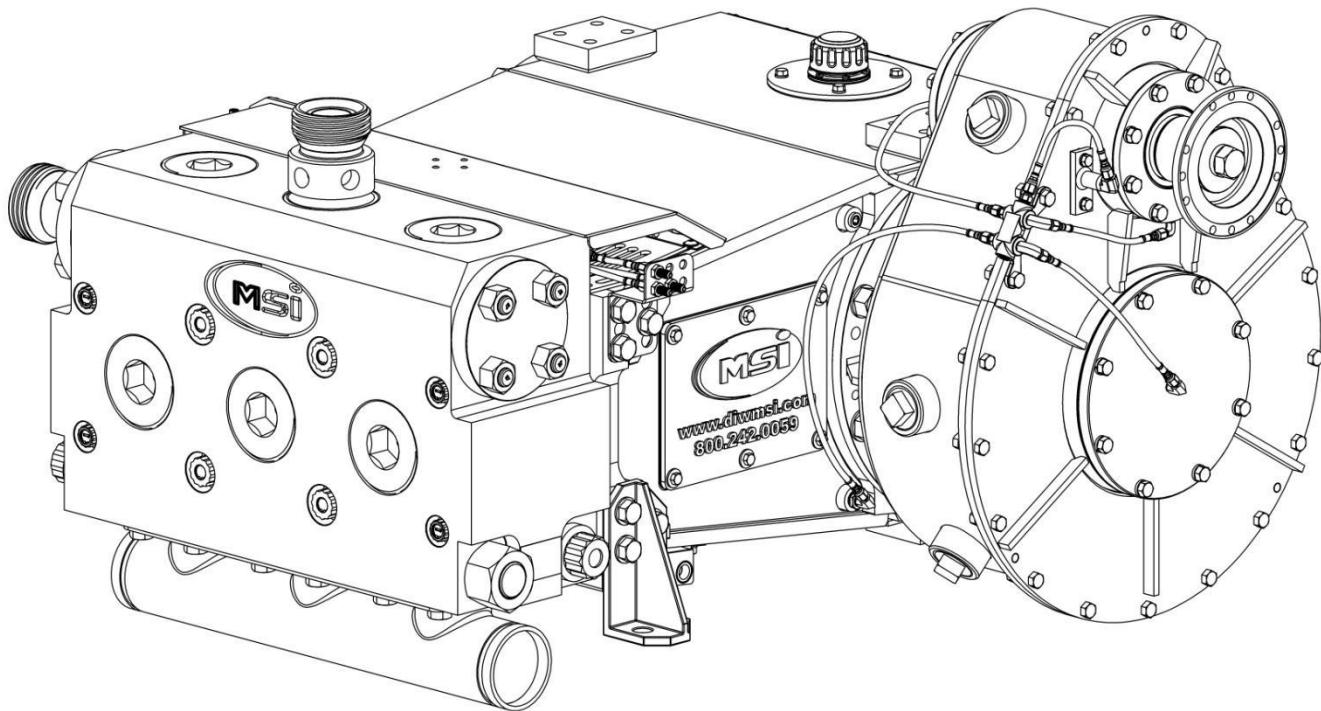




Technical Manual

MSI Hybrid™ Well Service Pumps



MSI – A Division of Dixie Iron Works, Ltd.
300 W. Main St.
Alice, TX 78332
www.diwmsi.com
(800) 242-0059

SECTION 1 **WARNINGS**

The MSI Hybrid™ Well Service Pump is used in high-pressure and high flow well service applications. High pressure equipment, if not used and maintained properly, can cause serious injury or death and damage to equipment and property. Not taking proper precautions and failing to perform routine maintenance and inspections can also contribute to loss of well control, and such loss could cause serious injury or death and damage to equipment and property.

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

Operating the equipment without safe-guards in place can result in serious injury or death and damage to equipment and property. It is the responsibility of the packager to design and install all guards designed to keep operators or maintenance personnel away from all moving parts.

Operating the equipment without an adequate, approved, properly maintained and correctly pre-set discharge pressure relief valve can result in serious injury or death, damage to equipment and property, and will void the factory warranty. It is the responsibility of the packager to select and install the relief valve. Be sure that no valves are placed between the pump outlet and the pressure relief valve.

Starting the pump without previously starting the lubricating oil circulation system and the suction supercharge-pump can result in damage to the equipment.

Running the pump without adequate oil at a safe lubrication pressure, flow, and temperature can result in damage to the equipment.

Starting the pump with dry and unlubricated fluid end plungers and packing can result in significant damage to the packing.

Running the pump without adequate inlet pressure can result in cavitations and the premature loss of valves, valve seats, and fluid ends. The resulting vibrations generated by the pump running while cavitating can also result in damage to the pump and to adjacent equipment.

Running the pump at speeds or pressures beyond those published in this manual will result in mechanical failures or pressure containment failures, including loss of well control. Such failures could cause serious injury or death and damage to equipment and property.

2.1 Pump Description

The MSI Hybrid™ Well Service Pump is a single acting reciprocating plunger pump used for fracturing, acidizing, cementing, well control, and circulating operations. It is rated for pumping fluids up to 15,000 PSI or at flow rates up to 929 GPM. With different materials it can handle many fluid types, including abrasive and corrosive fluids. Seals are also available for low temperature and CO₂ applications. The Hybrid™ Well Service Pump is designed to mount on a skid, a well service truck, or other rigid platform.

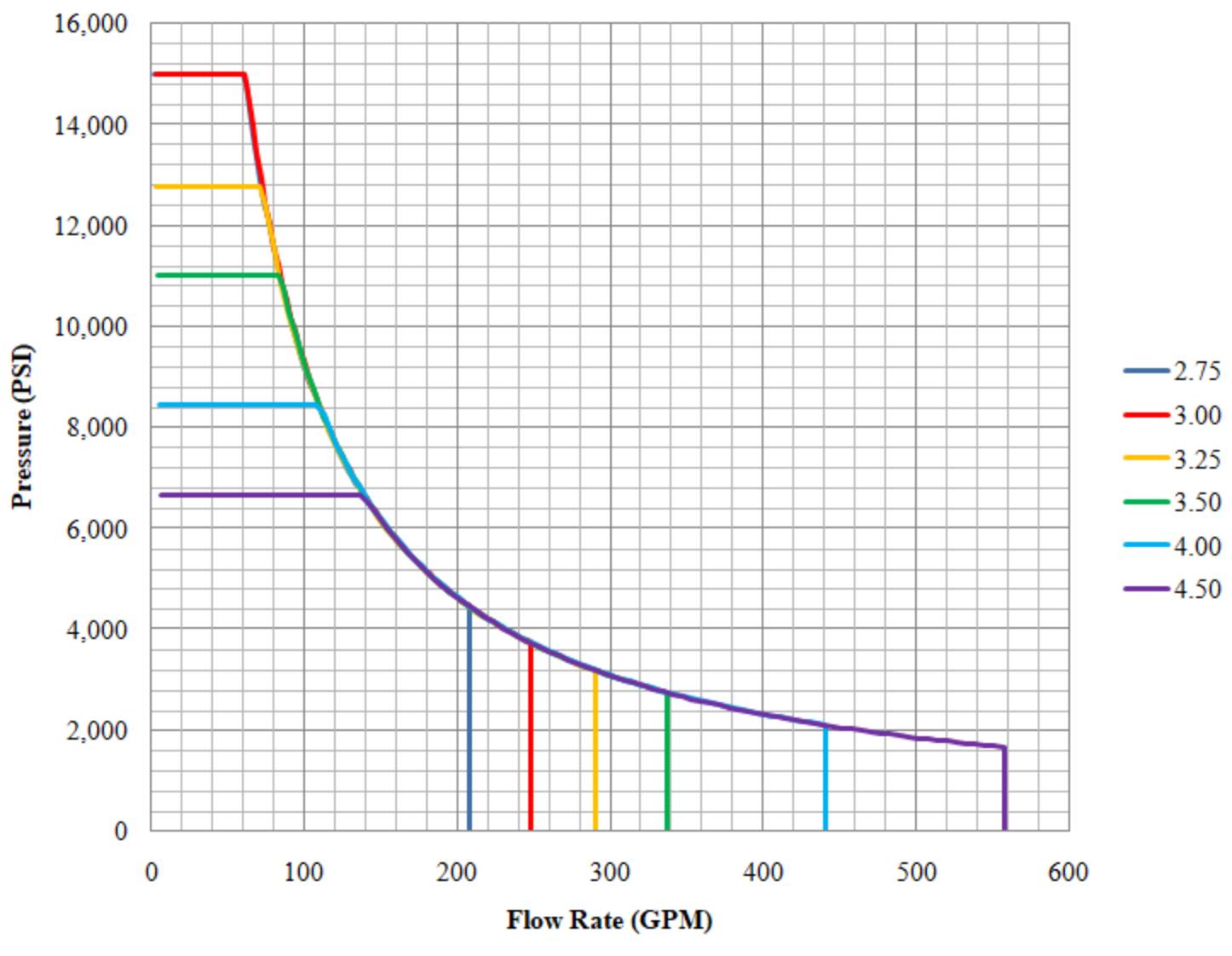
2.2 Pump Specifications

The MSI Hybrid™ Well Service Pump is available in 600 bhp triplex; 1000 bhp or 1300 bhp quintuplex compact models capable of being mounted back-to-back within US DOT width limits of 102". These models are rated for a 106,029 pound rod load. A 1500 bhp model is also available and is capable of being mounted back-to-back in a 120" width. This model is rated for a 150,000 pound rod load.

The MSI Hybrid™ Well Service Pump consists of three primary assemblies; a fluid end, power end, and gear reducer. The standard Xtreme Service™ fluid end is machined from a one-piece, high-strength, steel or stainless steel forging and includes a patented system of tension bolts that reduces the stresses in the fluid end. The gear reducer includes helical, precision ground gears manufactured to AGMA #10 quality or better. 600-1300 bhp models have a gear reduction ratio of 4.6111:1, the 1500 bhp model has a final reduction ratio of 8.8946:1. The power end is a welded, high-strength steel frame that is machined and line bored after stress relieving for accuracy.

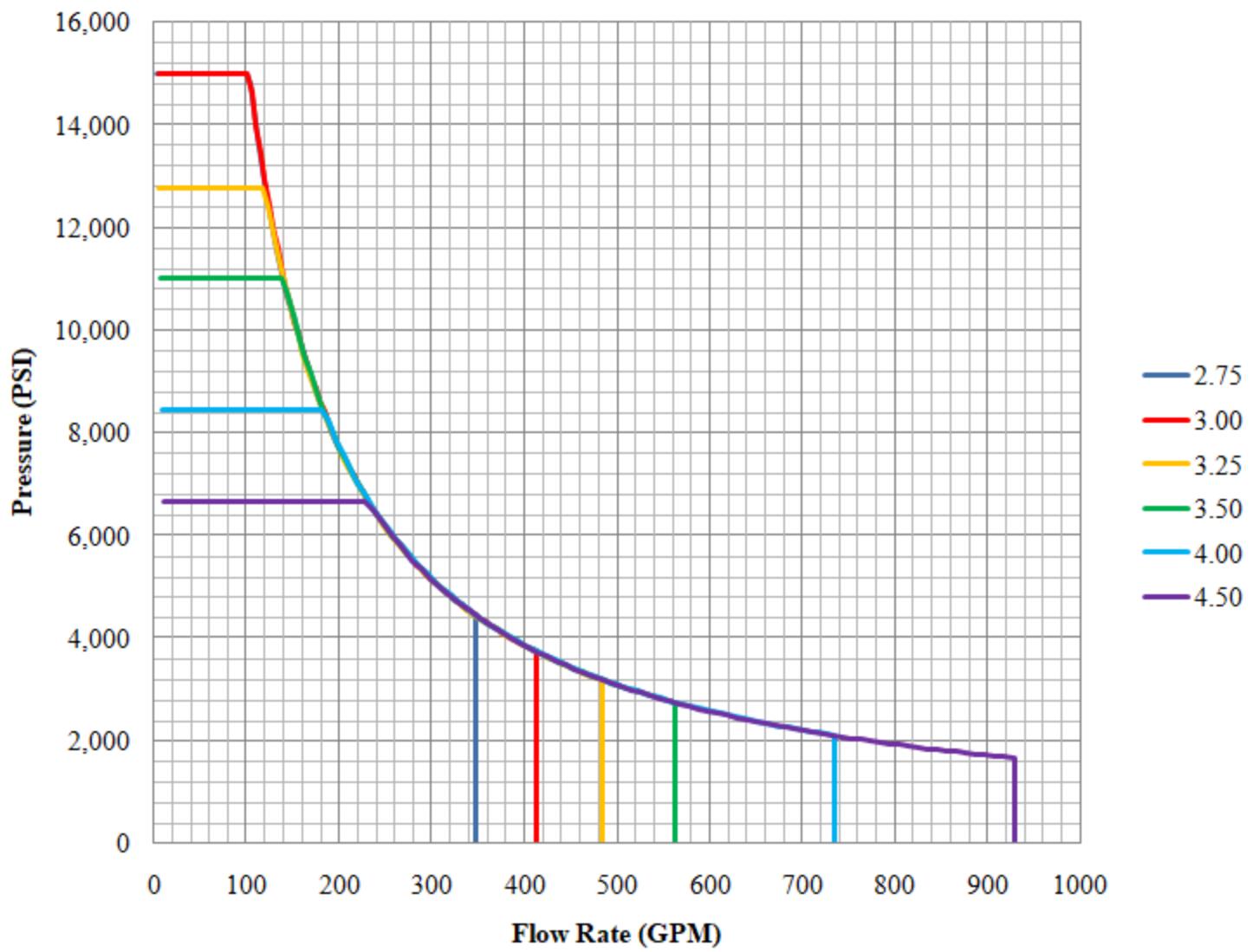
Performance charts for all models are presented in the following pages.

MSI 600 BHP



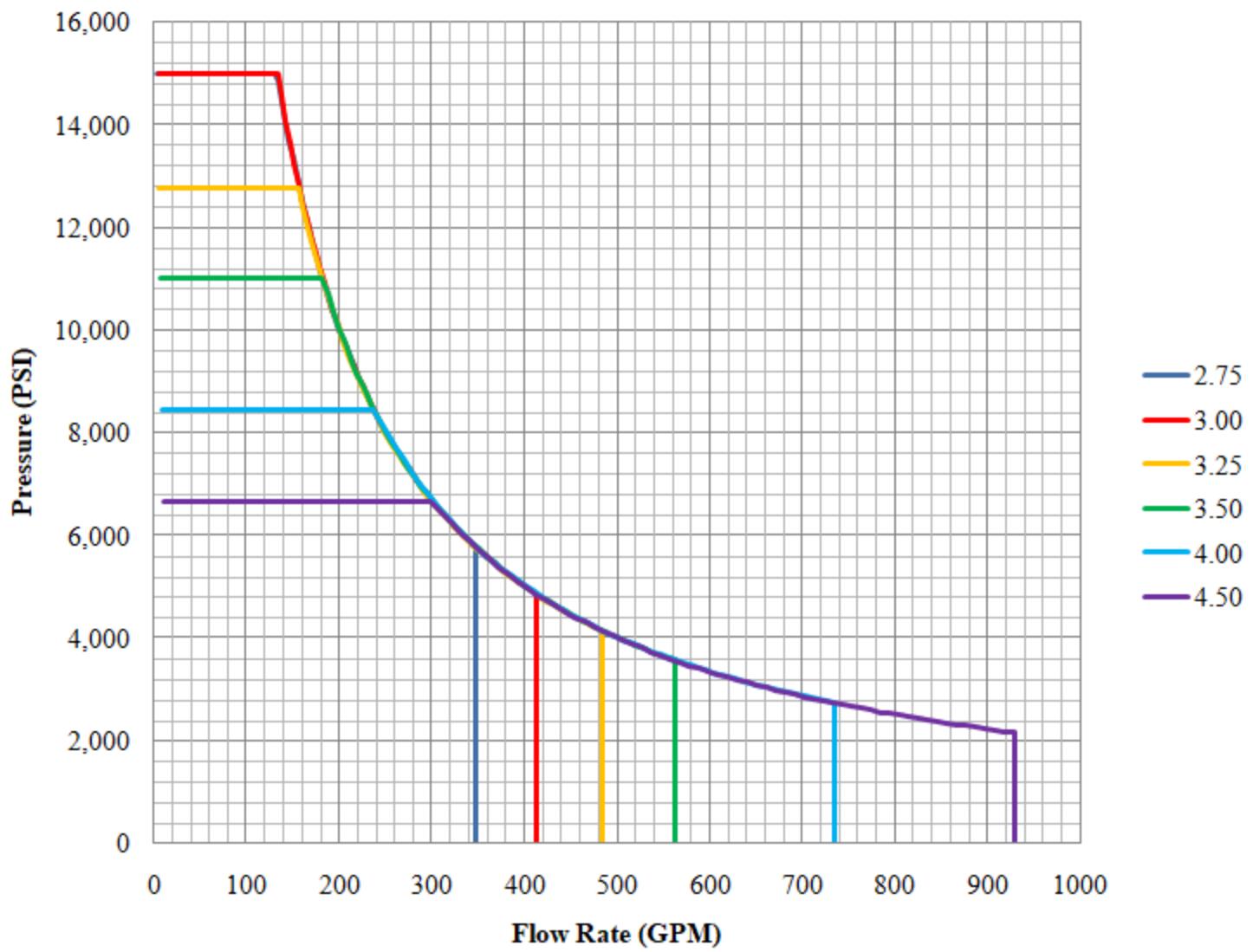
TIH-600									
PLUNGER		2.75	3.00	3.25	3.50	4.00	4.50	BHP	
GAL/REV		0.46	0.55	0.65	0.75	0.98	1.24		
R P M	25	GPM	12	14	16	19	24	31	134
		PSI	15,000	15,000	12,781	11,020	8,438	6,667	
	50	GPM	23	28	32	37	49	62	268
		PSI	15,000	15,000	12,781	11,020	8,438	6,667	
	100	GPM	46	55	65	75	98	124	536
		PSI	15,000	15,000	12,781	11,020	8,438	6,667	
	200	GPM	93	110	129	150	196	248	600
		PSI	9,999	8,402	7,159	6,173	4,726	3,734	
	300	GPM	139	165	194	225	294	372	
		PSI	6,666	5,601	4,773	4,115	3,151	2,489	
	450	GPM	208	248	291	337	441	558	
		PSI	4,444	3,734	3,182	2,744	2,100	1,660	

MSI 1000 BHP



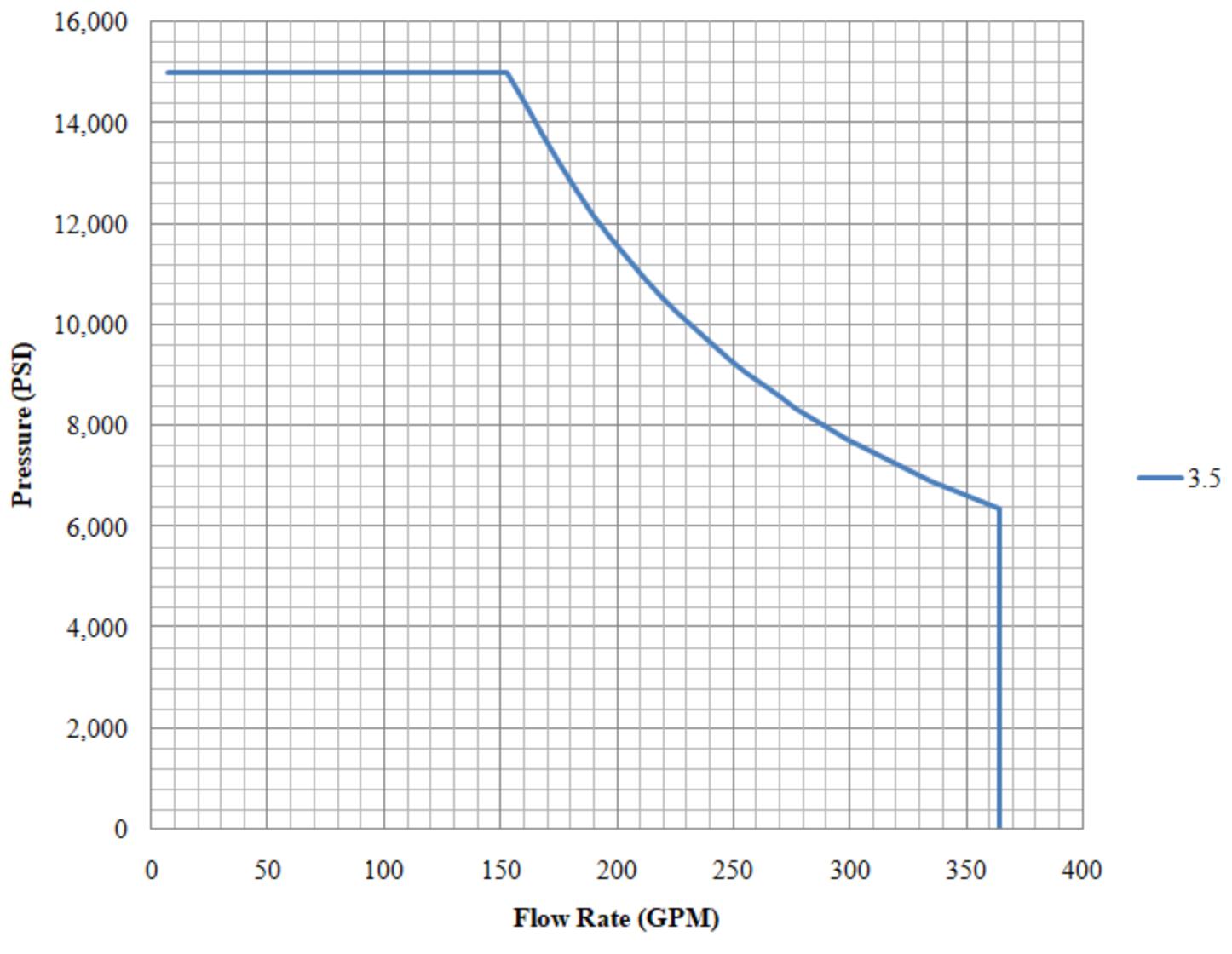
QIH-1000									
PLUNGER		2.75	3.00	3.25	3.50	4.00	4.50	BHP	
GAL/REV		0.77	0.92	1.08	1.25	1.63	2.07		
R P M	25	GPM	19	23	27	31	41	52	223
	25	PSI	15,000	15,000	12,781	11,020	8,438	6,667	
	50	GPM	39	46	54	62	82	103	446
	50	PSI	15,000	15,000	12,781	11,020	8,438	6,667	
	100	GPM	77	92	108	125	163	207	893
	100	PSI	15,000	15,000	12,781	11,020	8,438	6,667	
	200	GPM	154	184	215	250	326	413	1,000
	200	PSI	9,999	8,402	7,159	6,173	4,726	3,734	
	300	GPM	231	275	323	375	490	620	
	300	PSI	6,666	5,601	4,773	4,115	3,151	2,489	
	450	GPM	347	413	485	562	734	929	
	450	PSI	4,444	3,734	3,182	2,744	2,100	1,660	

MSI 1300 BHP



QIH-1300									
PLUNGER		2.75	3.00	3.25	3.50	4.00	4.50	BHP	
GAL/REV		0.77	0.92	1.08	1.25	1.63	2.07		
R P M	25	GPM	19	23	27	31	41	52	223
		PSI	15,000	15,000	12,781	11,020	8,438	6,667	
	50	GPM	39	46	54	62	82	103	446
		PSI	15,000	15,000	12,781	11,020	8,438	6,667	
	100	GPM	77	92	108	125	163	207	893
		PSI	15,000	15,000	12,781	11,020	8,438	6,667	
	200	GPM	154	184	215	250	326	413	1,300
		PSI	12,999	10,923	9,307	8,025	6,144	4,854	
	300	GPM	231	275	323	375	490	620	
		PSI	8,666	7,282	6,205	5,350	4,096	3,236	
	450	GPM	347	413	485	562	734	929	
		PSI	5,777	4,854	4,136	3,567	2,731	2,158	

MSI 1500 bhp



QIH-1500				
PLUNGER		3.50	BHP	
GAL/REV		1.46		
R P M	25	GPM	36	354
		PSI	15,000	
	50	GPM	73	709
		PSI	15,000	
	100	GPM	146	1,417
		PSI	15,000	
	200	GPM	292	1,500
		PSI	7,937	
	250	GPM	364	
		PSI	6,349	

SECTION 3 PRESERVATION

3.1 Preservation Considerations

Steel will rust unless proper measures are taken. The MSI Hybrid™ Well Service Pump is packaged and shipped with several preservation precautions in place. It is important to note the following suggestions for long-term storage or for protecting the pump between well service operations, especially if the pump is to be idle between well service jobs or in storage for long periods of time.

3.2 Preservation for Shipping

Every MSI pump undergoes factory acceptance testing (FAT) at the MSI test facility before it is cleaned, painted, and preserved for shipping. This FAT procedure involves operating the pump through a full range of horsepower and pressure. During the FAT, water is used as the pumping medium. Once the test is completed, the water residue in the fluid end is removed, and all fluid end internal parts are generously misted with water displacing protective lubricant. Following the FAT, the insides of the gear reducer and power end are fully coated with high grade lubrication oil. After final painting, the pump is shrink-wrapped to create a vapor barrier. Desiccant packets are placed within the shrink wrap to absorb internal moisture. If the pump is to be shipped overseas, it is also placed within a completely enclosed wooden crate which has been properly prepared for overseas shipments.

