

1. Remove the O-ring at each end of the valve (Figure 109). Discard the O-rings.
2. Locate the slits in the two white backup rings and carefully remove the rings. Remove the companion O-rings, as well (Figure 110). Discard the O-rings and backup rings.

**Note:** Note the orientation of the seals for installation.

3. Use a small screwdriver to depress the spring retainer. Use another screwdriver to remove the retaining ring. Insert the blade under the slit and rotate the ring out of the groove. Use caution to prevent bending or distorting the ring (Figure 111).

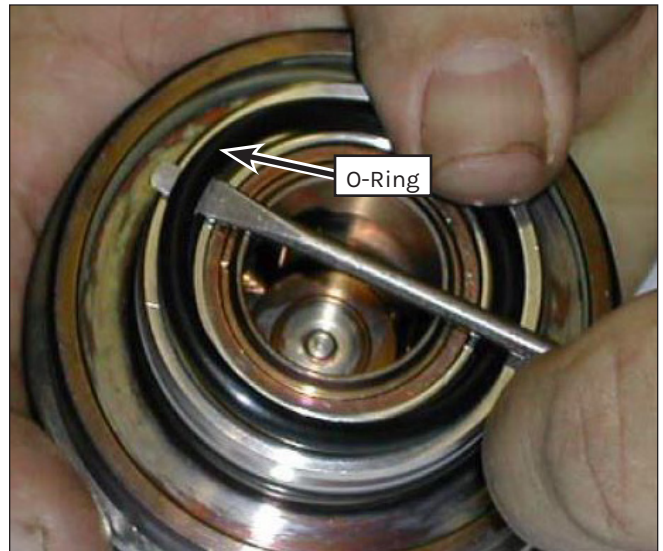


Figure 109: O-Ring Removal.

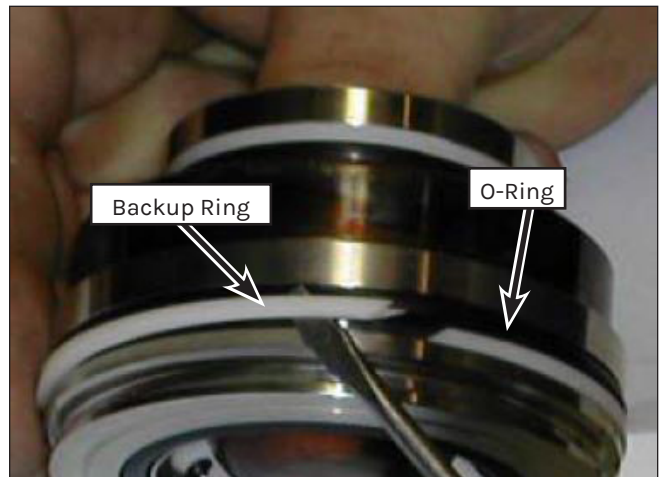


Figure 110: Backup Ring and O-Ring Removal.

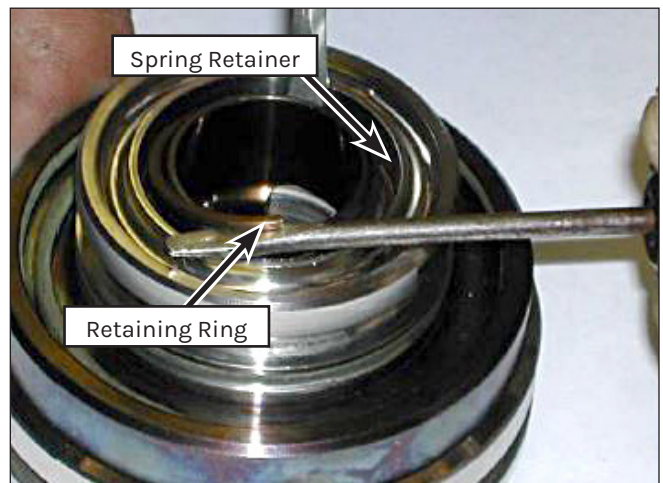


Figure 111: Removing the Retaining Ring.



4. Remove the valve spring retainer and valve spring (Figure 112).
5. Lift the assembly off of the suction valve and set the suction valve aside.
6. Insert a small screwdriver under the discharge spring (Figure 113). Carefully rotate the screwdriver until the spring releases from the groove.

**Note:** 3015 valves are equipped with a retaining ring to secure the discharge spring (Figure 114).

7. Remove the discharge valve and discharge spring.
8. Inspect the valves. Refer to “Valve Inspection” on page 70 for inspection criteria.

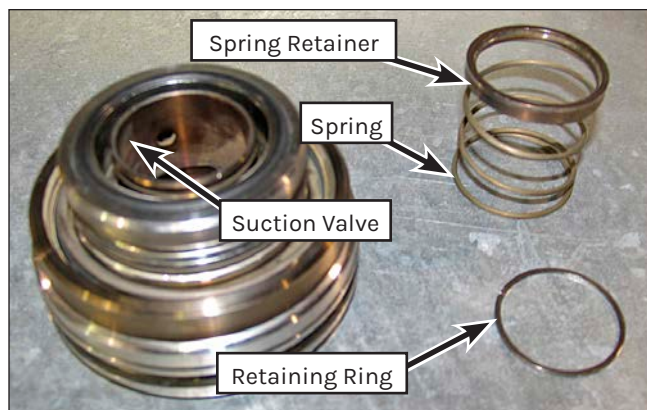


Figure 112: Retaining Ring and Spring Removal.

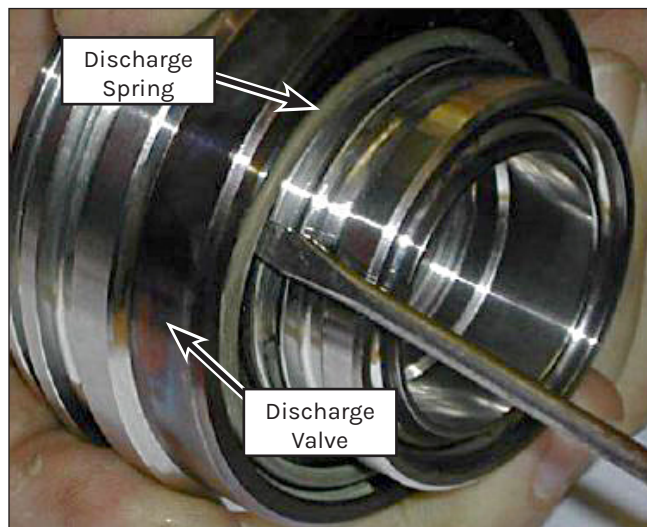


Figure 113: Discharge Spring and Valve Removal.



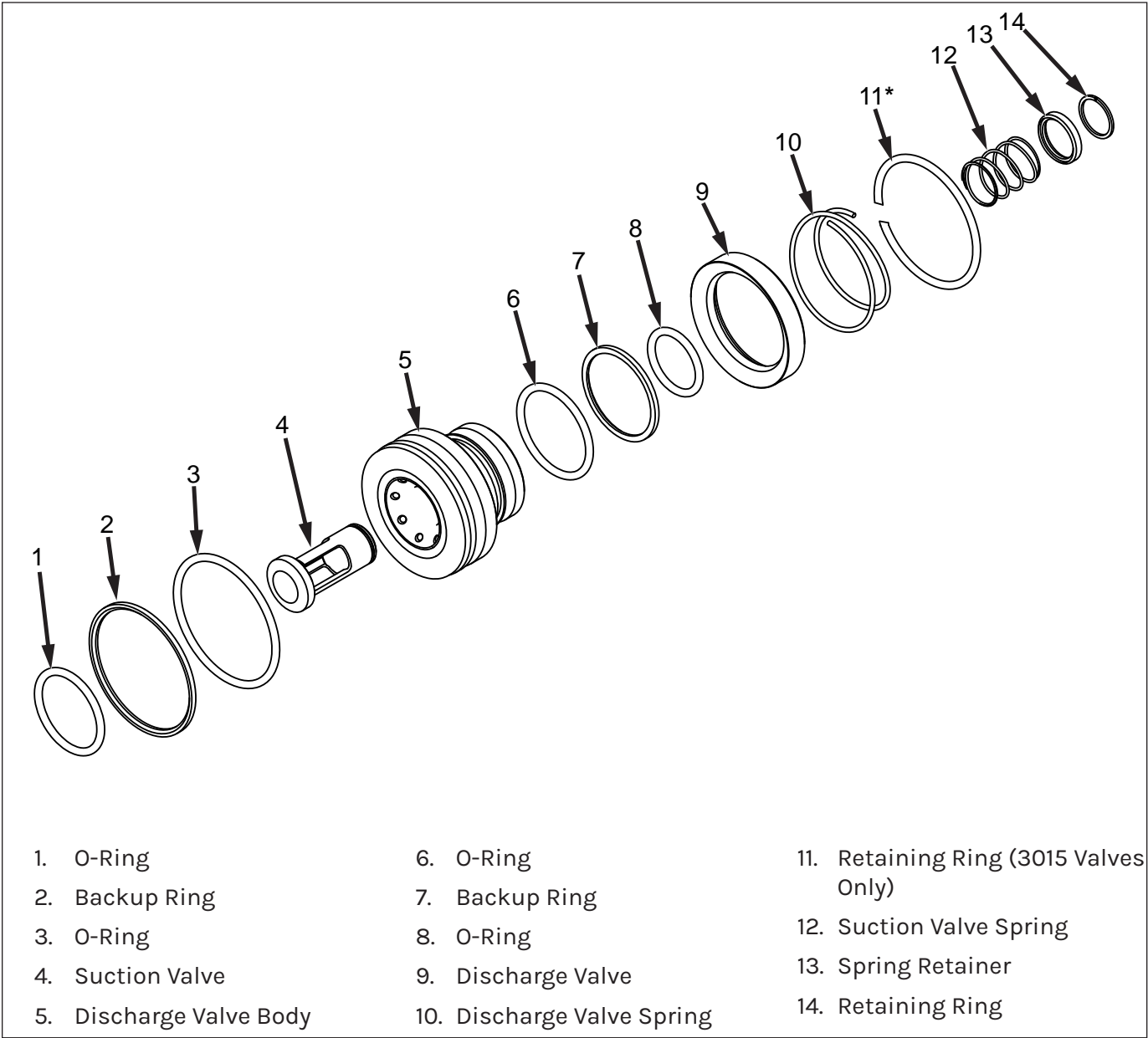


Figure 114: 15/20K Uni-Valve Exploded View.

### Assembly

1. Install the discharge valve onto the valve body. The shiny mating surface faces the holes on the valve body. Place the discharge spring into position on the valve (Figure 115).
2. Lock the spring in its retaining groove. Use a screwdriver to push the spring in place. Start at the base of the spring and follow along the coils to the top of the spring until it locks in its retaining groove.
3. Position the suction valve in the valve body (Figure 116).
4. Insert the suction valve spring and spring retainer into the valve body. Ensure the ledge the retaining ring sits on is positioned properly (Figure 117).
5. Press the spring retainer downward and install the retaining ring onto the suction valve.
6. Install the new O-rings and backup rings into their respective positions on the assembly (Figure 110).

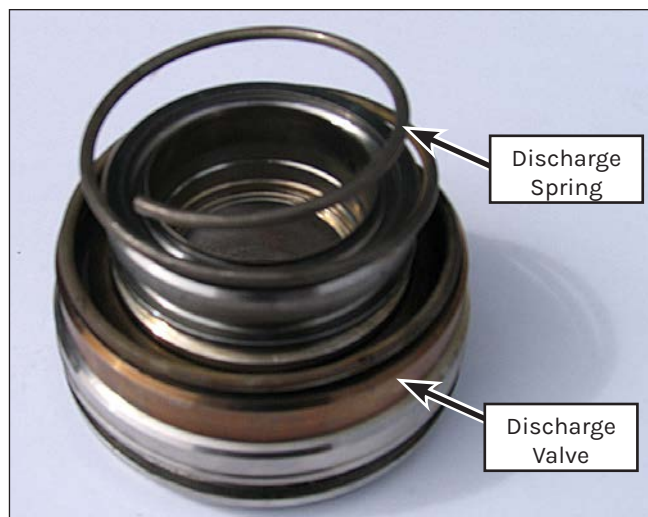


Figure 115: Discharge Installation.

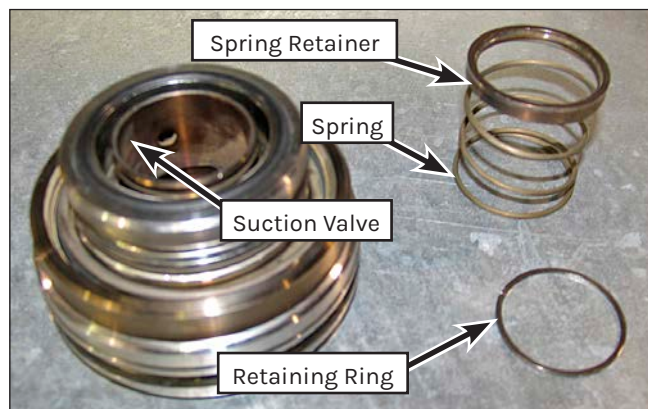


Figure 116: Suction Valve Installation.

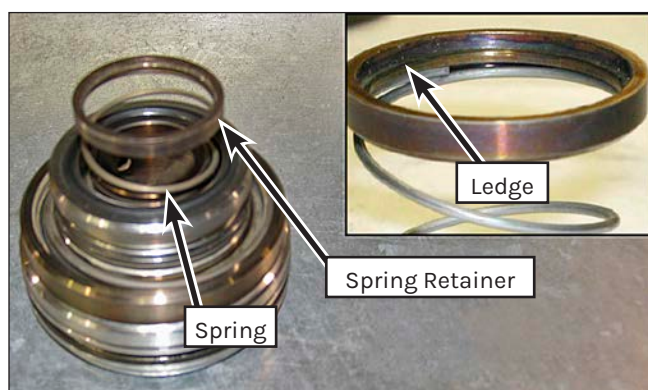


Figure 117: Spring and Retainer Installation.

