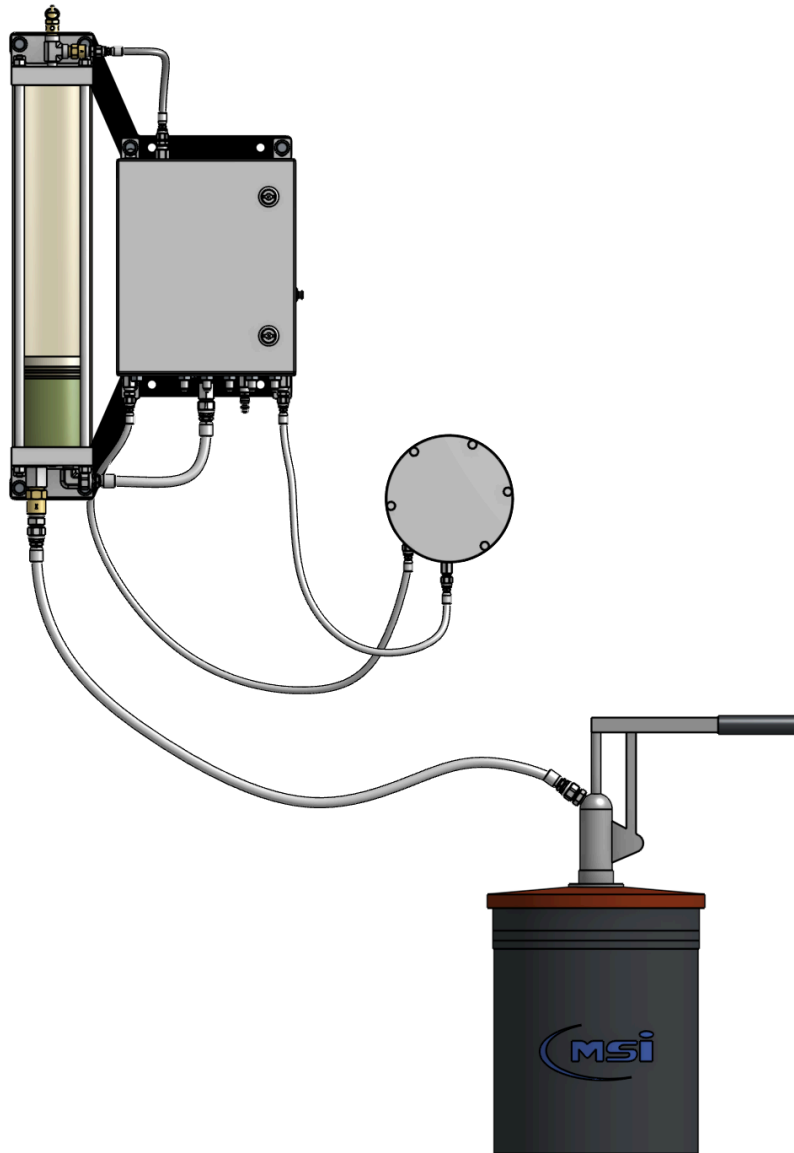




Technical Manual

MSI Auto-Lube™ System



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TABLE OF CONTENTS

WARNINGS	2
PRODUCT OVERVIEW	3
General Auto-Lube™ System	3
Gear Reducer Assembly	4
Panel Assembly	4
Reservoir Assembly	5
Bulk Lubricant Assembly	5
INSTALLATION	6
Panel & Reservoir Assembly Installation	6
Packing Lube and Air Hoses	7
System Air Supply	8
Lubricants	8
Initial Systems Check	8
SYSTEM OPERATION	12
Start-Up	12
Operation	12
Refilling the Reservoir	14
Shut-Down	16
Pump Bank Replacement	17
LUBRICATION RATE ADJUSTMENT	18
Lubrication Rate Adjustment	18
Air Pressure Adjustment	19
LUBRICATION RATES	20
TROUBLESHOOTING	22
GEAR DRIVE ASSEMBLY INSTALLATION	23

SECTION 1 WARNINGS

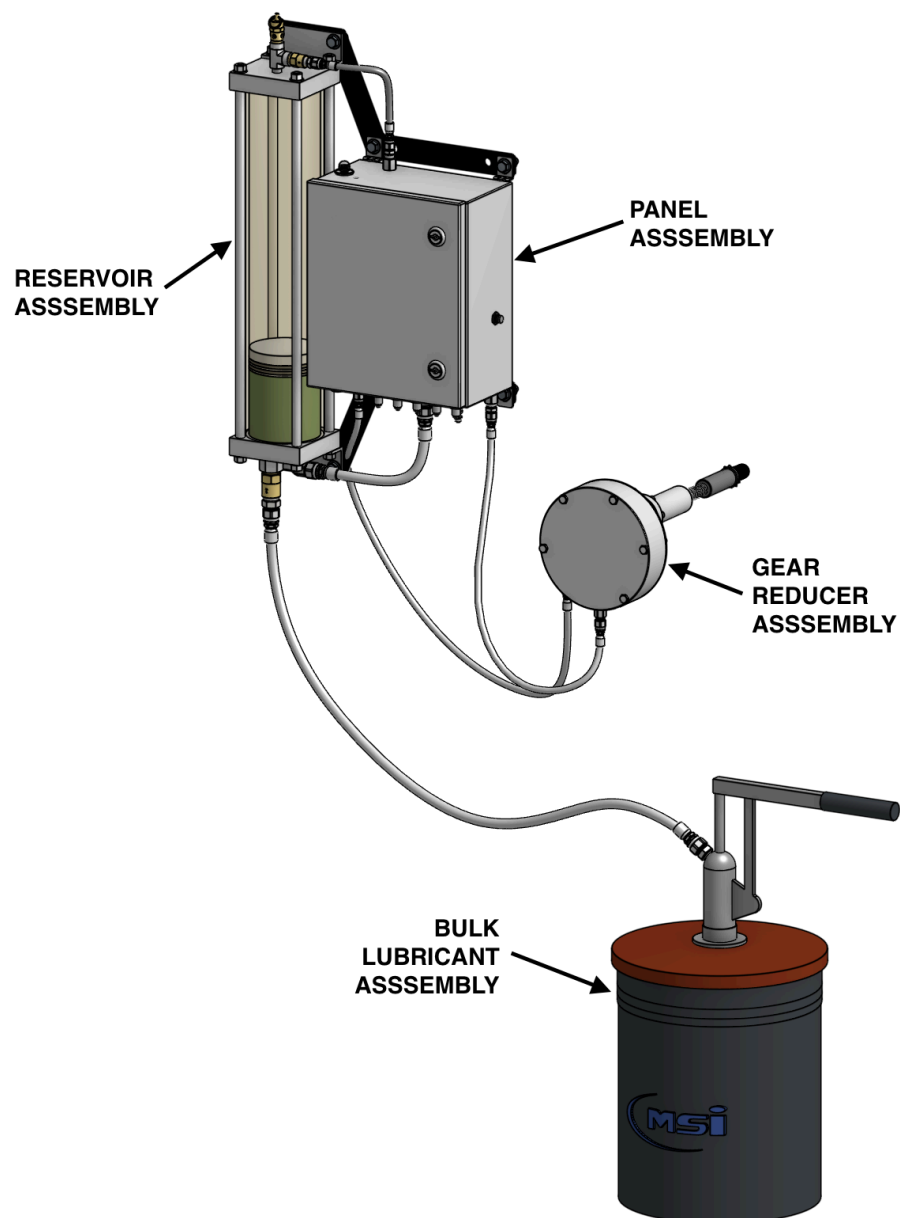
The MSI Auto-Lube™ System has hoses and fittings that are under high pressure. High pressure equipment, if not used and maintained properly, can cause serious injury and damage to equipment. Not taking proper precautions and failing to perform routine maintenance and inspections can also contribute to loss of plunger lubrication, and such loss could cause damage to equipment.

The Auto-Lube™ System is designed to lubricate plungers on all MSI Well Service Pumps. Therefore it is critical for safety and performance to ensure that there is always sufficient lubricant in the lubricant reservoir. Failure to do so may cause damage to equipment and void any warranty.

ALL OPERATORS AND MAINTENANCE PERSONNEL SHOULD BE THOROUGHLY TRAINED IN THE SAFE OPERATION, MAINTENANCE, AND INSPECTION OF THIS EQUIPMENT.