3.3 Preservation for Storage

If your new MSI Hybrid™ Well Service Pump, as packaged from MSI, will be in storage for longer than one month, then the following preservation measures should be taken:

After taking delivery of the pump, remove the top of the shipping crate for pump inspection; be careful to not damage the crate. Examine the pump and vapor barrier for any signs of condensation, this could indicate a broken seal or depleted desiccant. Remove and dry out any water found inside the packaging and replace the desiccant if necessary. Reseal the moisture barrier using sheet plastic and duct tape then reinstall the crate top. These steps must be performed if the pump was ocean freighted. If the pump will be stored in a tropical climate MSI recommends the above inspections are performed at least every 3 months. Always store the pump indoors to keep the unit protected from moisture.

Prepping the pump for operation after removing from long term storage (> 3 months):

Prior to attempting to operate a pump that has been in storage for greater than 3 months, it is recommended the following sealing elements at the least be replaced:

- Discharge flange lip seals
- Suction cover, discharge cover, and gauge connection lip seals
- All packing header and pressure rings
- Stuffing box adapter seals

The following sealing elements shall at the very least be removed and carefully inspected for damage and replaced as required:

- Packing nut o-rings

- Packing nut wiper ring
- Suction manifold o-rings

Refer to [Section 6](#) for start-up procedures.

If your pump has been in service:

For the Fluid End:

If the unit has been in service and will be stored for more than a couple of weeks, remove the valve covers from the fluid end and blow all moisture out with dry, compressed air. Wear proper protective gear while blowing out moisture to prevent contact with the well service fluid. Generously mist the inside of the fluid end with a suitable lubricant to displace trapped water and create a protective film on the metallic components. Replace the valve covers. Seal off all inlets and outlets with plastic sheet and tape or with mechanical blind seals. **CAUTION:** Well service fluid will be trapped between the inlet and outlet valves and will spill out when removing the suction valve covers. Preparation for spillage is important for safety and environmental reasons. A catch pan and appropriate absorbent materials will be needed.

For the Power End:

If the pump has been in service, moisture from humidity can enter through the oil cap/breather and will accumulate at the inside bottom of the power end. If this occurs, remove the back access panel (See [Section 11.4](#)) and wipe out the accumulated moisture with a suitable absorbent. **Do not use granulated absorbents inside the pump.** Replace the back cover after moisture has been removed. To further protect the pump from humidity while in storage, especially when stored near large bodies of water or in areas of high humidity, use duct tape to seal off the oil cap/breather. Sealing in this manner will be more effective if the air inside the pump is warmer than outside air prior to sealing the oil cap/breather. If the cap on the lubricating oil reservoir is a breather style cap, it should also be sealed at this time.

Outdoor Storage:

If the used pump is to be stored outdoors, it should be placed in a covered location that will protect the pump from direct exposure to moisture and sunlight. If a covering is not available, the pump should be covered and tied with a heavy duty tarp.

3.4 Preservation Between Jobs

The internal fluid end components can oxidize and corrode after exposure to well service fluid, especially if the well service fluid contains water, brine, or acids. If possible, remove the valve covers and use dry, compressed air to blow out moisture from the fluid end. After removing the valve covers, generously mist the inside with a suitable lubricating oil to displace moisture and create a protective film on the metallic components. Wear proper protection when working with compressed air on the inside of the fluid end. Covering all exposed discharge or suction openings will help in further preventing ingress of moisture to the pump.

SECTION 4 INSTALLATION

4.1 Pump Dimensions, Lifting Points and Mounting Requirements

Various pump models are available to view and download at www.diwmsi.com. Please contact MSI Engineering if a specific pump model and configuration is required [engineering@diwmsi.com].

The pump CG is noted in the previous drawings. Use only properly rated lifting harnesses for installation, removal, and maintenance of the MSI Hybrid™ Well Service Pump. Please note that the weights listed on the following pages are average weights based on typical pump configurations. Please contact MSI for configuration-specific weights.

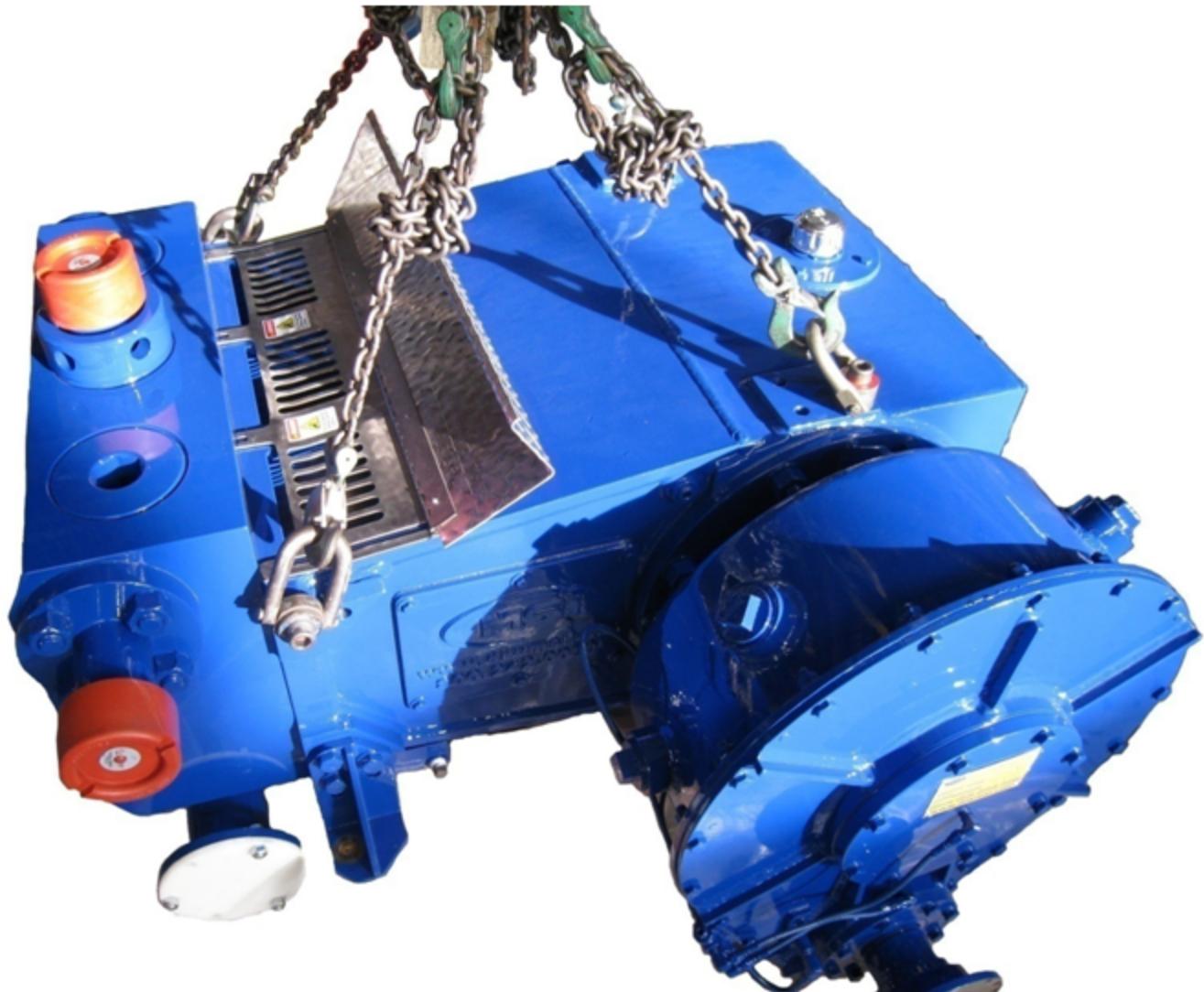
7/8"-9 UNC-2A Grade 8 screws should be used on the front mounting feet. 3/4-10 UNC-2A Grade 8 screws should be used on the rear mounting pads. Use all 10 mounting holes.

Safe lifting methods are shown below:

To lift the complete pump, install swivel eyes rated for lifting into four of the 3/4" -10 UNC holes at the locations shown.

Pump Total Weight:

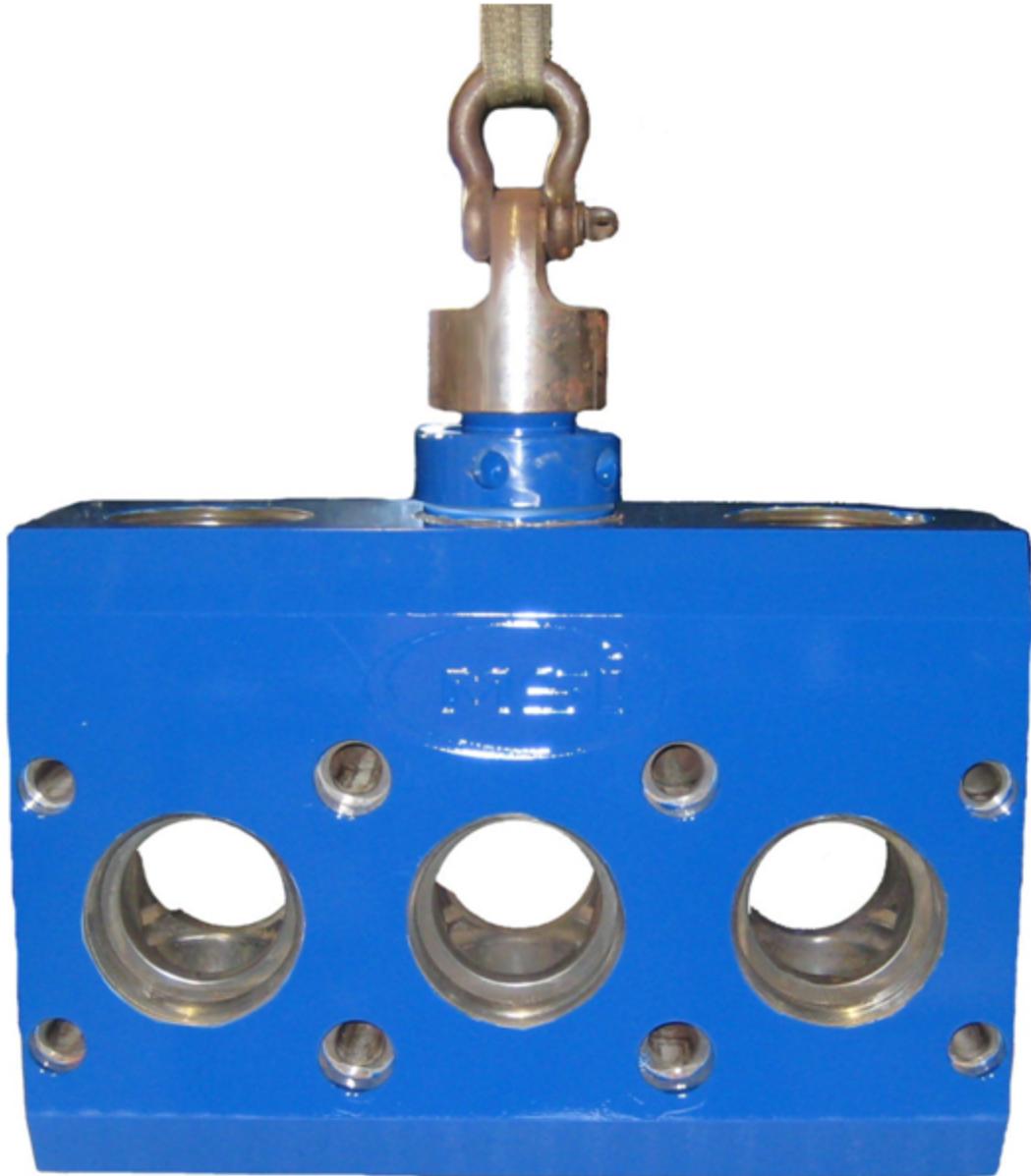
- TIH-600 | 4,700 LBS
- QIH-1000 & QIH-1300 | 7,500 LBS
- QIH-1500 | 11,500 LBS



To lift the fluid end use MSI lifting sub LSA0001 on a centered gauge connection.

Fully dressed fluid end total weights:

- TIH-600 | 1,600 LBS
- QIH-1000 & QIH-1300 | 2,500 LBS
- QIH-1500 | 3,200 LBS

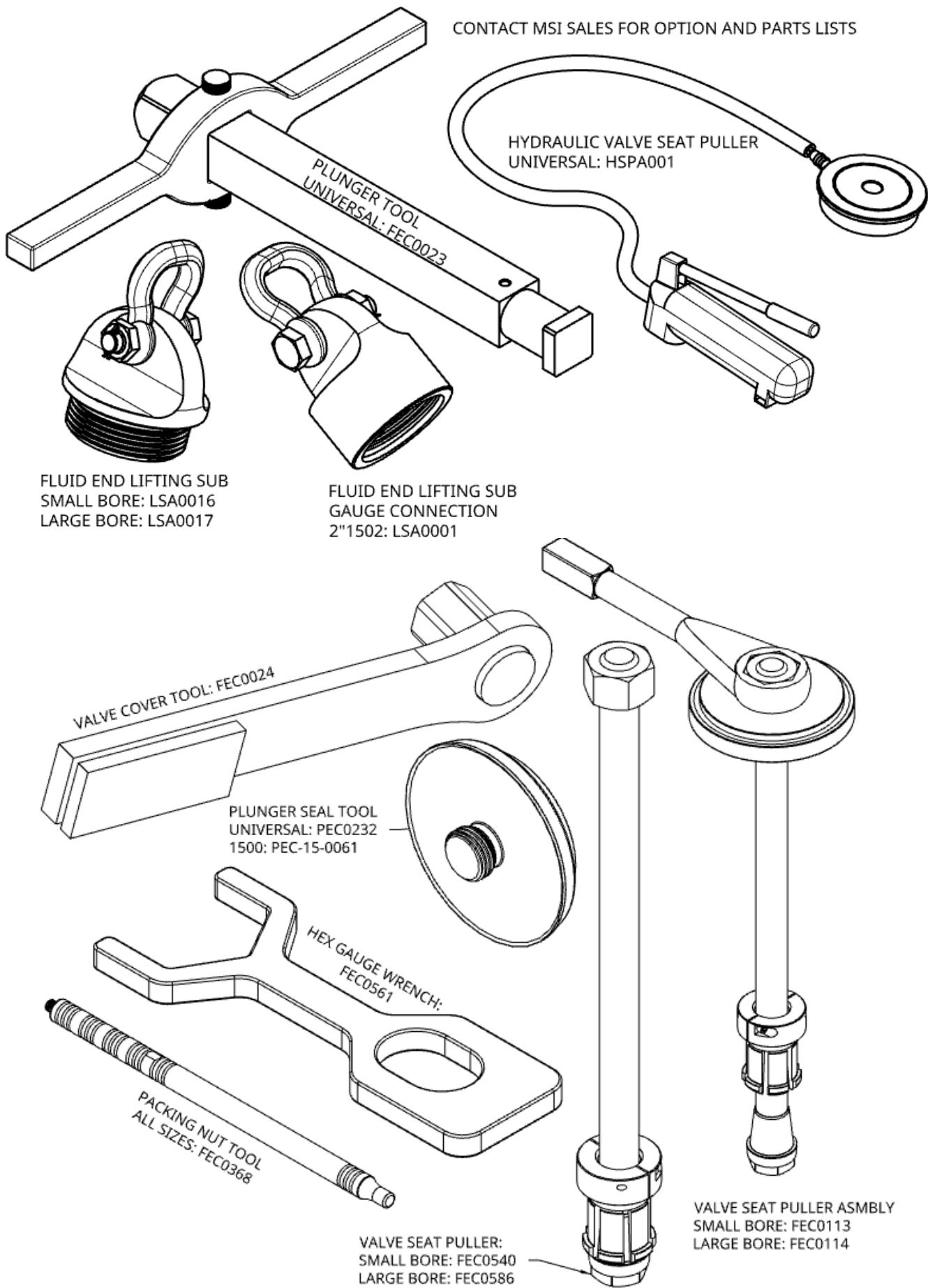


4.2 Maintenance Space Requirements

When determining the design of the pump installation, consideration must be given to the access needs for general maintenance of the pump. Working space is needed to replace consumables such as valves, fluid end plungers, and packing. Space is also needed to inspect and adjust the pinion bearing pre-load of the gear reducer (see [Section 10.2](#)). Consideration should also be given to major repairs that must be accomplished at the factory, and the pump package should be designed to allow for removal of the pump.

4.3 Pump Service Tools

Special tools are required to perform routine maintenance such as replacing packing, valves & seats, plungers, and seals.

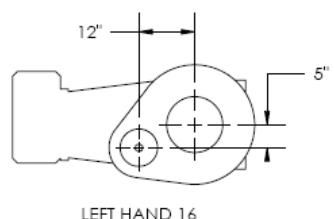
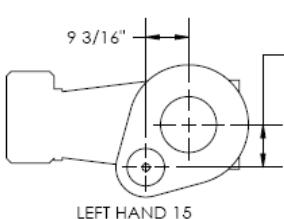
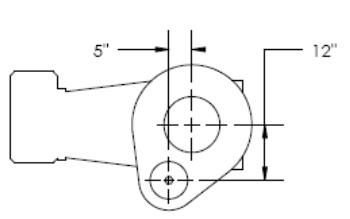
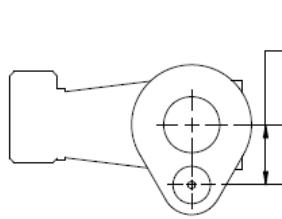
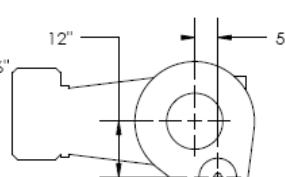
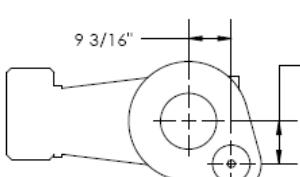
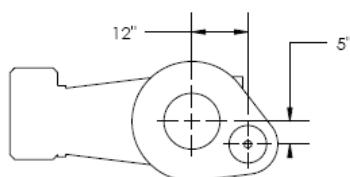
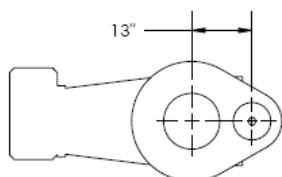
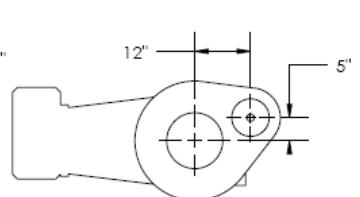
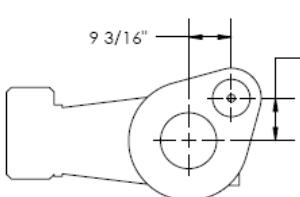
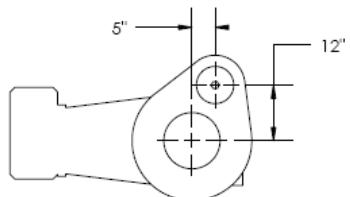
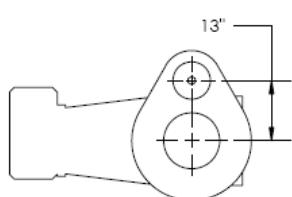
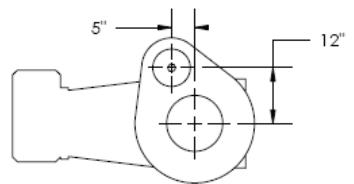
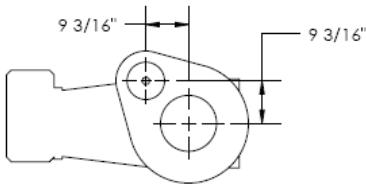
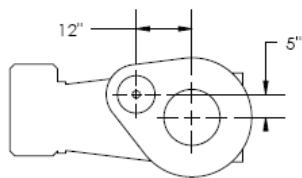
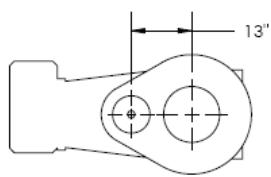


4.4 Pump Drive Connections and Locations

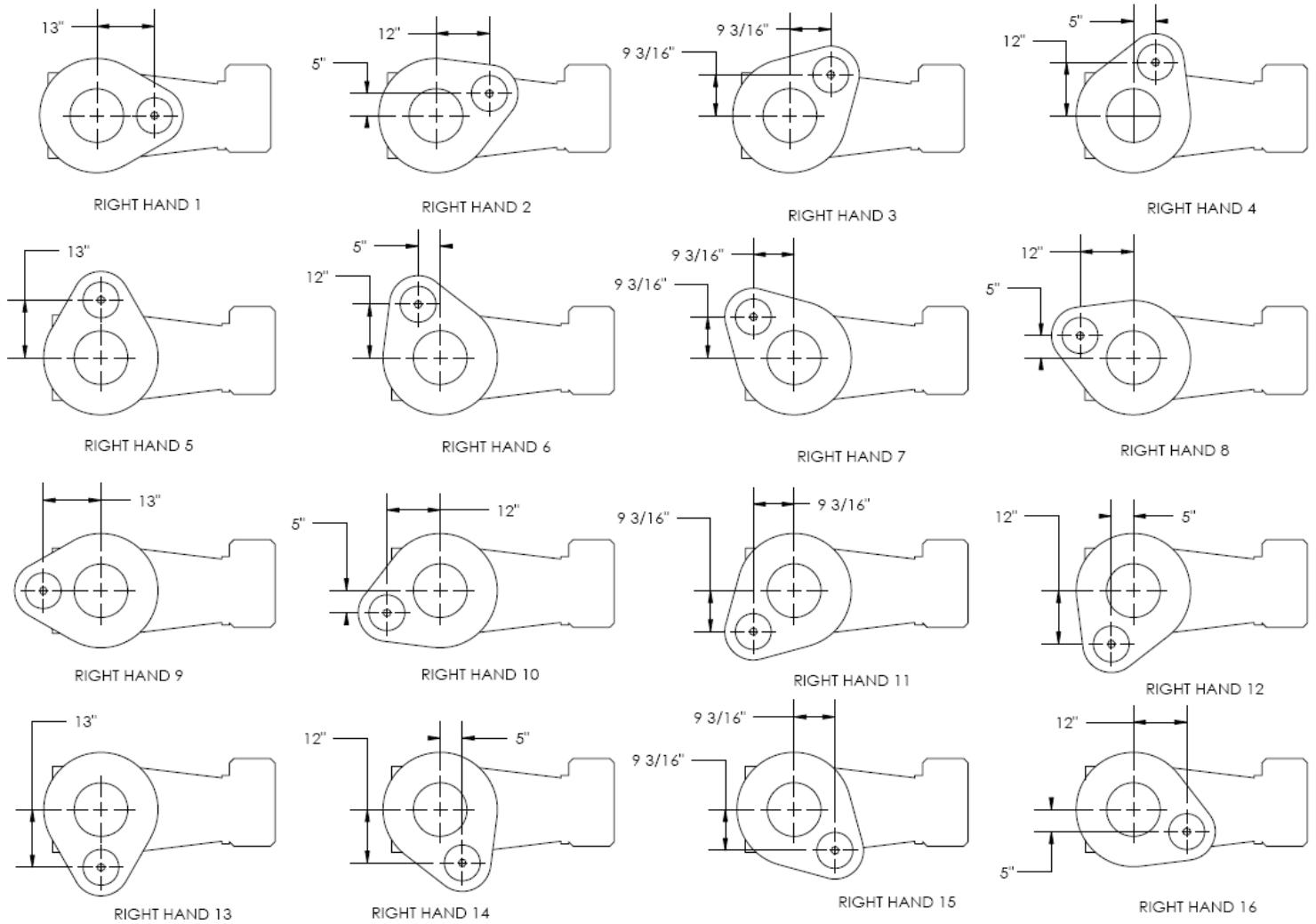
When determining the design of the pump installation, the position of the prime mover and shaft should match one of the positions shown on the following pages. The driveline shaft must include a slip joint with 1" minimum slip in the joint after installation.

Contact MSI Engineering for QIH-1500 gear position options.

POSITION DIMENSIONS ROUNDED TO THE NEAREST 1/16"



POSITION DIMENSIONS ROUNDED TO THE NEAREST 1/16"



4.5 Fluid Pumping Connections and Pressure Relief Considerations

When determining the design of the pump installation, clearance is recommended for inlet and outlet connections as well as providing for a pressure relief device for the discharge line. A pressure relief device is required for all applications of this pump. Failure to implement a pressure relieving device may result in significant damage to the pump and attached piping, serious injury or death of personnel, and will void the pump warranty. Please read the following concerning pressure relief devices and the allowable mounting locations.