## 40K Uni-Valve Service

### Disassembly

1. Use a small screwdriver to remove the two black O-rings from the valve (Figure 118).
2. Use the screwdriver to remove the seal retaining ring. Insert the blade under the slit and rotate the ring out of the groove (Figure 119). Use caution to prevent bending or distorting the ring.
3. Use the screwdriver to remove the ring seal (Figure 120) and seal support ring.
4. Turn the valve over.



Figure 118: O-Ring Removal.

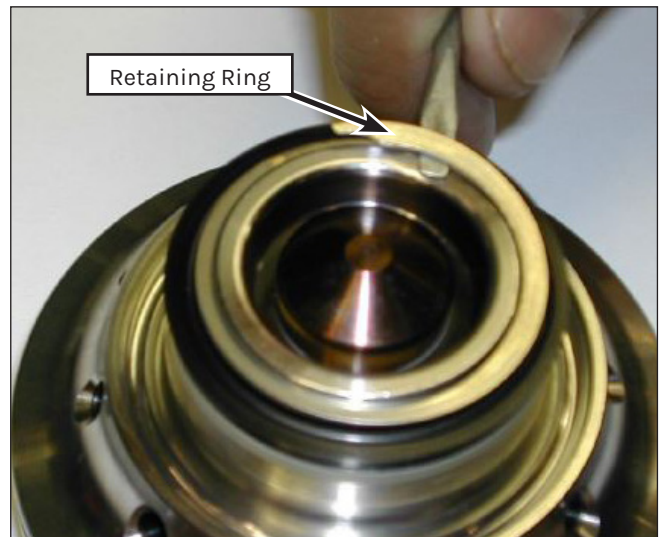


Figure 119: Retaining Ring Removal.

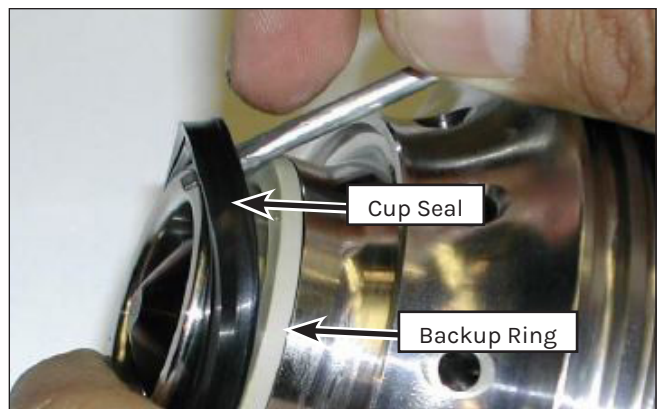


Figure 120: Cup Seal Removal.

5. Press down on the valve spring retainer and slide the spring keepers out from the assembly (Figure 121).
6. Remove the valve spring and valve spring retainer.
7. Remove the suction and discharge valves (Figure 122).
8. Inspect the valves. Refer to “Valve Inspection” on page 70 for inspection criteria.

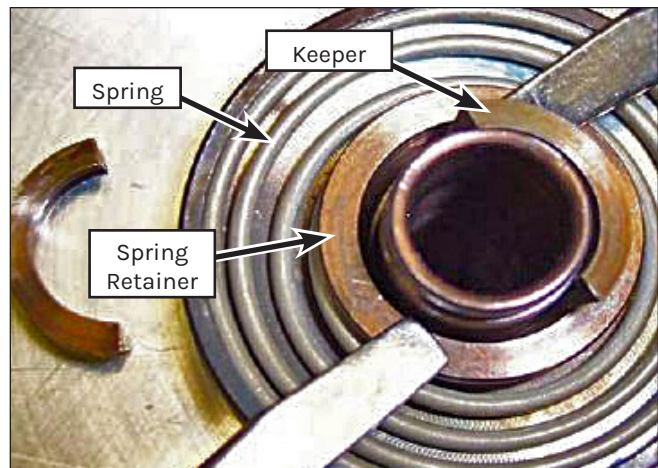


Figure 121: Spring Retainer Removal.

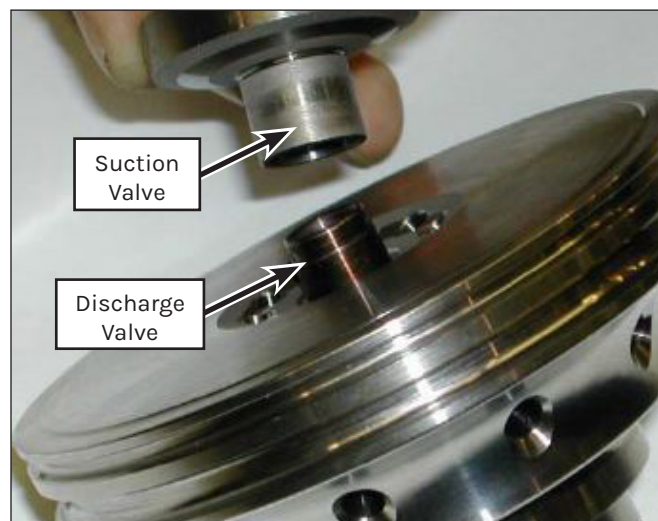


Figure 122: Valve Removal.



### Assembly

1. Install the discharge valve into the valve body (Figure 123).
2. Position the valve spring and valve spring retainer into place on the suction valve. Press down on the spring retainer to insert the keepers (Figure 124).
3. Place the backup ring (Figure 125) onto the assembly. Note the chamfer on the inside diameter of the backup ring. Orient the backup ring so the chamfer faces the valve body and the flat side of the ring faces the cup seal. Install the cup seal and the retaining ring.
4. Install the two O-rings (Figure 126).

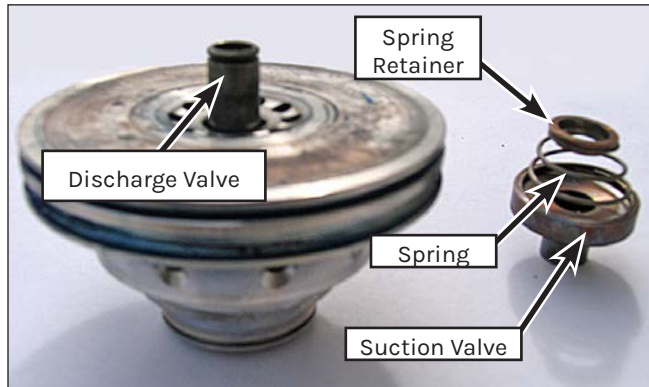


Figure 123: Valve Installation.

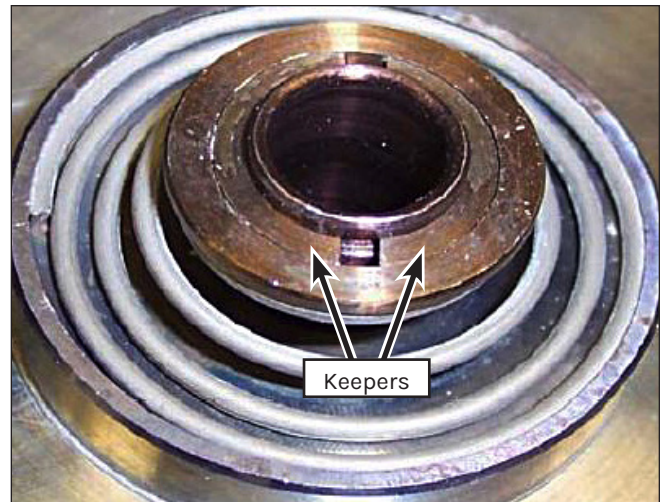


Figure 124: Installing the Keepers.

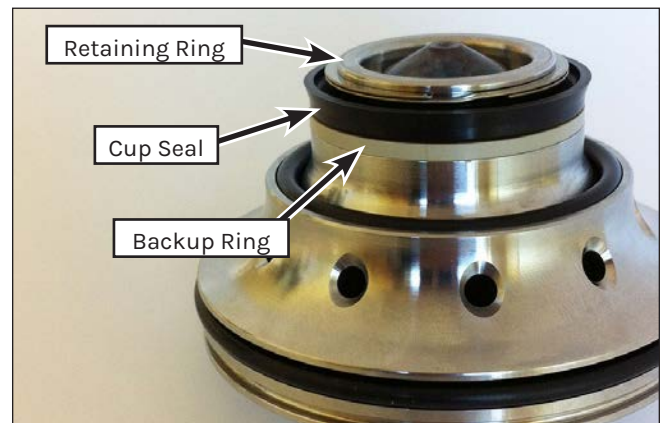


Figure 125: Install the Seal Ring.



Figure 126: Install the O-Rings.

### Valve Inspection

1. Inspect all seals and discard as necessary.
2. Inspect the valve components. Discard excessively pitted or otherwise damaged components (Figure 127).
3. For valves with minor wear or corrosion, recondition the valves as outlined in Valve Lapping.

### Valve Lapping

Lapping is a polishing process in which two surfaces are rubbed together with an abrasive between them. Lapping the valves at regular intervals ensures a tight fit between the valves and valve seat for proper sealing. Regularly lapping the valves allows the pump to operate efficiently and helps increase valve life.



### **ATTENTION**

Use silicon carbide lapping compound, 220 grit medium fine.

1. Disassemble the valve.
2. Apply lapping compound to the mating surface on the suction valve (Figure 128).
3. Place the valve into position on the valve body. Rotate the valve and valve body in opposite directions with a light pressure for approximately 30 seconds.
4. Pause lapping momentarily by disengaging surfaces. Rotate the parts in the opposite direction approximately 90 degrees. Do this a few times during lapping. This will ensure that the lapping compound distributes evenly along the valve and valve seat interface.

Repeat for approximately 2-5 minutes, until an even dull grey circular ring can be seen without any remaining pits or surface imperfections.

5. Clean off the excess lapping compound with a clean dry cloth. Inspect the contact surfaces for uniform, dull gray sealing rings (Figure 129).

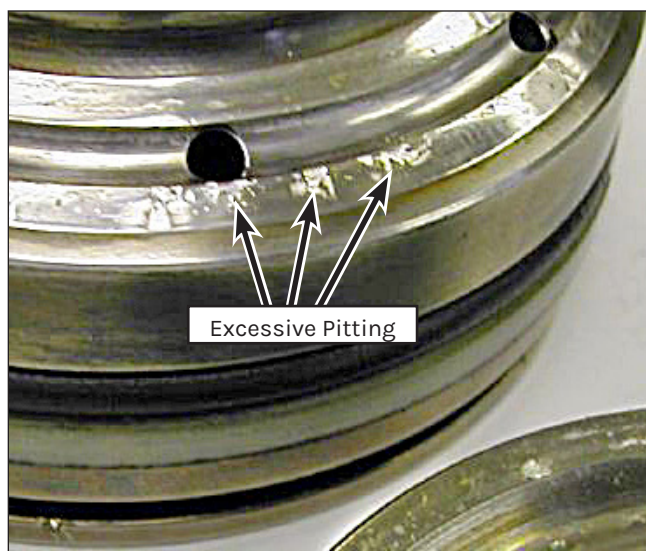


Figure 127: Valve Pitting.

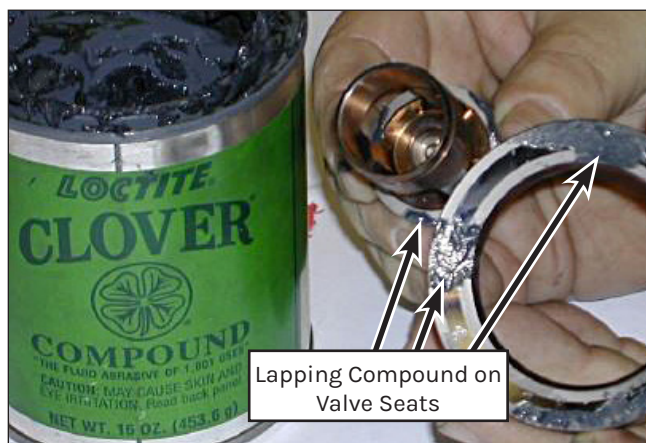


Figure 128: Typical example of lapping compound application.



Figure 129: Properly Lapped Valve Seats.



6. Continue the lapping process until the desired sealing surface is achieved.
7. Repeat the lapping process for the discharge valve.
8. When completed, clean all metal parts by submerging in a mineral spirits solution for a few minutes. Remove and air dry thoroughly with compressed air. Ensure that no compound or solution remains in the cross holes.

### Bypass Valve Cartridge Replacement

1. Remove the dump hose (Figure 130) from the bypass valve.
2. Using an adjustable wrench, remove the cartridge housing (Figure 131) from the valve.
3. Pull the cartridge (Figure 132) from the housing.
4. Inspect the diffuser (Figure 133) for jetting damage. Replace if damage is extensive.
5. Push the new cartridge into the housing until it snaps into place.
6. Install the cartridge housing back onto the bypass valve.
7. Install the dump hose onto the bypass valve.



Figure 131: Cartridge Housing Removal.

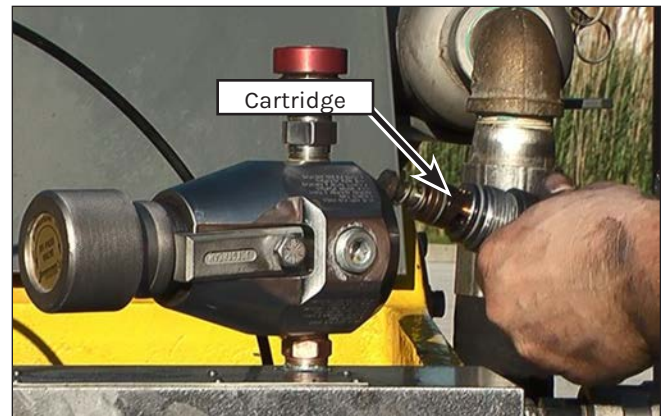


Figure 132: Cartridge Removal.