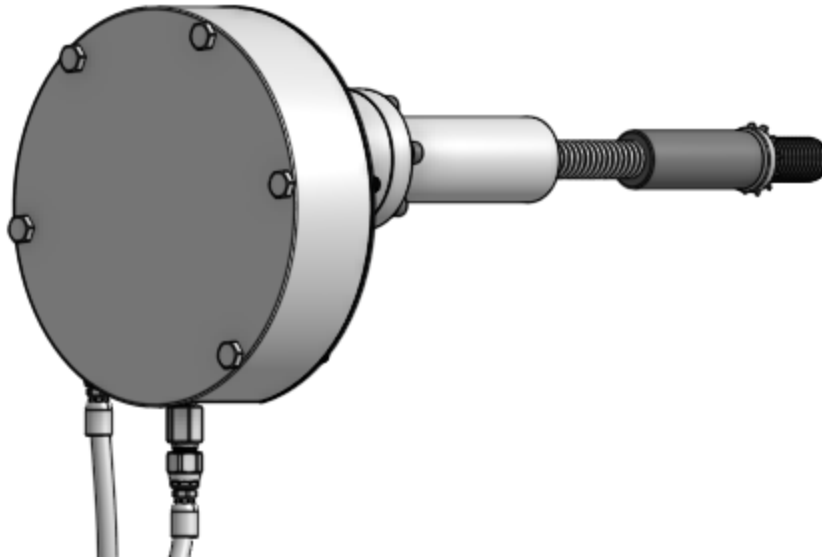
General Auto-Lube™ System

The [MSI Auto-Lube™ System](#) is a pneumatic-mechanical high pressure, non-electric, positive displacement packing lubrication system for use with oil or grease. Lubrication rates are mechanically controlled by the well service pump via a power take-off (PTO) from the crankshaft. Utilizing a PTO from the lubricated equipment allows the equipment itself, rather than a timer for example, to dictate the lubrication delivery rate. This eliminates over or under lubricating and ensures lubricant is supplied whenever the pump is in motion. The lubrication cycle is activated by rotation of the crankshaft. The Auto-Lube™ System can be used in conjunction with the [MSI Lube Relief System™](#) to provide outstanding lubrication performance to maximize packing life and reduce down time.



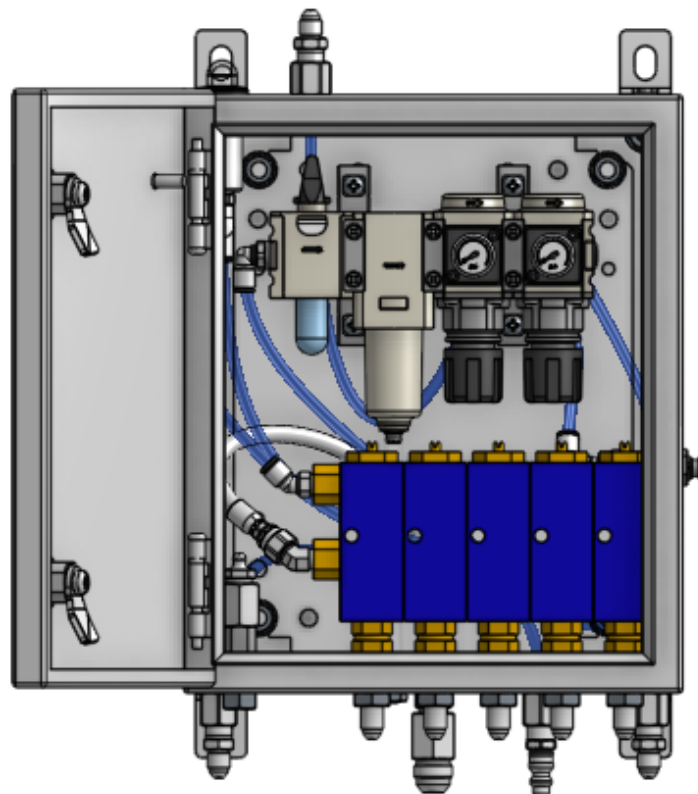
Gear Reducer Assembly [ALSA0007, Triplex & Quintuplex]

The gear reducer assembly controls the cyclic rate at which the lubrication is supplied to the pump via an input shaft that is mechanically connected to the pump crankshaft. Therefore the lubrication cycle (on and off) frequency has a linear relationship to pump speed. The faster the pump crankshaft turns, the more frequent the lubrication cycle, and conversely; as the pump speed decreases, the lubrication frequency decreases.



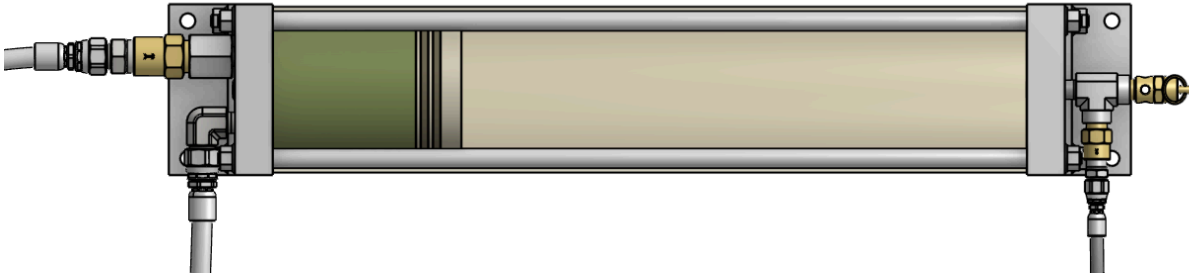
Panel Assembly [ALSA011 Triplex, ALSA0012 Quintuplex]

The panel assembly contains air preparation equipment and pumps to supply high pressure, precisely metered lubricant to the lubricated equipment.



Reservoir Assembly [ALSA0015, Triplex & Quintuplex]

The reservoir assembly stores one gallon of pressurized lubricant for supply to the panel assembly pumps. The reservoir can be refilled from a bulk storage container at any time to keep the system operational without interruption.



Bulk Lubricant Assembly [ALSA0016, Triplex & Quintuplex]

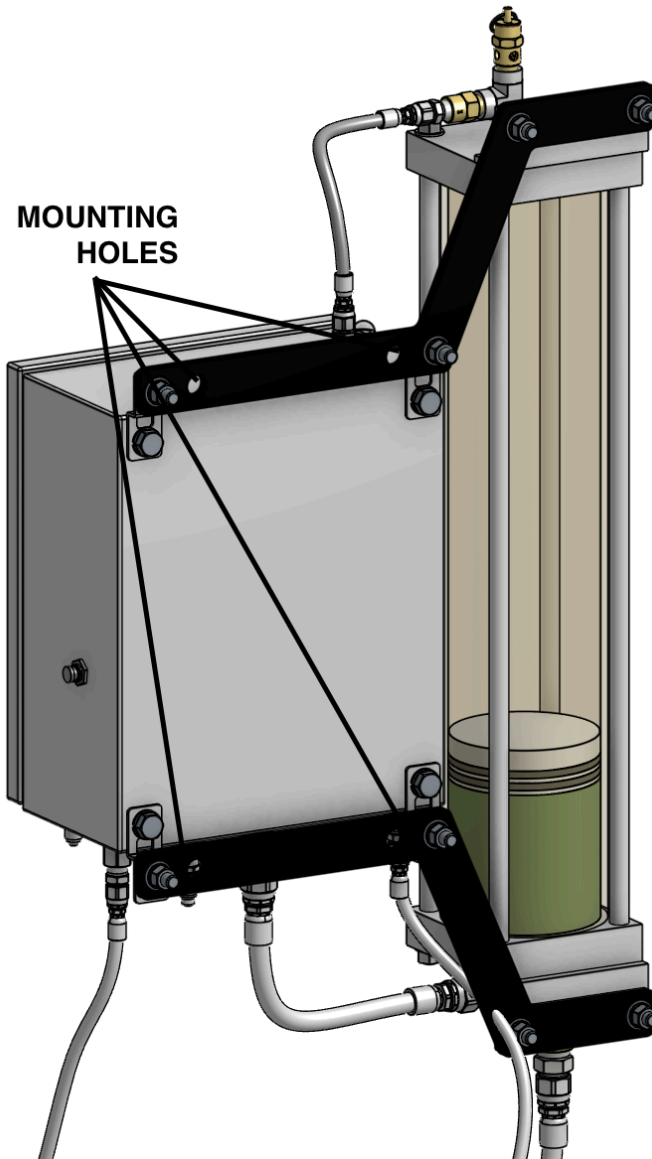
A 40 lb bulk metal container filled with MSI plunger grease permits quick fill of the reservoir to service the pump for many hours of operation. This simple hand pump can be replaced with electric or pneumatic pumps if desired.



SECTION 3 INSTALLATION

Panel & Reservoir Assembly Installation

The panel and reservoir assemblies are supplied connected by steel brackets. This sub-assembly should be mounted in a location that is easily accessible and as close as practical to the well service pump. Secure the brackets to a solid support frame by welding or bolting using the four 9/16" holes shown below.