Spring loaded ball and seat relief valves:

Pressure relief devices of this type rely on a ball and seat interface to create a seal. Force is exerted on the ball, typically with springs, to balance a predetermined line pressure. This type of pressure relief device is not designed for full opening once relief pressure has been achieved, in other words, a ball and seat relief valve is not a full volume relief device and if sufficient fluid volume is present may cause line pressure to continue to rise due to the small flow area available. As the line pressure exceeds the set pressure of the relief valve, the ball temporarily separates from the seat thus allowing excess pressure to flow through. Once line pressure has dropped below the set pressure of the relief valve, the ball will re-seat. Due to the small volume relief capacity of these types of pressure relief devices it is acceptable to install them on a fluid end gauge connection(s). While not intended as a full-bore volume relief device connection point, the gauge connection will provide a sufficient conduit for a ball and seat type relief valve. Valves or other closure devices shall not be installed between the pop-off valve and the fluid end. Always follow the manufacturer's recommendations for the installation, use, and maintenance of the relief valve.

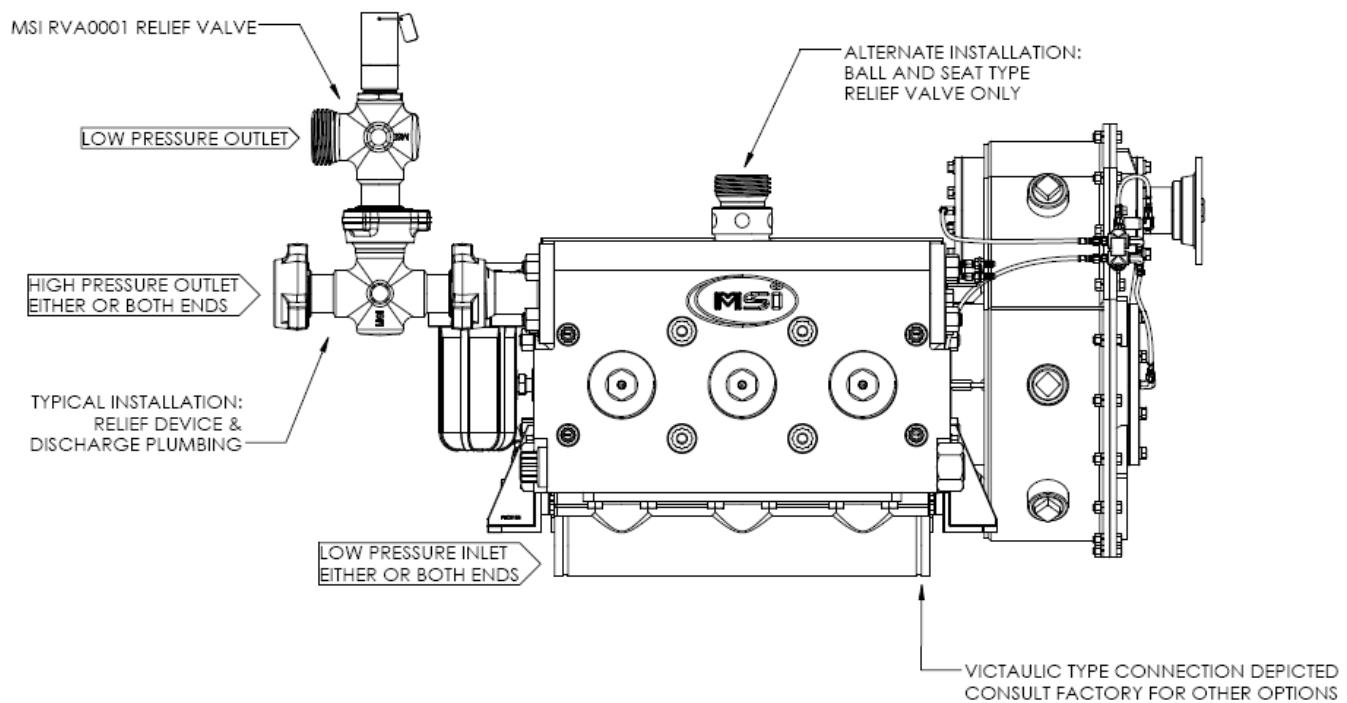
Full bore (pop-off) relief valves:

Full-bore relief valves are designed to allow full bore dissipation of pressure by relieving large volumes of fluid. As such, these relief devices must not be installed on the fluid end gauge connection(s). The pop-off valve should be installed as close to the fluid end as possible and in the discharge piping circuit at either the blind side of the fluid end (for single side discharge) or connected to a TEE fitting on the discharge side of the fluid end. Valves or other closure devices shall not be installed between the pop-off valve and the fluid end. Always follow the manufacturer's recommendations for the installation, use, and maintenance of the pop-off valve.

Relief set pressure guidelines:

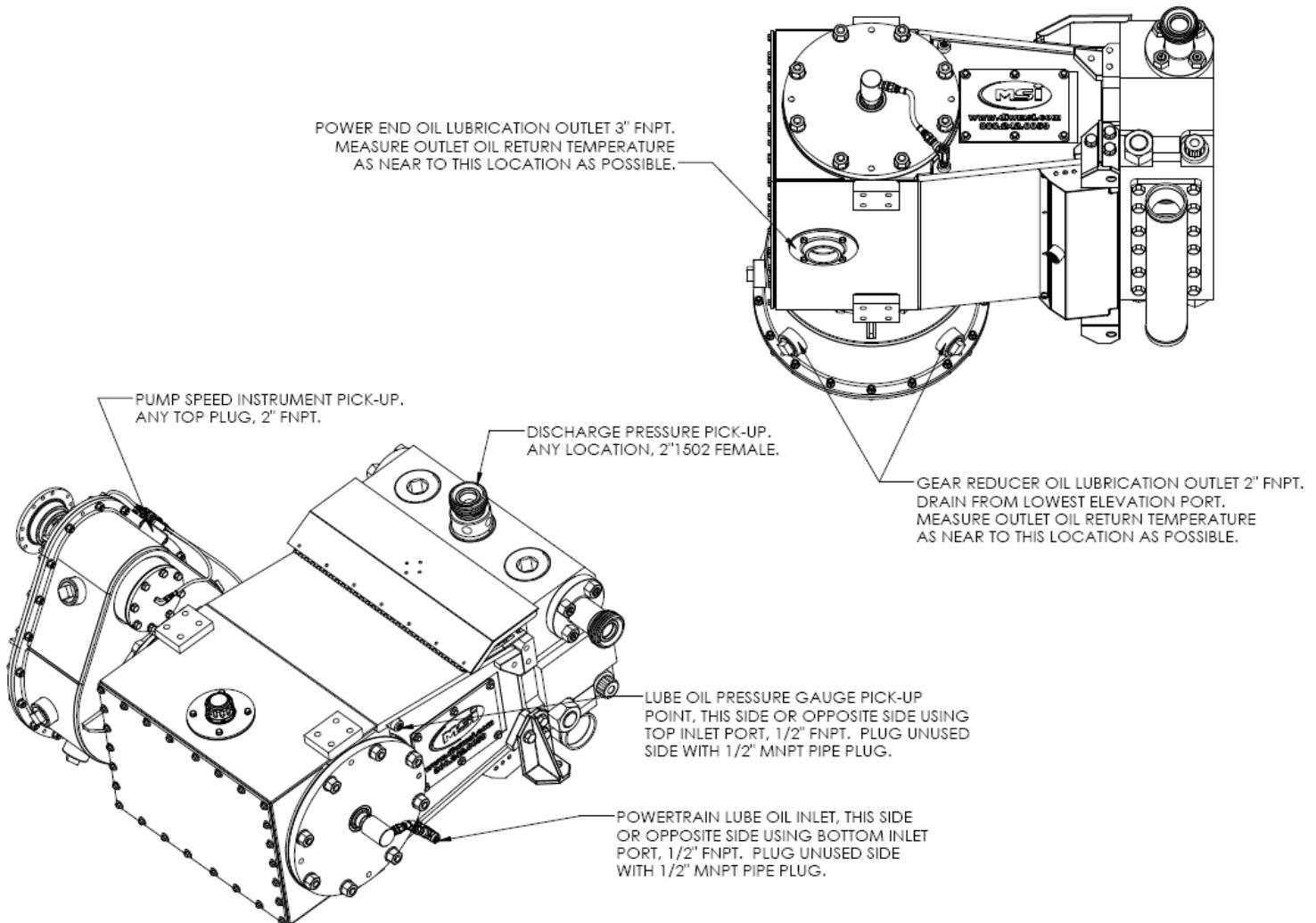
MSI recommends the relief pressure be set according to the maximum anticipated pressure that will be required for a given job, not to exceed the pressure rating of the pump based on plunger size.

See drawing on the following page for piping location dimensions and pressure relief mounting locations.



4.6 Pump Lubrication and Instrument Connections

Pump pressure, RPM, oil pressure, and oil temperature instruments and safety controls are recommended.



*The 1500HP Pump requires a drain line for each gear reducer.

4.7 Plunger Auto-Lube and Relief System

Available for the MSI Hybrid™ Well Service Pump are two systems which greatly enhance the performance of the pump by providing lubrication only when it is needed and maintaining a clean operating environment by routing waste lubricant to a reservoir.

The [MSI Auto-Lube System](#)™ (ALS) is a 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. This approach eliminates over or under lubricating and ensures lubricant is supplied whenever the pump is in motion. The Auto-Lube™ System can be used in conjunction with the MSI Lube Relief System™ to provide outstanding lubrication performance.

The [MSI Lube Relief System](#)™ (LRS) is a bolt-on system designed for use on any MSI Hybrid™ Well Service Pump. It is compatible with oil or grease and is most effective when used with a positive displacement automatic greasing system. The LRS can act as a standalone installment or be combined with the MSI Auto-Lube™ System for exceptional lubrication performance. This system has been designed to significantly improve packing life and eliminate the waste and environmental problems usually associated with lubrication systems that “flood” the packing gland with grease.

Please follow the above hyperlinks for additional information or contact MSI.

4.8 Charge Pump Intake

Unless careful attention is put into the design of the suction supply system, the well service pump can experience cavitation. The resulting erosion of components, and cyclical stresses into the flow lines as a result of vibrations, can be a serious hindrance to the safety and suitable operation of a well service package design. MSI therefore recommends the use of a centrifugal charge pump as part of a properly designed supply system.

Well service pump cavitations will occur if the pump suction pressure drops to a level approaching the vapor pressure of the fluid being pumped. Because of the rapid stopping and starting of fluid at each of the suction valves, especially at high flow rates, the sudden demand for fluid and resulting rapid pressure drop at the valve inlet can cause cavitation at the well service pump suction manifold inlet. MSI recommends that the inlet charge pressure be a minimum of 50 PSI.

A centrifugal charge pump should be sized to run at less than 100% flow capacity due to the cyclical nature of the inlet flow into a well service pump. The charge pump should be sized so that it can supply these sudden volumes of fluid that flow at momentary velocities and run 7%* higher than the average pump flow velocity. For slurry applications, the centrifugal pump should be sized for 1 1/2* times the recommended flow rate of the well service pump, considering the flow rate at the largest fluid end plunger size and pump RPM expected on any well service job. Also, the line between the centrifugal and the well service pump should be sized so that flow velocity changes do not exceed 1.5 feet per second.*

A cavitating pump can shake an entire well serviced truck and can even make offshore decks vibrate considerably. The resulting annoyance is not the only effect. Excessive vibrations can result in manifold and flow line fatigue failures, which could result in injury, death, equipment damage, and loss of well control.

Because well service pumps often pump slurries, it is also important that fluid velocities be kept high enough to prevent solids from settling out of the fluid. The settling solids will accumulate at bends or on the blind side of the suction manifold and can cement together into a solid mass. Design the system to eliminate any traps which may collect solids.

Flow velocities of the piping and NPSH leading into the centrifugal charge pump needs to be sized according to the centrifugal pump manufacturer's recommendation to prevent cavitations. A cavitating centrifugal pump will introduce vibrations and entrained air into the inlet of the well service pump and can cause it to cavitate.

If a suction supply line is inadequately designed and causes cavitation to occur at high flow rates, the use of a bladder type suction stabilizer will often eliminate the problem. Consult the stabilizer manufacturer for proper sizing and installation.

Placing a liquid filled 0-100 PSI pressure gauge with pulsation snubber nearest to the suction inlet of the well service pump is useful for diagnosing cavitation problems. If the gauge needle vibrates excessively, the pump may be cavitating. Keeping the charge pressure at the inlet at 50 PSI or above for high pumps RPMs should resolve this.

* These numbers are taken from a popular centrifugal pump manufacturer's handbook on sizing a centrifugal pump for charging a reciprocating pump while pumping slurries. Consult the manufacturer of your selected centrifugal pump for specific recommendations on your application.

4.9 Pump Discharge Requirements

The pump discharge pressure rating is a function of plunger diameter and rod load rating of the power end. Never exceed the pressure rating stated on the fluid end nameplate or the pressure rating of connected equipment, whichever is lower. Even if the pump is rated for a higher pressure than its intended well service use, a pressure relief valve is required as part of an operational system. If the discharge line is suddenly blocked, the pump may overpressure which can result in personal injury, death, equipment damage, and loss of well control. Never operate this MSI pump without a suitable pressure relief device set for the maximum pressure that the well service pump and all connected piping and equipment can be safely operated. Do not place a valve between the MSI well service pump outlet and the pressure relief device.

4.10 Pump Safety Precautions

All moving parts should be covered by guards which are adequate to keep operators or maintenance personnel from coming in contact with moving parts. An approved pressure relief device shall be installed and maintained as near to the pump outlet as possible. Oil temperature and pressure warning and/or shut-off shall be used to prevent equipment damage due to failed bearings in the powertrain. Adequate chemical fire extinguishers should be installed near the approach to the pump. Failure to heed these precautions can result in equipment and personnel damage or injuries.

4.11 Preparing Pump for Use

Prior to operating the pump, check all connections, electrical instrumentation connections, fluid piping connections, and mechanical drive connections. Ensure that all safety guards are in place and secure. Verify that the discharge and suction flow paths are open and not dead-headed. Be sure a pressure relief device is properly installed and set to the right relief pressure and that nothing is blocking the relief flow line.

For start-up and shut-down procedures, see [**Section 6**](#).

SECTION 5 LUBRICATION REQUIREMENTS: POWER TRAIN AND PLUNGERS

5.1 Lubrication Capacity Requirements

The MSI Hybrid™ Well Service Pump is a dry sump, i.e., it is not intended to contain a volume of lubricating oil. A separate lubrication oil reservoir is required with a 50 gallon minimum capacity; it should be installed below the plunger pump power end. It is recommended that a separate reservoir be used for each well service pump on units with multiple well service pumps. Separate reservoirs prevent contaminants in one system from affecting both lubrication systems and well service pumps. While the MSI Hybrid™ Well Service Pump greatly reduces contamination, it is still prudent for the user to take all precautions to ensure long equipment life by keeping lubrication systems separate and clean. Fill the reservoir with 45 gallons of the proper lubricating oil listed in [Section 5.8](#). A valve installed at the lowest point in the tank is recommended to allow for accumulated water to be removed.

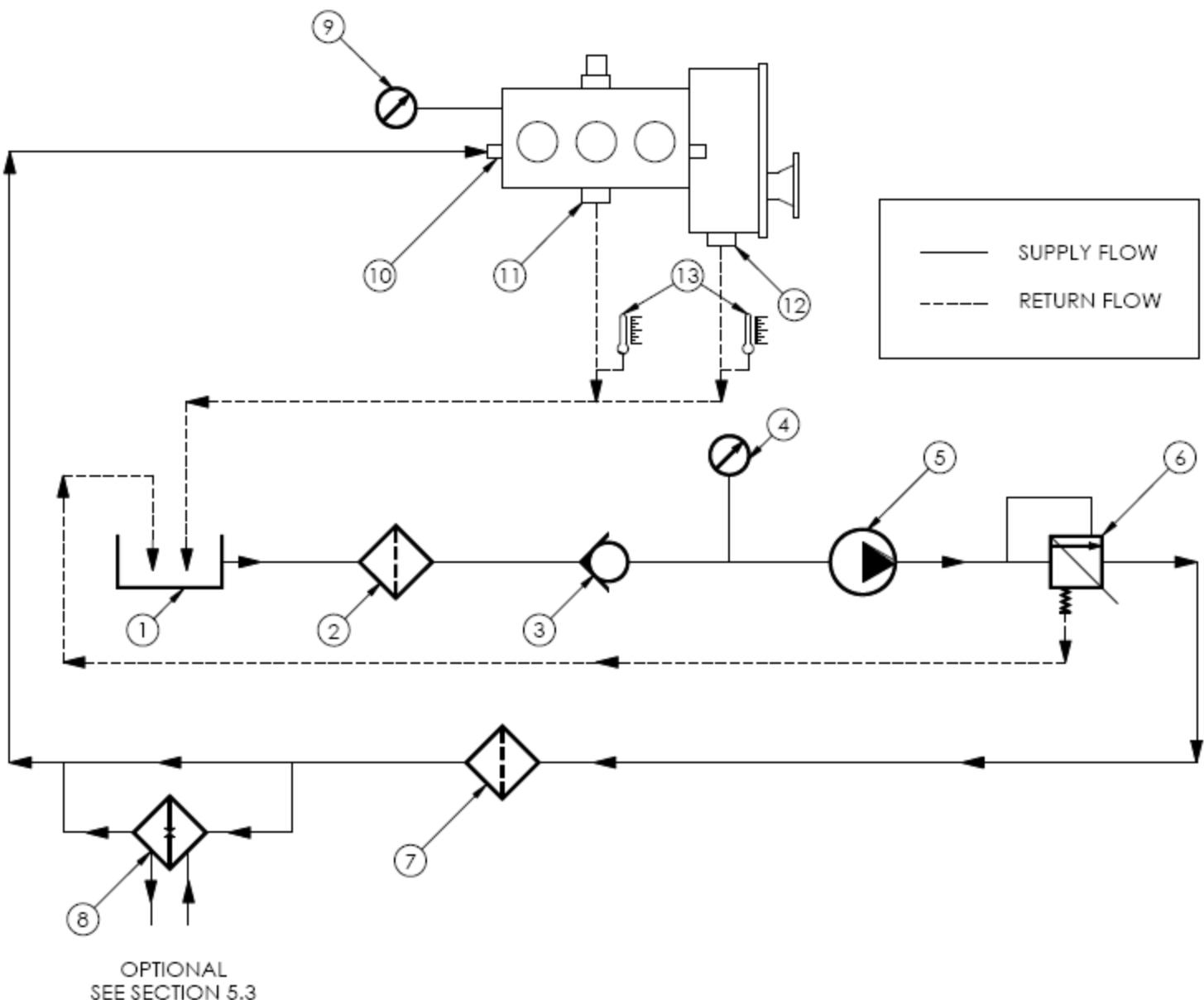
The MSI Hybrid™ Well Service Pump is not equipped with an internal lubrication pump. The packager must add a lubrication pump to one of the PTOs of the prime mover. The lubrication oil pump should be rated for 20 GPM and 300 PSI and be capable of pumping 90 wt oil. One lubrication pump must be dedicated to each well service pump.

When designing the system, it is important to locate the lubrication oil pump on a PTO on the drive train that is engaged whenever the prime mover (i.e. diesel engine) is running and not on a PTO that rotates only when the transmission is in gear. A properly designed system will allow for oil circulation through the MSI Hybrid™ Well Service Pump prior to rotating the pump drive shaft and after the pump drive shaft rotation has been stopped when the transmission has been returned to neutral. This is recommended so that the oil will warm up prior to putting the pump into gear. The warmed oil will flow with less resistance and will better lubricate the moving parts. Additionally, this will allow the oil to cool the pump after the plunger pump rotation has been stopped.

It is important to mount the lubrication pump as low as possible so that the pump does not cavitate as a result of having to lift the fluid from the reservoir. If at all possible, the pump should be mounted below the outlet of the reservoir.

A pressure gauge shall be placed as close to the top lubrication inlet port as possible to monitor lubrication pressure. Pressure at this location must always be kept above 40 PSI, and flow rate to the plunger pump is recommended to be at least 12 gpm at the inlet for a quintuplex, and at least 8 gpm for a triplex. Connect the lubrication oil inlet line to the lower lubrication inlet port on either side of the well service pump; plug the unused lubrication pipe ports with 1/2" NPT pipe plugs. Do not exceed 450 PSI lubrication pressure at the MSI Hybrid™ Well Service Pump power end lubrication inlet. (This pressure limitation does not apply to the fluid end plunger lubrication system.)

5.2 Typical Lubrication Schematic



ITEM NO.	DESCRIPTION
1	RESERVOIR, VENTED 50 GALLON MIN CAPACITY
2	SUCTION STRAINER, 50 GPM MIN. 300 SQ IN MIN. 40-100 MESH w/3-5 PSI RELIEF
3	CHECK VALVE, SWING 1 1/2" ID MINIMUM
4	VACUUM GAUGE, LIQUID FILLED, 0-30" Hg
5	PUMP, GEAR TYPE, 20 GPM, 300 PSI MIN. ENGINE OR TRANSMISSION DRIVEN
6	RELIEF VALVE, ADJUSTABLE, 60-200 PSI, 3/4" ID 20-25 GPM MIN.
7	FILTER, 50 GPM/200 PSI MIN. 25-33 MICRON ELEMENTS, w/ 15-25 PSI RELIEF
8	HEAT EXCHANGER--SEE MANUAL FOR SIZING
9	PRESSURE GAUGE, LIQUID FILLED, 0-200 PSI
10	POWER END LUBE INLET, 1/2" NPT-F
11	POWER END LUBE DRAIN, 3" NPT-M
12	GEAR REDUCER DRAIN, 2" NPT-F
13	TEMPERATURE TRANSDUCER/GUAGE, 0-250°F

5.3 Heat Generation, Dissipation and Cooling

In most applications, the lubrication system will require a heat exchanger to maintain recommended oil temperature and pressure. In some cold-start applications an oil heater may be needed. For calculating heat dissipation of the pump by the surrounding air, use the following surface areas:

- TIH-600: 46 ft²
- QIH-1000/1300: 60 ft²
- QIH-1500: 70 ft²

Refer to the oil manufacturer for the recommended operating temperature range. In all cases, do not allow the oil temperature to exceed the manufacturer's temperature rating, or 250°F; whichever is lower.

In tests conducted by MSI the pump typically operates at a mechanical efficiency of approximately 96%.

5.4 Lubrication Relief Valve

A relief valve should be part of any MSI Hybrid™ Well Service Pump lubrication system. MSI recommends a relief valve that is rated for 20-25 GPM and 60-200 PSI to relieve excess pressure which could damage filters, lines, gauges, or other connected equipment. Using a pump rated for 20 GPM and 300 PSI, the pressure relief valve can be set for 180 PSI if the oil pump is only supplying oil to the well service pump. Oil with a viscosity rating of 220 cSt at 100°F will provide adequate flow in ambient temperature ranges of 20°F-110°F. When the lubricating oil is cold it will shear over the relief valve to shed excess pressure, once the viscosity decreases this shearing will be reduced or eliminated. The relief valve may need to be adjusted as the oil temperature changes in order to maintain an internal well service pump pressure of 40 PSI. The return line should be sized to accommodate the full capacity of the pump and should drain directly into the reservoir.

5.5 Lubrication Filtration

Clean oil has a direct correlation to the life of the moving parts in the pump; the cleaner the oil is, the longer the pump will last. Limiting moisture in the oil will also greatly extend the life of the moving parts in the pump. The MSI Hybrid™ Well Service Pump is designed to prevent migration of well service fluids into the lubrication system. However, even with the MSI Hybrid™ Well Service Pump there is still a need for an effective filtering system since contamination can come from other locations. Using a properly sized oil filter on your system and changing the filters regularly will significantly reduce downtime and maintenance costs.

It is highly recommended that you use filters with a built in bypass valve rated for 15 to 25 PSI so that oil will still reach the moving parts inside the pump in case of a filter clog.

Water from humid air can enter the pump through the oil cap/breather and will greatly increase the rate of wear of the moving parts. It is highly recommended that a water drain be placed at the lowest point in the reservoir and that it be drained after each use of the pump.

MSI strongly recommends that a serviceable magnet be placed near the suction inlet of the lubricant reservoir. Metallic particulate can come from several sources and limiting the amount of particulate which may exposed to bearings will significantly increase the life span of all equipment serviced by the lubrication system.

5.6 Lubrication Attachment Points

See [Section 4](#) for drawings showing lubrication inlet and outlet locations.

5.7 Fluid End Plunger and Packing Lubrication Requirements

It is essential for the effectiveness and life of the plunger packing to provide sufficient lubrication to the fluid end plungers and stuffing box. Failure to do so may result in short packing life, plunger damage, and costly downtime. Typical fluid end plunger lubrication systems utilize either an air over oil pneumatic or positive displacement grease system. Either lubricating method is acceptable as long as the following guidelines are heeded.

The lubricant should be suitable for the entire operating temperature range of the well service pump, resist water, inhibit corrosion, and provide wear protection. Oils used for plunger lubrication will typically have a viscosity index of about 95, and greases will be NLGI grade 0 to 2; depending on the application.

5.8 Oil Change and Oil Types

API Service Classification GL-5 Extreme Pressure (EP) gear oils are required for lubrication of the power end and gear reducer. These oils contain additives that allow sustained high loads and prevent oxidation, rust, and foaming. The oil viscosity should be selected based on the anticipated ambient start-up and steady-state operating temperatures.