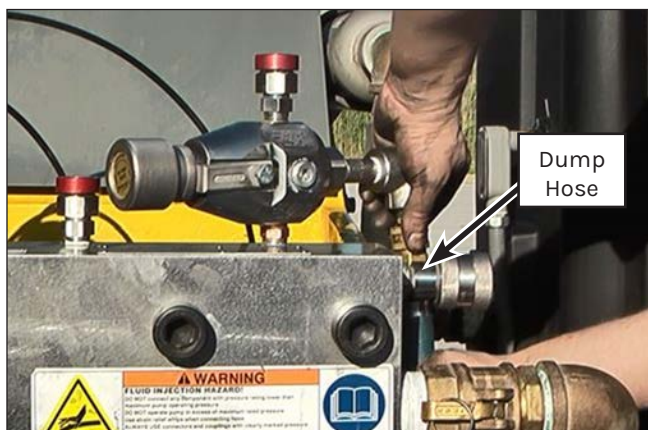


Figure 130: Dump Hose Removal.

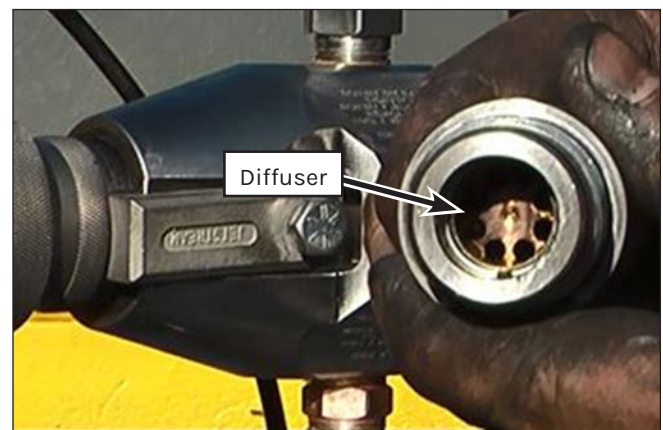


Figure 133: Seating Surface Inspection.

## Power End

### Checking Power End Oil Level

The most accurate method to check the oil is when the unit is on level ground and has not been in use for 5 to 8 hours. If the pump has been in use and the oil needs to be checked refer to the alternate methods as outlined in “Alternate Oil Check Methods” following this procedure.

**Note:** Because of varying factors such as temperature, the oil in the pump will completely settle between 5 and 8 hours.

1. Locate the sight gauge (Figure 134) on the back of the power end case. With the pump off (for 5 to 8 hours), the oil should be at the Full level.
2. If the reservoir is low, add 80W/90 detergent free gear oil while the engine is off. Remove the fill plug and add oil through the port in the back plate.

### CAUTION

*Under no circumstances should you operate the pump if there is no oil visible in the sight gauge at rest no matter what method is used to check the oil level.*

### Alternate Oil Check Methods

**Method 1:** If the pump is at or near operating temperature and needs to be stopped during operation for purposes of checking the oil, stop the pump, wait 1-2 minutes and check the sight gauge. As long as oil is visible in the gauge, the oil level is acceptable. If oil needs to be added, add 80W/90 detergent free gear oil while the engine is off. Remove the fill plug and add oil through the port.

**Method 2:** If the pump has been run recently, but it is not known how long it has been standing idle, the oil level can still be reliably checked. With the unit on level ground and the engine running at slow speed, engage the PTO so the pump turns

over slowly for 10-15 seconds. Disengage the PTO. Check the oil-level at the site gauge. If the oil level is still visible in the gauge, there is sufficient oil in the crankcase to run the pump. Optimally, the level should be halfway between the bottom of the site glass and the ADD line.

The typical oil level for a pump that has been operating and then brought to a stop is shown in (Figure 135). The oil level will be at or near the full mark only after the pump has been at rest for 5 to 8 hours.

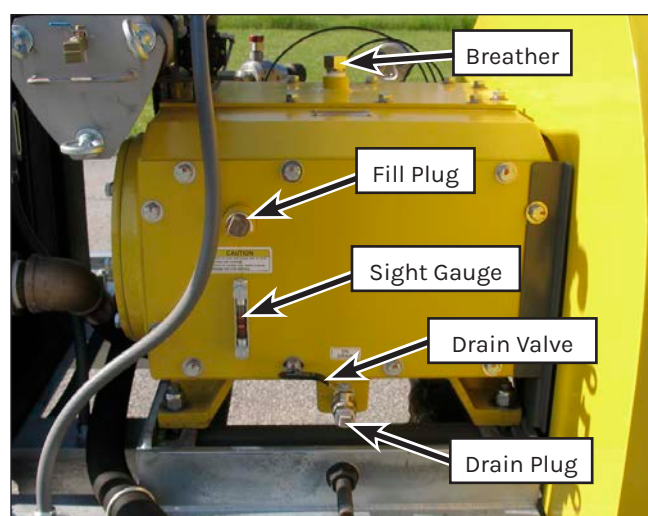


Figure 134: Oil Check and Change.



## Changing the Power End Oil

1. With the engine off, remove the drain plug (Figure 136) from the oil drain valve located on the back of the power end case.
2. Place a container below the valve large enough to capture the oil. Refer to the oil capacities listed below.
3. Install an extension hose/pipe to extend the drain past the trailer frame, if desired.
4. Open the ball valve to drain the oil.
5. After the oil has drained from the case, close the ball valve and install the plug.
6. Remove the back cover plate and inspect the magnets at the bottom of the pump for metal shavings or filings. Clean the magnet. If excessive shavings or filings were present, inspect the crankshaft journal bearings.
7. Install the back cover plate.
8. Add 80W/90 gear oil through the fill plug.
  - 3000 Series Pumps: 5 gal. (22 L)
  - 3600/4200 Series Pumps: 9 gal. (34 L)
9. Install the fill plug when done filling.

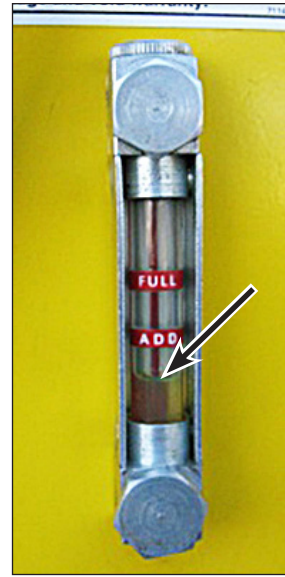


Figure 135: Typical Oil Level for Recently Operated Pumps.

## Checking PTO Oil level

1. With the engine off and clutch disengaged, check the oil level in the PTO sight gauge (Figure 135). The oil should be approximately half way up on the sight gauge.
  - a. If oil is needed, remove the breather and add 10W40 synthetic oil through the open port until the oil level begins to show in the sight gauge. Continue adding oil slowly once visible in the sight gauge so as not to overfill. The oil is slow to drain into the reservoir.
  - b. Install the breather.

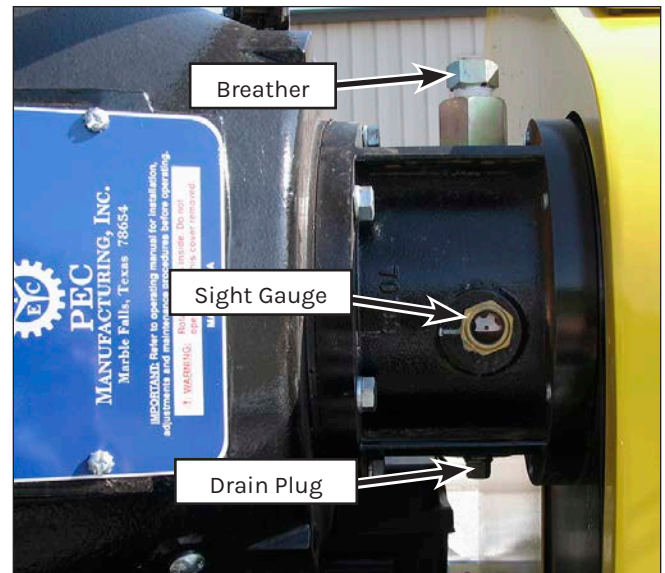


Figure 136: PTO.

## Changing PTO Oil

1. Place a container below the PTO large enough to capture the oil in the PTO case (26 oz) (0.77 L).
2. Remove the drain plug (Figure 135) and allow the oil to fully drain from the case.
3. When the oil has drained, install the drain plug.
4. Remove the breather and fill with 10W40 synthetic oil until it begins to show in the site gauge. Continue adding oil slowly once visible in the site gauge so as not to overfill. The oil is slow to drain into the reservoir.
5. Install the fill plug.

## Checking Belt Tension



### CAUTION

*Belts must be adjusted properly. Improper adjustment can lead to belt slippage and failure, or PTO bearing damage caused by excessive belt tension.*

1. Disengage the clutch and stop the engine.
2. Open the access cover on the belt guard.
3. Locate the decal on the cover to find the correct belt tension specification.
4. Adjust the deflection O-ring (Figure 137) on a belt tension tool for the proper deflection as specified on the decal. Slide the force O-ring to the bottom of the scale. Use a five barrel tension tool if power bands are used on your unit (Figure 138).
5. Position the tension tool in the middle of one of the belts mid-way between belt pulleys. Press on the tool until the deflection O-ring is even with the adjacent belt. On five barrel tensioners, press until the gauge plate (Figure 138) touches the adjacent belt.

**Note:** Power bands are five times the single belt force.

6. Release pressure and inspect the reading at the bottom edge of the force O-ring(s) (Figure 137) on the tension tool. Adjust the

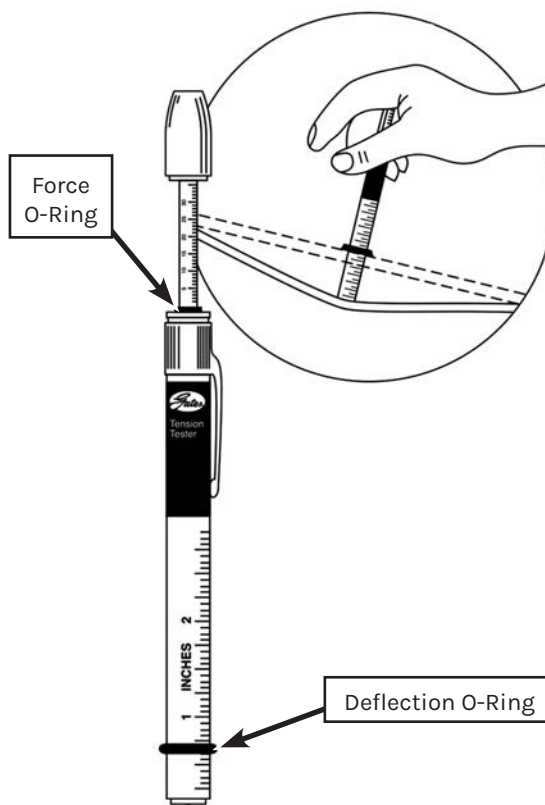


Figure 137: Single Belt Tension Tester.

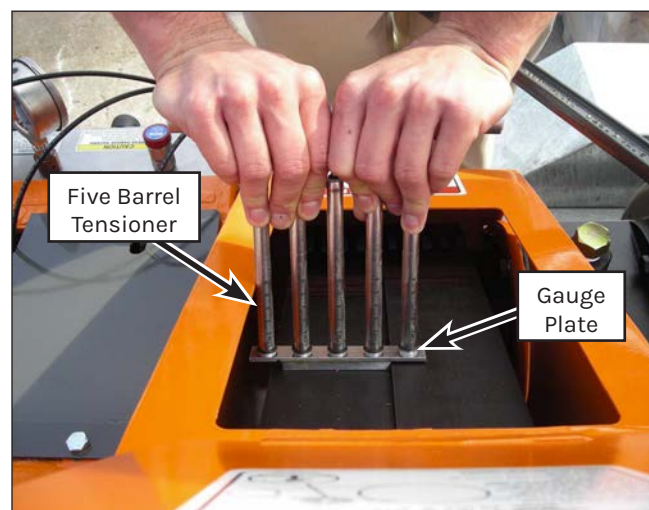


Figure 138: Power Band Tensioning

belt if necessary. Refer to “Adjusting Belt Tension”.

## Adjusting Belt Tension

1. Loosen the four pump mounting bolts (Figure 139). the bolts are located on each corner of the pump.
2. Adjust the tension by turning the tensioner nut . Turn clockwise to increase belt tension. Turn counter-clockwise to decrease belt tension.
3. Tighten the four pump mounting bolts to ensure a proper tension reading.
4. Recheck the belt tension as outlined in “Checking Belt Tension” on page 74.



### ATTENTION

*If belt slippage occurs after tensioning, replace the belts. Check the tension after the first 20 minutes of operation with the new belts.*

## Replacing the Belts

1. Remove the five mounting nuts (Figure 140) that secure the belt guard to the unit.
2. If a hoist is available, attach a hoist and appropriate lifting apparatus to the belt guard. Lift the belt guard from the unit. The weight of the belt guard is approximately 70 lb (32 kg). If a hoist is not available, use two people to carefully lift the guard from the unit.
3. Loosen the four pump mounting bolts (Figure 139).
4. Turn the tensioner nut counter-clockwise and move the pump to decrease the belt tension enough to allow belt removal.
5. Remove the belts and discard. Place the new belts into position.
6. Adjust the tension using the tensioner nut and then check the tension as outlined in “Checking Belt Tension” on page 74.
7. Lift the belt guard back onto the unit and install the five nuts and washers that secure the guard to the unit.