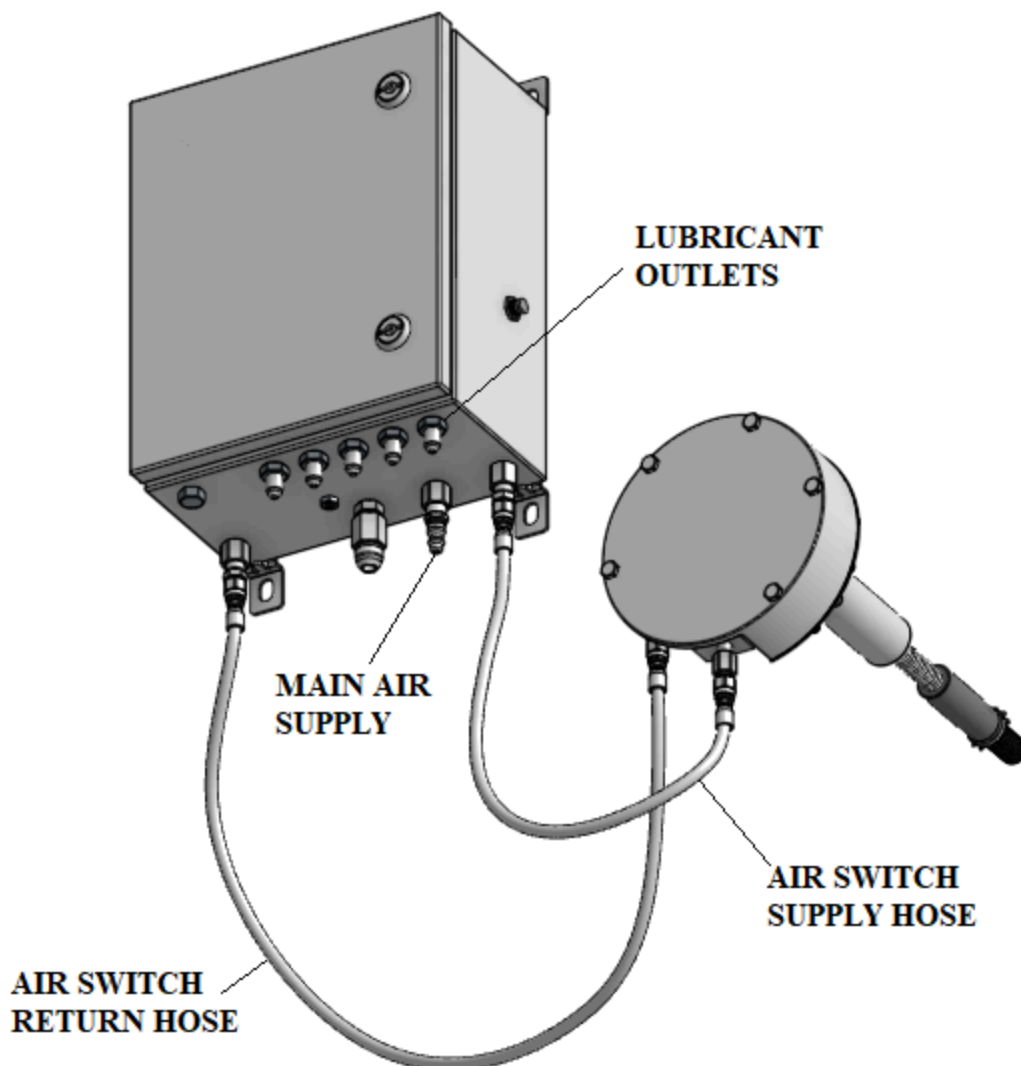


Abrasion resistant hoses for the reservoir shown above are included. If the installation requires mounting the panel and reservoir assemblies further apart than the provided hoses permit, longer hoses can be used. MSI recommends keeping the hoses as short as possible.

Packing Lube and Air Hoses

Due to variations in individual installations the following hoses must be provided by the installer:

- Main air supply hose from pressure source to panel assembly.
 - Rated for at least 200 psig and 250°F.
 - A ¼" industrial plug end fitting is provided for quick-connect applications with a coupling-ended hose. If a permanent connection is desired MSI recommends a shut-off valve be installed outside of the panel assembly to permit isolation of the system from air pressure for servicing.
- Air switch supply and return hoses.
 - -4 size braided stainless steel hose with ¼" JIC 37° female swivel fittings, rated to 200 psig
- High pressure lubrication hoses, one per packing gland.
 - -4 braided stainless steel hose with ¼" JIC 37° female swivel fittings, rated to 3000 psig.



Generally, the installed air hoses should be kept as short as possible. Systems including a bulk container are provided with a three foot hose connecting the bulk container and reservoir. If necessary, the hose between the reservoir and bulk container may be replaced with a longer hose but should be kept as short as possible.

Route the hoses such that they are free of excessive bends, do not create a tripping hazard, and are clear from danger of being snagged or entangled. Secure hoses to steel structures with clamps to avoid transmission of forces to the fittings should accidental contact occur. Ensure air valve hoses (supply and return) going from the panel assembly to the gearbox air valve are correctly connected as shown in the preceding image.

System Air Supply

Only compressed air is required to power this system. A serviceable filter/separator is integrated into the panel assembly to ensure proper system function.

Inlet air requirements:

- 100 – 145 psig
- < 150°F (200°F peak)
 - prolonged operation at temperatures higher than 150°F may cause malfunction of the panel assembly equipment or tubing

Lubricants

The lubricant should be selected based on what works best for the well service pump operating conditions. For most applications, MSI recommends using MSI Plunger Grease™ [MSI PN GREASE001]. This is a water-resistant, non-soap, NLGI Grade 2 plating grease for operating temperatures between -18°F to 400°F. MSI Plunger Grease™ prevents metal to metal contact, reduces temperatures, and is resistant to oil separation.

Other greases may be used as long as they meet NLGI standards for Grades 000, 00, 0, 1, or 2. Oil may also be used with the Auto-Lube™ System and should have a Viscosity Index (per ASTM D2270) of at least 95. Oils in this category are usually machine way lubricants, rock drill oils, or conventional motor oils. MSI strongly recommends that any other lubricants are thoroughly tested for suitability to the operating environment prior to acceptance into operations.

Only clean, new lubricant should be used in the Auto-Lube™ systems. Recycled lubricants or lubricants with fillers may contain contaminants that could obstruct or damage the pumping elements or check valves and must be avoided. Even small particulates in the grease may clog the lubrication pumps, preventing grease from being delivered to the well service pump packing.

Initial Systems Check

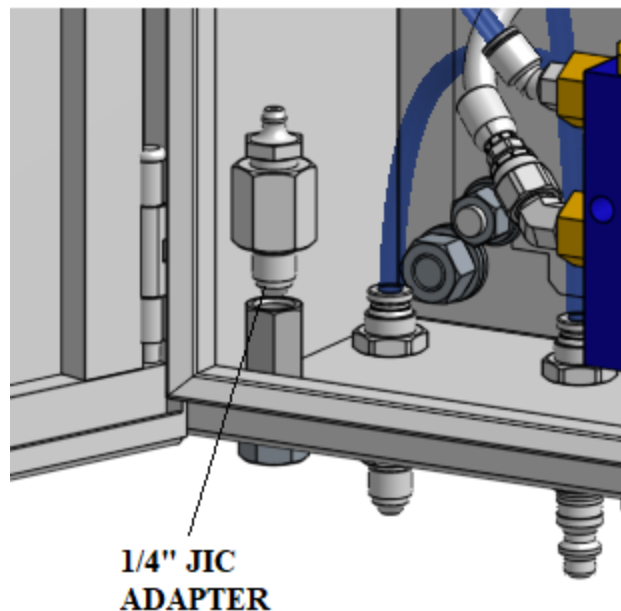
The following procedure should be performed after initial installation, system maintenance, or relocation to verify that all systems are functioning properly.

NOTE: The panel assembly and gearbox assembly were factory acceptance tested using a small amount of MSI Plunger Grease. This testing is performed to ensure the internal connections are properly made, systems are all functioning correctly, and that air has been purged from the system and primed with grease.

Installation assurance checks:

- 1) Ensure all connections are properly made-up and leak-free.

- a) System air supply.
 - b) Panel assembly to gear reducer air switch supply.
 - c) Panel assembly to gear reducer air switch return.
 - d) Packing lubricant supply lines (one per packing gland).
- 2) All lubrication supply lines must be primed using a lubricant that meets the requirements of **Section 3**. A hand operated grease or oil-dispensing gun may be used to prime each line individually. For filling the high pressure packing lubrication lines a JIC hose swivel to grease zerk fitting adapter is conveniently located inside the panel assembly enclosure and may be used to fill each plunger supply hose. Simply connect this adapter to the individual lube line to prime it, make sure it is disconnected at the packing end before priming. Once the lines have been primed, reconnect them to the lubricant outlets on the panel assembly.

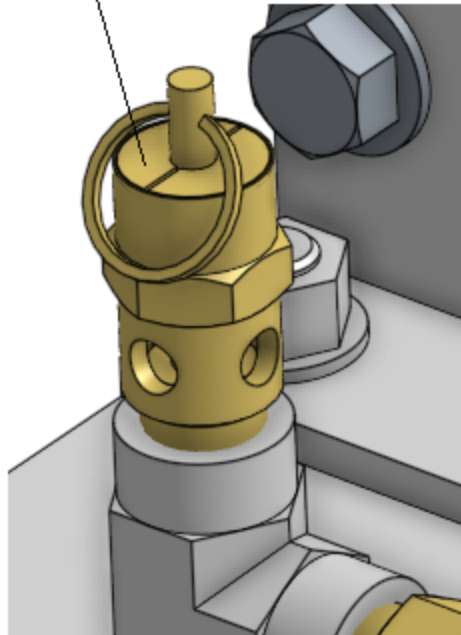


NOTE: If using the MSI Lube Relief System™ the supplied relief pressure gauge may be used to indicate when a line has achieved prime. Once the gauge registers at least 40 psig pressure for the first primed line, move on to the next line. The gauge will “blip” once each successive line is primed. Repeat this step for each lubrication line.