5.9 Cleaning Plunger Lubrication Drip Pan

The drip pan is intended to collect plunger lubricant that bypasses the sealing element. Failing seals may result in lubricant accumulating in the pan, especially with grease lubricated pumps. It is critical to the safe and effective operation of the pump that this waste lubricant not be permitted to accumulate. Replace seals as needed then clean the pan by removing the screws and sliding the pan out from below the pump. Clean then reinstall it.

6.1 Start-Up Procedure

During start-up, follow proper operating and safety procedures for dealing with well control and well service manifold valves. This start-up procedure does not apply to well control, but to the recommended start-up of the MSI Hybrid™ Well Service Pump after well control procedures have been followed.

- 1) Prior to operating the pump, check all electrical, fluid, and mechanical connections.
- 2) Check that the drive shaft is securely attached and that all safety guards are securely in place.
- 3) Verify that the MSI Hybrid™ Well Service Pump discharge and suction flow lines are open and not dead-headed.
- 4) Ensure that the pressure relief valve is properly installed, set to a safe pressure relief setting, and that no blockage or closed valves are restricting the relief line.
- 5) Check the indicator on the Maxbolts™ that join the fluid end to the power end. Each bolt has a mechanical indicator in the face which represents bolt tension. The Maxbolts™ should all indicate at approximately 90%-95% on the dial. If this is not the case, see tightening instructions in [Section 9.6](#).
NOTE: The Maxbolts™ do not need regular adjusting; only make adjustments if the indicators indicate a drop in tension. Replace immediately if the tension indicator is not functioning.

*If your MSI Hybrid™ Well Service Pump is equipped with an Xtreme style fluid end, it will have Maxbolts™ installed longitudinally through the fluid end. The tension on these bolts is pre-set at the factory and should not need adjustment.

- 6) Check the pump lubrication oil reservoir for fluid level and for proper oil type ([See Section 5.8](#)).
 - 7) Start the lubrication pump and allow it to circulate. Make sure lubrication pressure and flow is within the range shown in [Section 5.1](#). Check for leaks or unusual noises. For unusual noises, see [Section 13](#). Allow the lubrication pump to run long enough to warm up the oil if this is a cold weather start-up. Starting the well service pump with cold oil may damage moving parts due to poor circulation. Allow the oil pump to run until the oil temperature reaches approximately 70°F.
 - 8) Open any valves in the suction line. Start the centrifugal charge pump that provides flow and pressure to the MSI Hybrid™ Well Service Pump inlet. Check for leaks or unusual noises. For unusual noises see [Section 13](#).
 - 9) Start the fluid end plunger packing lubrication system, and check to see if it is adjusted to the recommended output rating (see [Section 5.7](#)). Do not proceed until the packing gland is primed with lubricant.
- CAUTION:** Be sure that the packing access port safety cover is fastened in place before starting the pump. See [Section 11.1](#)
- 10) Put the prime mover into low gear, and start the pump.

- 11) Check for system leaks or unusual noises. If unusual noises are heard, shut the pump off and see [Section 13](#).
- 12) Increase speed and pressure slowly, checking for leaks or unusual noises.
- 13) Ensure that lubrication oil pressure, flow, and temperature are kept in the recommended ranges throughout operation of the pump. For recommended lubrication pressure, flow, and temperature ranges; see [Section 5.1 and 5.8](#).
- 14) During cold service starts it is best to let the oil warm up prior to running the pump at high RPMs or high pressures.
- 15) If the pump was delivered with valves installed, then the valves were already seated during the FAT test. If the valve seats were replaced in the field, the following procedure must be followed to set the valve seats:
 - a) The tapered valve seats must be fully seated to allow optimum flow area between the valve and the seat. Washout may also occur between the valve and the fluid end if the valves are not fully seated.
 - b) Connect a 3/4" to 1" orifice test choke to the discharge circuit and adjust it to fully open. Shift the transmission into first gear, and increase the throttle setting to achieve 50-100 crank RPM. Slowly increase discharge pressure using the test choke until a series of audible popping noises are heard. This indicates the seats have properly set in the taper. Do not exceed the max pressure rating of the pump during this procedure.
- 16) If the fluid end plunger or packing has been replaced, then the packing nut may need to be retightened after the pump is run under pressure for a few revolutions. The packing in this pump is non-adjustable; therefore, fully tightening the packing nut is required to properly set the gland length. See [Section 9.2](#) for instructions on this.

6.2 Shut-Down Procedure

During shut-down, follow proper operating and safety procedures for dealing with well control and well service manifolds valves. This shut-down procedure does not apply to well control, but to the recommended shut-down of the MSI Hybrid™ Well Service Pump after well control procedures have been followed.

- 1) Shift the transmission into neutral, allowing the pump to coast to a stop.
- 2) Shut off the plunger lubrication system.
- 3) Shut off the centrifugal pump supplying the suction pressure to the MSI Hybrid™ Well Service Pump.
- 4) Close any valves necessary to isolate the pump from the well service fluid in the circulation tank.
- 5) Leave the prime mover running so that oil to the MSI Hybrid™ Well Service Pump will continue to circulate and cool down any internal parts that were under heavy load prior to the shut-down.
- 6) When oil temperature has stabilized, the lubrication oil pump can be shut-down.
- 7) Flush out the fluid end of the pump with water to eliminate any solid or chemical residues left over from the well service operation.
- 8) If the pump will be moved to another location or back to the well service yard, drain any water from the lubrication oil reservoir after the oil has returned to ambient temperature.
- 9) If the pump is to be idle for more than a day, follow the fluid end preservation procedure in [Section 3](#).

7.1 First 100 Hours

- Change the pump lubrication oil filters every 25 hours for the first 100 hours of run time.
- Thoroughly clean the pump lubrication oil suction strainer after the first 50 hours and 100 hours of operation.
- Change the pump lubrication oil after the first 100 hours of operation, and clean the reservoir.

7.2 Daily Preventative Maintenance

- Check the fluid level in the lubrication oil reservoir, drain off water, and service magnet.
- Check the fluid level in the fluid end plunger lubrication reservoir.
- Check the plunger pump for fluid leaks.
- Check the pump lubrication oil system for leaks.
- Check the fluid end plunger lubrication system for leaks.
- Check the supercharge piping for leaks.
- Check the fluid end bolts, see [Section 6.1.5](#).

7.3 Weekly Maintenance

- Check all items on the “daily” list.
- Check all valves, inserts, valve seats, and springs.
- Check all discharge and suction valve cover seals.
- Check suction pulsation dampener for correct pre-charge if applicable.

7.4 Every 100 Hours

- Check all items on the “daily” and “weekly” lists.
- Check all plunger pump-mounting bolts to ensure that they are tight.
- Change pump lubrication oil filters.
- Check all the supplies needed for routine maintenance, such as o-rings, fluid seals, valves, valve inserts, valve seats, valve springs, packing, oil seals, filter elements, etc.

7.5 Every 250 Hours

- Check all items on the “daily,” “weekly,” and “100 hours” list.
- Change the pump lubrication oil, and refill with the proper grade of gear oil for upcoming ambient

conditions.

NOTE: To minimize the costs of oil changes it is recommended to test oil samples and establish a replacement schedule based on the oil contamination rate for the type of service the pump is in. If this approach is not implemented then the oil should be changed every 250 hours.

- Thoroughly clean the pump lubrication suction strainer.
- Remove and inspect the fluid end plungers and packing assembly components.
- Replace all packing pressure rings and header rings.
- Clean the plunger pump's oil breather and the lubrication oil reservoir breather.

7.6 Yearly, or as Recommended, Preventative Maintenance

- Replace worn fluid end plungers and packing brass.
- Replace worn or corroded valve covers, suction valve stops, packing nuts, discharge flanges, pump tools, etc.
- Replace all discharge flange seals and suction manifold seals.
- Replace any defective gauges and instruments.

7.7 Inspection of Bearings and Gears

Inspection of the gears, bearings, and journal bearings should be made every 500 hours. Check the oil filter for telltale signs, such as flaking metal. Also, check for end play on the pinion shaft, see [Section 10.2](#).

SECTION 8 SPARE PARTS LIST, EXPENDABLES

8.1 Recommended Spare Parts List

MSI recommends that at a minimum the following spare parts be available during pump operation. See [Section 9](#) for size specific part numbers. Contact MSI for availability of expendables packages for all plunger sizes.

8.2 Fluid End Parts

Item	Triplex Quantity	Quintuplex Quantity
Fluid End Plunger	1	2
Lantern Ring	3	5
Packing Nut	1	2
Packing Set	3	5
O-Ring, Stuffing Box – Fluid End Side	3	5
Back-Up, Stuffing Box – Fluid End Side	3	5
O-Ring, Stuffing Box – Nut Side	3	5
Back-Up, Stuffing Box – Nut Side	3	5
O-Ring, Packing Nut	6	10
Seal, Discharge Cover	3	5
Seal, Suction Cover	3	5
Stuffing Box Adapter	3	5
Valve or Valve Insert	3	5
Valve Spring	3	5
Valve Stop	3	5

8.3 Power End Parts

Item	Triplex Quantity	Quintuplex Quantity
Power End Plunger Seal	3	5
O-Ring, Suction Manifold	3	5
Gasket, Power End Plunger Seal Housing	3	5

SECTION 9 FLUID END

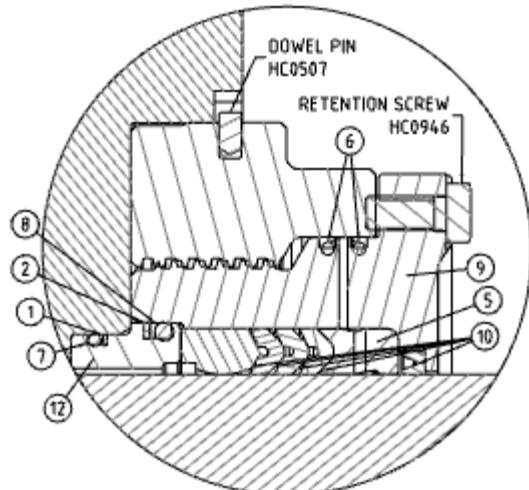
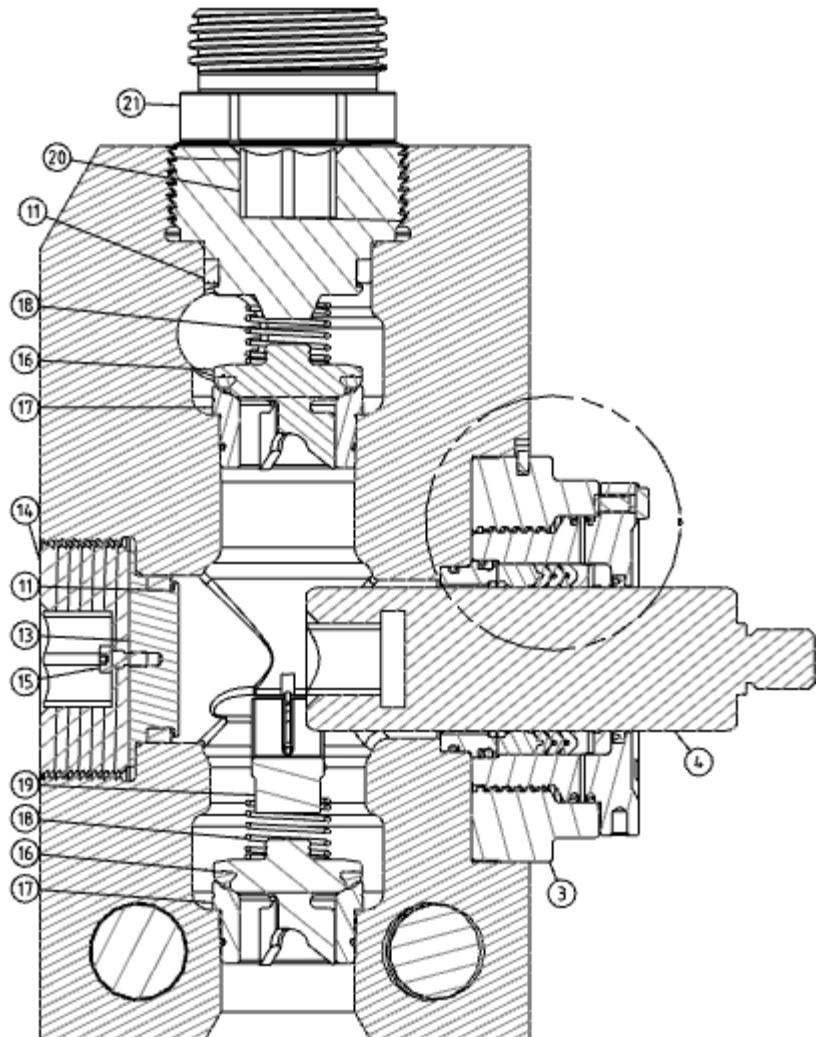
9.1 Detail Section Drawings, Service Tools

See drawings on the following pages.

FLUID END ASSEMBLY - SECTION VIEW - 2.75" - 3.00"

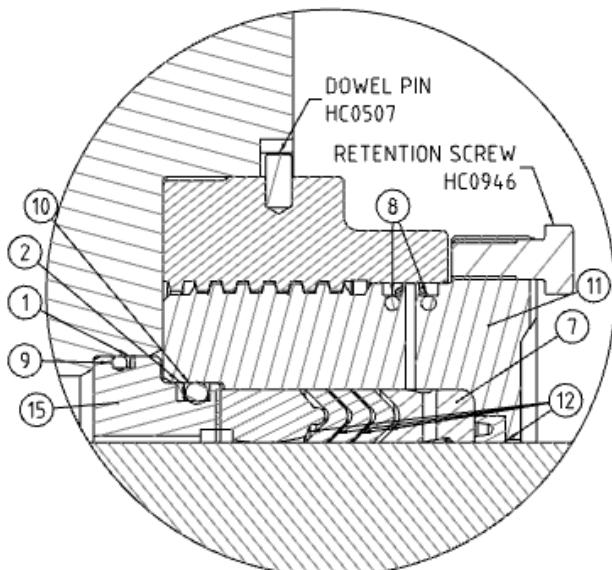
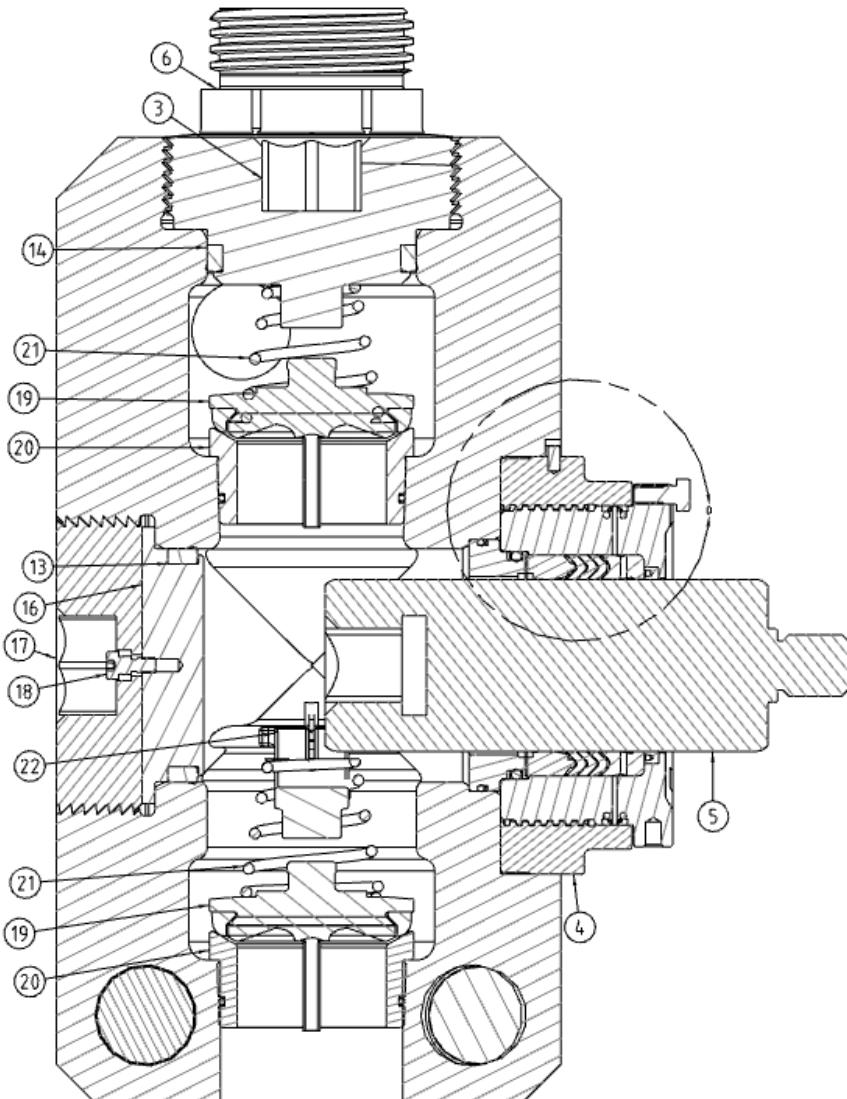
ITEM NO.	DESCRIPTION	PART NUMBER	
		2.75"	3.00"
1	BACK-UP RING, SB FE SIDE	OC0077	
2	BACK-UP RING, SB PE SIDE	OC0077	OC0064
3	FLUID END ADAPTER	FEC0402 (600,1000)	FEC0494 (1300)
4	FLUID END PLUNGER	FEC0313	FEC0314
5	LANTERN RING	FEC0353	FEC0354
6	O-RING, PACKING NUT	OC0151	
7	O-RING, SB FE SIDE	OC0076	
8	O-RING, SB PE SIDE	OC0076	OC0085
9	PACKING NUT	FEC0346	FEC0347
10	PACKING SET	FEC0069	FEC0033
11	SEAL, SUCTION/DISCHARGE COVER	FEC0095	
12	STUFFING BOX ADAPTER	FEC0066	FEC0010
13	SUCTION COVER GLAND	FEC0338	
14	SUCTION COVER NUT	FEC0339	
15	SUCTION COVER NUT BOLT	HC0454	
16	VALVE	FEC0504 (INSERT FEC0504-1)	
17	VALVE SEAT	FEC0453	
18	VALVE SPRING	FEC0093	
19	VALVE STOP ASSEMBLY	FEC0382	

ITEM NO.	DESCRIPTION	PART NUMBER	
		TRIPLEX	QUINTUPLEX
20	DISCHARGE COVER NUT	FEC0089	FEC0149
21	GAUGE CONNECTION	FEC0556	FEC0582



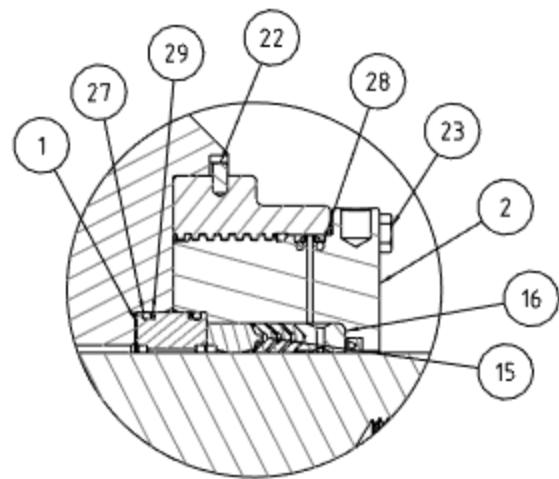
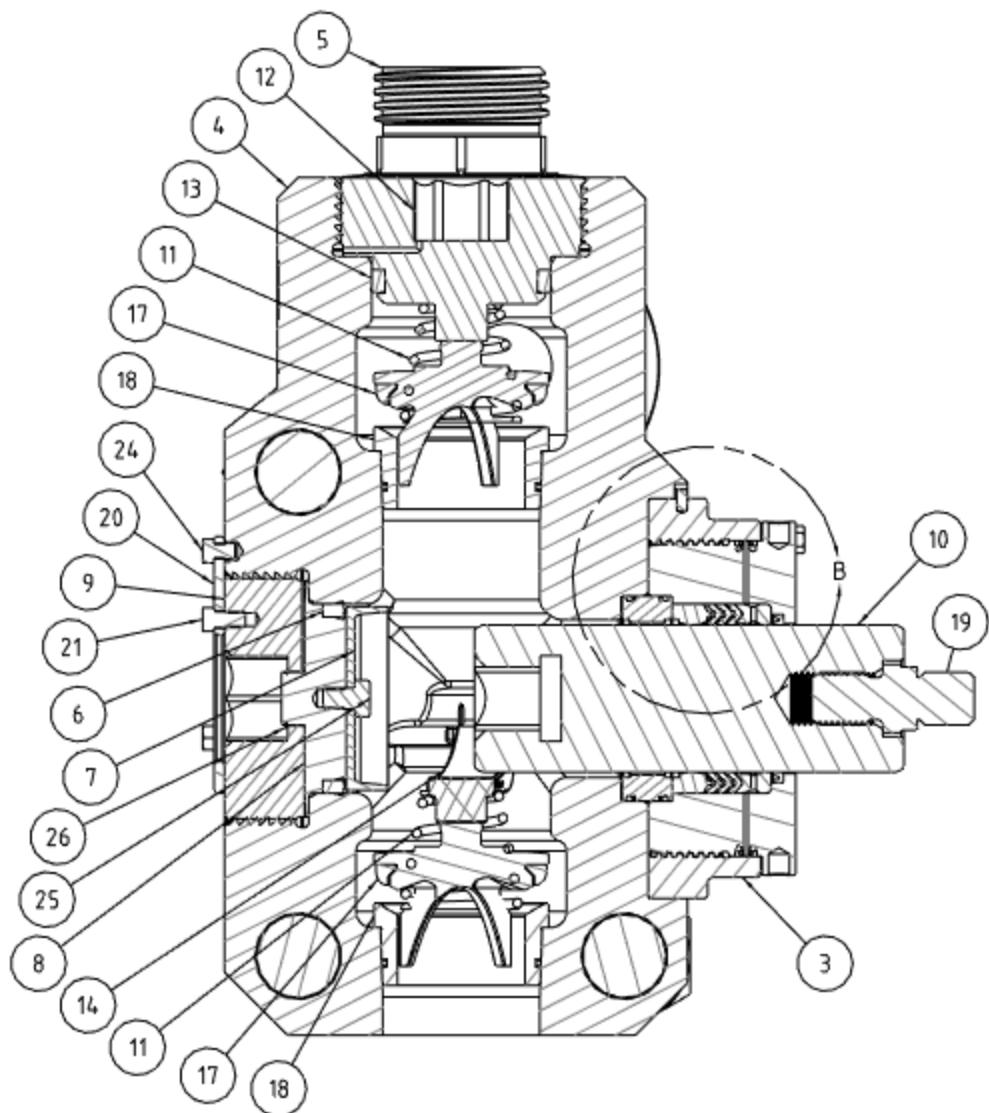
FLUID END ASSEMBLY - SECTION VIEW - 3.25" - 4.50"

ITEM NO.	DESCRIPTION	PART NUMBER			
		3.25"	3.50"	4.00"	4.50"
1	BACK-UP RING, SB FE SIDE			OC0066	
2	BACK-UP RING, SB PE SIDE	OC0139	OC0068	OC0070	OC0072
3	DISCHARGE COVER NUT		FEC0005		
4	FLUID END ADAPTER		FEC0403		
5	FLUID END PLUNGER	FEC0315	FEC0316	FEC0317	FEC0318
6	GAUGE CONNECTION		FEC0583		
7	LANTERN RING	FEC0358	FEC0355	FEC0356	FEC0357
8	O-RING, PACKING NUT		OC0150		
9	O-RING, SB FE SIDE		OC0065		
10	O-RING, SB PE SIDE	OC0138	OC0067	OC0069	OC0071
11	PACKING NUT	FEC0351	FEC0348	FEC0349	FEC0350
12	PACKING SET	FEC0258	FEC0054	FEC0055	FEC0040
13	SEAL, SUCTION COVER		FEC0013		
14	SEAL, DISCHARGE COVER		FEC0015		
15	STUFFING BOX ADAPTER	FEC0260	FEC0058	FEC0059	FEC0036
16	SUCTION COVER GLAND		FEC0340		
17	SUCTION COVER NUT		FEC0341		
18	SUCTION COVER NUT BOLT		HC0454		
19	VALVE		FEC0472 (INSERT FEC0472-1)		
20	VALVE SEAT		FEC0473		
21	VALVE SPRING		FEC0003		
22	VALVE STOP ASSEMBLY		FEC0383		



FLUID END ASSEMBLY - 1500HP

ITEM NO.	PART NO.	DESCRIPTION
1	FEC-15-001	STUFFING BOX ADAPTER, 3.50", 1500HP
2	FEC-15-002	PACKING NUT, 3.50" 1500HP
3	FEC-15-003	ADAPTER, FLUID END, LARGE BORE, 1500HP
4	FEC-15-004	FLUID END, 3.50", 1500HP
5	FEC0583	GAGE CONNECTION, 1500HP
6	FEC-15-008	SEAL, SUCTION COVER, 1500HP
7	FEC-15-014	CAGE, 1500HP WSP
8	FEC-15-017G	SUCTION COVER GLAND, 1500HP WSP (CAGE, 2PC, INT SPR)
9	FEC-15-017N	SUCTION COVER NUT, 1500HP WSP (CAGE, 2PC, INT SPR)
10	FEC-15-350	PLUNGER, FLUID END, 3.50", 1500HP
11	FEC0003	VALVE SPRING, 3.25"-4.50" 72# (WSP) CONICAL
12	FEC0005	DISCHARGE COVER, 3.50"-4.50" (WSP)
13	FEC0015	SEAL, DISCHARGE COVER 3.25"-4.50" (600/1000HP)
14	FEC0019	VALVE STOP, 3.25"-4.50" (WSP)
15	FEC0077	PACKING SET, 3.5" SUPERGOLD, WSP
16	FEC0355	LANTERN RING, 3.50" 3SF (WSP HYBRID)
17	FEC0472	VALVE COMPLETE, MSI, P-4 (3.25-4.50)
18	FEC0473	VALVE SEAT, MSI, P-4 (3.25-4.50)
19	FEC0495	PONY ROD STUD, HYBRID WSP
20	FEC0585	SUCTION COVER KEEPER, ALL WSP
21	HC0004	HEX HD, 3/8"-16 x 0.75" GRADE 5
22	HC0507	DOWEL PIN, 1/4" x 0.50"
23	HC0946	HEX HD, 3/8"-16 x 0.88" GRADE 5
24	HC0948	HEX HD, 3/8"-16 X 0.50", GR 2
25	HC2060	HEX HD, 1/2"-13 X 0.75" GRADE 8
26	HC2061	SPIRAL RETAINING RING-SS, 1 1/4" SHAFT HEAVY DUTY
27	OC0093	O-RING, (2-247 BUNA 90)
28	OC0220	O-RING, (2-265 BUNA 90)
29	OC0221	PAR-BACK, 8-247 PTFE



DETAIL B

9.3 Replacing Fluid End Plunger and Packing

The fluid end plungers and packing should be inspected for wear or corrosion after each well service job and be replaced as needed.