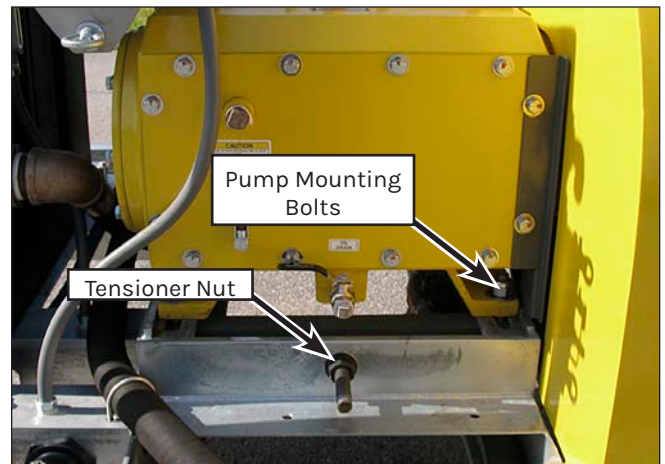


Figure 139: Adjustment Hardware.

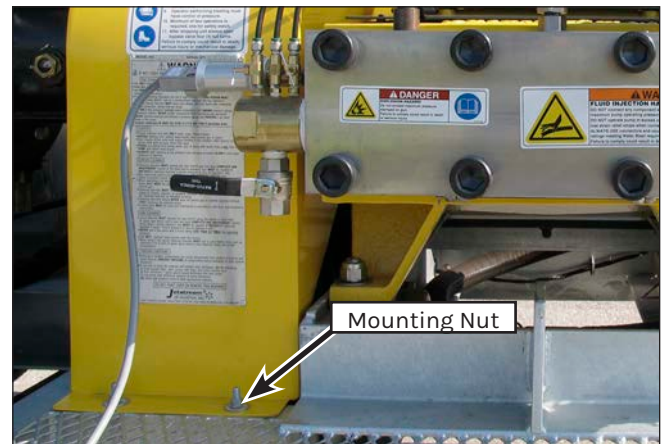


Figure 140: Belt Guard Hardware.



Figure 141: Belt Guard Removal.



## Charge Pump

### Removal

1. Park the trailer on a hard, level surface and chock the wheels. For skid mounted units, lift the unit onto a hard, level surface and install cribbing under the unit for access to the charge pump.
2. Drain the water from the water tank.
3. Remove the five mounting nuts (Figure 142) that secure the belt guard to the unit and lift the guard from the unit.
4. If a hoist is available, attach a hoist and appropriate lifting apparatus to the belt guard. Lift the belt guard from the unit. The weight of the belt guard is approximately 70 lb (32 kg). If a hoist is not available, use two people to carefully lift the guard from the unit.
5. Remove the charge pump drive belt (Figure 143) by releasing the belt tension using the spring loaded tensioner.
6. Remove the drive sheave by removing the bushing screws and reinstalling them in the threaded holes in the bushing. Tighten the screws to separate the tapered bushing from the sheave. Loosen the set screw in the bushing and remove the bushing.
7. Remove the output hose (Figure 144) and the supply hose from the charge pump.
8. Remove the two capscrews (Figure 144), nuts and washers that secure the charge pump to the mounting bracket. Remove the charge pump.

### Installation

1. Place the charge pump into position on the mounting bracket. Install the two capscrews (Figure 144), nuts and washers that secure the charge pump to the bracket. Tighten the capscrews to 9 ft. lb (12 N·m).
2. Place the sheave bushing in place and install the set screw. Install the sheave onto the bushing. Check for proper belt alignment (Figure 143).
3. Connect the supply hose and outlet hose to the charge pump.

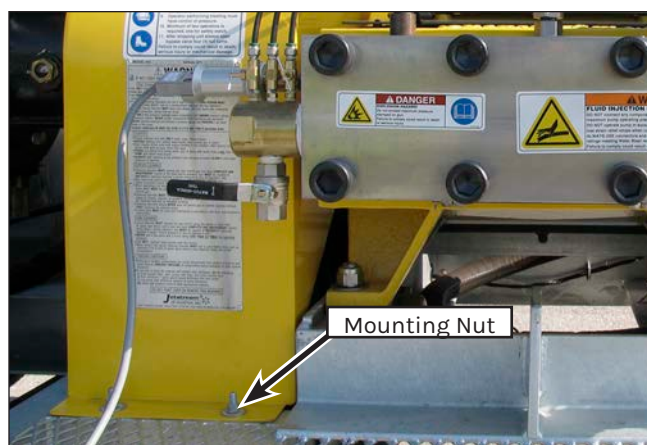


Figure 142: Belt Guard Hardware.

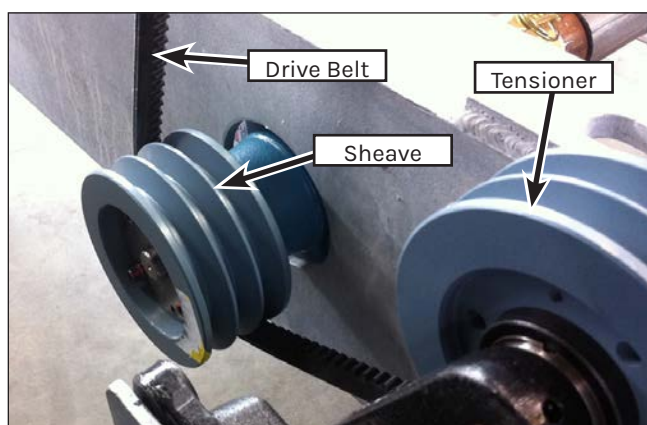


Figure 143: Charge Pump Drive.

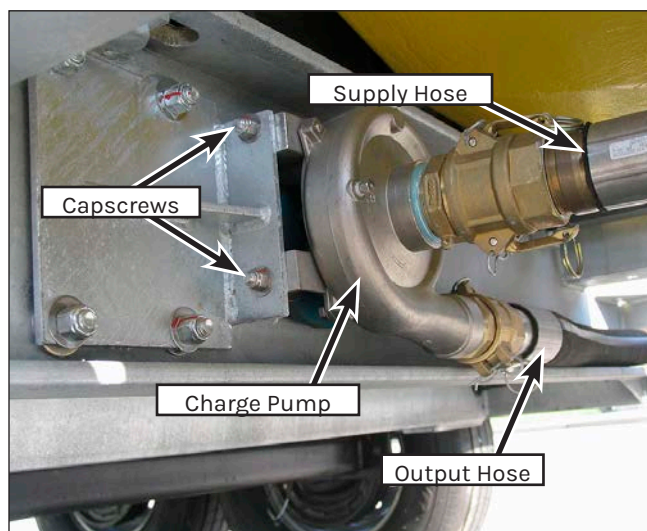


Figure 144: Charge Pump Removal.



4. Install the charge pump drive belt.
5. If a hoist is available, attach a hoist and appropriate lifting apparatus to the belt guard. Lift the belt guard from the unit. The weight of the belt guard is approximately 70 lb (32 kg). If a hoist is not available, use two people to carefully lift the guard from the unit.
6. Install the five nuts and washers that secure the guard to the unit (Figure 142).

## Crosshead Pony Rod Seals

### Removal

1. Relieve pressure from the pump, shut off the engine and disengage the clutch.
2. Turn off the water supply and drain the water tank.
3. Drain the oil from the crankcase. Refer to “Changing the Power End Oil” on page 73 for instructions.
4. Open the rod box cover.
5. Disconnect the water lubrication lines if desired for easier access.
6. Position the pony rod to be serviced so that it is at top dead center (plunger fully extended towards the crankshaft). Pull on the drive belts to rotate the pump (Figure 145).



### **WARNING**

Use caution when rotating the pump as this can be a pinch hazard.

7. Remove the two capscrews that secure the plunger coupling (Figure 146) to the plunger and remove the coupling. Rotate the pump until the pony rod is fully retracted.

**Note:** The coupling halves are a machined pair. Keep the two halves together.

8. Slide the rubber deflector (Figure 146) off of the pony rod.
9. Remove the three capscrews and washers that secure the rod box cover to the frame. Remove the cover. Remove the rubber washers that sit below the mounting plate.
10. Using a 1/4" hex driver, loosen the set screw inside the bolt hole 2-3 full revolutions (Figure 147).



Figure 145: Rotating the Belt Drive.

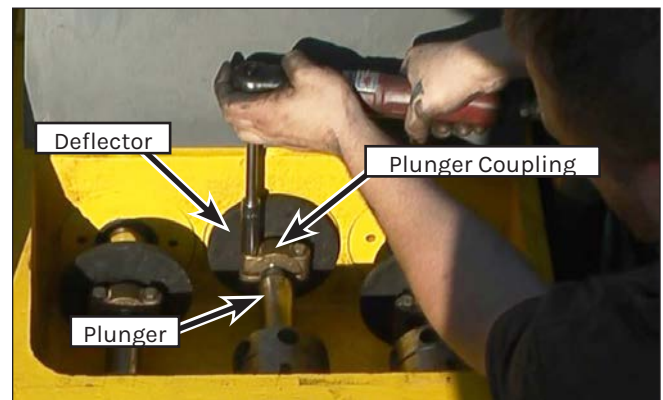


Figure 146: Plunger Coupling Removal.

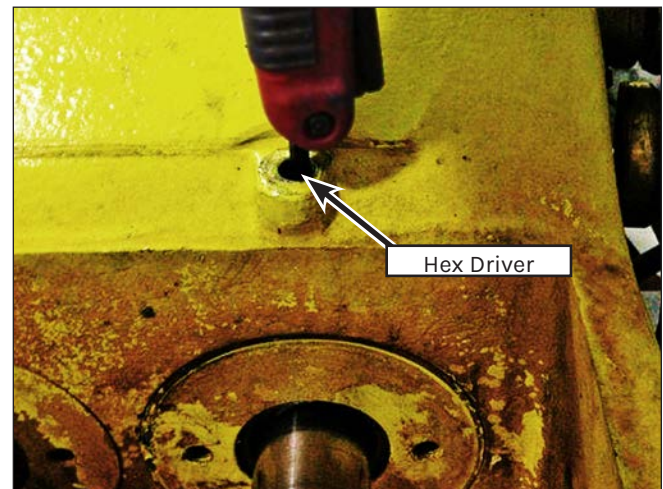


Figure 147: Set Screw Access.

11. Install two 1/2"-13 UNC capscrews (Figure 148) into the seal plate.
12. It may be necessary to use a long pry bar with the power frame as a lever to pry the back of the bolts. The seal plate should pop out from its bore. Remove the plate (Figure 149).
13. Remove the O-ring and press the seals from the plate. Discard the O-ring and seals.
14. Repeat for the remaining crosshead seals, if necessary.

### Installation

1. Place the seal plate in a hydraulic or arbor press with the inboard side facing up. Place the red outboard seal into position and orient the seal (Figure 149).
2. Use the press to press the seal into the plate until it is flush with the face of the plate. Use caution to avoid damaging the seal.

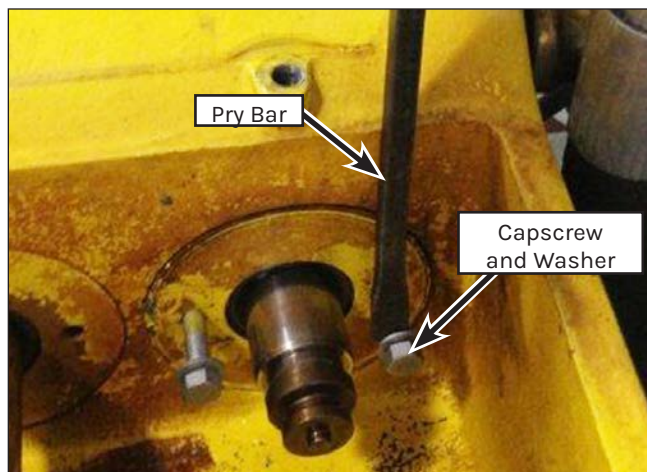


Figure 148: Seal Plate Removal.

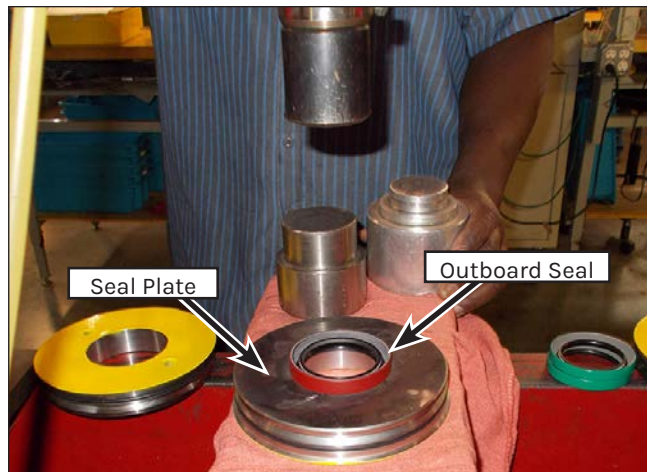


Figure 149: Outboard Seal Installation.



Figure 150: Pressing the Seal.



3. Place the green inboard seal into position on top of the outboard seal and orient the seal (Figure 151). Press the seal into the plate until it is flush with the face of the plate. Use caution to avoid damaging the seal.
4. Install a new O-ring (Figure 152) onto the seal plate. Lubricate the O-ring with O-ring lubricant.
5. Lubricate the inner seals with clean oil.
6. Repeat the prior steps for the remaining seal plates, if necessary.
7. Clean the seal plate bore and chamfer with emery cloth. Smooth any rough edges that can cut or damage the O-ring.
8. Carefully install the seal plate onto the pony rod and into the bore using hand pressure only. Do not hammer the plate into place. The plates must be flush with the frame.
9. Using a 1/4" hex drive, tighten the set screw that secures the plate to 15 in.-lb. (1694 mN·m) inside the access holes.
10. Install the deflector (Figure 153) onto the pony rod.
11. Extend the plunger from the stuffing box to meet the pony rod.
12. Place the plunger coupling into position and install the capscrews that secure the plunger. Tighten to 20 ft.-lb.(27 N·m).
13. Place the rubber washers into position on the frame and then place the cover into position. Install the three capscrews and washers that secure the cover.
14. Add oil to the crankcase as outlined in "Changing the Power End Oil" on page 73.