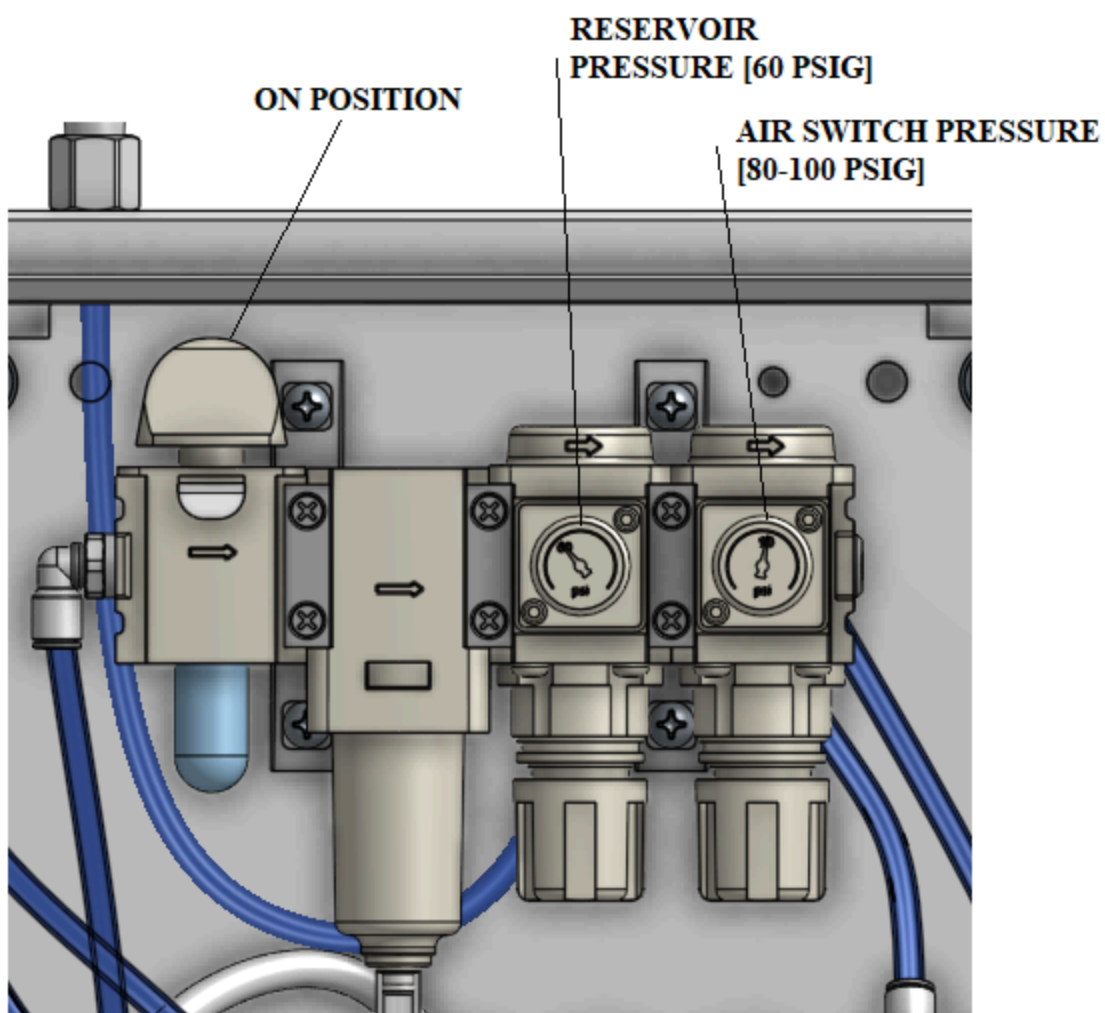
- 3) Enable system air supply and rotate control valve handle to the ON position. This valve will remain in the ON position at all times during pump operation.
- 4) Check for air leaks and tighten or replace fittings as necessary.
- 5) Verify pressure setting of regulators in panel assembly.
 - a) Reservoir regulator (left side of panel) should register 60 psig. **Do not exceed 65 psig on the reservoir regulator as this may cause system malfunction.** If necessary, the reservoir relief valve may be adjusted to a higher or lower relief pressure. Turn the adjustment screw CW to

increase relief pressure, CCW to decrease relief pressure. The default setting of the relief valve is 75 psig.

**ADJUSTMENT
SCREW**



- b) Air switch regulator (right side of panel) should register between 80 psig and 100 psig.
- 6) If all checks pass turn the system OFF using the control valve if not about to begin operating the plunger pump.

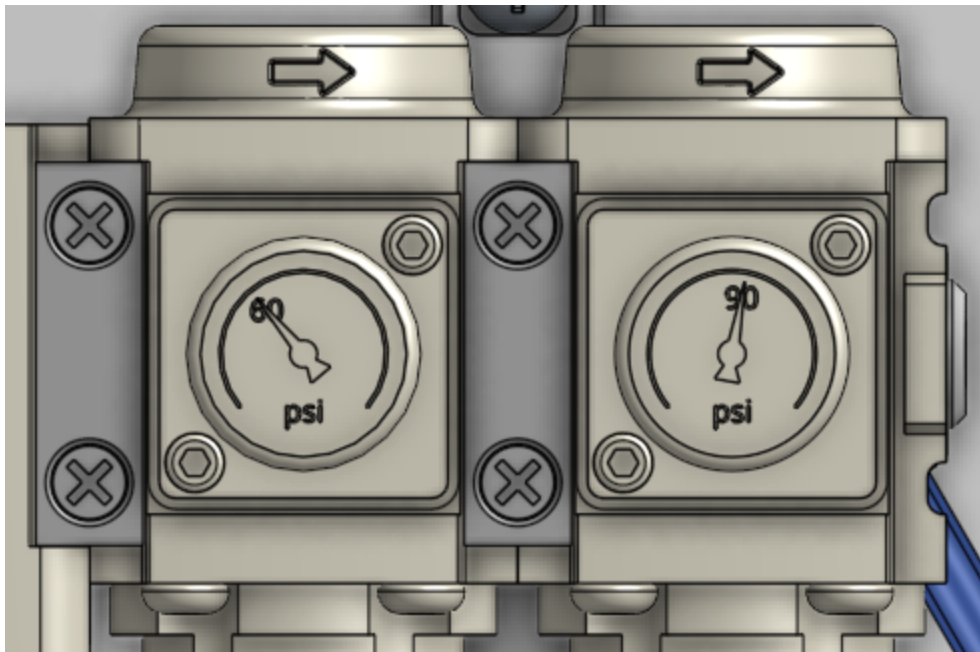


SECTION 4 SYSTEM OPERATION

Start-Up

During start-up, follow proper operating and safety procedures for dealing with rotating machinery and high pressure equipment.

- 1) Check lubricant level before and during every job, replenish as needed. Use only new, clean lubricant that meets the requirements of Section 3. See next section for refilling procedures.
- 2) Check that the air filter/separator is functioning properly. It should automatically drain fluids from the bowl out through the bottom of the enclosure. Empty and clean the bowl and drain tube as needed.
- 3) Turn the air valve to the ON position and verify both regulators register air pressures as shown below.

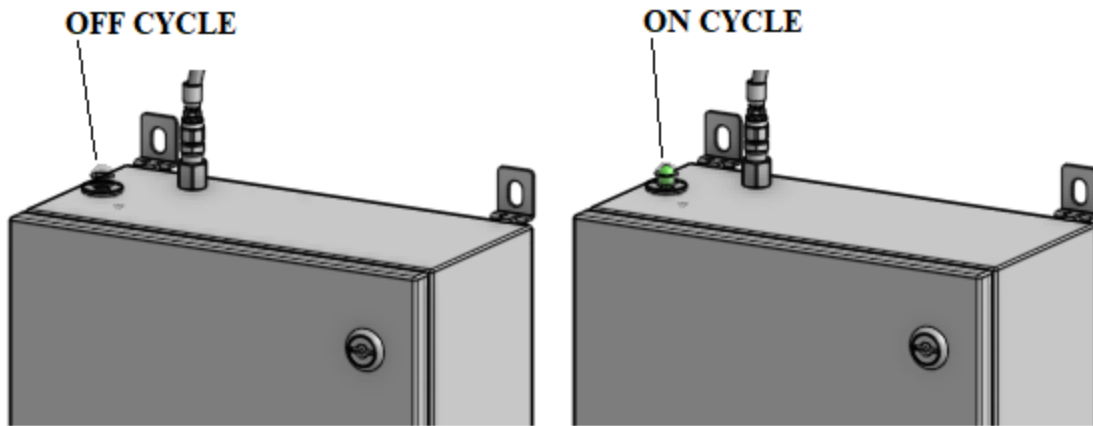


- 4) Turn the control valve to the OFF position to verify that it effectively shuts off air pressure from the system and that the vent muffler is in good condition. Air pressure will gradually relieve through the muffler and both gauges should register 0 psig once the valve has been closed for a few seconds.

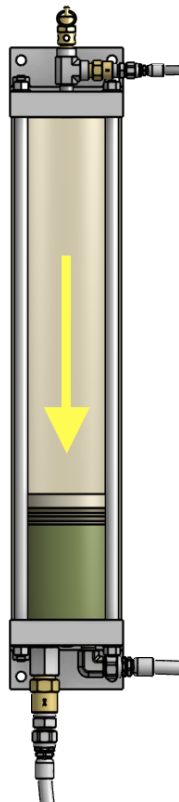
Operation

- 1) Turn the control valve to the ON position. This valve is to be left ON at all times unless the system requires servicing or the pump will not be operated for an extended period of time. MSI recommends locking the enclosure during operation to discourage tampering with the pressure regulators and metering pump settings.

- 2) Engage the well service pump and as it is rotating check that the green air indicator is cycling on and off. This indicates that the intermittent air signal necessary for proper operation is being provided by the switch on the gearbox assembly. If the air cycle indicator does not trip, shut the unit down and consult the troubleshooting guide in **Appendix B**.