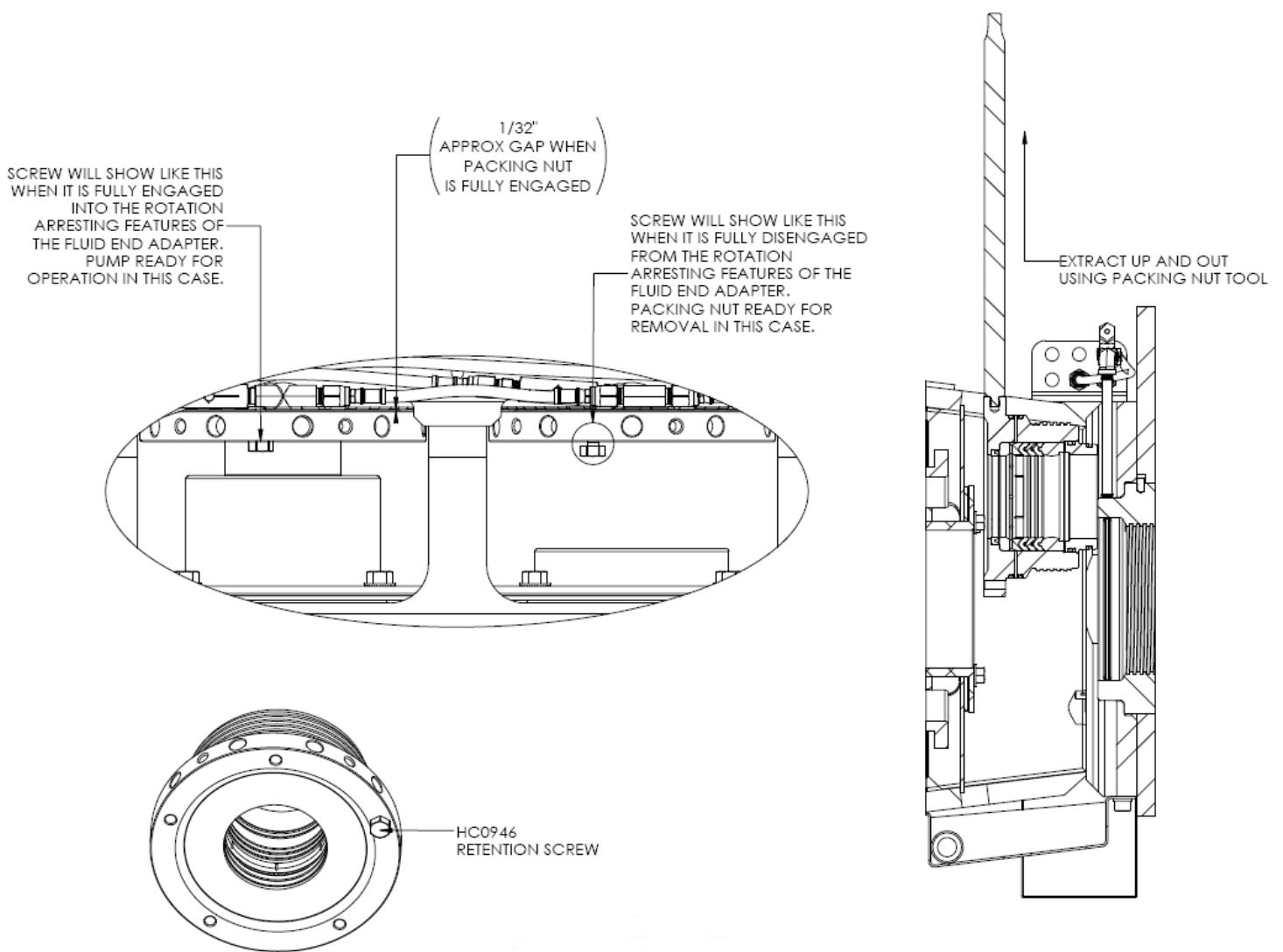
CAUTION: Do not perform any service on the fluid end until you have verified that there is no pressure in the discharge system, the suction charge pump is off and isolated, and suction pressure has been relieved. A closed valve near the discharge can trap pressure between the discharge and the closed suction valves of the pump. Bleed off this pressure before continuing. Do not perform service on the fluid end with the drive engine running. If there is a bladder-type pulsation dampener on the system, either isolate it or bleed the nitrogen pressure from the bladder. Failure to follow these precautions can lead to serious injury.

- 1) Remove the suction cover using the valve cover tool. Replace cover nut seal if damaged.
 - a) If the cover nut has a keeper plate back-out the retention screw prior to removing the nut.
- CAUTION:** Well service fluid may be trapped between the inlet and outlet valves and will spill out when removing the suction valve covers. Expectation of and preparation for this is important for safety and environmental reasons. A catch pan, appropriate absorbent materials, and personal protective equipment (PPE) will be needed.
- 2) Loosen the retaining screws on the plunger safety cover using a 9/16" wrench and slide it towards the rear of the pump to expose the packing service port.
- 3) With a 9/16" wrench, back out the packing nut retention screw approximately 2 turns. This will disengage the rotation arresting slot of the fluid end adapter and allow the packing nut to rotate. Loosen the packing nut at least one full turn using the included packing nut tool (FEC0368).
- 4) Unscrew the fluid end plunger from the power end plunger using the plunger tool and extract it from the fluid cylinder through the suction cover bore. Be careful not to damage the fluid end plunger while removing it. Check each fluid end plunger for wear, scoring, pitting, and corrosion on the hard surface area, and check for damage to the face and threads that mate with the power end plunger. Replace as needed.
- 5) Continue unscrewing the packing nut until the threads are no longer engaged yet the nut is still supported by the fluid end adapter, then turn until a tapped hole is facing up. Screw the threaded end of the packing nut tool into the packing nut and extract through the packing service port. Inspect the o-rings on the packing nut for signs of cutting, chemical attack, or dry rot. Replace as required.
- 6) Remove the stuffing box adapter from the packing nut by tapping out with a brass punch, be careful not to damage the seal bore. Inspect the o-rings and back-up rings on the adapter for signs of cutting, chemical attack, or dry rot. Replace as required.
- 7) Remove the packing set from the packing nut. Examine each ring of packing, the header ring, and the brass lantern ring for excessive wear and scoring. Replace as required.
- 8) Blow compressed air through each lubrication port on the packing nut to ensure that the lubrication passage is unobstructed.

CAUTION: Always wear appropriate PPE, especially eye protection, when using compressed air to clean pump parts.

- 9) Reinstall packing in the reverse order from which it was removed: wiper seal, lantern ring, packing set (header ring last), stuffing box adapter. Lightly coat all parts with assembly grease such as Lubriplate® No. 105 Assembly Paste.
- 10) Reinstall the packing nut using the packing nut tool and screw in until tight and then back it off one turn. This will reduce the chances of damaging the packing seals when installing the fluid end plunger.
- 11) Clean the fluid end plunger and lubricate the threads with an anti-seize thread compound. Coat the hard surface area of each plunger with a light lubricant only, and insert it into the packing. Using the plunger tool bump the plunger into the packing while holding it as straight as possible to the packing bore centerline. Continue bumping the plunger through the packing until the threaded end just passes through the packing nut. Using the driveline, turn the crankshaft slowly until the power end plunger contacts the threaded end of the fluid end plunger. Tighten the fluid end plunger to the torque value specified in [Section 14](#).
- 12) Tighten each packing nut until it comes to a solid stop. There should be about 1/32" gap between the packing nut face and fluid end adapter face. This indicates that the packing nut is fully engaged.
- 13) The packing nut retention screw must be aligned with the rotation arresting slot of the fluid end adapter. It may be necessary to rotate the packing nut slightly CCW to achieve alignment. Once aligned with the first available slot, rotate the packing nut retention screw clockwise until the hex end is flush with the packing nut face and snug with a 9/16" wrench. Do not over tighten the screw.
- 14) Reinstall the suction covers using the valve cover tool.
 - a) If the cover nut has a keeper plate, align the retention screw with the retention hole and rotate screw to engage the hole, do not over-tighten.
- 15) Slide the safety cover back over the packing access ports and re-tighten the screws.

PACKING NUT INSTALLATION AND REMOVAL



9.4 Replacing Valves and Seats

The valves, springs, and seats should be inspected for wear or corrosion after each well service job and replaced as needed.

CAUTION: Do not perform any service on the fluid end until you have verified that there is no pressure in the discharge system, the suction supercharge pump is off and isolated and suction pressure has been relieved. Do not perform service on the fluid end with the drive engine running. If there is a bladder type pulsation dampener on the system, either isolate it, or bleed the nitrogen pressure from the bladder. Failure to follow these precautions can lead to serious injury.

- 1) After heeding the safety precautions, remove the suction and discharge covers, and/or gauge connection(s), using the valve cover tool.
 - a) If the cover nut has a keeper plate back-out the retention screw prior to removing the nut.

CAUTION: Well service fluid will be trapped between the inlet and outlet valves and will spill out when removing the suction valve covers. Expectation of and preparation for this is important for safety and environmental reasons. A catch pan, appropriate absorbent materials, and proper PPE will be needed.

- 2) Remove the spring and discharge valve from the top of the fluid cylinder.
- 3) Rotate the pump by hand until the plunger is clear of the bore being serviced. Do this for each remaining bore.
- 4) Remove the suction valve stop from the fluid cylinder by turning the stop approximately 90 degrees.

CAUTION: If the valve stop has a spring retainer it is critical that the spring not be forced to move further than necessary to disengage it from the retention slot in the fluid end bore. See figure at the end of this section.

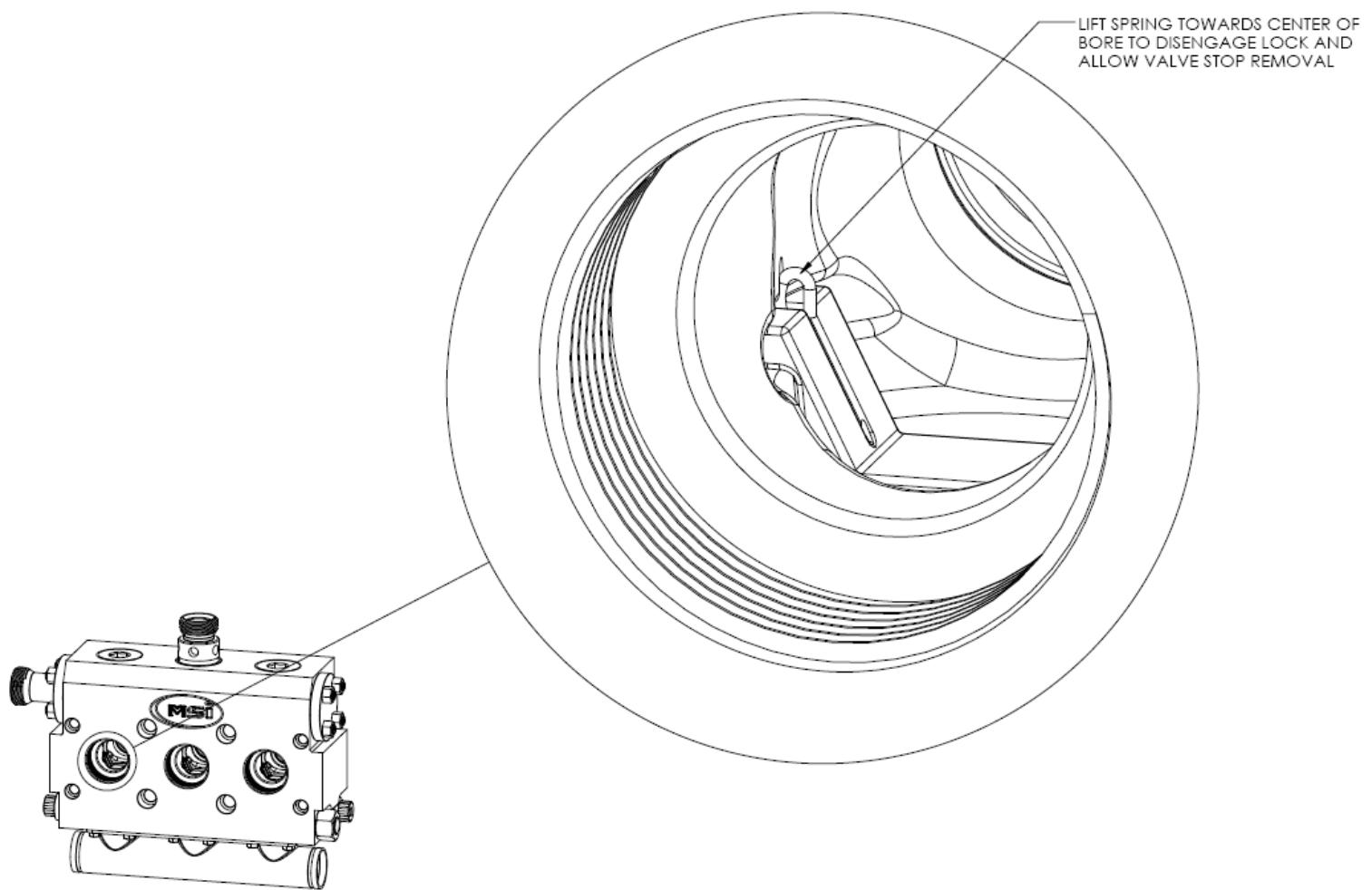
- 5) Remove the valve spring and suction valve.
- 6) Remove the discharge and suction valve seat using the valve seat tool. The tapered bore in the fluid cylinder must be thoroughly cleaned and lightly hand polished with 220-240 grit Emery cloth prior to installing new seats.
- 7) Thoroughly clean each new valve seat OD taper before installing. Do not apply a lubricant to the seat, it must be installed clean and dry. After hand tight installation of the valve seat, press the valve seat into the taper using a heavy steel bar with a Teflon or wood pad, then hammer the valve seat into the taper. Final seating of the valves takes tremendous force and must be accomplished by operating the pump per [Section 6.1](#).

CAUTION: MSI highly recommends that only valves and seats from the same manufacturer be used. In comparison the parts may look similar but slight variations in design and manufacture could cause the pump to operate unsatisfactorily. The flow characteristics of the valve, valve seat, valve stop, and valve spring are all designed for optimum flow through an MSI fluid end. Using valve components not supplied by MSI can result in rough operation of the pump due to insufficient fluid flow area around the valve. Insufficient flow area will result in excessive turbulence, cavitations, damaging vibrations, and premature wear of the fluid end

and its internal components. Excessive vibrations can result in manifold and flow line fatigue failures, which could result in injury, death, equipment damage, and loss of well control.

- 8) Reinstall the suction valve spring and the suction valve stop. For spring retained valve stops make certain the retaining spring is securely seated in the groove in the cylinder. If the spring does not securely engage the slot remove the valve stop and reset the spring by bending it slightly away from the valve stop. Replace the valve stop assembly if the spring or roll pin are damaged or missing.
- 9) Remove the seals from each of the discharge and suction covers. Clean the covers thoroughly and if necessary remove surface rust from cover and fluid cylinder seal bores with 220-240 grit Emery cloth. Reinstall new seals, making sure they are facing the direction shown in the sketch in [Section 9.1](#).
- 10) Coat the suction cover and discharge cover threads with anti-seize thread compound, and coat the seal with light grease. Finally, install the cover nuts with the valve cover tool.
 - a) If the cover nut has a keeper plate, align the retention screw with the retention hole and rotate screw to engage the hole, do not over-tighten.

VALVE STOP REMOVAL



9.5 Discharge Connections and Inspection Requirements

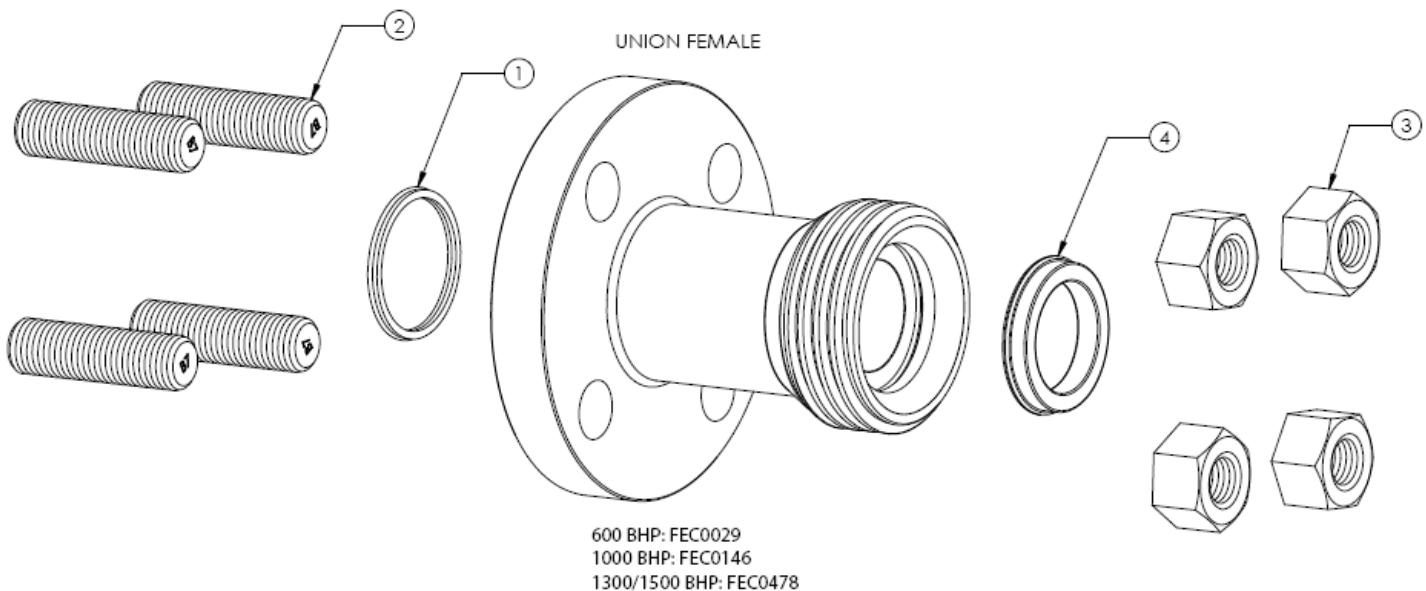
The discharge flange connections and related discharge piping and pressure relief valve should be inspected after each well service job.

- 1) Detach both discharge flanges by removing the nuts on each flange. Use a 1-5/8" wrench to remove the nuts on 600, 1300, and 1500 bhp pumps; use a 1-7/16" wrench to remove the nuts on a 1000 bhp pump.
- 2) Remove the discharge flange seals from each outlet.
- 3) If there is surface rust on the sealing surfaces of the discharge flange or fluid cylinder they must be cleaned and lightly hand polished with 220-240 grit Emery cloth.
- 4) Inspect the discharge flange bores for erosion or corrosion. Contact MSI for wall thickness recommendations and only replace these with original equipment made by MSI. Failure to use the properly designed and manufactured discharge flanges can result in injury, death, equipment damage, and loss of well control.
- 5) Inspect the discharge flange studs and nuts for signs of thread damage or stud elongation. Replace if any defects are found. Only replace these with original equipment supplied by MSI. Failure to use the proper grade of studs and nuts can result in injury, death, equipment damage, and loss of well control. **Only use rated "B7" studs per ASTM A193 or "L7" studs per ASTM A320. Use heavy hex grade 2H nuts per ASTM A194.**
- 6) Put a light coating of oil or grease on new discharge flange seals and install them into the fluid end. Next carefully reinstall the discharge flanges taking care to not damage the new seals. Install and torque the nuts to the value shown in [Section 14](#).
- 7) Clean and inspect the discharge pressure relief valve per the manufacturer's recommendations and replace or repair as needed.
- 8) Inspect all discharge manifolds per the manufacturer's recommendations and replace as needed.

NOTE: If sand, cement, or other solids were used in the last well service job, all manifold lines need to be cleared, cleaned, and inspected. See MSI Minimum Wall Chart (Dixie Engineering Specification 9-2014) for inspecting MSI flow control components. Also, clean out the fluid end and inspect all internal components and replace as needed.

DISCHARGE FLANGE COMPONENTS

ITEM NO.	DESCRIPTION	PART NUMBER	
		600 1300 1500 BHP	1000 BHP
1	DISCHARGE FLANGE SEAL	FEC0014	FEC0148
2	DISCHARGE FLANGE STUD	HC0091	HC0174
3	DISCHARGE FLANGE NUT	HC0092	HC0085
4	UNION RESILIENT SEAL	UC0011	UC0013



DISCHARGE FLANGES CAN BE PROVIDED WITH MALE OR FEMALE HAMMER UNIONS IN STRAIGHT OR ELBOW CONFIGURATIONS.

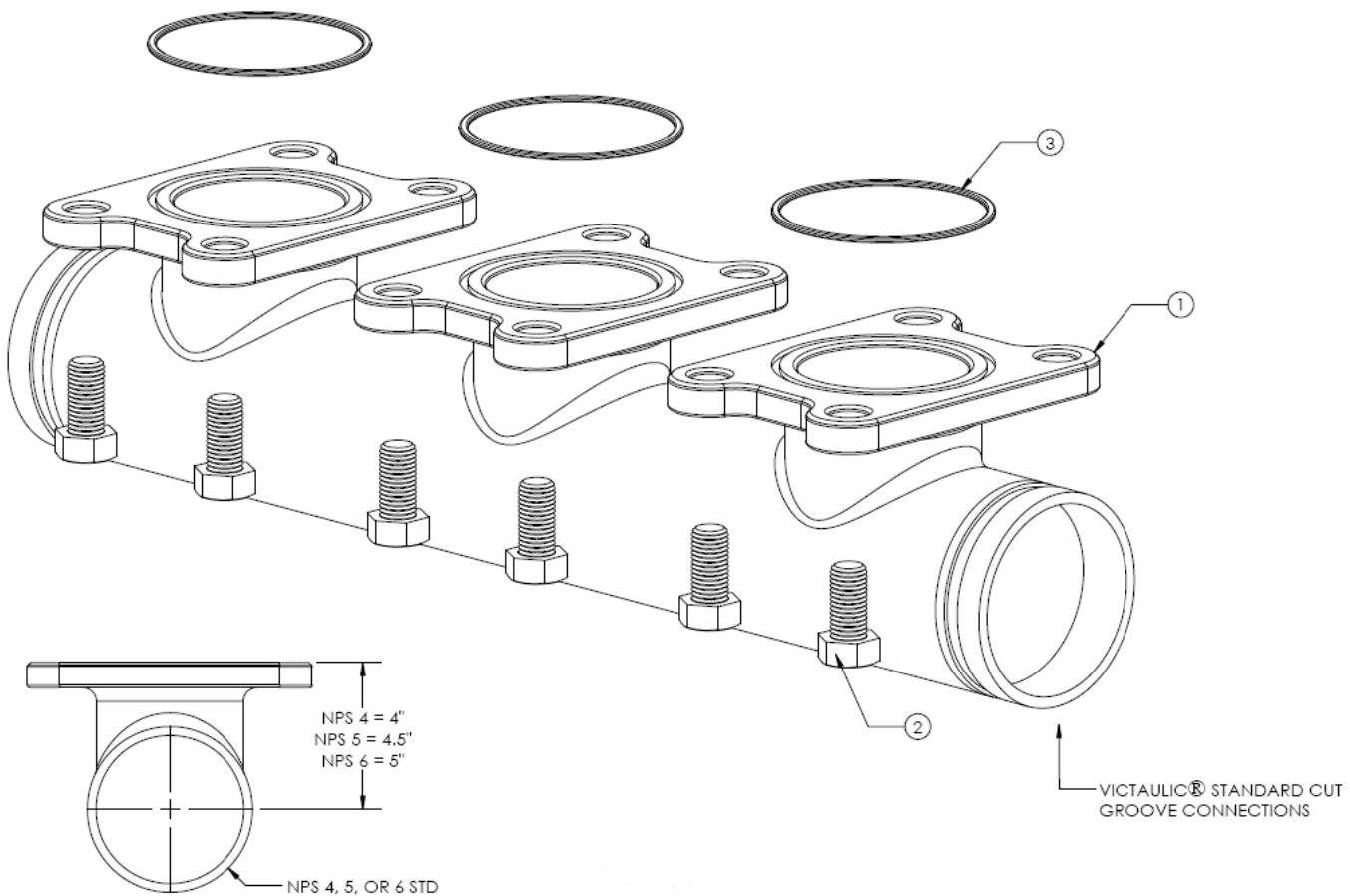
Suction Manifold and Connections

- 1) Disconnect the suction line from the suction manifold.