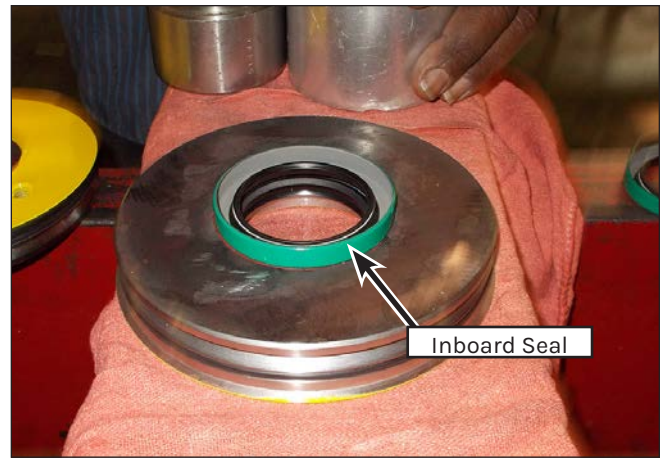


Figure 151: Inboard Seal Installation.

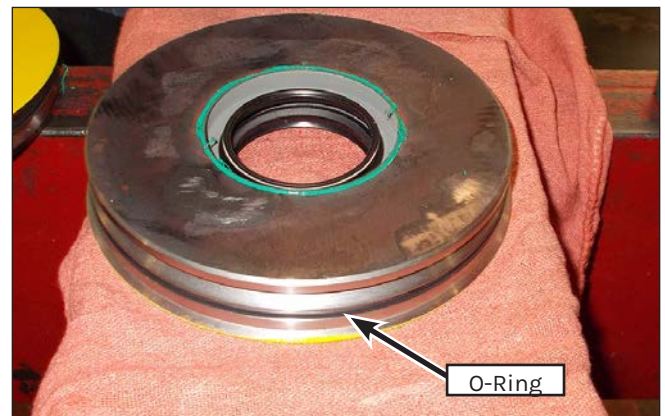


Figure 152: O-Ring Installation.

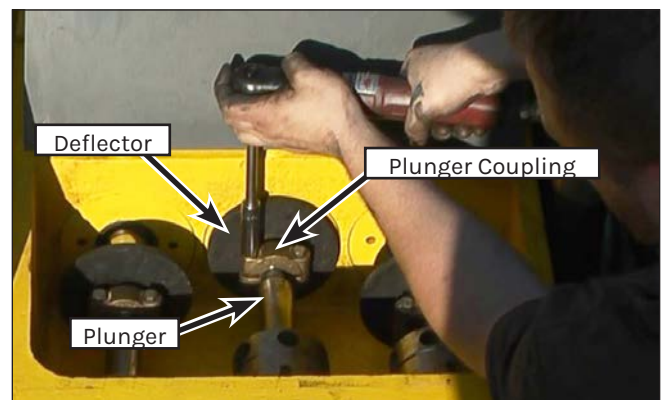


Figure 153: Plunger Connection.

## Rod Journal Bearings

### Removal

1. Drain the oil from the power end as outlined in “Changing the Power End Oil” on page 73.
2. Once drained, remove the capscrews, washers and lockwashers from the back plate (Figure 154). Remove the plate, belt guard and gasket. If the gasket is stuck to the frame, it can remain.
3. Remove the rod cap capscrews (Figure 155) from each rod journal. Rotate the pump by pulling on the belts (Figure 156), to gain access to the capscrews as needed.



### **WARNING**

Use caution when rotating the pump as this can be a pinch hazard.

4. Once the capscrews are removed, remove each rod cap from the crankshaft. Observe the stamp marks on the top of the cap and rod for correct assembly.
5. To check the bearing life, proceed to Inspection. If the bearings are known to be worn, continue to the following step.

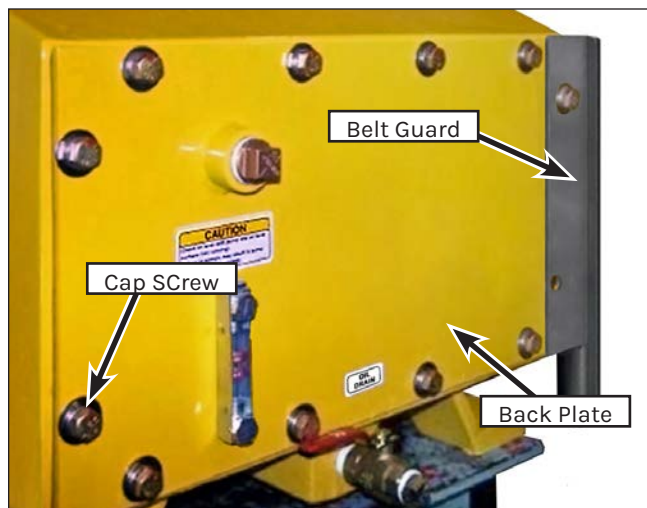


Figure 154: Back Plate Removal.

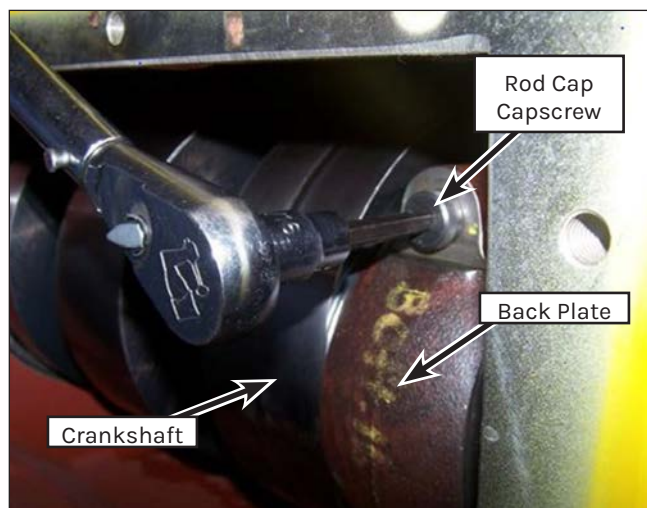


Figure 155: Rod Cap Removal.



Figure 156: Rotating the Pump.



6. Remove the journal bearing from the rod cap and discard (Figure 157).
7. To access the inner journal bearing (Figure 158), push the connecting rod away from the crankshaft. Slide the bearing from the rod.

### **Inspection**

1. Wipe the excess oil from the end cap bearings.
2. Install a small strip of plasti-gauge onto the end cap bearing (Figure 159).
3. Position the end cap with capscrews back onto the matching connecting rod.
4. Screw in the capscrews by hand and then tighten to the proper torque:
  - 3000 Series Pumps: 45 ft.lb (61 N·m)
  - 3600/4200 Series Pumps: 80 ft.lb (108 N·m)
5. Remove the end cap.

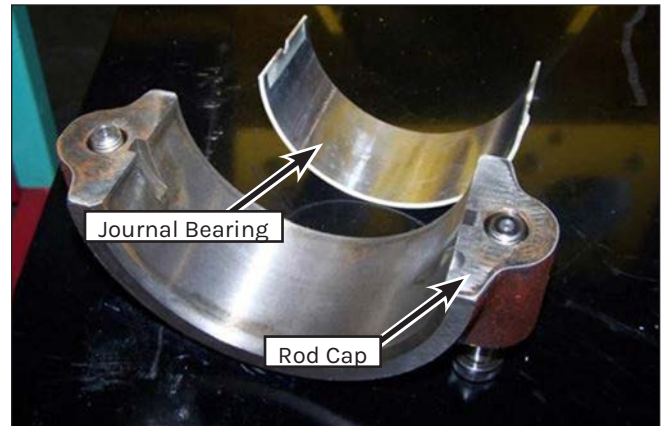


Figure 157: Bearing Removal.

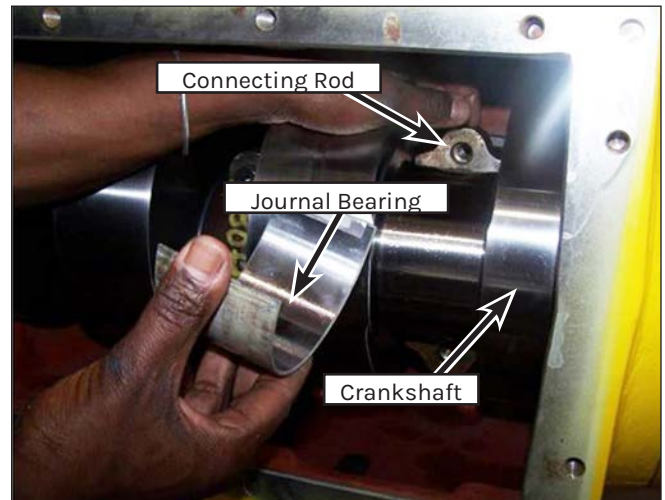


Figure 158: Inner Bearing Removal.

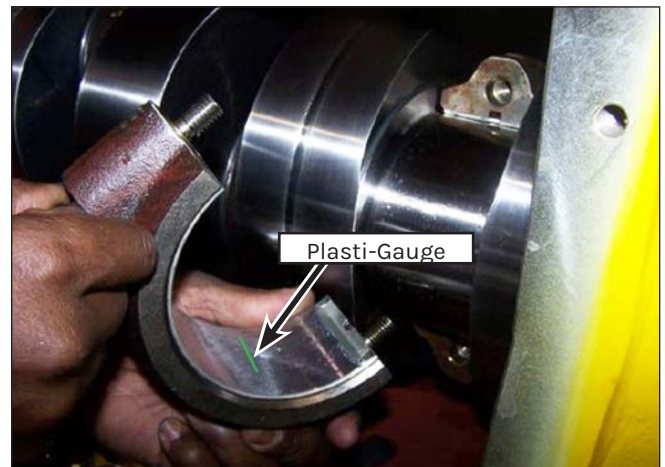


Figure 159: Plasti-Gauge Installation.

6. Measure the flattened plasti-gauge using the gauge wrapper (Figure 160).
7. If the thickness of the plasti-gauge exceeds 0.012 in. (0.31 mm), replace the bearings. If the bearings do not exceed the criteria, the bearings can be reused.

**Note:** New part clearances are as follows:

- Series 3000: 0.001 in. (0.025 mm) - 0.005 in. (0.13 mm)
- Series 3600/4200: 0.002 in. (.05 mm) - 0.005 in. (0.13 mm)

### **Installation**

1. Apply clean new oil to the new connecting rod journal bearing (inner diameter only) (Figure 161).
2. Slide the bearing (Figure 162) into the connecting rod from below the crankshaft journal.



### **ATTENTION**

*The journal bearings have tabs that match the inner diameter of the connecting rods. Ensure the bearings are properly oriented in the tabs when installing (Figure 163).*

3. Apply oil to the inner surface of the cap end bearing.
4. Properly orient the grooves and install the bearing in the rod cap.
5. Place the two capscrews into the rod cap.



Figure 160: Plasti-Gauge Measurement.



Figure 161: Lubricating the Bearing.



Figure 162: Rod Bearing installation.

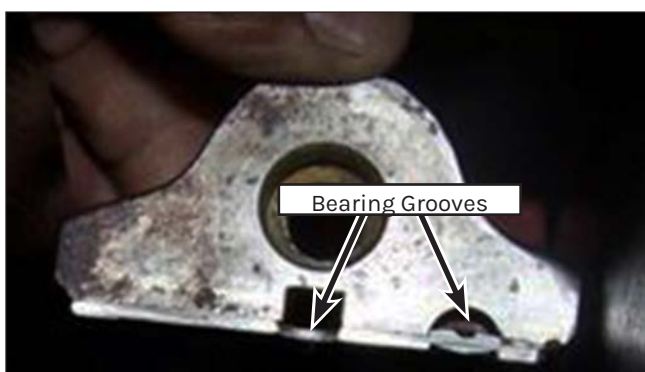


Figure 163: Bearing Grooves.

6. Pull the connecting rod (Figure 164) onto the crankshaft and place the rod cap into position aligned with the connecting rod. Ensure the stampings (Figure 165) on the cap and rod match.
  7. Screw in the capscrews by hand and then tighten to the proper torque:
    - 3000 Series Pumps: 45 ft.lb (61 N-m)
    - 3600/4200 Series Pumps: 80 ft.lb (108 N-m)
  8. With the first rod connected, rotate the pump by pulling the belts. Allow the crankshaft to turn a few revolutions to ensure the rod was properly installed.
- If the crankshaft spins freely, the bearings were properly installed.
- If the crankshaft does not spin freely, remove the journal bearings and replace with another set.
9. Repeat the previous steps for installation of the remaining journal bearings.
  10. Place the back plate (Figure 166), belt guard and gasket into position on the frame.
  11. Install the capscrews, lock washers and flat washers. Tighten the capscrews to the proper torque.
    - 3000 Series Pumps: 20 ft.lb (27 N-m)
    - 3600/4200 Series Pumps: 35 ft.lb (47 N-m)
  12. Fill the power end with oil as outlined in "Changing the Power End Oil" on page 73.

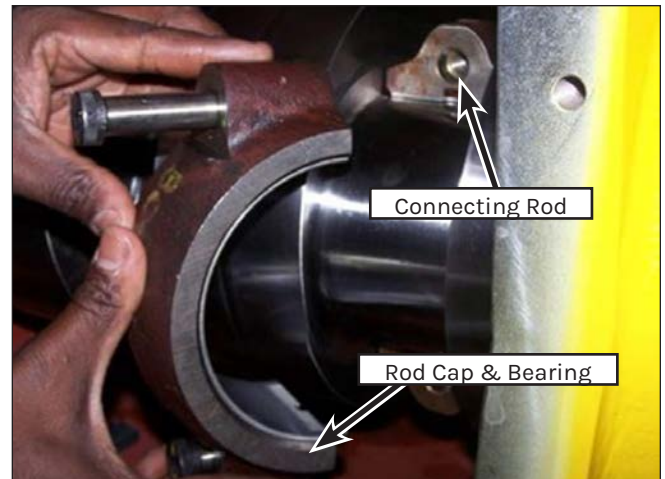


Figure 164: Rod Cap Installation.