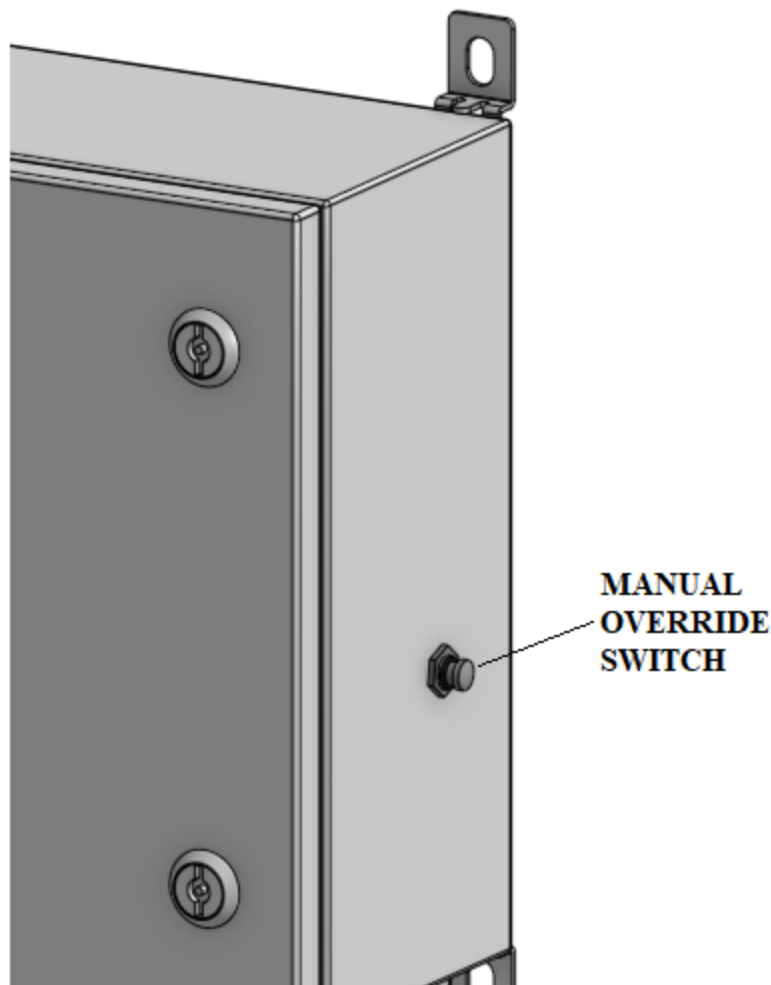
- 4) During operation, verify that lubricant is being supplied to the packing glands, this can be done in several ways:
- a) Look for downward movement of the reservoir piston which would indicate lubricant is being pumped.



- b) Expulsion of lubricant from packing nut wiper seal. This only applies to pumps with a reverse installed wiper seal that will allow excess lubricant to be purged.
- c) For units utilizing the Lube Relief System™, look for blips in the pressure gauge during Auto-Lube™ System cycling.

5) Monitor lubricant levels in reservoir assembly and replenish as needed.

NOTE: A manual override switch is integrated into the panel assembly on the right side of the enclosure. This switch will mimic the operation of the air switch on the gear reducer assembly and allows the system to be cycled without rotating the pump. To manually cycle the system press and release the button in a slow action; depress the button for one full second then release for one full second before depressing again. Each cycle of the button will cycle the pumps one time.

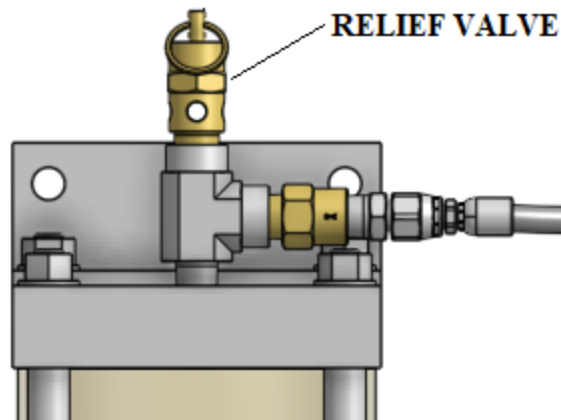


Refilling the Reservoir

IMPORTANT: It is essential to the proper operation of this system that only **CLEAN** lubricant enters the system. Operators must take precautions to assure that foreign matter is not introduced into the system during refilling activities.

It is recommended that the hose between the bulk lubrication supply and reservoir be primed with lubricant before it is connected to the reservoir to avoid introducing air. Entrapped air can be purged by pumping lubricant into the reservoir until the piston reaches the upper head and stops. The relief valve will automatically release trapped air as pressure builds, but can also be opened manually during this operation by pulling the ring to vent pressure. The same procedure should be followed if lubricant is trapped on the top side of the piston.

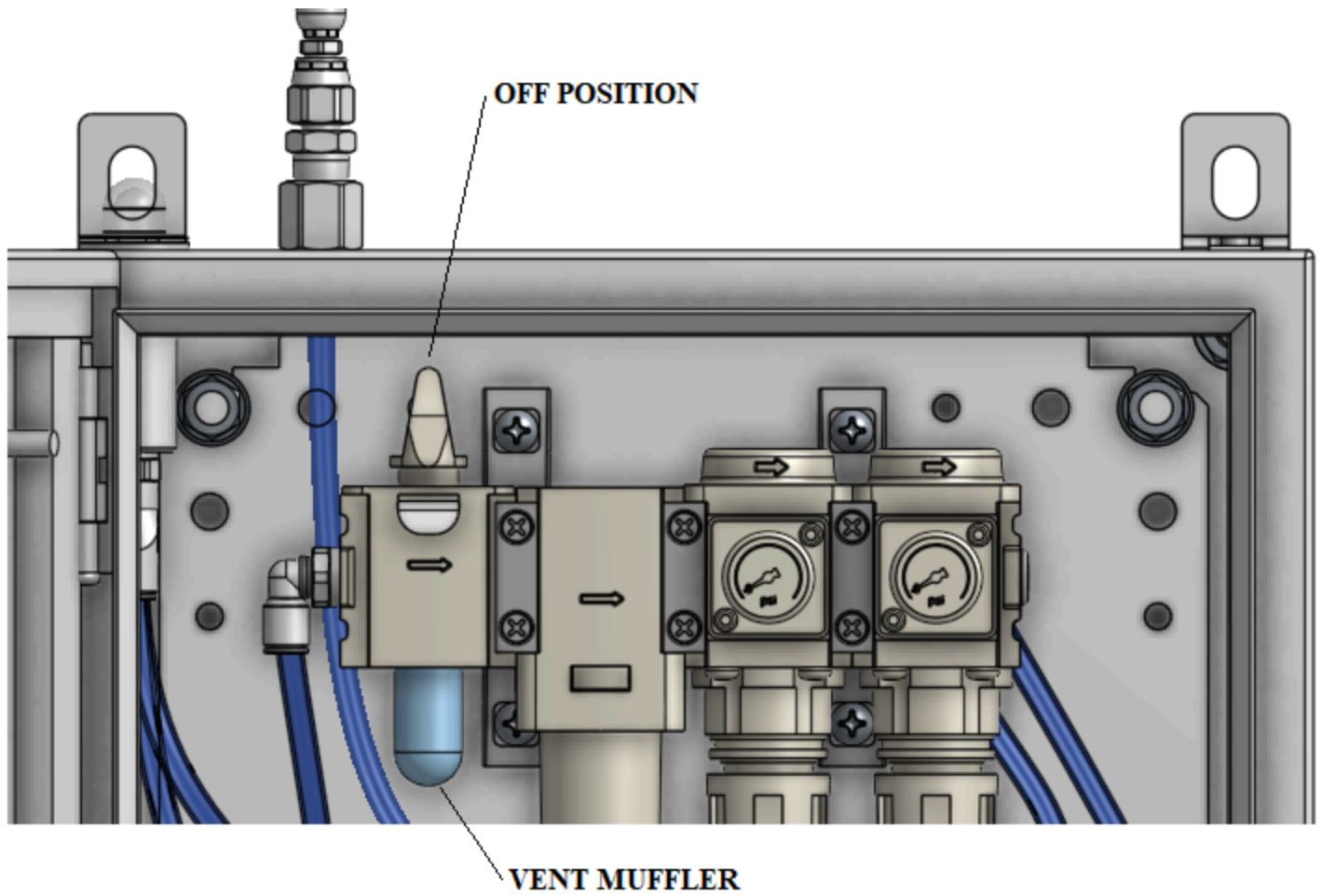
WARNING: Once the piston has reached the top of the reservoir, continued pumping from the bulk source will cause lubricant to forcefully exit the relief valve on top of the reservoir. Stop filling BEFORE the piston is at the top of the reservoir!



Shut-Down

After the well service pump has been completely shut down, open the panel assembly enclosure and rotate the control valve to the “OFF” position. This will disable the system and vent all remaining air pressure through the valve’s exhaust port. The gauge pressures should gradually drop to zero. If desired the system can be “locked-out” by pulling the tab on the control valve out and installing a locking device to keep the valve in the OFF position.