CAUTION: If there is a bladder-type pulsation dampener on the suction system, isolate it or bleed the nitrogen pressure from the bladder. Failure to do so can result in injury. Idle bladders can rupture and cause fluid and loose components to be ejected from the suction lines during a valve or fluid end plunger change. Follow proper safe practices.

- 2) Remove the suction manifold by loosening the 3/4" screws using a 1-1/8" wrench.
- 3) Inspect the bottom of the fluid cylinder for erosion and corrosion. Thoroughly clean and lightly polish the bottom face of the fluid cylinder with 220-240 grit Emery cloth.
- 4) Remove the o-rings from the suction manifold. Clean out the o-ring grooves, and install new o-rings.
- 5) Clean the unit for examination.
- 6) Examine the suction manifold for erosion, corrosion, or areas that would hinder the surfaces from sealing properly. Examine the inside welds where the pump inlets connect to the manifold pipe. If more than 0.050" of material has been eroded or corroded from the inside of the manifold, replace the suction manifold.
- 7) Lightly grease the o-rings when reinstalling the manifold and torque the cap screws per [Appendix C](#).

SUCTION MANIFOLD
COMPONENTS - EXPLODED



NOTE:
MANIFOLD SHOWN IS TYPICAL, OTHER SIZES AND CONFIGURATIONS
ARE AVAILABLE, CONTACT MSI SALES FOR OPTIONS.

9.7 Replacing the Fluid End

Follow the procedure in [**Section 9.2**](#) for removing the fluid end plungers, packing nuts, and valves.

Follow the recommendations found in [**Section 4.1**](#) for preparing to lift the fluid.

The fluid end is attached to the power end by the tension indicating Maxbolts™. Do not begin to remove these bolts until a lifting harness is in place and the slack has been removed.

- 1) Remove packing lubrication supply and discharge lines from the fluid end adapters.
- 2) Loosen Maxbolts™ using only heavy-duty 12 point standard sockets. Remove all but the two top center bolts. As these last two bolts are loosened, work the lift hoist so that it is positioned over the fluid end's center of gravity. With some tension on the lifting harness, carefully remove the last two bolts. The center of gravity is approximately over the center of the front face. Maintain control of the fluid end after it is free from the power end.
- 3) If the fluid end is being removed for inspection, the inside must be cleaned to bare metal and a liquid dye penetrant or magnetic-particle inspection performed to see if there are any stress cracks in any of the large bores. Do not reuse a fluid end that contains stress cracks. The fluid end cannot be repaired by welding. If it is cracked, it must be replaced.

CAUTION: A primary cause of failure in steel fluid ends is cracks which initiate at corrosion pitting sites. Carefully examine the fluid end wetted surfaces for corrosion pitting. Severe pitting greatly increases the likelihood of crack formation and failure can occur relatively unexpectedly.

- 4) Whether replacing the old fluid end or installing a new one, inspect all openings for damage or contaminates. Clean as necessary.
- 5) Before installing a fluid end, clean the mating IDs on the power end frame and the male pilot on the fluid end adapter rings, then lightly hand polished with a 220 to 240-grit Emery cloth. Coat the mating surfaces with a light oil or grease.
- 6) Before installing the fluid end, clean the Maxbolts™ and coat all contact areas (threads, underneath bolt head, deck of fluid end counterbore) with only Dow Corning® G-n Metal Assembly Paste. Be certain to replace the hardened steel washers if using a stainless steel fluid end.

CAUTION: Using high quality assembly paste is crucial to achieving proper tension in the Maxbolts™. Low quality assembly pastes may prevent the bolt from achieving proper pre-load.

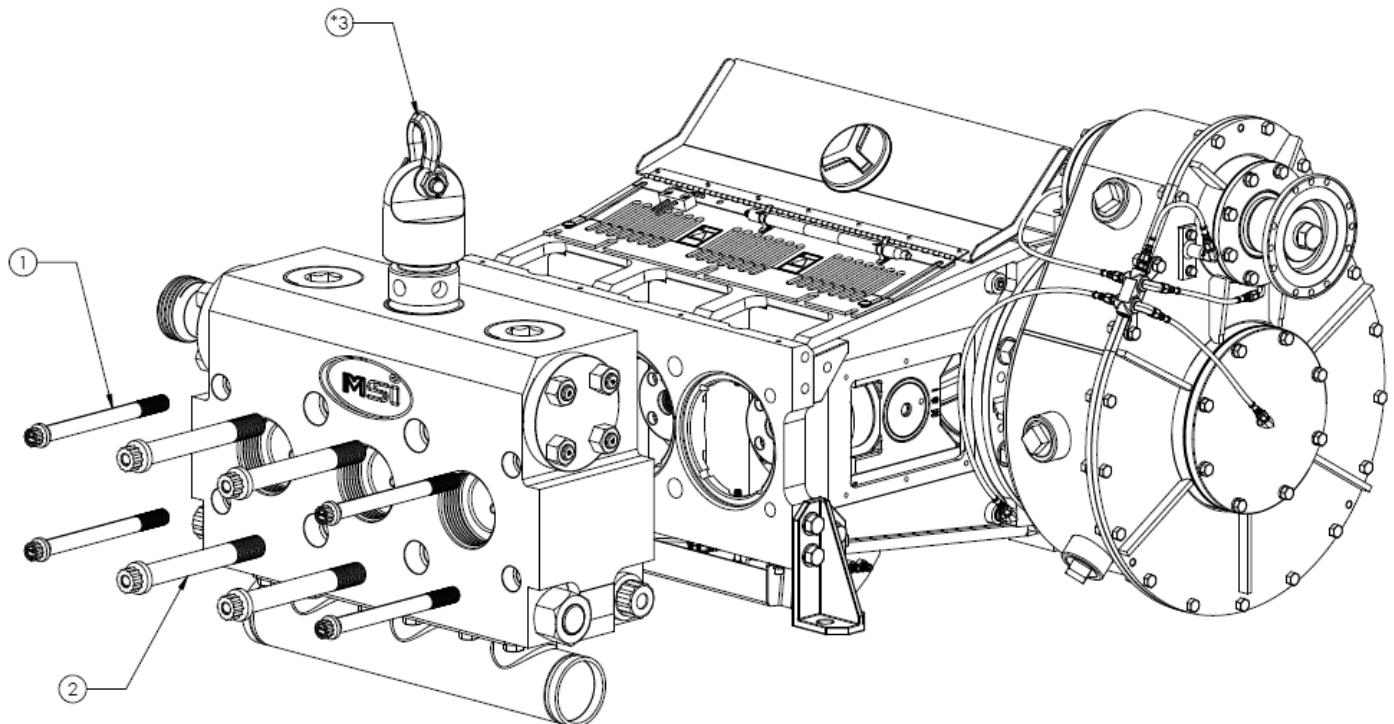
- 7) Prepare for lifting per [**Section 4.1**](#), and have two top Maxbolts™ ready to thread into place. Lift the fluid end in place. Do not release the holding pressure against the fluid end until the first two top bolts are hand tight.
- 8) Apply torque to the Maxbolts™ until the indicator reaches approximately 90%-95%. If the indicator is not working, replace the bolts with new ones obtained from MSI.

CAUTION: Do not attempt to tighten the Maxbolts™ with a torque value. Use only the dial indicator to determine when the pre-load has been achieved, this is the most accurate method. Insufficient pre-loading of the bolts can result in fatigue failure of the bolt which may result in catastrophic failure of the pump.

- 9) Replace the fluid end plungers and packing nuts per [Section 9.2](#).
- 10) Replace the valves per [Section 9.3](#).
- 11) Reconnect the discharge lines, pressure relief valve, and the instrument connection for the pressure transducer.
- 12) Follow the start-up procedure in [Section 6.1](#) and check for leaks.

FLUID END REMOVAL

ITEM NO.	DESCRIPTION	PART NUMBER
1	FLUID END BOLT 1"	HC0135
2	FLUID END BOLT 1 $\frac{3}{8}$ "	HC0136
*3	2"1502 LIFTING SUB	LSA0001



1000/1300 BHP PUMPS USE 12 HC0136 BOLTS.
1500 BHP PUMP USES HC2002 BOLTS.

*AVAILABLE SEPARATELY

SECTION 10 GEAR REDUCER

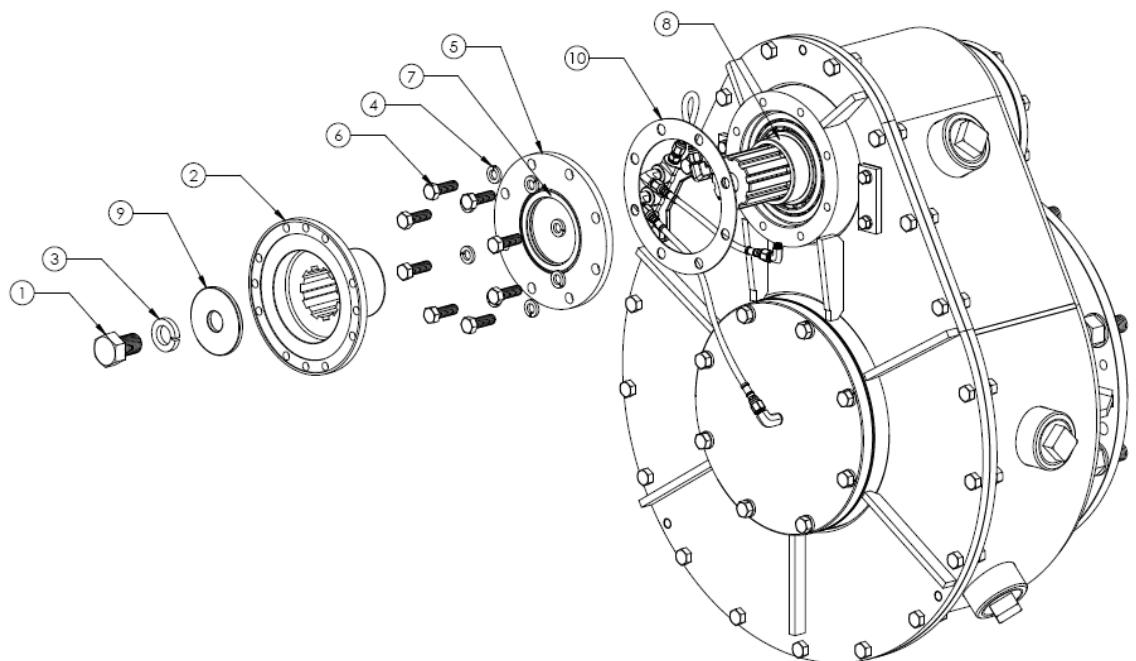
Due to the need for special tools and special training, MSI does not recommend field repair of the gear reducer. If repairs are needed, the entire pump should be returned to an MSI repair facility. When field service of the gear reducer is needed, it should be completed in a clean, well equipped shop by a trained well service pump technician.

10.1 Drawings and Part Numbers

See drawing on the following page.

GEAR REDUCER SHIM ADJUSTMENT

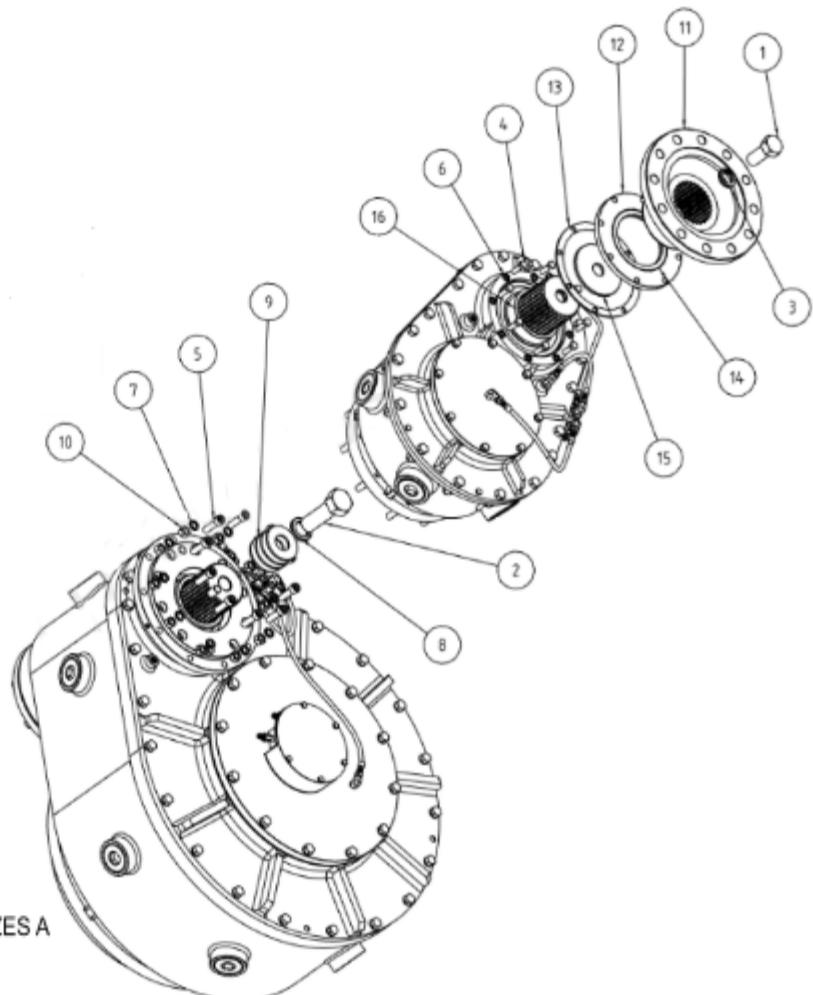
ITEM NO.	DESCRIPTION	PART NUMBER	
		TRIPLEX	QUINTUPLEX
1	FLANGE BOLT	HC0103	
2	*COMPANION FLANGE	GRC0041	GRC0049
3	LOCK WASHER	HC0101	
4	LOCK WASHER	HC0100	
5	PINION CAP	GRC0034	GRC0070
6	PINION CAP BOLT	HC0096	
7	PINION OIL SEAL	GRC0027	GRC0073
8	PINION SPACER	GRC0035	GRC0052
9	RETAINER WASHER	GRC0042	GRC0048
10	SHIM SET	GRC0032	GRC0055



* THE STANDARD TRIPLEX PUMP COMPANION FLANGE UTILIZES A SPICER SERIES 1810 CONNECTION, THE QUINTUPLEX PUMP UTILIZES A SPICER SERIES 1950 CONNECTION.
INPUT FLANGE OPTIONS ARE AVAILABLE, CONTACT MSI SALES

**GEAR REDUCER SHIM
ADJUSTMENT-1500 HP**

ITEM NO.	DESCRIPTION	PART NUMBER
1	HEX BOLT 1-8 x 2.5"	HC1211
2	HEX BOLT 1-1/4 x 4"	HC1196
3	SPRING LOCK WASHER 1"	HC0101
4	HEX BOLT 3/8-16 x 1.25"	HC0664P
5	SOCKET HEAD 1/2-13 x 1.75"	HC0035
6	LOCK WASHER 3/8"	HC0099
7	LOCK WASHER 1/2"	HC0100
8	SPRING LOCK WASHER 1 1/4"	HC1197
9	FLAT WASHER 1 1/4"	HC0713P
10	HEX NUT 1/2-13	HC0098P
11	INPUT FLANGE	GRC0049
12	PINION BEARING RETAINER	GRC-15A-023
13	PINION GEAR SHIM SET	GRC-15A-024
14	PINION SHAFT OILSEAT	GRC0073
15	RETAINER WASHER	GRC0048
16	PINION SHAFT SPACER	GRC0052



* THE STANDARD TRIPLEX PUMP COMPANION FLANGE UTILIZES A SPICER SERIES 1810 CONNECTION, THE QUINTUPLEX PUMP UTILIZES A SPICER SERIES 1950 CONNECTION.
INPUT FLANGE OPTIONS ARE AVAILABLE, CONTACT MSI SALES

10.2 Checking and Adjusting Bearing Preload

Over time the tapered roller bearings in the gear reducer will wear. It is necessary to periodically inspect the end play and make adjustments to restore bearing preload by changing the shim stack height. MSI recommends contacting pump technical support for assistance in measuring and adjusting bearing preload.

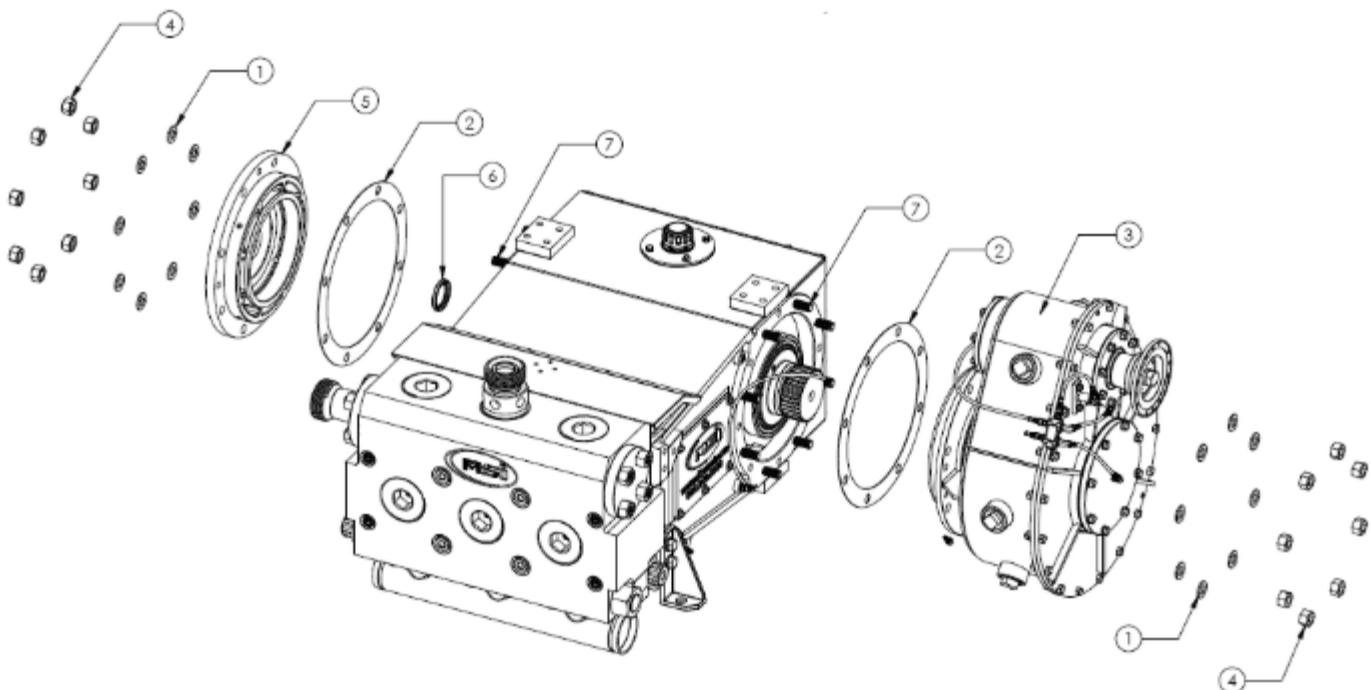
10.3 Removal of Gear Reducer and Bearing Housing

The gear reducer and outer main bearing housing may be removed from the power end for repairs and service.

- 1) Remove the prime mover drive shaft safety guards and disconnect the drive shaft from the pump input shaft companion flange.
- 2) Disconnect the lubrication lines from the gear reducer.
- 3) Attach a lifting device to the gear reducer (see [Section 4.1](#)). Use multiple lift points to balance and stabilize the gear reducer once it is free from the power end.
- 4) Use a 1 7/16" wrench to remove the 7/8" hex nuts and washers that connect the gear reducer to the power end.
- 5) 3/4"-10 UNC tapped holes are provided in the gear reducer flange for using jack screws.
- 6) Pull the gear reducer away from the power end to disengage the main gear from the crankshaft.

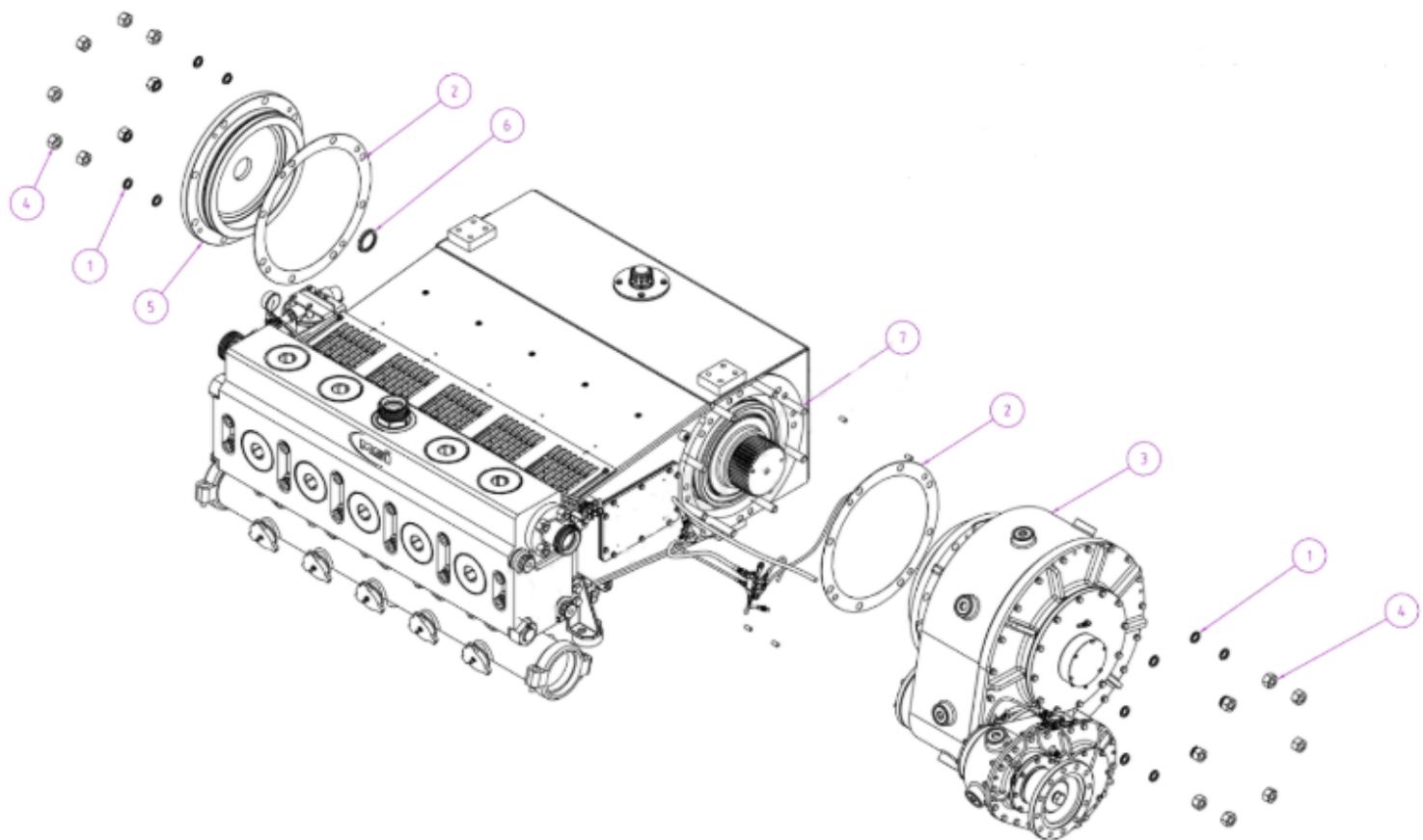
**GEAR REDUCER & BEARING
HOUSING REMOVAL**

ITEM NO.	DESCRIPTION	PART NUMBER	
		TRIPLEX	QUINTUPLEX
1	FLAT WASHER, HARDENED	HC0087	
2	GASKET	PEC0031	
3	GEAR REDUCER	GRA0001	GRA0003
4	HEX NUT	HC0085	
5	MAIN BEARING HOUSING	PEC0063	
6	BEARING HOUSING SEAL	PEC0061	
7	STUD BOLT	HC0084	



**GEAR REDUCER & BEARING
HOUSING REMOVAL- 1500HP**

ITEM NO.	DESCRIPTION	PART NUMBER
1	FLAT WASHER, HARDENED	HC0101
2	GASKET	PEC-15-0035
3	GEAR REDUCER	GRA-15-001
4	HEX NUT	HC0092
5	MAIN BEARING HOUSING	PEC-15-0036
6	BEARING HOUSING SEAL	PEC0061
7	STUD BOLT	HC2022

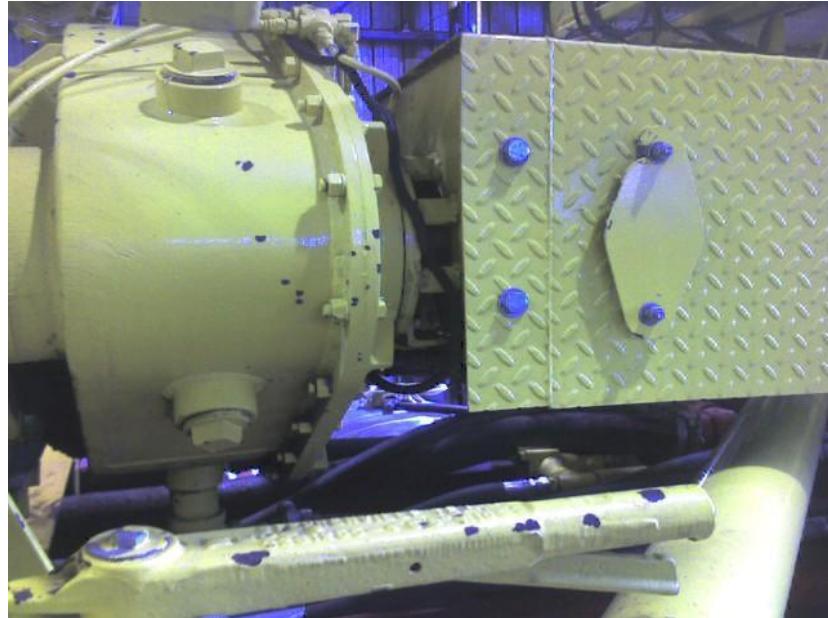


SECTION 11 POWER END

11.1 Safety Guards

Do not operate the pump without the proper safety guards securely in place.