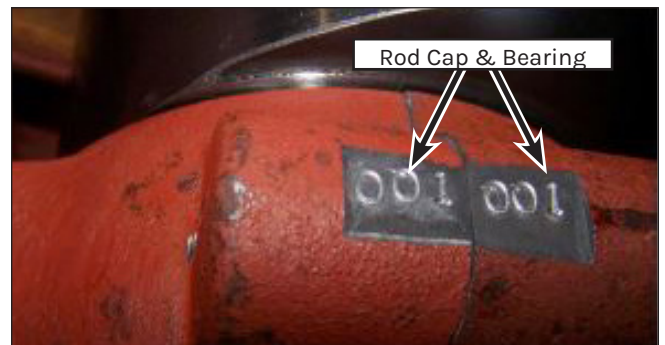


Figure 165: Matched Parts Stampings.

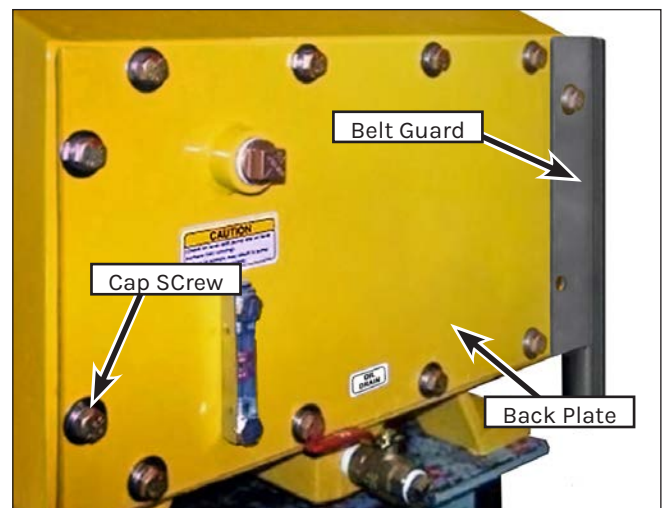


Figure 166: Cover Plate Installation.



## Crosshead and Connecting Rod Assembly

### Removal

1. Remove the crankshaft from the pump as outlined in “Crankshaft” on page 88.
2. Use two people to lift the crosshead/connecting rod assemblies from the crankcase. The weight and location of the assemblies make it difficult for one person to remove on their own.

### Disassembly

1. Remove the two set screws from the crosshead (Figure 167). The set screws are installed on top of one another in the same hole.
2. Slide the pin out from the assembly (Figure 168).
3. Remove the connecting rod from the crosshead.
4. Keep the components for each assembly together.
5. Disassemble the remaining assemblies.

### Bushing Inspection

1. Use a micrometer to measure the outer diameter of the pin in three places and record the measurements.
2. Add the three measurements and divide by 3 to get the average diameter.
3. Use an inside micrometer to measure the bushing in the connecting rod in three places and record the measurements.
4. Add the three measurements and divide by 3 to get the average diameter.
5. Subtract the diameter of the pin from the inside diameter of the bushing. If the remainder is greater than 0.008 in. (0.2 mm), the bushing must be replaced. Note the new bushing will require honing after installation into the connecting rod to achieve the clearance listed below.

**Note:** New part clearances are as follows:

- Series 3000: 0.0030 in. (0.08 mm) - 0.0037 in. (0.09 mm)
  - Series 3600/4200: 0.0040 in. (0.1 mm) - 0.0047 in. (0.12 mm)
6. Repeat for the remaining assemblies.



Figure 167: Set Screw Removal.

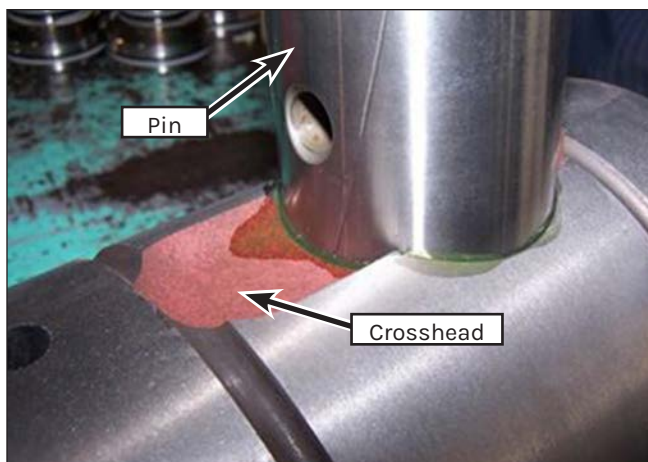


Figure 168: Pin Removal.

**Crosshead Inspection**

1. Use a micrometer to measure the outer diameter of the crosshead in three places and record the measurements.
2. Add the three measurements and divide by 3 to get the average diameter.
3. Use an inside micrometer to measure the crosshead bore in the power frame in three places and record the measurements.
4. Add the three measurements and divide by 3 to get the average diameter.
5. Subtract the diameter of the crosshead from the inside diameter of the crosshead bore. If the remainder is greater than 0.012 in. (0.31 mm), the crosshead must be replaced.

**Note:** New part clearances are as follows:

- Series 3000: 0.004 in. (0.1 mm) - 0.007 in. (0.2 mm)
- Series 3600/4200: 0.006 in. (0.15 mm) - 0.009 in. (0.23 mm)

6. Repeat for the remaining assemblies.

**Assembly**

1. Clean all surfaces of the crossheads, pins, and connecting rods using brake cleaner.
2. Inspect all surfaces of the crossheads, pins, and connecting rods for any signs of damage. Replace any suspect or damaged parts.
3. Inspect the long bore oil passage through the length of the connecting rod. Use a wire or a long handle brush to clear passage if necessary.
4. Insert the connecting rod into the bottom of the crosshead and line up the bores.
5. Lubricate the pin (Figure 169) with clean oil and insert the pin into the hole in the side of the crosshead.
6. Align the hole in the connecting rod with the pin as it is slipped in.
7. Thread the first set screw into the crosshead hole until it touches the pin, then back off a 1/4 turn. Slide the pin into position and tighten the set screw ensuring the screw is engaged in the counterbore of the pin. Tighten the set screw to 30 ft lb (41 N·m).

8. Apply Loctite Red-271© onto the threads of the second backup set screw.
9. Install the second set screw on top of the first set screw. Tighten to 36 ft lb (49 N·m) (Figure 170).
10. The crosshead is now ready for installation in the pump.

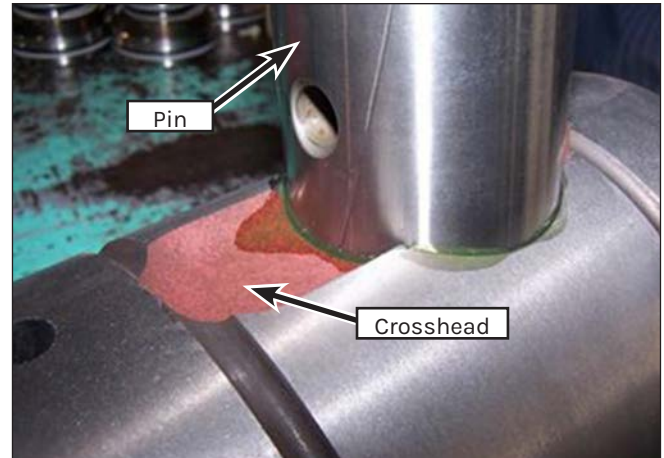


Figure 169: Pin Placement.



Figure 170: Second Set Screw Installation.

## Installation

1. Place the crosshead/connecting rod assemblies into position inside of the crankcase.
2. Install the crankshaft as outlined in “Installation” on page 89.

## UNx Pump

### Removal

1. Drain the water tank.
2. Remove the bypass hose and supply hose (Figure 171). If the supply hose is connected to the secondary filter, disconnect it from the filter.
3. Remove the two screws that secure the hydro-throttle switch housing to the cartridge and disconnect the switch.
4. If equipped, the secondary filter switch must be disconnected. Remove the two screws that secure the switch cover (Figure 172) and disconnect the wiring. Unscrew the conduit fitting from the switch housing and lay the conduit and wiring aside.
5. Remove the belts as outlined in “Replacing the Belts” on page 75.
6. Use a marker to mark the location of the pump footings for easier installation.
7. Remove the four pump mounting cap-screws and nuts.
8. Attach a hoist and lifting apparatus to the pump as shown in (Figure 173). The weight of the pump is approximately:
  - 3000 Series: 1200 lb. (544 kg)
  - 3600/4200 Series: 2200 lb. (998 kg)
9. Lift the pump from the unit and place in a suitable location for servicing.
10. If shims were under the pump, keep the shims together and note their proper location.

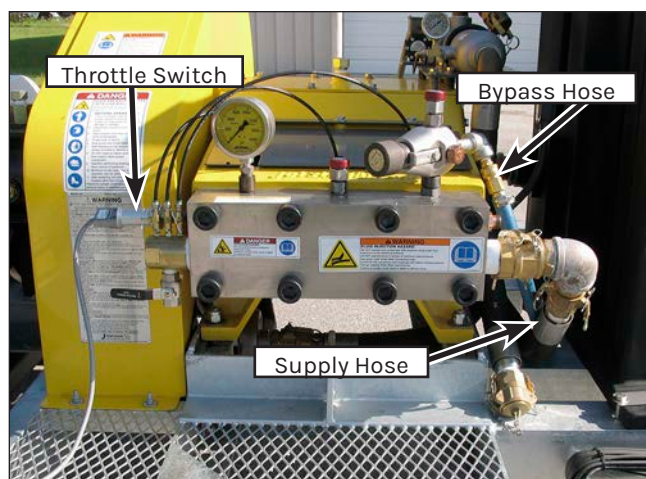


Figure 171: Pump Removal Preparation.

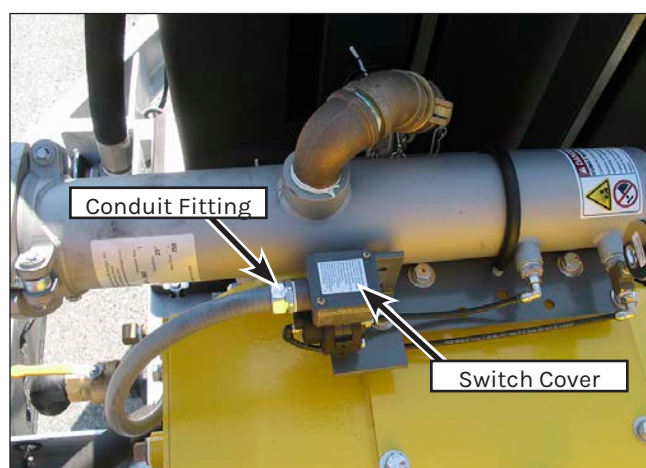


Figure 172: 40K Switch Wiring.

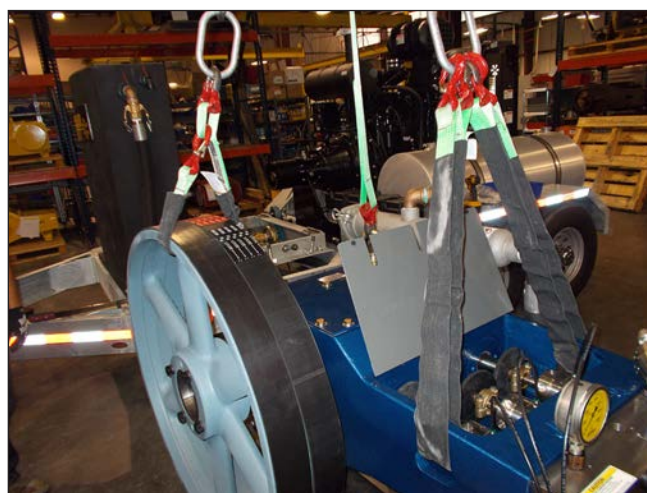


Figure 173: Lifting the Pump.



## Installation

1. If shims were under the pump, place the shims in their proper location.
2. Apply an anti-seize compound to the four pump mount channels (Figure 174).
3. Attach a hoist and lifting apparatus to the pump as shown in (Figure 175). The weight of the pump is approximately:
  - 3000 Series: 1200 lb. (544 kg)
  - 3600/4200 Series: 2200 lb. (998 kg)
4. Place the pump into position on the unit and position the pump near the position markings that were made during removal. Once in position, remove the lifting apparatus.
5. Loosely install the pump hardware.
6. Install the belts onto the pulleys. Adjust the belt tension as outlined in “Adjusting Belt Tension” on page 75.
7. Install the belt guard.
8. If equipped with a secondary filter, insert the switch wiring into the switch housing and connect the conduit fitting (Figure 176) to the housing. Connect the wires and install the switch cover.
9. Place the hydro-throttle switch (Figure 177) in place on the hydro-throttle cartridge. Install the two screws that secure the hydro-throttle switch to the cartridge.
10. Install the bypass hose (Figure 177) and supply hose.



Figure 174: Apply Anti-Seize to the Pump Channels.

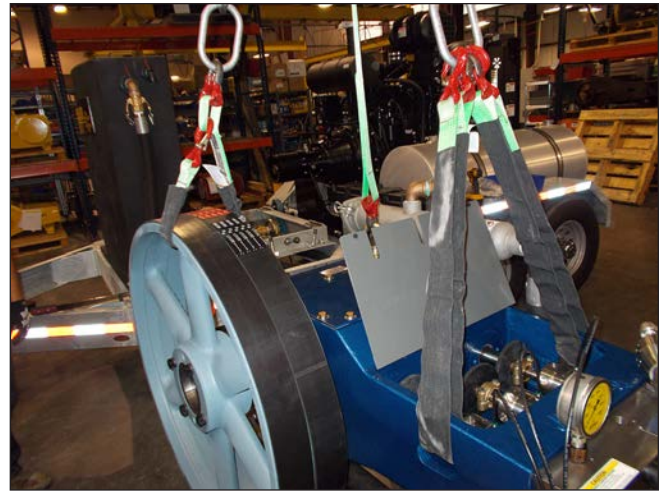


Figure 175: Lifting the Pump.