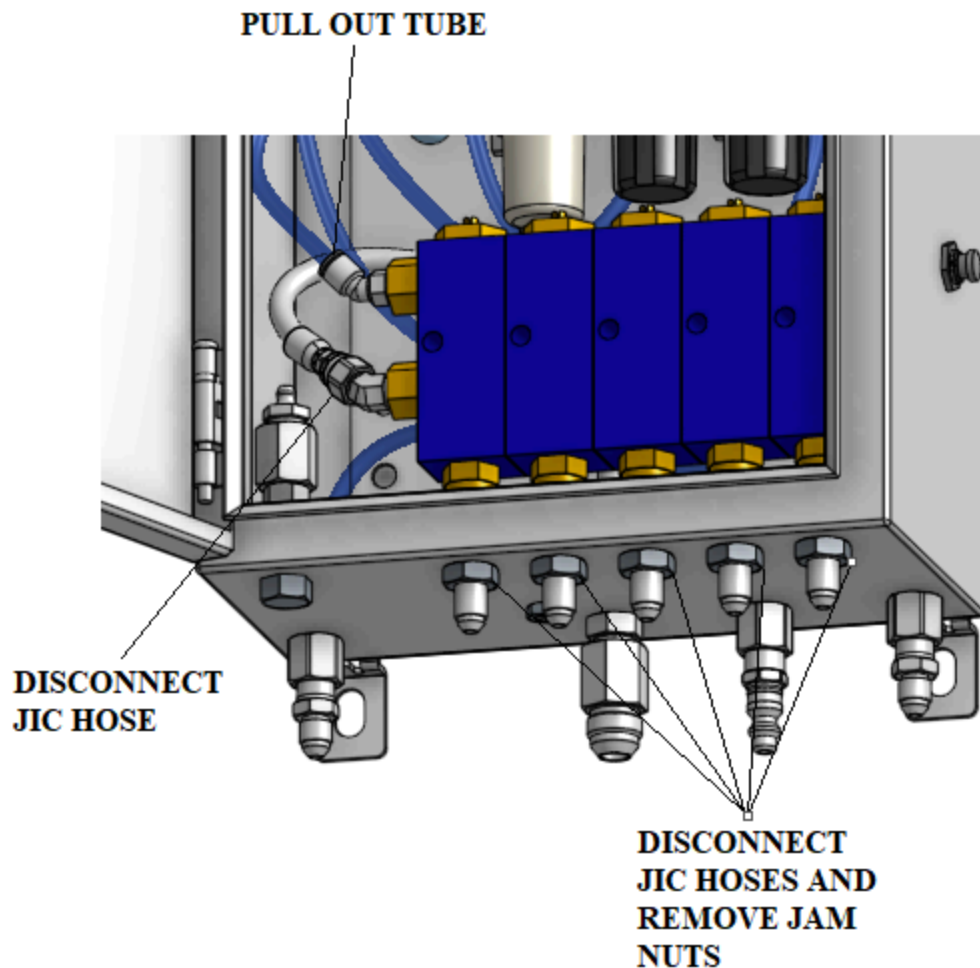
WARNING: Even after the control valve has been turned to the “OFF” position air pressure is still present in the reservoir! Before disconnecting any fittings from the reservoir you must purge all pressure by pulling the ring on the relief valve until air ceases to flow.



Pump Bank Replacement

If a pump becomes clogged the entire pump bank may be quickly replaced with minimal downtime. This of course requires having spare units readily available for installation. ALSA0017 is the replacement 5 feed unit for quintuplex pumps, ALSA0018 is the replacement 3 feed unit for triplex pumps.

For information on servicing the pumps please contact MSI Tech Support.

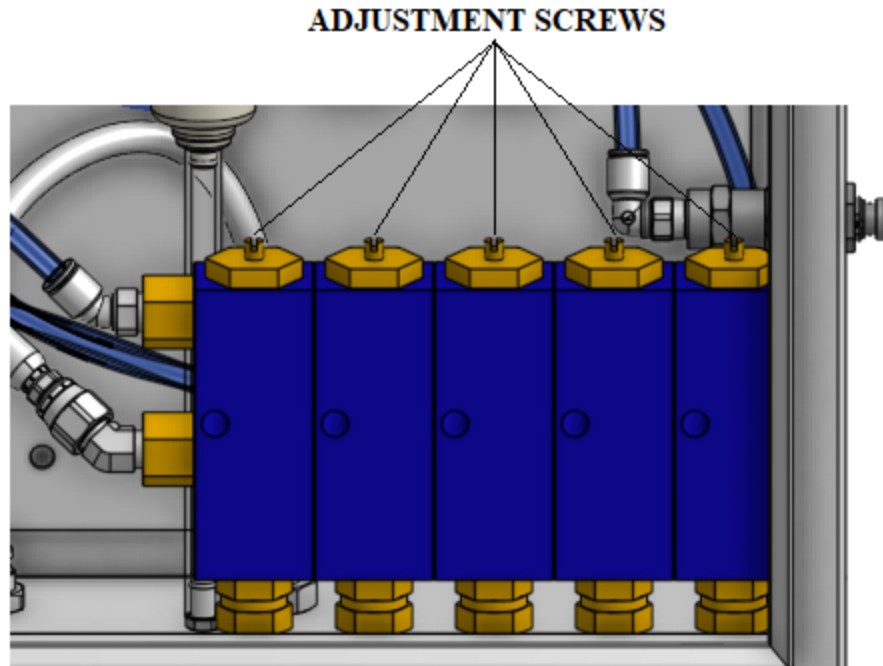


SECTION 5 LUBRICATION RATE ADJUSTMENT

Lubrication Rate Adjustment

The injector pumps have been preset by MSI to provide an optimal volume of lubricant for most well service pump packing lubrication needs. If desired, the lubrication volume injected per cycle may be changed to increase or decrease the amount of lubricant supplied per unit time. Below are the steps to adjust the lubrication rate.

- 1) Stop the well service pump.
- 2) Unlock the latches and open the enclosure.
- 3) Open the enclosure and turn the control valve to the OFF position. Wait for the air pressure in the hoses to release. This will occur through the muffler at the bottom of the control valve body.
- 4) Advance adjustment screw (turn CW) until it stops; the stem is now set to full close position.



- 5) Unscrew (turn CCW) adjustment screw to desired setting. See **Appendix A** for flow rates.

NOTE: Adjustment screw factory setting is 3 full turns out from full close position.

- 6) Turn control switch to ON position.
- 7) Close the enclosure door and lock the latches.

CAUTION: Immediately following any adjustment of the injector pumps closely monitor the equipment being lubricated to make certain that the lubrication rate is sufficient. Over or under lubricating may cause premature packing failure or produce a large amount of wasted lubricant.

Air Pressure Adjustment

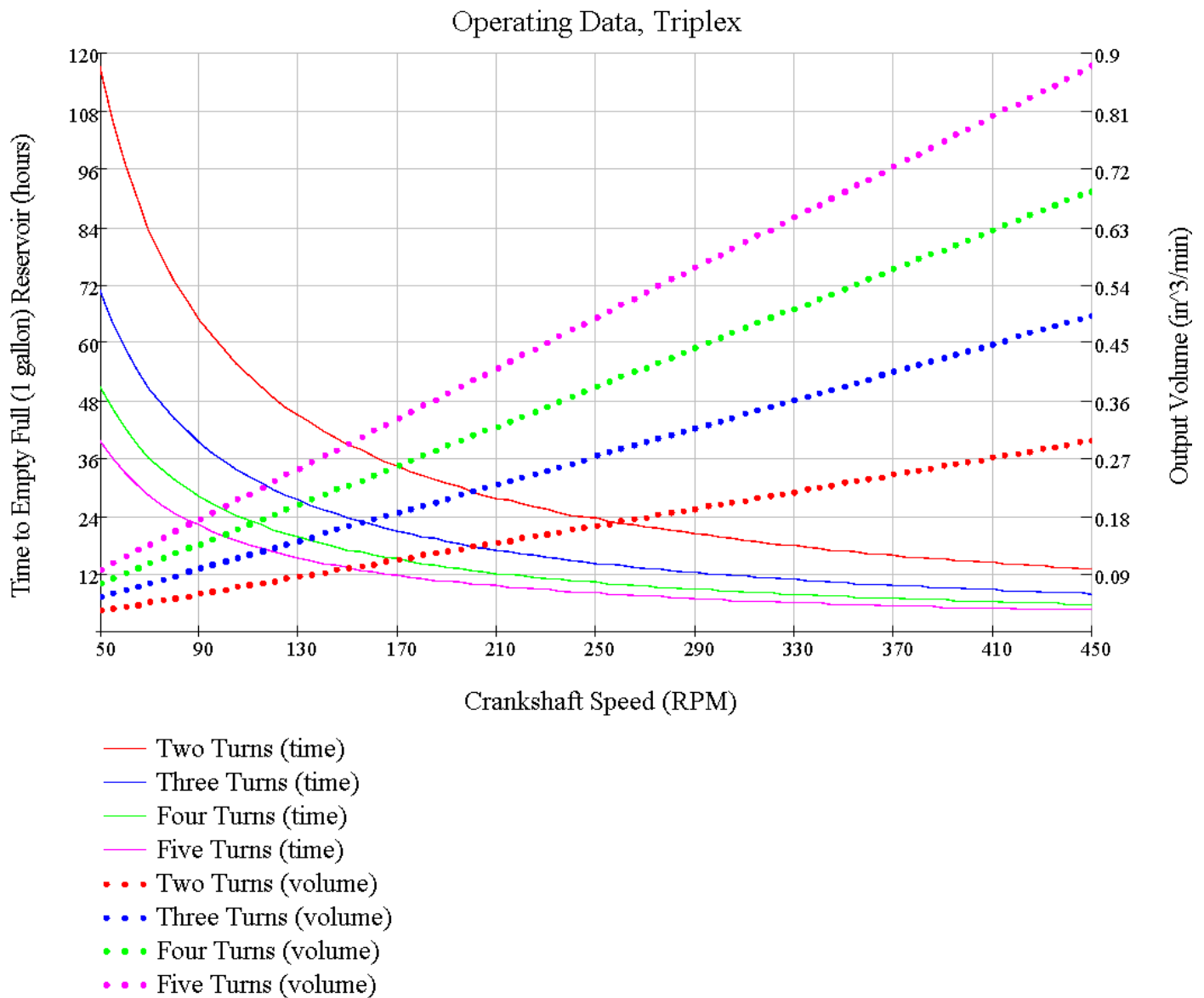
In certain cases, such as high pump speeds or when long air hoses are used, it may be necessary to increase the pressure of the air supplied to the gearbox assembly air valve. Doing so will increase the air replenishment rate, which may reduce lagging cyclic periods. This is done by performing the following steps.