The drive shaft and the windows containing the moving fluid end plungers and power end plungers must be covered with appropriate safety guards.



GEAR REDUCER AND DRIVE SHAFT GUARD



PLUNGER PORT SAFETY GUARD AND WEATHER SHIELD

11.2 Removing and Lifting of the Power End

Due to the complexity involved in performing repair work on the power end, MSI does not recommend complete disassembly of the power end in the field. If the power end requires rework, the well service truck or skid should be brought to an MSI repair facility. If the entire well service unit cannot be returned, then return the complete pump with the gear reducer and fluid end still attached.

- 1) To remove the entire assembly, detach all piping, electrical controls, plunger lubrication system, gear reducer lubrication oil connections, the driveshaft guard, and the driveshaft companion flange connection.
- 2) Remove the mounting bolts attaching the pump to the well service unit.
- 3) Lift pump using the procedure in [Section 4.1](#).
- 4) To reinstall the pump after rework, follow the instructions in [Section 4](#).

11.3 Access Panels and Gaskets

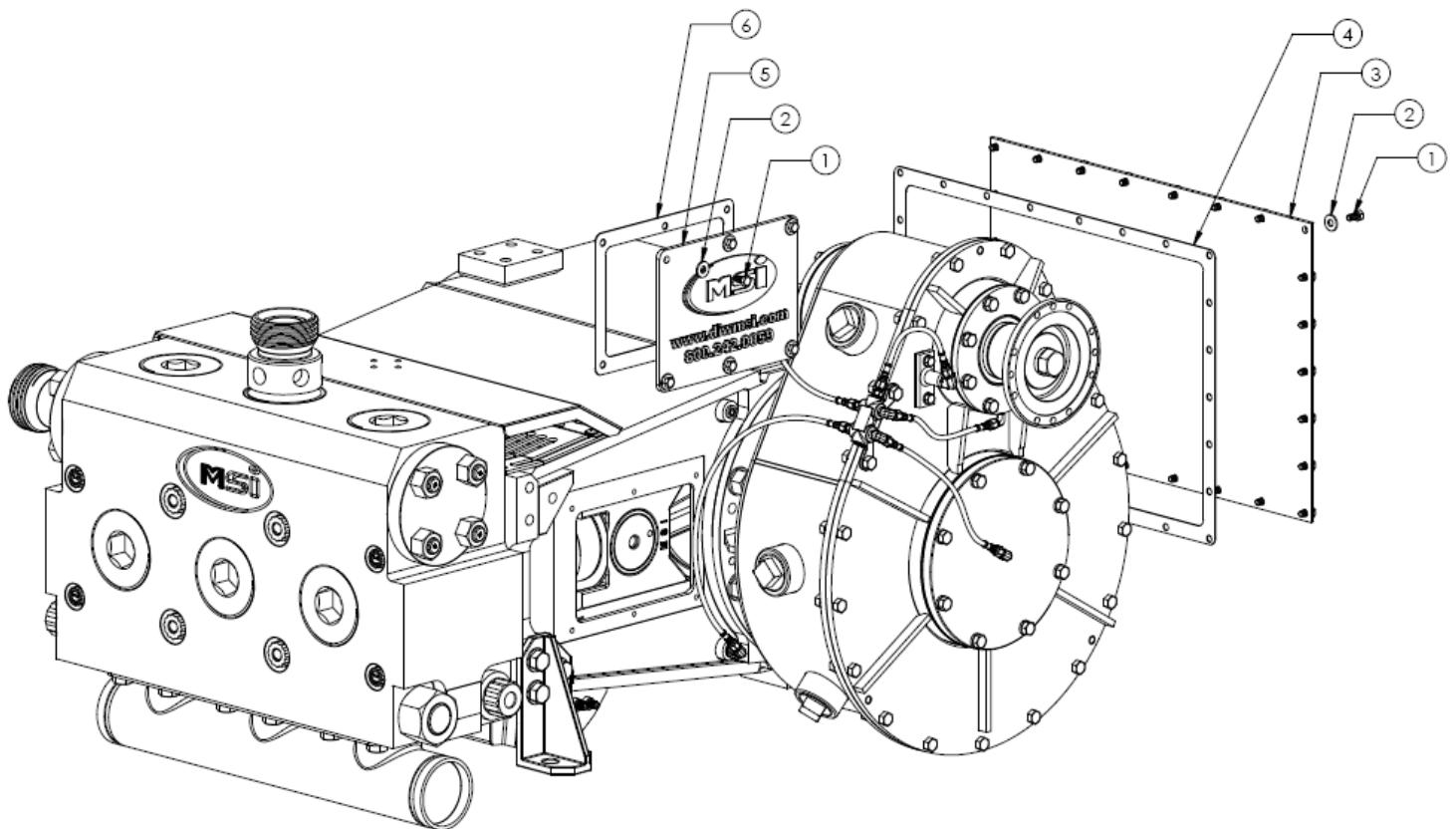
Do not work on or inspect the pump with the drive engine running or with pressure in the fluid end.

There are three panels on the power end: one on each side for accessing the crossheads, crosshead guides, power end plungers, and wrist pins, and one at the back for accessing the connecting rod and the crankshaft journal bearings. Care should be taken when removing the access panels to prevent any contaminants, such as rain, dirt, or sand, from entering the power end.

- 1) Remove the plunger lubrication relief system reservoir.
- 2) Remove the screws attaching the side panels and the rear cover using a 9/16" wrench. Do not attempt to run the pump with these panels removed. To check for motion, disconnect the driveshaft and rotate the pump by hand.
- 3) With the panels removed, check for particles in the bottom of the power end frame. Remove all solid particles. If there is any metal or brass in the frame, the power end will require a thorough inspection at an MSI repair facility.
- 4) Using an absorbent rag, remove any condensation inside the power frame. **Do not use granulated absorbents in the pump.**

POWER END ACCESS PANELS

ITEM NO.	DESCRIPTION	PART NUMBER		
		TRIPLEX	QUINTUPLEX	1500HP
1	ACCESS COVER BOLT		HC0004	
2	ACCESS COVER WASHER		HC0002	
3	REAR ACCESS COVER	PEC0077	PEC0095	PEC-15-0039
4	REAR ACCESS GASKET	PEC0080	PEC0096	PEC-15-0040
5	SIDE ACCESS COVER	PEC0078		PEC-15-0037
6	SIDE ACCESS GASKET	PEC0079		PEC-15-0038



11.4 Replacing Power End Plunger, Seal Housing, and Seals

The power end plungers have a special surface treatment to reduce friction and wear; as a result they should not need to be replaced on a regular basis. If the power end plunger seals are leaking they should be removed and inspected. The power end plungers can be extracted from the pump without removing the fluid end. If the gear reducer is in position that blocks the side access window it will need to be removed or indexed to another position. Otherwise, remove the fluid end per instructions in [Section 9.6](#) and extract the power end plungers through the front of the power frame.

- 1) Using a 9/16" wrench loosen the two retaining screws on the plunger safety cover and slide it out of the way.
- 2) Remove the fluid end plungers per instructions in [Section 9.2](#).
- 3) Remove the power end plunger seal housing by removing the four hex head cap screws with a 9/16" wrench. If necessary, rotate the pump to clear the housing of the power end plunger. Take appropriate measures to prevent contaminants entering the power end.
- 4) Remove the seal from the power end plunger seal housing. Clean the power end seal housing, including the seal gland. Inspect the seal for signs of damage such as cracks or a dull wiping edge. Replace seal as required.
- 5) Before reinstalling the power end plunger seal housing the seal installation tool will need to be screwed onto the end of the power end plunger. This tool will help guide the seal onto the plunger and prevent damage to the wiping edge. See drawing on the following page.
- 6) Gently guide the power end plunger seal housing over the installation tool until it is fully engaged onto the plunger. Continue forward until the housing flange is in contact with the power end. Reattach using the socket head cap screws.

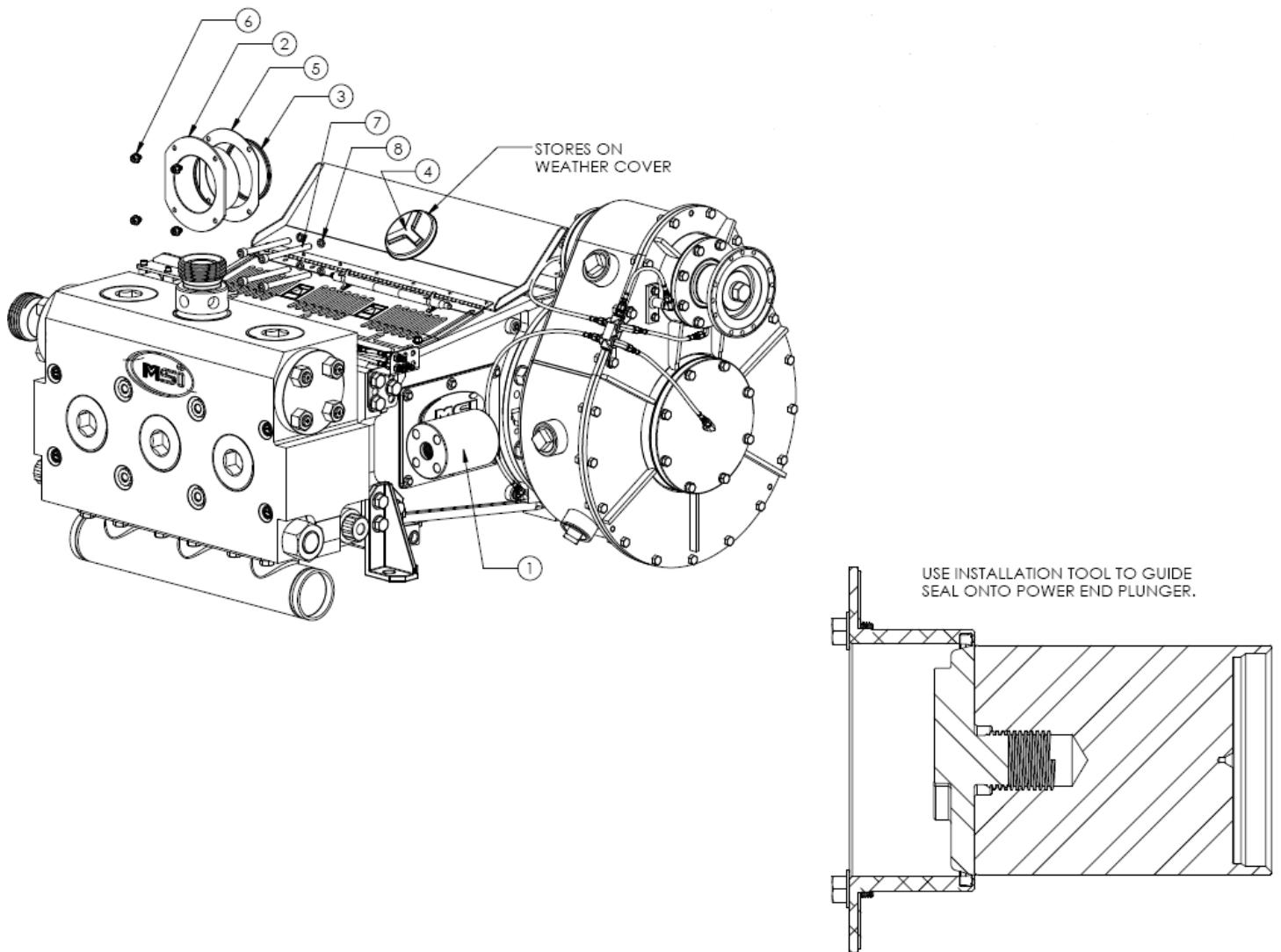
NOTE: Power end leaks are typically a symptom of damaged power end plunger seals. It is not necessary to continue with the following steps unless damage to the power end plunger or seal housing is suspected.

- 7) Remove the plunger lubrication relief system reservoir.
- 8) Remove both side access panels from the pump using a 9/16" wrench.
- 9) Rotate the pump until the outboard cylinder is at bottom dead center.
- 10) Place a clean rag between the power end plunger and crosshead guide. While supporting the power end plunger, remove the four screws using a 3/8" hex socket.
- 11) Carefully remove the power end plunger through the side access window being careful not to damage the outside sealing surface. Clean and inspect the power end plunger sealing surface. Ensure it is not scored, scratched, or pitted. Replace the power end plunger if needed.
- 12) Repeat above steps 7-10 for the opposite outboard cylinder.
- 13) Remove the four screws from the inboard power end plunger.

- 14) Rotate pump until the inboard crosshead and either outboard crosshead are aligned, the inboard power end plunger may now be removed from the side access cover. This process must be repeated for the middle cylinder of the quintuplex pump.
- 15) Install new seals in the power end plunger seal housing according to the drawing.
- 16) Reassemble in the reverse order of these instructions
- 17) Apply Loctite® Threadlocker Blue to the 1/2"-13 socket head cap screws and torque to 75 ft-lbs.
- 18) Install the power end plunger seal housing per instructions 5-6.
- 19) Slide the safety cover back over the packing service ports and re-tighten the screws.
- 20) Empty, clean, and reinstall the plunger lubrication relief system reservoir.

POWER END PLUNGER SERVICE

ITEM NO.	DESCRIPTION	PART NUMBER	
		TRIPLEX/ QUINTUPLEX	1500 HP
1	POWER END PLUNGER	PEC0220	PEC-15-0042
2	POWER END PLUNGER SEAL HOUSING	PEC0221	PEC-15-0043
3	POWER END PLUNGER SEAL	PEC0222	PEC-15-0044
4	POWER END PLUNGER SEAL INSTALLATION TOOL	PEC0232	PEC-15-0061
*5	POWER END PLUNGER SEAL HOUSING GASKET	PEC0237	OC0094
6	POWER END PLUNGER SEAL HOUSING SCREW	HC0945	HC0945P
7	POWER END PLUNGER SCREW	HC0467	HC1214
8	POWER END PLUNGER LOCK WASHER	HC0023	



*1500 BHP pump seal housings use an o-ring instead of a gasket.

11.5 Replacing Crankshaft Journal Bearings and Connecting Rods

- 1) Remove the access panels per [Section 11.3](#).
- 2) Working through the rear cover opening, remove the hex screws connecting the rod to the crosshead pin using a 3/16" hex socket wrench (3/8" on 1500 bhp) with a universal knuckle and extension. In order to access each of the four screws per rod, rotate the crankshaft until screws are accessible.
- 3) There are dowel pins that align the crosshead pin to the connecting rod. With screws removed, support the end of the rod at the crosshead and push the crosshead forward to disengage the dowel pins. If the rod does not easily release from the crosshead pin the crosshead may be tapped from the back of the pump or pried forward through the side access window. Block one of the other crossheads before doing this to prevent the crankshaft from rotating.
- 4) Use pliers to remove the 1/8" cotter pins from the connecting rod bolts. Discard the cotter pins, they are not intended for reuse and must be replaced after removal.
- 5) Using a 15/16" wrench, remove each of the four 5/8" castellated nuts and bolts from each connecting rod.

NOTE: Each connecting rod and cap is matched. It is extremely important that they be kept together at all times. Perform the following steps one rod at a time to prevent potential for mismatch during reassembly. Assembling with mismatched rods and caps may result in severe damage to the pump.

- 6) Support the cap of the connecting rod and gently tap it from both ends using a brass punch to disengage the dowel pins. Be extremely careful not to mar the journal surface of the crankshaft.
- 7) Push the connecting rod forward to disengage it from the crankshaft. Rotate the crankshaft until the rod can be removed from beneath the journal. Inspect the shell bearing for signs of scoring, pitting, spalling, or excessive heat. If the backing material is visible the bearing must be replaced. It is critical that bearings are always replaced as a set.
- 8) The connecting rod journal bearings have tangs that mate to recesses in the connecting rod. It is imperative that these tangs be oriented such that they prevent rotation within the connecting rod during operation. See drawing on the following page for more information.
- 9) Reassemble in the reverse order.
 - a) Model specific steps:
 - (a) 600/1000/1300 bhp
 - (i) Install the (4) 3/8"-16 connecting rod screws using Loctite® Threadlocker Blue and torque to 40 ft-lbs of torque.
 - (b) 1500 bhp
 - (i) Install the (6) 1/2"-13 connecting rod screws using Loctite® Threadlocker Blue and torque to 75 ft-lbs of torque.
 - 10) Install the 5/8"-11 castellated nuts using Loctite® Threadlocker Blue and torque to 150 ft-lbs of torque.

If the journal bearings are to be reused they must be reinstalled in the exact connecting rod piece they were removed from, keeping items marked during disassembly is important to prevent mismatch.

The connecting rods retain the crosshead pins and prevent the crossheads from rotating inside their bore. Be aware that once the connecting rods are removed the crosshead could rotate and allow the crosshead pin to fall out of the bore. Care should be taken during disassembly to prevent this from occurring.

11.6 Replacing Crosshead, Crosshead Pins and Crosshead Bushings

- 1) Remove the fluid end plungers per instructions in [Section 9.2](#).
- 2) Remove the access panels per [Section 11.3](#).
- 3) Remove the power end plungers and seal housings per instructions in [Section 11.4](#).
- 4) Remove the connecting rods per [Section 11.5](#).
- 5) From the side access windows, remove the crosshead pin using the 3/4"-10 tapped hole and a threaded rod. Be extremely careful not to strike the pin against any surfaces during extraction.
- 6) Rotate the crossheads 90° and remove them through the side access windows. Inspect crossheads for signs of wear or scoring, replace as necessary.

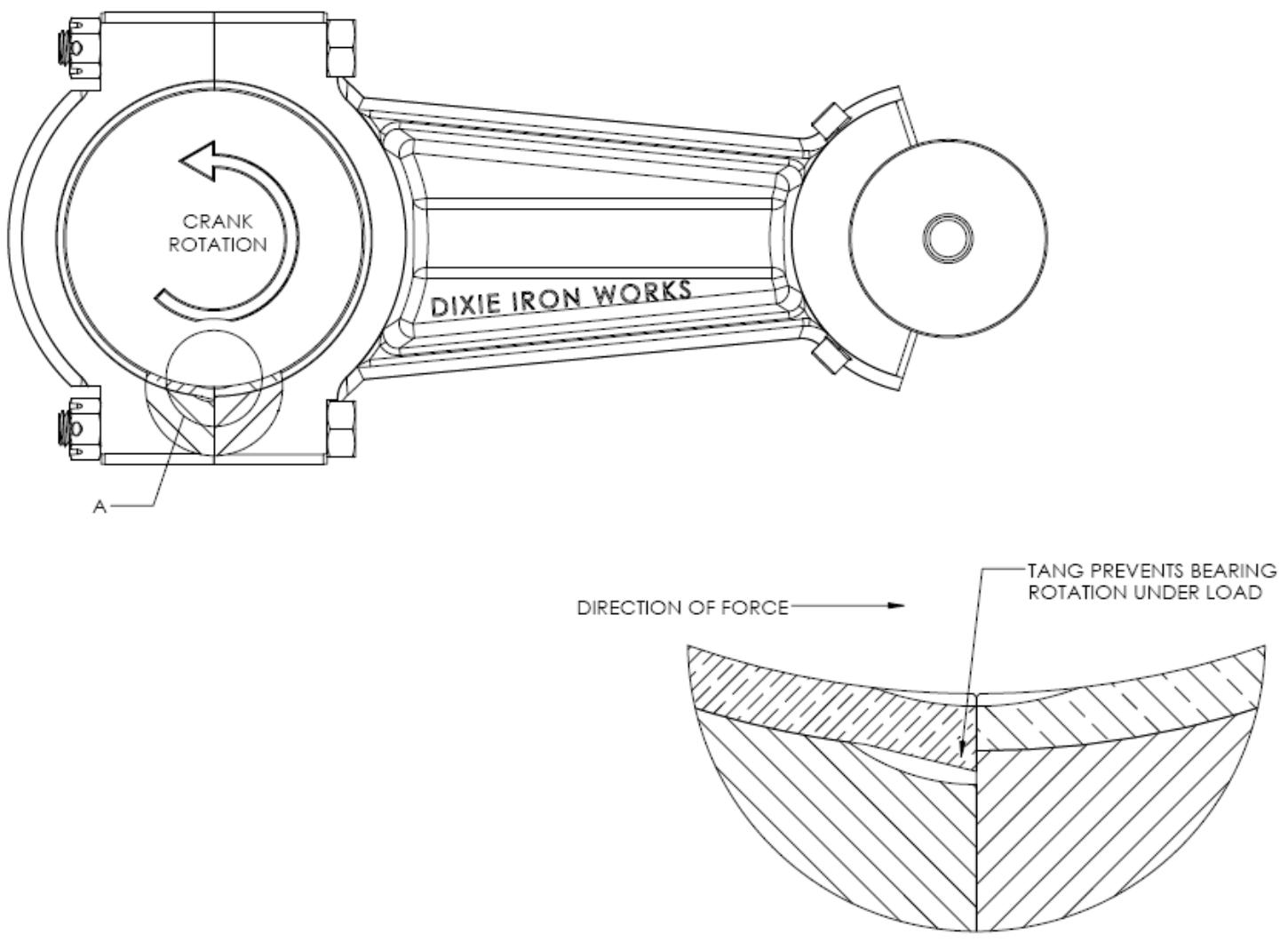
NOTE: Work from the outside in to remove all of the crosshead pins and crossheads.

- 7) Inspect the crosshead pins and bushings for damage, wear, or signs of discoloration from excessive heat. Discoloration would tend to suggest that the bearing is not receiving sufficient lubrication, check lubrication plumbing for obstructions.

