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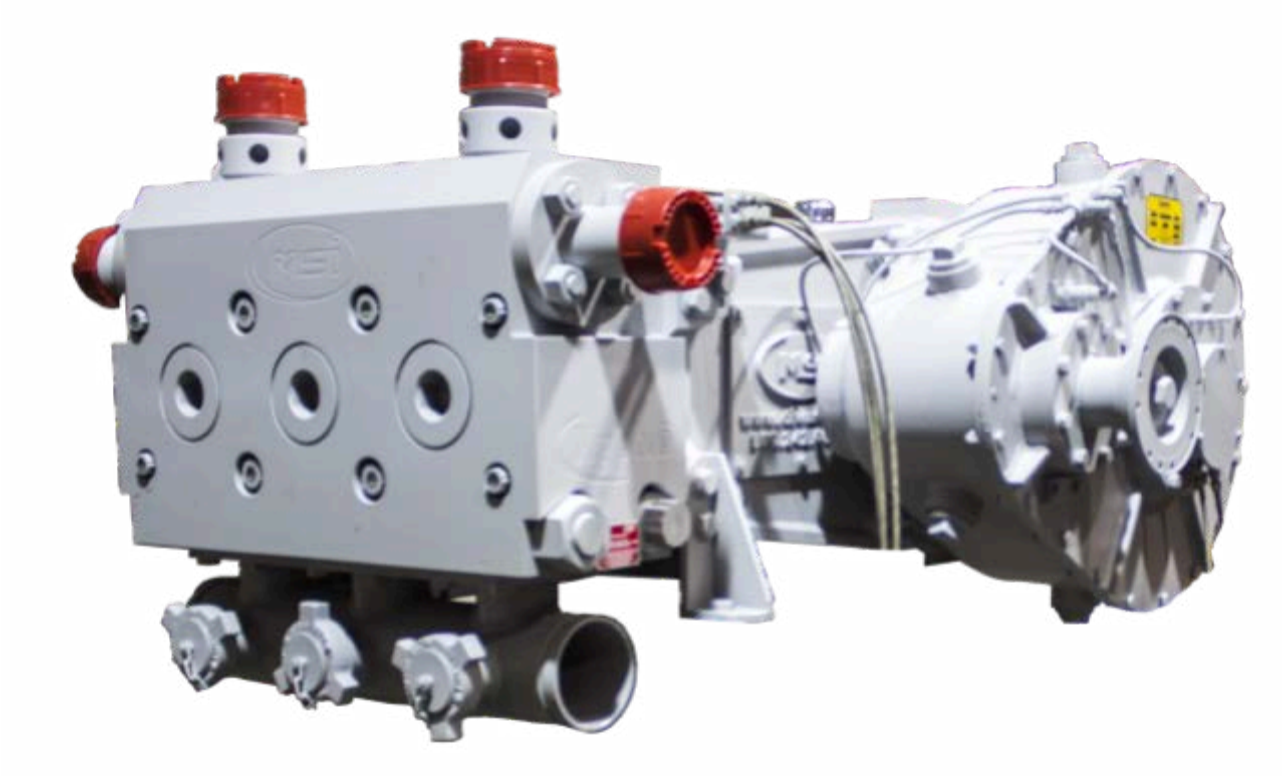

Technical Manual for
MSI TI-600 Pump/ MSI QI-1000 Pump

Revision B **Jan 22, 2025**

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1.00 General Description

The MSI TI-600 is a 600 horsepower triplex pump. The MSI QI-1000 is a 1000 horsepower quintuplex pump. These pumps are suited for oilfield service applications.

These pumps are composed of three main components: Power Frame, Fluid End, and a Gear Reducer. The pump is designed for sixteen left and right-hand configurations of the Gear Reducer without removing the crankshaft.

The Power Frame is composed of the crankshaft, the crossheads, the crosshead guides, connecting rods, and diaphragm seal housing in a high-strength steel frame. The Power Frame should be mounted to a skid or other rigid platform before operating (see 1.30).