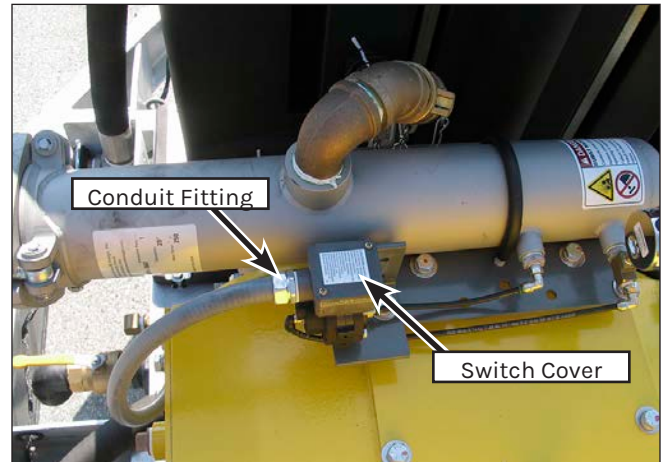


Figure 176: 40K Switch Wiring.

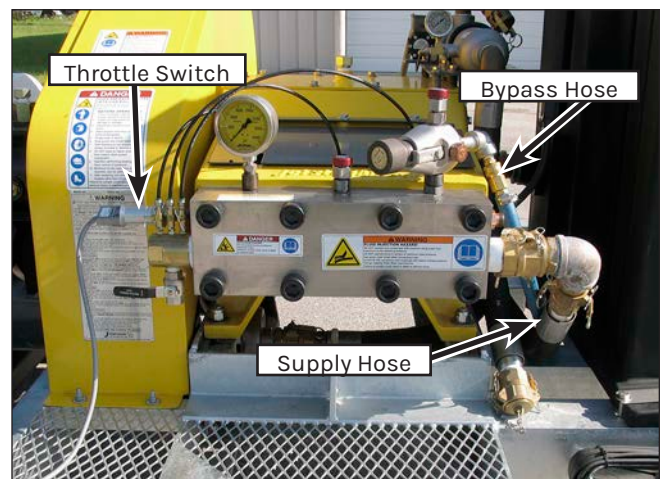


Figure 177: Connect the Switch and Hoses.

## Crankshaft

### Removal

1. Remove the pump from the unit. Refer to “UNx Pump” on page 86.
2. Open the rod box cover and remove the two capscrews that secure the plunger coupling (Figure 178) to the plunger and remove the coupling.

**Note:** The coupling halves are a machined pair. Keep the two halves together.

3. Remove the connecting rod end caps as outlined in “Rod Journal Bearings” on page 80.
4. Remove the 12 capscrews and washers that secure the top cover (Figure 179) to the power frame. Remove the cover and the gasket.
5. Remove the 12 capscrews and washers that secure the rear cover (Figure 179) and belt guard to the power frame. Remove the cover, guard and gasket.

6. Pull the three connecting rod/crosshead assemblies towards the fluid end as far as possible.
7. Remove the eight capscrews and washers that secure the inboard side plate (Figure 179) to the power frame.
8. Remove the side plate and shims. Keep the shims together.
9. Remove the eight capscrews and washers that secure the outboard side plate (Figure 179) to the power frame.

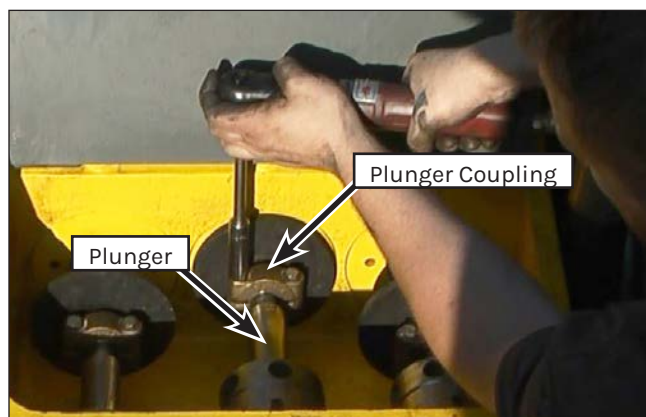


Figure 178: Plunger Coupling Removal.

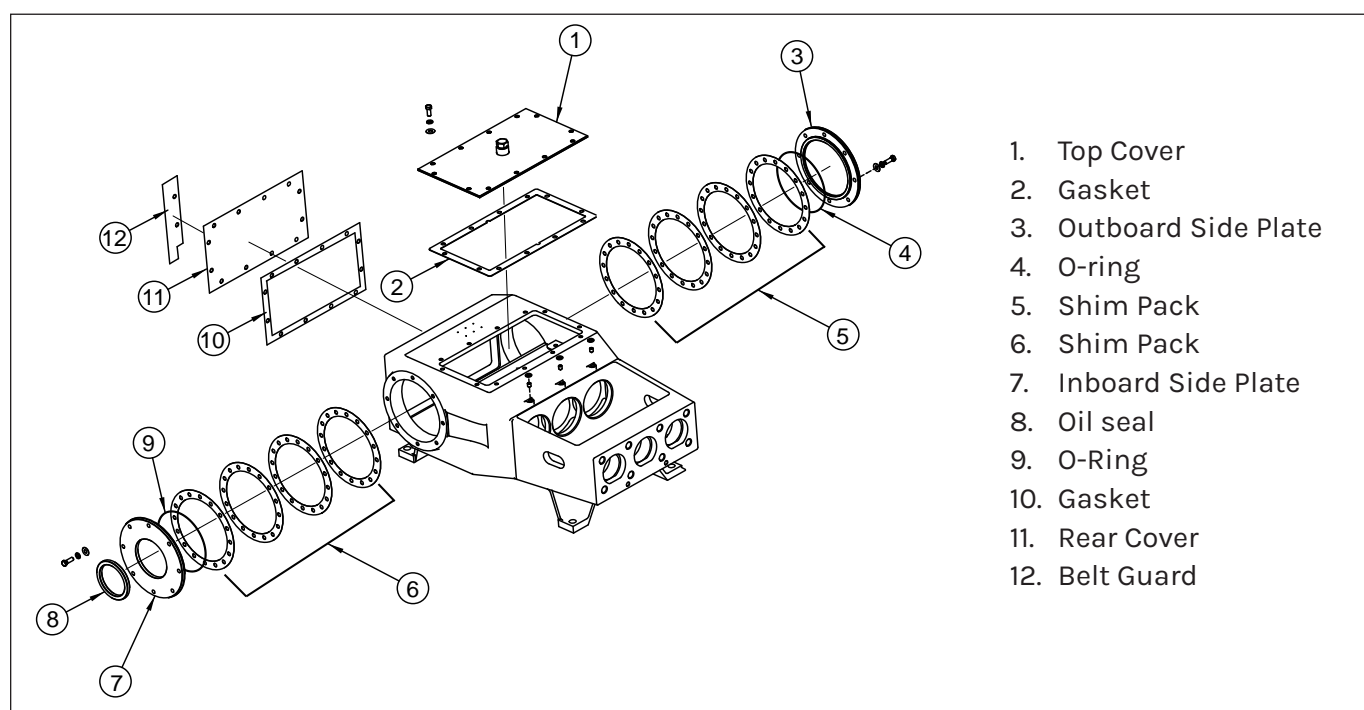


Figure 179: Power End Covers.

10. Remove the side plate and shims while supporting the crankshaft. Keep the shims together.
11. Using a wood block and a hammer, hit either end of the crankshaft to unseat it from its bearing bores.

### **WARNING**

Use caution when unseating the crankshaft. The crankshaft will fall approximately 1 in. (25 mm) as it slides out of the tapered race and can cause bodily harm.

12. Install two threaded rods (1 in.-8NC x 8 in.) into the ends of the crankshaft to aid in removal.
13. Using two people, lift the crankshaft from the power frame. The weight of the crankshaft is approximately:
  - 3000 Series: 125 lb. (57 kg)
  - 3600/4200 Series: 325 lb. (147 kg)
14. Remove the bearings from the crankshaft. Contact Jetstream for assistance with this task.

### **Installation**

1. Heat the crankshaft bearings in a 250°F (121°C) oven for 20 minutes. Check the bearing color as they are heated. If the bearings turn blue or black they are overheated.

### **CAUTION**

Temperatures in excess of 250°F (121°C) will damage the bearing. If the bearings have been heated over the limit, discard the bearings.

2. When ready, slide the bearings onto each end of the crankshaft until they are fully seated (Figure 180).
3. Verify that the bearing turns on the shaft.
4. Allow the crankshaft assembly to cool.
5. Install the outer bearing race (Figure 181) onto the inboard bearing.
6. Install the outer bearing race (Figure 182) into the power frame using a rubber mallet. Install the race so it is flush with the face of the case.



Figure 180: Bearing Installation.

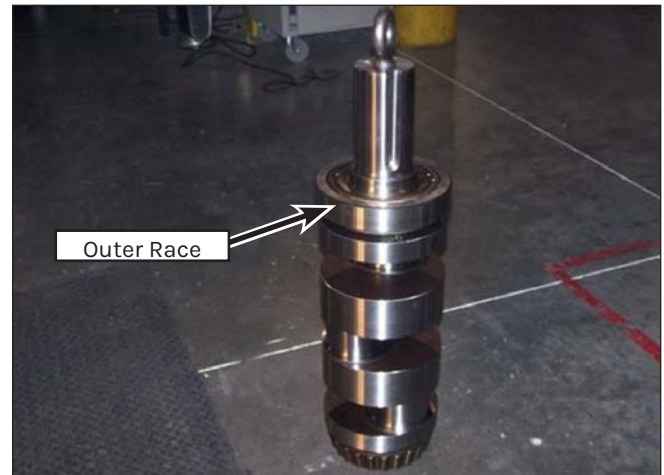


Figure 181: Outer Race Installation.

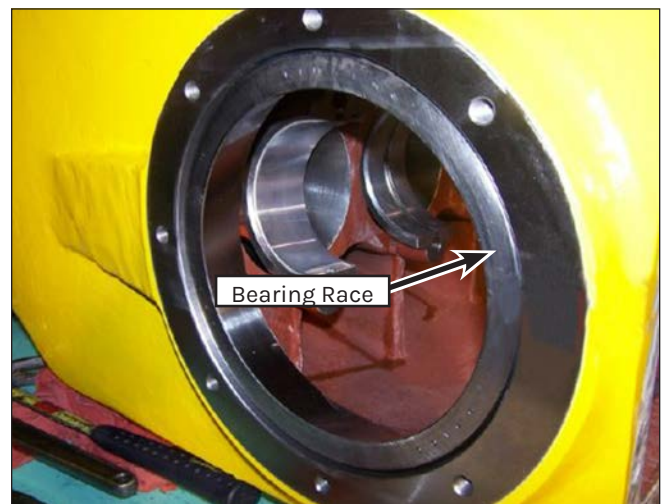


Figure 182: Bearing Race Installation.



7. Place the three crosshead/connecting rod assemblies into place (Figure 183). Allow clearance for the crankshaft by pushing them towards the fluid end.
8. Install two threaded rods (1 in.-8NC x 8 in.) into the ends of the crankshaft to aid in installation.
9. Using two people, lift the crankshaft into the power frame. The weight of the crankshaft is approximately:
  - 3000 Series: 125 lb. (57 kg)
  - 3600/4200 Series: 325 lb. (147 kg)
10. Using a wood block and a hammer, hit either end of the crankshaft to seat it in the bearing bore. Ensure the outer bearing race (Figure 184) is inside the power frame case.
11. Tap in the bearing race on the opposite end of the crankshaft if not already installed.
12. Install a new oil seal and O-ring onto the inboard side plate. Install the outboard and inboard side plates with the original shim packs. Ensure the thickness of each shim pack is equal on both ends. Install four equally spaced side plate capscrews and tighten to 50 ft.lb (68 N·m) (Figure 185).

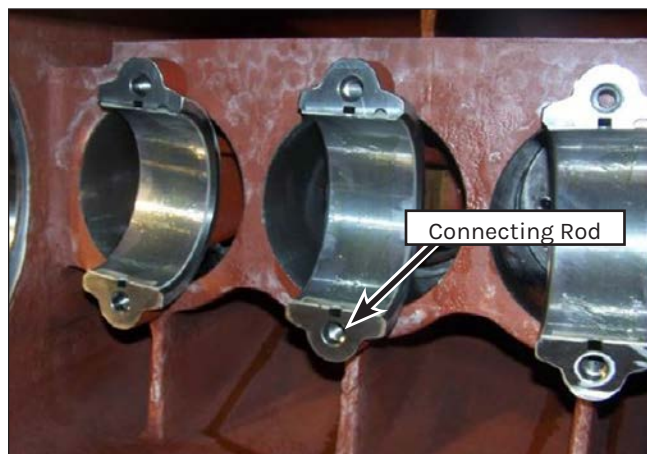


Figure 183: Connecting Rod Installation.