- 1) Stop the well service pump and unlock then open the panel assembly enclosure. Make sure the Auto-Lube™ system is set to the ON position.
- 2) On the right side regulator, pull the cylindrical sleeve downward to disengage the lock.
- 3) Rotate the sleeve in (CW) to increase valve air supply pressure. The indicated pressure should increase as the sleeve is rotated CW.
- 4) Push the sleeve upwards to lock the pressure setting.
- 5) Close the case door and lock it.

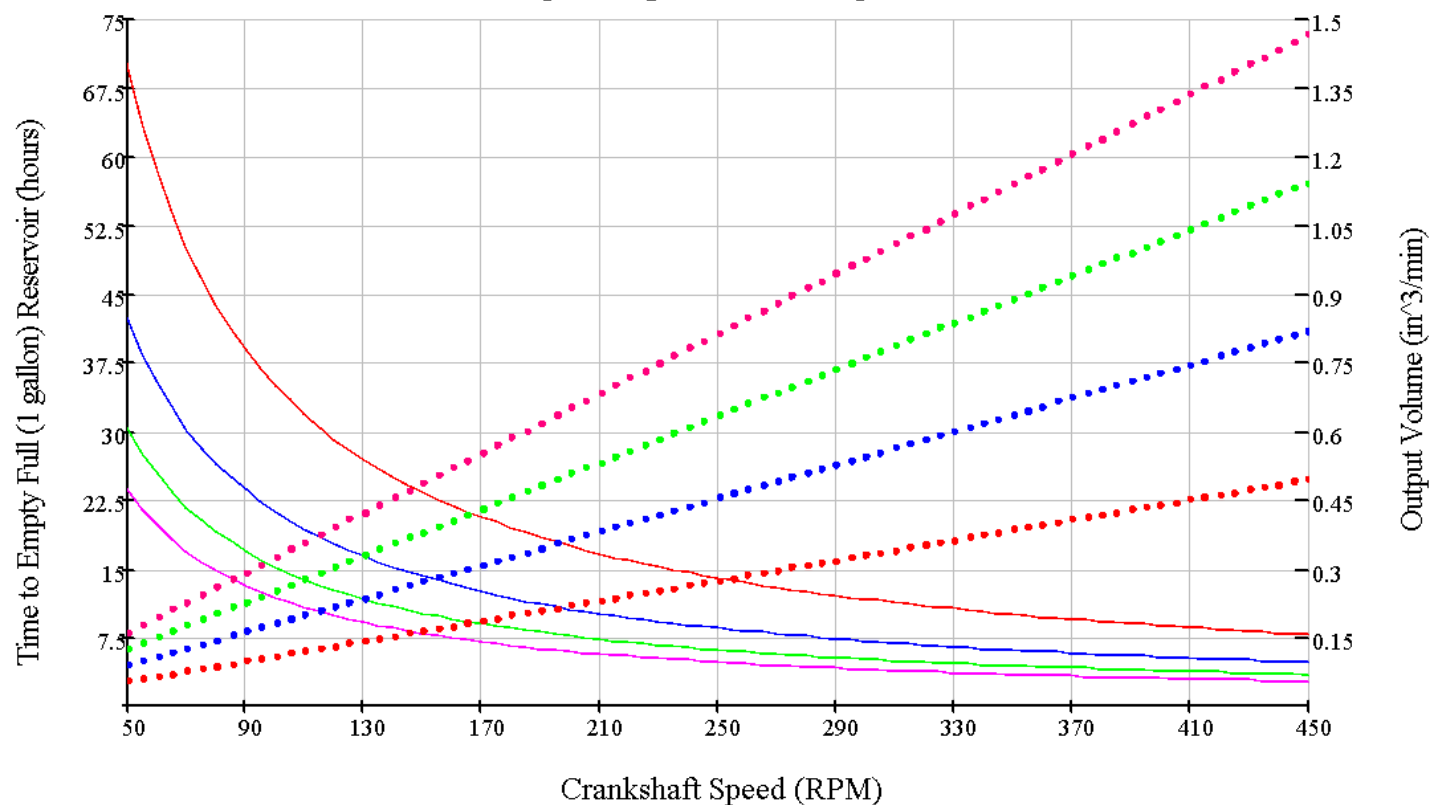
NOTE: The left side regulator controls air pressure to the lubrication reservoir. This regular should always be set to 60 psig.

Appendix A LUBRICATION RATES

The following charts plot lubrication flowrate and consumption rates over time for variable output settings and crankshaft speeds. The plotted curves are based on turns of the pumping element adjustment screw from full close. This information may be used for fine tuning of the Auto-Lube™ System by determining what lubrication rates best fit the pumping conditions.



Operating Data, Quintuplex



- Two Turns (time)
- Three Turns (time)
- Four Turns (time)
- Five Turns (time)
- ... Two Turns (volume)
- ... Three Turns (volume)
- ... Four Turns (volume)
- ... Five Turns (volume)

Appendix B TROUBLESHOOTING

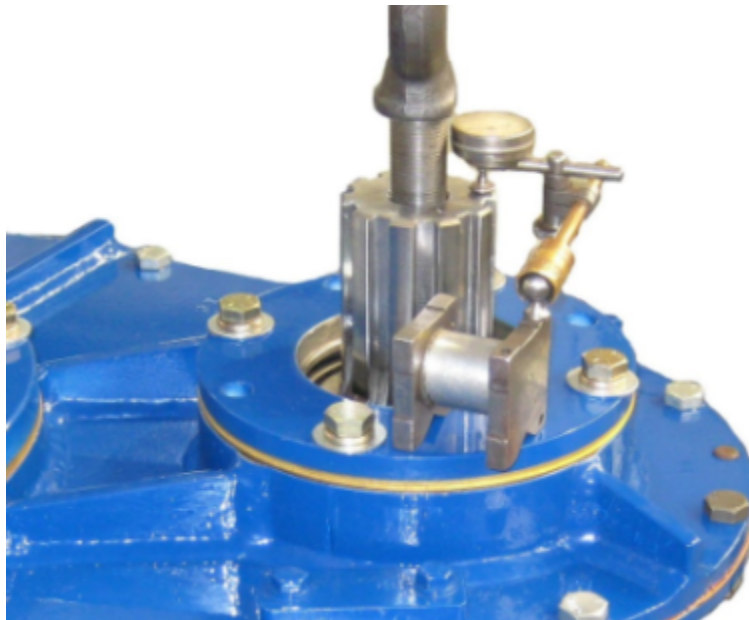
Known possible malfunction symptoms and their solutions:

<i>Symptom</i>	<i>Likely Cause</i>	<i>Solution</i>
System not pumping grease on any cylinder (indicator bulb not tripping)	System is “OFF”.	Turn system “ON”.
	Cut, broken, or loose air hose.	Inspect and tighten or replace damaged hoses.
	Absent or insufficient air pressure.	Ensure supply air pressure is at least 100 psig.
	Air switch on gear reducer assembly is stuck in open position (indicator bulb on continuously).	Remove valve cover on gear reducer assembly then clean and lubricate air valve.
	Lubrication reservoir empty or low.	Replenish lubricant reservoir.
	Reservoir relief valve is stuck open .	Repair or replace relief valve.
	Hoses to air switch are reversed.	Swap air hoses at panel assembly.
System not pumping grease to individual cylinder(s) (indicator bulb tripping)	Obstruction in individual supply circuit, or damaged supply line.	Check for obstructions in hose from pump to packing nut and clear out if needed, check for clogged pump. Repair or replace damaged lines.
Poor system response	High crankshaft speed (> 400 rpm).	Increase pressure to air switch (see Section 5).
	Very long air hoses to gearbox valve.	
High lubrication waste	Injector pumps set at rate that exceeds pumping lubrication demands	Decrease injector pump rates (see Section 5).
Overheating packing	.Injector pumps set at rate insufficient for pumping conditions	Increase injector pump rates (see Section 5).
Grease not entering reservoir from main grease supply when pumped	Trapped air pressure above the grease cylinder piston due to the relief valve stuck closed.	Service or replace relief valve.
Grease flowing from the weep holes in the lubrication pumps	Contaminated grease has entered the system and clogged at least one of the lubrication pumps .	The pump(s) needs to be removed and cleaned. Reservoir may need to be emptied of contaminated lubricant and the entire system purged.