NOTE: Due to the construction of the crosshead bushing it cannot be reused once it has been removed from the crosshead. If the bushing needs replacement contact MSI for repair options

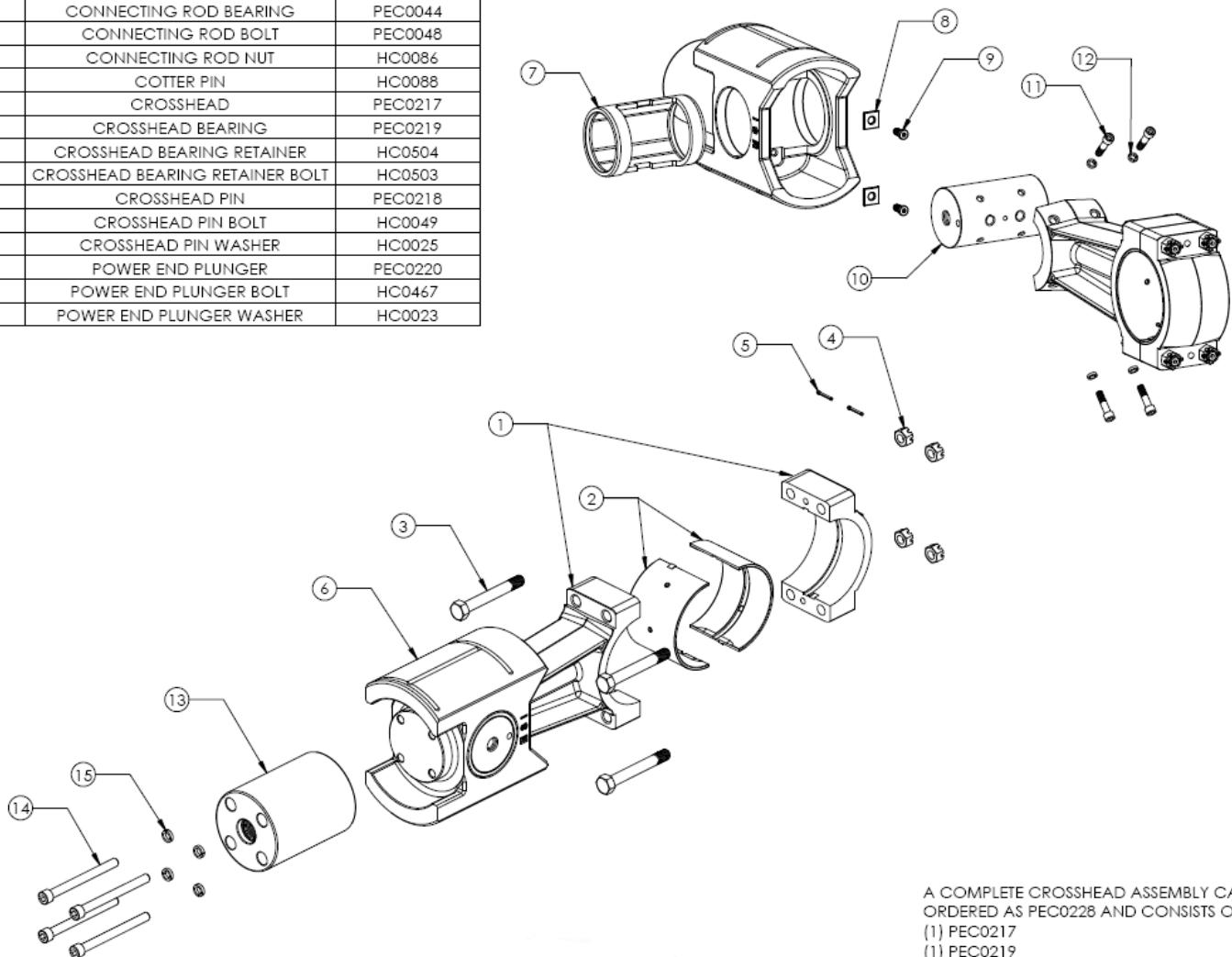
- 8) Reassemble in the reverse order of these instructions.

CONNECTING ROD INSTALLATION



**RECIPROCATING ASSEMBLY -
EXPLODED**

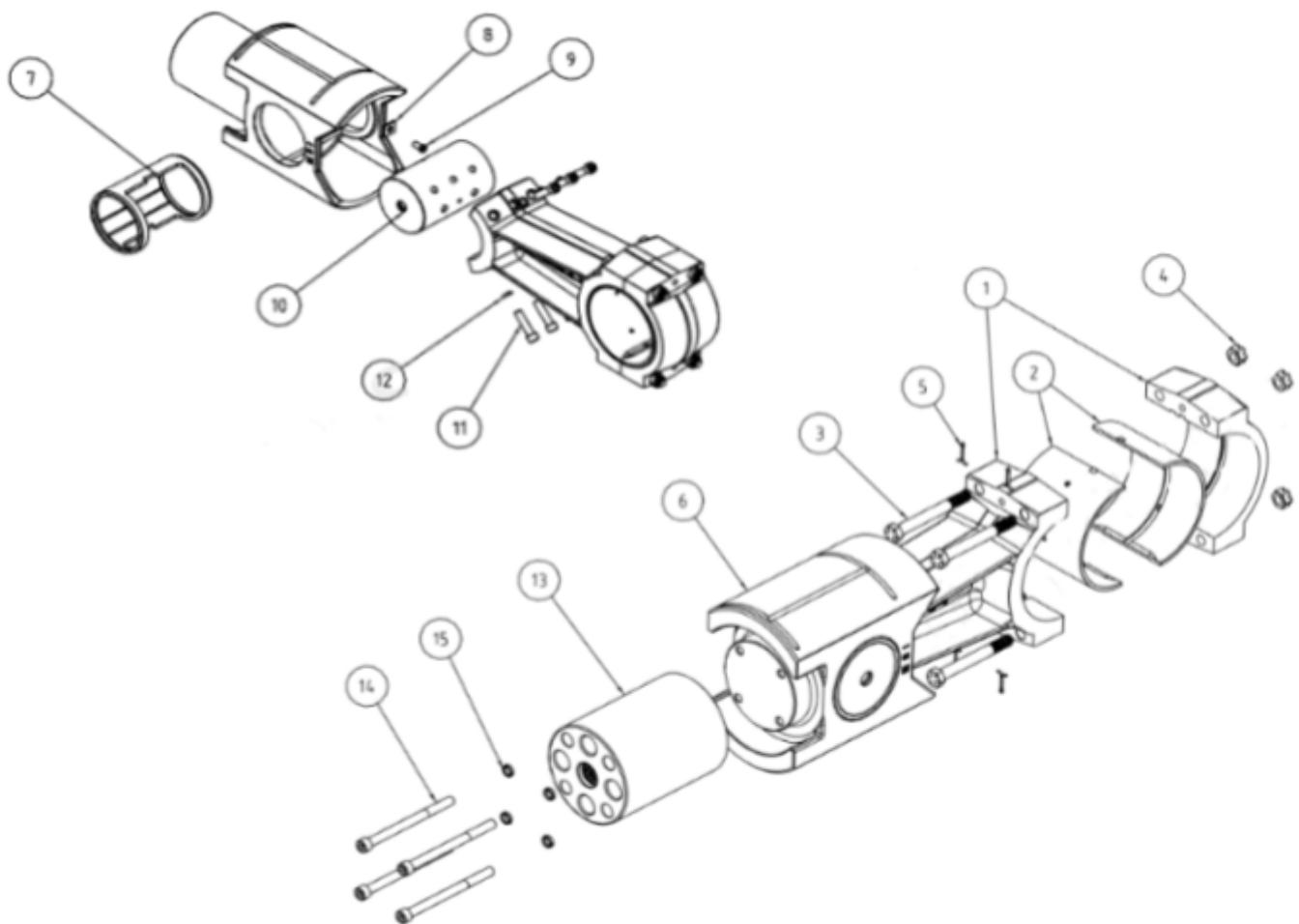
ITEM NO.	DESCRIPTION	PART NUMBER
1	CONNECTING ROD	PEC0216
2	CONNECTING ROD BEARING	PEC0044
3	CONNECTING ROD BOLT	PEC0048
4	CONNECTING ROD NUT	HC0086
5	COTTER PIN	HC0088
6	CROSSHEAD	PEC0217
7	CROSSHEAD BEARING	PEC0219
8	CROSSHEAD BEARING RETAINER	HC0504
9	CROSSHEAD BEARING RETAINER BOLT	HC0503
10	CROSSHEAD PIN	PEC0218
11	CROSSHEAD PIN BOLT	HC0049
12	CROSSHEAD PIN WASHER	HC0025
13	POWER END PLUNGER	PEC0220
14	POWER END PLUNGER BOLT	HC0467
15	POWER END PLUNGER WASHER	HC0023



A COMPLETE CROSSHEAD ASSEMBLY CAN BE ORDERED AS PEC0228 AND CONSISTS OF:
 (1) PEC0217
 (1) PEC0219
 (2) HC0503
 (2) HC0504

**RECIPROCATING ASSEMBLY -
EXPLODED-1500 HP**

ITEM NO.	DESCRIPTION	PART NUMBER
1	CONNECTING ROD	PEC-15-0002
2	CONNECTING ROD BEARING	PEC-15-0003
3	CONNECTING ROD BOLT	PEC-15-0048
4	CONNECTING ROD NUT	HC0086
5	COTTER PIN	HC0088
6	CROSSHEAD	PEC-15-0047
7	CROSSHEAD BEARING	PEC-15-0049
8	CROSSHEAD BEARING RETAINER	HC0504
9	CROSSHEAD BEARING RETAINER BOLT	HC0503
10	CROSSHEAD PIN	PEC-15-0041
11	CROSSHEAD PIN BOLT	HC0250
12	CROSSHEAD PIN WASHER	HC0023
13	POWER END PLUNGER	PEC-15-0042
14	POWER END PLUNGER BOLT	HC1214
15	POWER END PLUNGER WASHER	HC0023

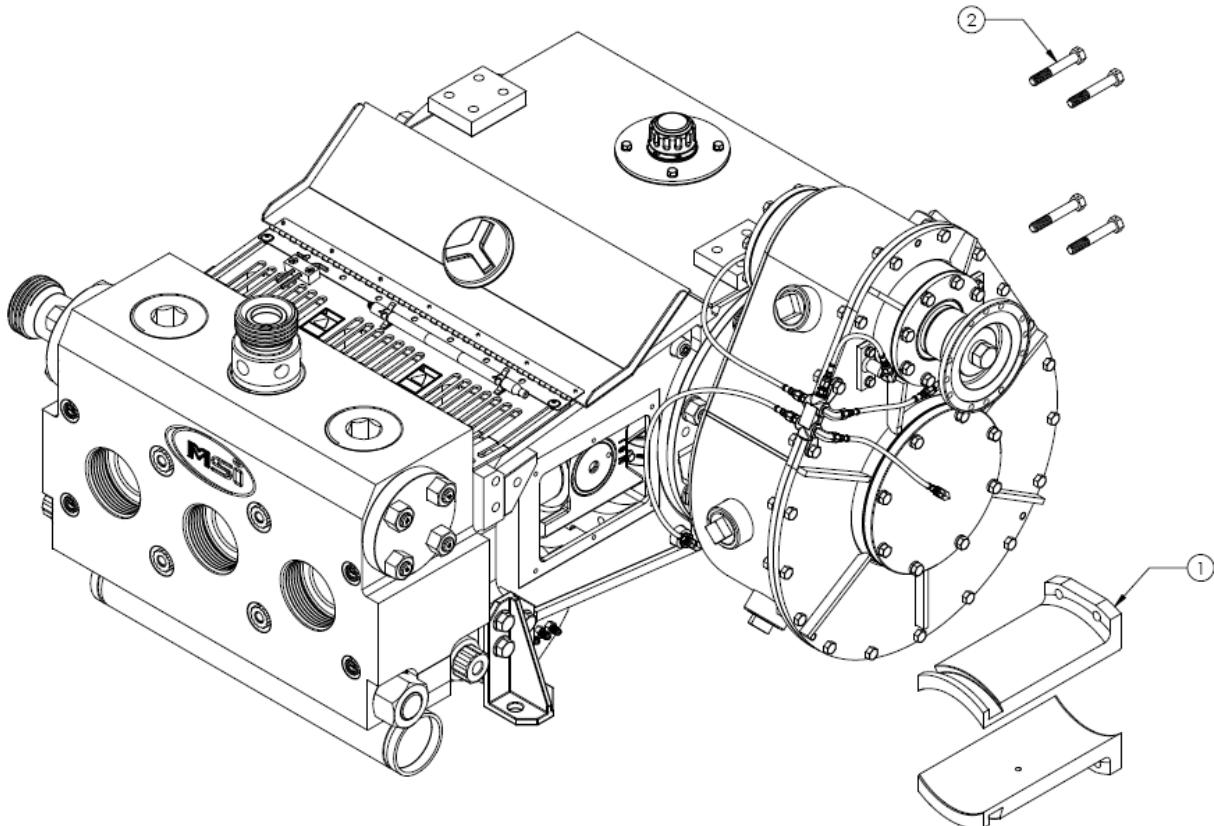


11.7 Replacing Crosshead Guides

- 1) Remove the fluid end plungers per instructions in [Section 9.2](#).
- 2) Remove the access panels per [Section 11.3](#).
- 3) Remove the power end plungers and seal housings per instructions in [Section 11.4](#).
- 4) Remove the connecting rods per [Section 11.5](#).
- 5) Remove the crosshead pins and crossheads per instruction in [Section 11.6](#).
- 6) Remove the lubrication oil hoses from the fittings in the rear of the crosshead guides using a 9/16" open end wrench.
- 7) Model specific steps:
 - a) 600/1000/1300 bhp
 - (a) Remove the rear screws that hold the crosshead guides into place using a 15/16" socket. Slide the crosshead guides backward to release them. Remove the guides through the side access panel openings. Inspect the crosshead guides for signs of scoring, uneven wear, or excessive heat. Replace as necessary.
 - (b)
 - b) 1500 bhp
 - (a) Use a 3/8" hex wrench, remove the 1/2" NPT plugs on top and bottom of the power end to gain access to the crosshead retaining screws then remove the 7/16" screws that retain the slides using the same wrench. Be prepared to support the upper slide so that it does not fall when the screws are removed.
- 8) When reinstalling the crosshead guides apply Loctite® Threadlocker Blue to the crosshead slide screws and torque them to 50 ft-lbs. Do not apply excessive torque to the screws, doing so may distort the guides and cause damage to the pump if operated in that condition.

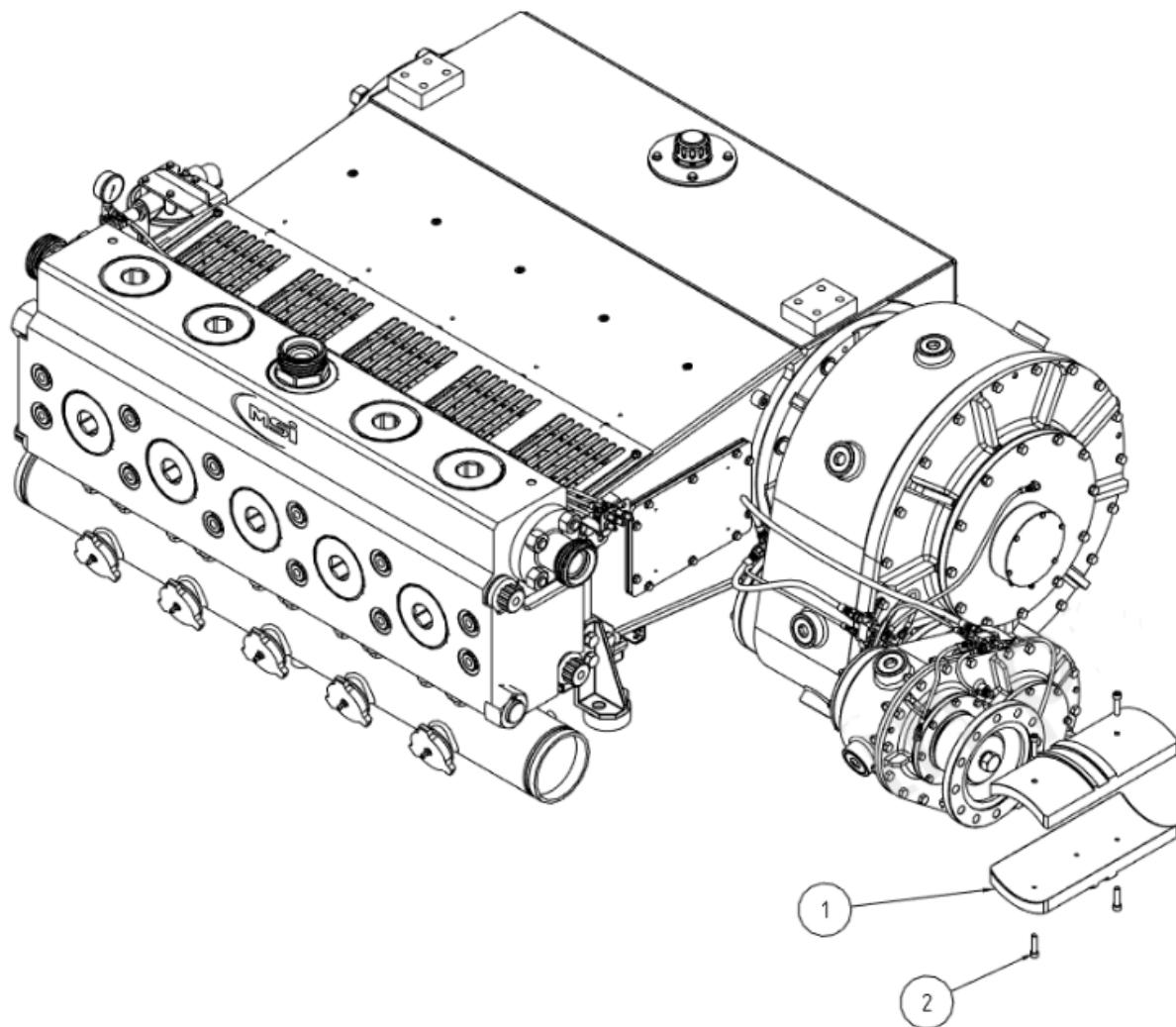
CROSSHEAD SLIDE REMOVAL

ITEM NO.	DESCRIPTION	PART NUMBER
1	CROSSHEAD GUIDE	PEC0056
2	CROSSHEAD GUIDE BOLT	HC0083



CROSSHEAD SLIDE REMOVAL
1500HP

ITEM NO.	DESCRIPTION	PART NUMBER
1	CROSSHEAD GUIDE	PEC-15-0027
2	CROSSHEAD GUIDE BOLT	HC1216



Appendix A TYPICAL PUMP FORMULAS

LEGEND:

- A = Area (square inches)
- AR = Area Required (square inches)
- BHP = Brake Horse Power
- FR = Flow Rate (gallons per minute)
- FRM = Flow Rate Max (gallons per minute)
- FV = Flow Velocity (feet per second)
- GPR = Gallons (US) Per Revolution
- HHP = Hydraulic Horsepower
- ID = Inside Diameter (inches)
- ME = Mechanical Efficiency
- NC = Number of Cylinders
- PD = Plunger Diameter (inches)
- PSI = Pounds per Square Inch
- RL = Rod Load (pounds force)
- RPM = Revolutions Per Minute
- SL = Stroke Length (inches)
- T = Torque (foot-pounds force)

a. To calculate the HHP output when the rate and pressure are known:

$$\frac{FR \times PSI}{1714} = HHP$$

b. To calculate the BHP input recommended when the rate, pressure, and mechanical efficiency are known:

$$\frac{FR \times PSI}{(1714 \times ME)} = BHP$$

c. To calculate the maximum possible pressure when the BHP, rate, and ME are known:

$$\frac{BHP \times (1714 \times ME)}{FR} = PSI$$

d. To calculate the maximum possible rate when the BHP, PSI, and ME are known:

$$\frac{BHP \times (1714 \times ME)}{PSI} = FR$$

e. To calculate rod load when the fluid end plunger diameter and pressure are known:

$$PD \times PD \times 0.7854 \times PSI = RL$$

- f. To calculate the maximum possible pressure at a given rod load when the RL rating and fluid end plunger diameter are known:

$$\frac{RL}{PD \times PD \times 0.7854} = PSI$$

- g. To calculate the flow in gal/rev (GPR) when the fluid end plunger diameter, stroke length, and number of cylinders is known:

$$\frac{PD \times PD \times 0.7854 \times SL \times NC}{231} = GPR$$

- h. To calculate the fluid flow velocity through a pipe or hose when the GPM and pipe size are known:

$$Pipe\ ID \times Pipe\ ID \times 0.7854 = A$$

$$\frac{FR \times 0.3208}{A} = FV$$

- i. To calculate the internal size of piping recommended to maintain a specified flow velocity when the GPM and desired flow velocity are known:

$$\frac{FR \times 0.3208}{FV} = AR$$

- j. To calculate the maximum allowable GPM through a specified flow velocity when the internal area of the pipe and the desired flow velocity are known:

$$\frac{FV \times AR}{0.3208} = FRM$$

- k. To calculate pinion shaft or driveline torque when the input BHP and pinion shaft RPM are known:

$$\frac{BHP \times 5252}{RPM} = T$$

Conversion Factors:

Multiply:	By:	To Obtain:
Barrels (U.S.)	42	Gallons (U.S.)
Gallons (U.S.)	0.023809	Barrels (U.S.)
Gallons (U.S.)	231	Cubic Inches
Cubic Inches	0.004329	Gallons (U.S.)
Cu. Ft./Sec.	448.831	GPM
GPM	0.002228	Cu. Ft./Sec.
Head Feet (water)	0.4331	PSI
PSI	2.309	Head Feet (water)
Kilowatts	1.341	Horsepower
Horsepower	0.7457	Kilowatts

Listed below are some common conditions that may require troubleshooting and their possible solutions.

Lubrication Oil Running Hot

- High ambient temperatures.
- Wrong grade of gear oil.
- Lubrication pump volume is not sufficient.
- Lubrication pump cavitation.
- Heat exchangers not functioning properly or undersized. (See [Section 5.3](#))
- Lubrication oil returning on top of pinion and bull gear, resulting in high oil shear between gear teeth.
- Running the pump at max speed for a longer duration than the design of the lubrication cooling system can withstand.
- Air, water, or other contaminants in the lubrication oil.
- Insufficient lubrication oil volume in reservoir. Reservoir lubrication oil volume in gallons should be 2.5 times the lubrication pump volume in gallons per minute.
- Impending mechanical failure within the power end or gear reducer.
- Defective temperature transducer and or temperature gauge.
- Faulty temperature transducer cable.

Lubrication Oil Pressure Running Low

- High ambient temperatures; excessively high oil temperature causing low viscosity.
- Lubrication oil relief valve set too low or leaking.
- Ruptured oil line inside of power frame.
- Lubrication oil pump is worn out or not functioning properly.
- Lubrication oil pump is cavitating due to a low suction head.
- Lubrication oil pump inlet line blocked, or shutoff valve for isolating pump from reservoir is blocked or partially closed.
- Air entering the lubrication oil pump suction inlet due to a loose connection, which allows air to be sucked into the inlet, or a fluid level in the reservoir that is too low or so low that it causes a vortex, which allows air into the inlet.

- Clogged oil filter(s) or faulty bypass valve in the filter(s).
- Defective pressure transducer or pressure gauge.
- Faulty pressure transducer cable.

Pump Running Rough

- Insufficient suction head for the demand at the pump speed in which the rough running occurs. Check for obstruction in the suction line, for solids that have collected in the suction line restricting flow, for a partially closed valve, or if the centrifugal pump was not sized properly to provide 50 PSI at the pump inlet at max rated RPM of the pump. If the inlet pressure gauge needle is oscillating radically, then the pump is cavitating due to one or more of these reasons. A cavitating pump will shake the entire well service unit.
- Valve leaking, broken spring, or broken valve guide.
- Air in the fluid entering the pump.
- Ruptured suction stabilizer bladder, the bladder has lost its nitrogen charge, or the charge pressure was set too high. A properly charged suction stabilizer is set to 30-40% of the operating suction line pressure.
- Pump is operating at the same pressure as the pressure relief valve, and the valve is cycling open and closed.
- Solids in the pumping medium are trapped between the valve and valve seat.
- Valve insert is damaged or missing. Valve guide legs are damaged or missing.
- Pumped fluid is hot, causing flashing of the fluid during the suction stroke.
- Broken or worn internal moving parts.
- Cracked fluid end.

Loss of Pumping Pressure

- Valve leaking due to damaged or missing insert, broken spring, or broken valve guide.
- Leaking or improperly set pressure relief valve.
- Overpressure resulting in subsequent failure of rupture disk safety devices.
- Insufficient suction head for the demand at the pump speed in which the pressure drop is occurring. Check for obstruction, solids that have collected in the suction line restricting flow, a partially closed valve, or if the centrifugal pump was not sized properly so that it will provide 50 PSI at the pump inlet at max rated RPM of the pump.
- Ruptured suction stabilizer bladder, the bladder has lost its nitrogen charge, or the charge pressure was set too high. A properly charged suction stabilizer is set to 30-40% of the operating suction line

pressure.

- Solids in the pumping medium are trapped between the valve and valve seat.
- Pumped fluid is hot, causing flashing of the fluid during the suction stroke.
- Broken or worn internal moving parts.
- Cracked fluid end.
- Leaking fluid end plunger packing.
- Blown valve cover seals.

Lubrication Vent Smoke

- Insufficient flow of lubricating oil causing overheating of bushings or bearing surfaces. Continuing to run the pump will cause expensive repairs.
- Failure of bushings, bearings, or gear teeth. Continuing to run the pump will cause expensive repairs.
- Vapor around the hot oil filler cap on a cold day.

Revision P

Corrected typo on page 65. Omitted the extra 0 in the part numbers.

Added Hex Gauge Wrench to the Tool section.

Replaced all old style gauge connection part numbers with the new hex style. FEC0096 was replaced with FEC0556. FEC0151 was replaced with FEC0582. FEC0011, FEC0012 and FEC-15-0007 all replaced by FEC0583



MSI – A Division of Dixie Iron Works, Ltd.
300 W. Main St.
Alice, TX 78332
www.diwmsi.com
(800) 242-0059
(361) 664-6597