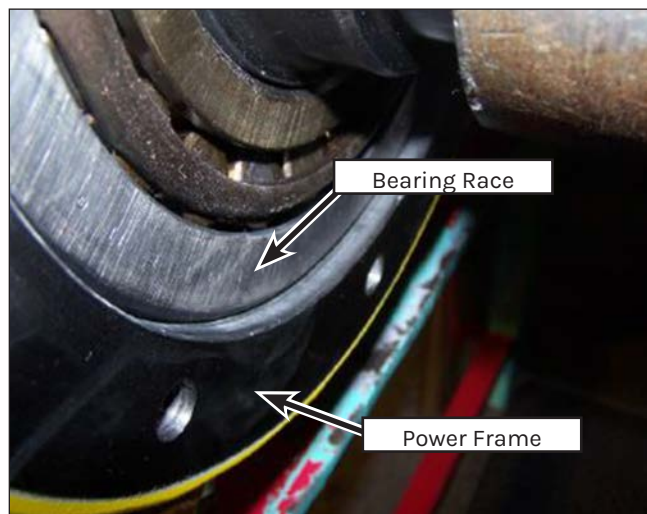


Figure 184: Crankshaft Seating.



Figure 185: Side Plate Installation.

13. Mount a magnetic base dial indicator on the crankshaft with the indicator pin on the inside edge of the rear opening, as shown in Figure 186.
14. With a firm, slow but not sudden pull in both directions the total end play should read within 0.001 inch (0.03 mm) - 0.004 inch (0.10 mm) tolerances.
15. Use a prybar (approx. 3 ft. (91 cm)) to move the crankshaft back and forth from left to right. Use firm, but not hard pressure. Record the movement of the indicator while prying in both directions. Add the measurements. Total indicator reading (sum of movement in both directions) should be 0.001 in. (0.0254 mm) - 0.004 in. (0.1016 mm). Check several times for consistency.
16. Add or remove shims as necessary to bring the endplay within the specified range. Keep the shim packs within 0.010 in. (0.254 mm) of each other.
17. Install the remaining capscrews onto the inboard and outboard side plates. Tighten the capscrews to 50 ft.lb (68 N·m).
18. Oil the bearings and install the connecting rods onto the crankshaft and install the crankcase cover as outlined in “Rod Journal Bearings” on page 80.
19. Install the three plunger couplings, connecting the plungers to the pony rods (Figure 187).
20. Place the top cover and gasket into place. Install the 12 capscrews and washers that secure the top cover to the power frame. Tighten the capscrews to 50 ft.lb (68 N·m).
21. Position the rear cover, belt guard and gasket into place. Install the 12 capscrews and washers that secure the components to the power frame. Tighten the capscrews to 50 ft.lb (68 N·m).
22. Add oil to the crankcase. Refer to “Changing the Power End Oil” on page 73.

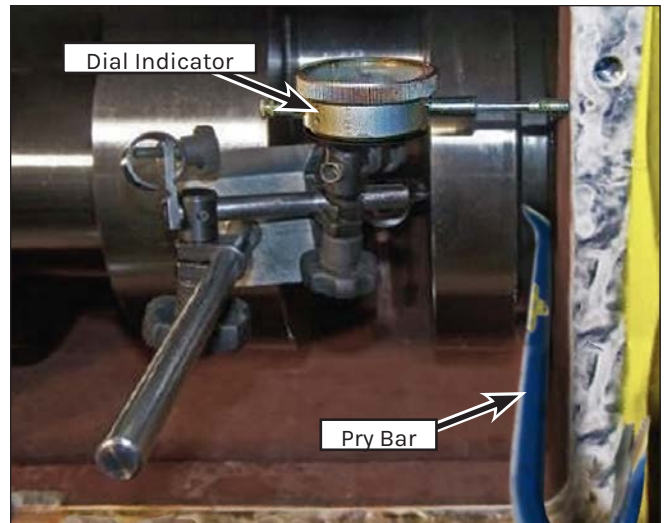


Figure 186: Dial Indicator Mounting.

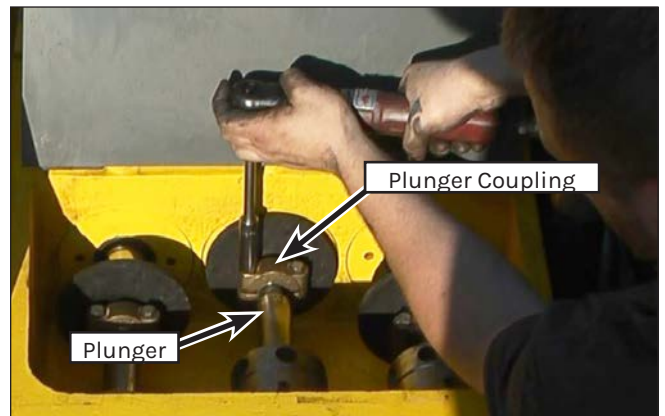


Figure 187: Plunger Coupling Installation.





# TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	REMEDY
High discharge pressure	Nozzle too small	Replace nozzle
	Restriction in hose or lance	Test hose/lance without nozzle
	Inaccurate pressure gauge	Replace gauge
Low discharge pressure	Nozzle too large	Replace nozzle
	Nozzle worn	Replace nozzle
	Insufficient water tank level	Fill tank, unplug vent
	Inaccurate pressure gauge	Replace gauge
	Belts slipping	Increase belt tension
	Leaking or sticking pump valves	Service or replace valves
	Worn pump plunger packing	Replace packing
	Leaking control gun, hose, fitting	Repair or replace
	Dirty filter bag	Replace filter bag
Excessive pulsation in pump discharge	Low water tank level	Fill tank, unplug vent
	Leaking pump valves	Repair or replace valves
	Broken pump valve springs	Replace springs
	Worn pump plunger packing	Replace packing
	Belts slipping	Increase belt tension
	Dirty filter bag	Replace filter bag
Vibration in unit	Pump pulsating excessively	See Excessive pulsation above
High pump packing gland temperature	Insufficient packing lube water flow	Increase lube hose pressure
		Clean guide bushing holes
	Water too hot	125°F max
Pump noise	Low lubricant level	Fill with lubricant
	Pump cavitation	See “Excessive pulsation in pump discharge” above
	Loose plunger clamps	Tighten plunger clamps
	Worn bearings	Replace bearings
	Worn crosshead(s)	Replace crosshead(s)/repair crosshead
	Excessive crankshaft end play	Adjust endplay
Leakage from pump manifold leakage holes	Damaged valve seal	Replace seal
Leakage from hydraulic throttle control	Damaged piston seal	Replace seal

PROBLEM	POSSIBLE CAUSE	REMEDY
Insufficient water lubrication	Needle valves not properly adjusted	Adjust the needle valves
	Air in the system	Open the manifold drain with pump on
	Plugged lines	Remove debris from lubrication lines
Leakage from pump manifold uni-valve leakage holes	Damaged valve seal	Replace seals
Leakage from discharge fitting leakage holes	Damaged fittings or seals	Replace the fittings and/or seals
Pump oil leaking from breather	Check oil level	Add oil as necessary
	Verify use of proper oil type	See "Oil Specifications" on page 62
Water in pump oil	Cross head oil seal leak	Replace seal
	Cold oil	Continue to run until oil temp increases to adequate temperature
Engine will not return to idle when control gun dumping	Excessive hose back pressure	Reduce hose string length
	Throttle control piston sticking	Repair throttle control unit
Engine will not increase in speed when control gun first closes	Engine idle speed too low	Increase idle speed
	Large gun nozzle	Decrease nozzle size
Insufficient water lubrication	Needle valves not properly adjusted	Adjust the needle valves
	Air in the system	Open the manifold drain with pump on
	Plugged lines	Remove debris from lubrication lines
Poor packing life	Hot water	125°F max
	Insufficient water flow	Adjust water flow
	Dirty water	Clean/replace filter
	Scored/pitted plunger	Replace plunger
	Gland nut loose	Tighten nut

# TRAINING

## Safety Training

Only trained personnel may setup, operate, or maintain this equipment.

Waterblast operators must be aware of the dangers that exist while using water blasting equipment. The cleaning nozzle's discharge jet(s) can inflict serious bodily injury. Jetstream® recommends demonstrating to new operators the potential damage of the discharge jet(s). This can be done by showing the effect of a waterjet from a straight tip nozzle cutting a scrap piece of 2 in. x 4 in. (50 mm x 100 mm) wood.

A safety training DVD is available from Jetstream® at their website ([www.waterblast.com](http://www.waterblast.com)).

Training materials are also available from the Water Jet Technology Association (WJTA) ([www.wjta.org](http://www.wjta.org)).

instruction to make sure that each operator is thoroughly familiar with the design and function of the unit and accessories, enabling him to safely put the new equipment to optimal use.



### 3. Follow-up

Within thirty days of delivery, and again within sixty days, the Solutions Provider will call to answer any questions and ensure complete satisfaction.



### 4. Trust

If any questions or problems arise, the Jetstream team is available and committed to providing prompt answers and solutions.

## New Start-up Training

In order to ensure customers satisfaction, Jetstream has developed the Right Start program, a four-step plan designed to provide the owners and operators of new Jetstream waterblast units with the knowledge and support needed to feel familiar, confident and satisfied with Jetstream equipment and personnel.



### 1. Transportation

Once a new waterblaster is built and thoroughly tested, the Shipping Manager contacts the new owner to arrange for the unit's arrival to the right place at the right time.



### 2. Training

All new waterblasters include personal training by the Right Start Technician. Training involves both classroom and "hands-on"

## FS Solutions Training

FS Solutions training begins where Right Start training stops. Our certified training covers all skill levels and incorporates: safety, application, troubleshooting, and field maintenance training.

For more information contact Jetstream.

## Additional Training Opportunities

Jetstream offers multiple certified training classes designed to promote safe, efficient, and profitable operation.

For more information on any of the other available Jetstream training opportunities please contact Jetstream at 1-800-231-8192 or visit us at [www.waterblast.com](http://www.waterblast.com).





## APPENDIX A: TECHNICAL SPECIFICATIONS

### General Unit Information

TwinForce™ pumps come in a wide variety of engines and waterblast output pressures. The unit is trailer mounted.

The versatility of these Jetstream waterblast units allows operators to modify the pump to change to different operating pressure ranges when necessary.

There are three basic ranges of pressure and are usually referred to as 15K, 20K, and 40K. These are abbreviated names to easily denote the maximum operating pressure.

- The 15K pumps can operate up to 15,000 psi (1000 bar).
- The 20K pumps can operate up to 20,000 psi (1400 bar).
- The 40K pumps can operate up to 40,000 psi (2750 bar).

The three pressure ranges are achieved by converting the part of the pump known as the fluid end. Each pressure range has its own manifold, stuffing boxes and plungers. The materials and construction differs with the pressure range. The various plunger diameters control the discharge volume. The stuffing boxes are matched to the plungers in most cases, but some are used with a range of plunger sizes, so it is important to keep them together. Instructions for converting to other pressure ranges are detailed in “Pressure Conversion” on page 45. Contact Jetstream Customer Service or Engineering with any questions.



TwinForce™ Series Waterblast Unit





# APPENDIX B: LONG TERM STORAGE PROCEDURE

(BULLETIN NO. REV)	PAGE
SB1003	Page 1 of 4



## SERVICE BULLETIN

<b>SUBJECT</b> Procedure for long term storage of 3000, 4200, 5000Q, and 6000 powerends					
<b>ISSUED BY</b> Engineering – Bill Slovak	<b>ISSUE DATE</b> 11/17/10	<b>EFFECTIVE DATE</b> 1/1/2011	<b>END DATE</b> -	<b>PRIORITY</b>	<b>SENSITIVITY</b>

**SCOPE**  
Long term storage is defined as 30 days or more without use. International shipments from Jetstream of Houston qualify for this procedure due to possible combination of shipping and customs storage time.

**STORAGE ENVIRONMENT**  
The minimal environmental requirement is a closed shelter (such as a warehouse) to eliminate effects of sun, wind, sand, or other debris. Large temperature and humidity changes must be avoided to prevent condensation build up and rust inhibitor deterioration.

**RUST INHIBITOR**  
Vapor corrosion inhibitors (VCI), in the form of oil additives, are to be used to protect internal power end parts from corrosion due to atmospheric moisture.

The following known suppliers and product trade names are specified for corrosion inhibitor use in Jetstream powerends:

<b>Manufacturer:</b>	Daubert Cromwell 12701 S Ridgeway Ave Alsip, Illinois 60803 800 535 3535 708 293 7750	PMS Products Inc 76 Veterans Dr #110 Holland, Michigan 49423 616 355 6615 800 962 1732
<b>Product:</b>	Nox-Rust 1100 VCI liquid 5 gallon pail	Boeshield T-9 12 oz aerosol

Note: See following spec sheets for details of these products.

**PROCEDURE**  
**Ocean shipment:**  
After assembly is complete the regular quantity of standard oil is poured into the powerframe via the back plate filler elbow. Then the Nox-Rust 1100 oil is poured in over the top. Use 4 oz of Nox-Rust per gallon of oil in powerend.

3000	5 gallons	20 oz Nox-Rust 1100
4200	9 gallons	36 oz
5000	12 gallons	48 oz

**Air shipment:**  
Before assembly the entire inside surface of the powerframe needs to be sprayed with Boeshield T-9 aerosol paying special attention to the bare metal machined surfaces. The powerframe can then be assembled normally. No oil is placed in the pump due to the air shipping regulations.

The powerend will need to be sealed after the rust inhibitor is in place. Remove the breather on top of the powerend and replace with a plug of the appropriate size. Tie the breather to the plug with a zip tie for storage and as an alert that the plug is in place and needs to be replaced before operation.

This procedure is good for one year of storage. After one year the powerend will need to be inspected and fresh VCI added per above guidelines.

**START UP**  
There is no need for removal of rust inhibitor products before starting up equipment. The powerend should be opened up and inspected by removing the top plate and visually checking the condition of all visible bare metal surfaces. Replace the breather plug with the correct breather before operating powerend.



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WARNING: Breathing diesel engine exhaust exposes you to chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

- Always start and operate the engine in a well-ventilated area.
- If in an enclosed area, vent the exhaust to the outside.
- Do not modify or tamper with the exhaust system.
- Do not idle the engine except as necessary.

For more information go to [www.P65warnings.ca.gov/diesel](http://www.P65warnings.ca.gov/diesel).



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