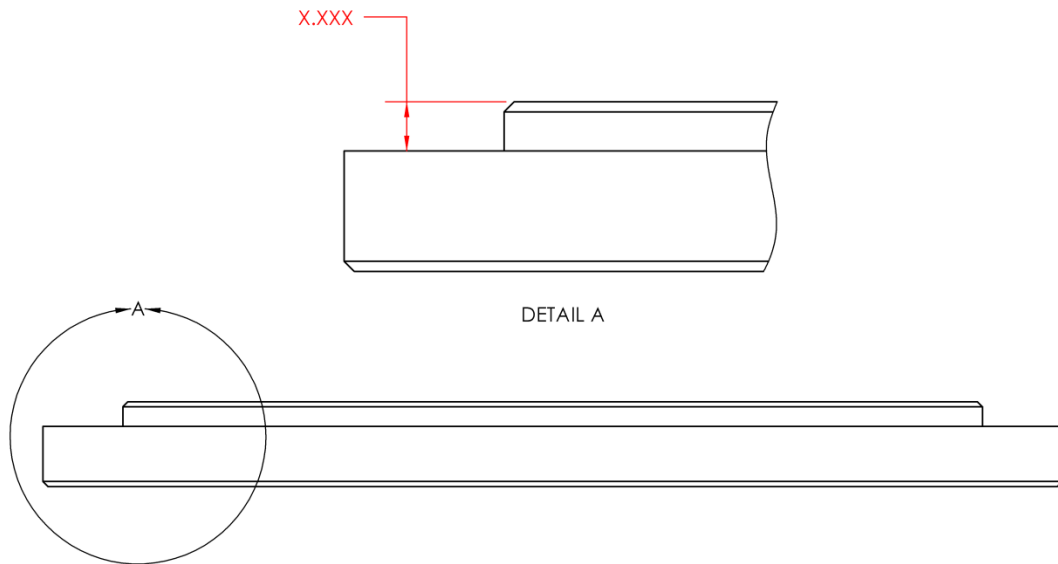
Aftermarket installations may require replacing the bearing retainer plate with one that is prepped for receiving the gear reducer assembly. Some later pump models may have a retainer plate already prepped for adding the Auto-Lube™ System. If this is the case, remove the external blanking cover and continue directly to **Step 6**.

It is crucial that bearing pre-load is properly set following the Auto-Lube™ system installation. Following the ensuing steps will help make certain that this is done correctly.

- 1) Before removing any components from the gear reducer, check the pinion shaft endplay using a dial indicator. Place the magnetic dial indicator on the pinion bearing retainer plate and move the pinion back and forth axially (install a bolt or bull ring into the pinion end for grasping). Take note of whether the dial indicates any movement. If any movement is present the bearings will need to be shimmed to properly set the bearing preload at 0.003" – 0.005". For example, if the indicated endplay is 0.007", a total of 0.010" – 0.012" shim thickness should be removed. *Shim thickness adjustment of pinion may require adjustment of bull gear bearing shims, see **Step 3.a**.*



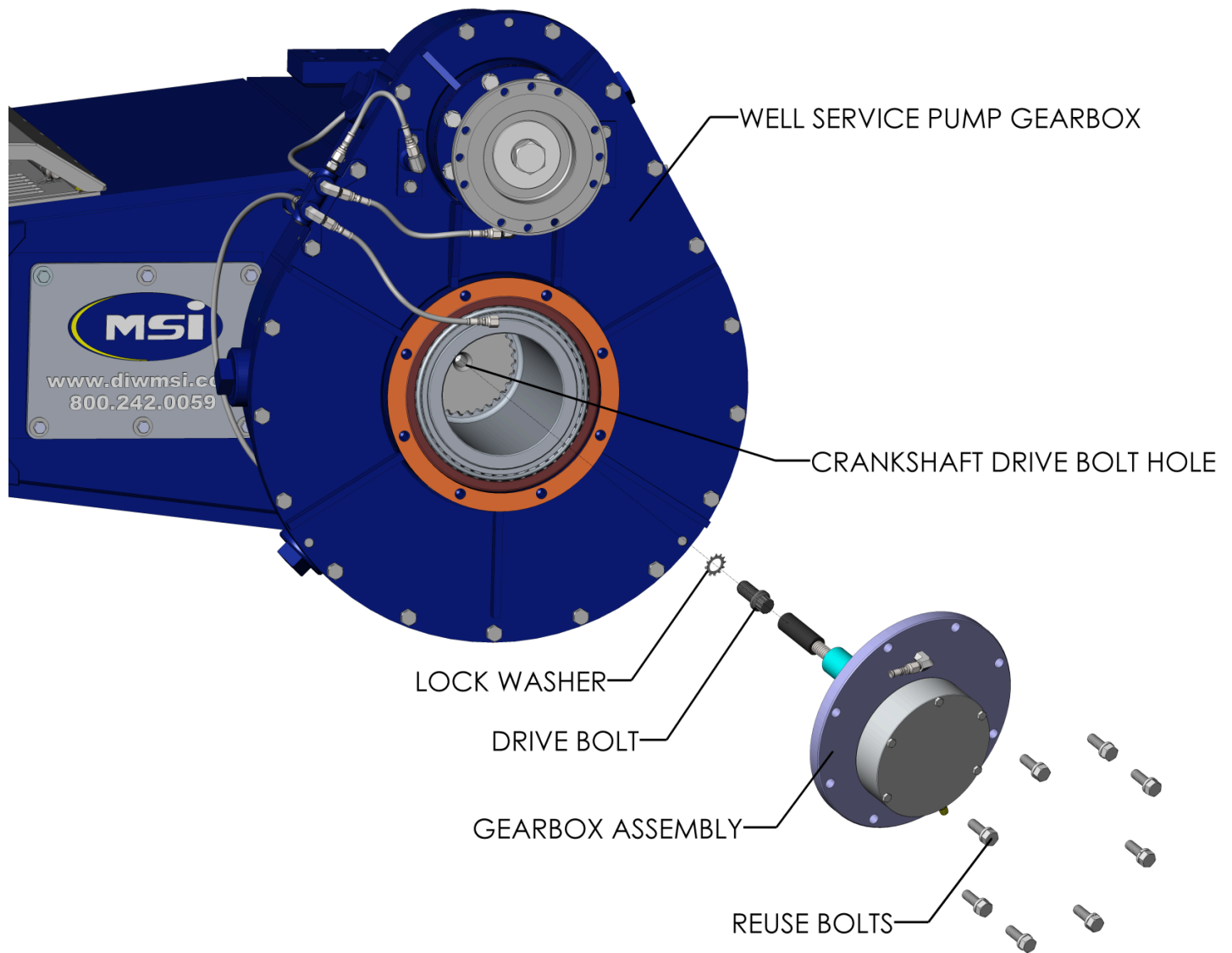
- 2) Disconnect bearing lubrication line from bearing retainer fitting.
- 3) Once the pinion bearing preload has been properly adjusted, the bull gear bearing retainer plate may be removed. Before installing the new Auto-Lube™ ready retainer plate, a measurement is required to determine the shims required to properly preload the bull gear bearings. This is done by checking the distance from the flange face to the bearing race lip face with a depth micrometer to the nearest thousandth of an inch (X.XXX"). See following image for reference.



If the new bearing retainer plate is within 0.001" of the old plate, no shim change is necessary, proceed to **Step 4**. If the distance is greater than 0.001" the shim thickness will need to be adjusted. A measured distance of the new retainer plate which is less than the old retainer plate will require shims to be removed at the same value. If the new retainer plate measures a distance greater than the old retainer plate, shims will need to be added at the same value. For example, if the old retainer plate measures 0.292 and the new retainer plate measures 0.287, a total of 0.005" shim thickness will need to be removed.

- a. *If in **Step 1** the pinion bearing shims required adjustment, the bull gear shims will need to be adjusted as well. Generally, the bull gear bearings will wear at a rate equivalent to the reduction ratio of 4.61:1. If for example 0.010" – 0.012" of shim stock was removed in step 1, then 1/4.61 of that should be removed from the bull gear bearing shim stack. Using the above example this would result in about 0.002" – 0.003" shim thickness reduction.*

- 4) Reconnect lubrication line that was disconnected in **Step 2**. A longer hose is supplied with the Auto-Lube™ to accommodate any possible change in mounting position that would result in the original lubrication line not reaching the fitting, or reaching but being tight or in a bind.
- 5) Install gearbox assembly drive bolt and lock washer onto crankshaft and torque bolt to 70 – 100 ft-lb_f. See following image for detail.



- 6) Insert the gearbox assembly into the pump gearbox until the drive socket makes contact with the bolt installed in **Step 6**. Rotate the assembly until the socket fully engages the bolt. It is important that the socket be fully engaged and not just resting on the top of the bolt head.
- 7) Orient the assembly such that the cover window and valve are pointing down. This will prevent rainwater or contamination such as dirt from accumulating inside the cover, which could potentially cause the air switch to malfunction. Reinstall bolts removed in **Step 3** (dry threads torque 60 ft-lbs, lubricated threads torque 45 ft-lbs).



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