The Fluid End is composed of valves, springs, intake manifold, discharge flanges and various access covers. The Fluid End is machined from a one-piece, high-strength steel forging. One Fluid End will accept plunger sizes from 2.75 to 3.00 inches and the other plungers 3.25 to 4.50 inches in diameter. The Fluid End is bolted to the Power Frame with high-strength tension-indicating bolts.

The Gear Reducer houses a helical AGMA #10 precision ground pinion and gear providing a reduction ratio of 4.61:1.

1.10 Recommended Shipping and Storage

Every MSI pump is fully factory acceptance tested (FAT) at MSI before it is cleaned, painted, and preserved for shipping. This FAT procedure runs the pump through the 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 prevent excessive exposure to humidity and rain. 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.

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

Inspect the unit.

Look for any condensation or accumulation of water inside the shrink wrapping which 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. Keeping the unit out of moisture or away from salt spray is helpful.

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 cover

nuts, valve stop, springs and valve covers from the fluid end and blow all moisture out. 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, springs, valve stop, and cover nuts. Seal off all inlet and outlets 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 in the inside bottom of the power end. If this occurs, remove the back access panel 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:

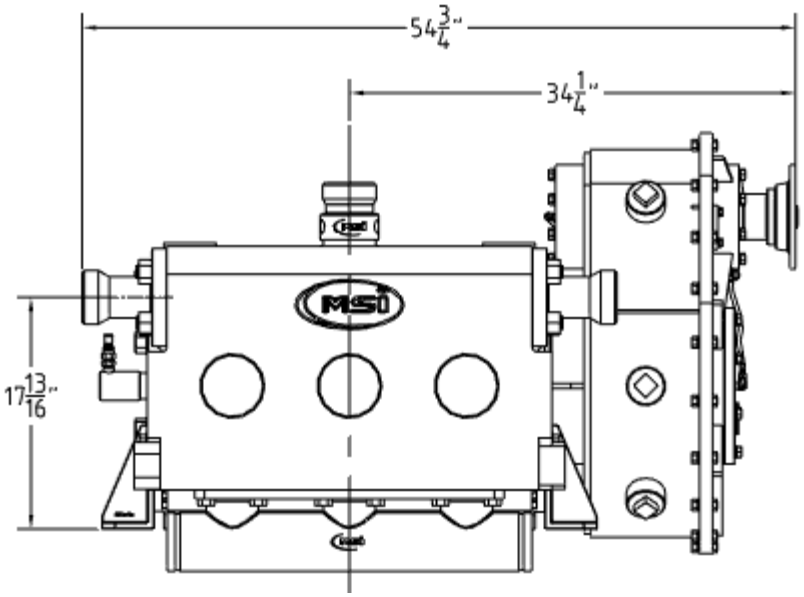
If the used pump is to be stored outdoors, it should be placed in a covered location that will protect the pump from direct exposure to moisture and sunlight. If a covering is not available, the pump should be covered and tied with a heavy duty tarp.

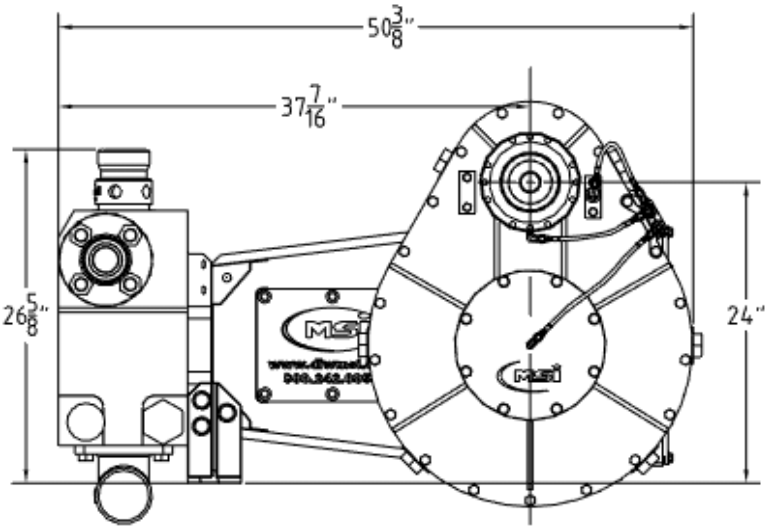
Preservation Between Jobs:

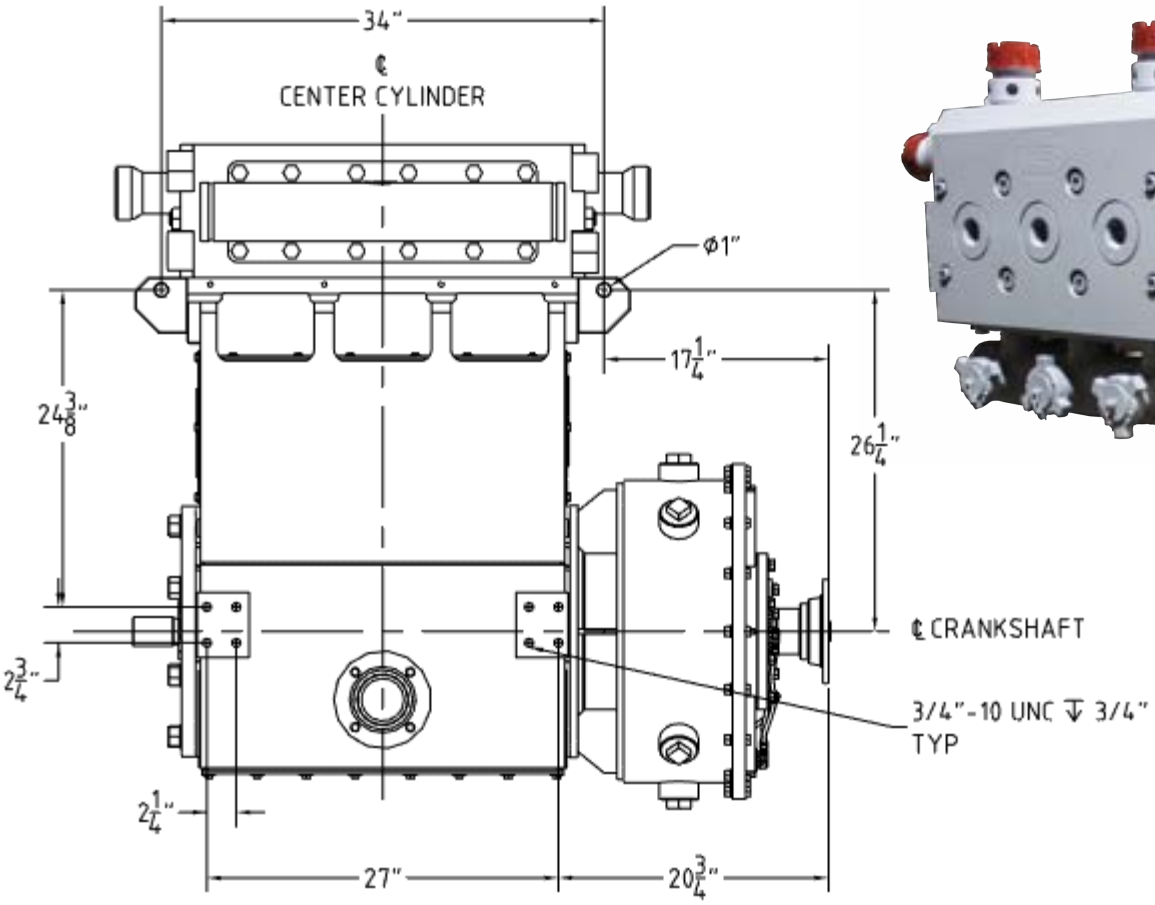
The internal fluid end components can oxidize and corrode after exposure to well service fluid, especially if the well service fluid contained water, brine, or acids. If possible, remove the valve covers and use compressed air to blow out moisture from the fluid end (see CAUTION statement above). After 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.

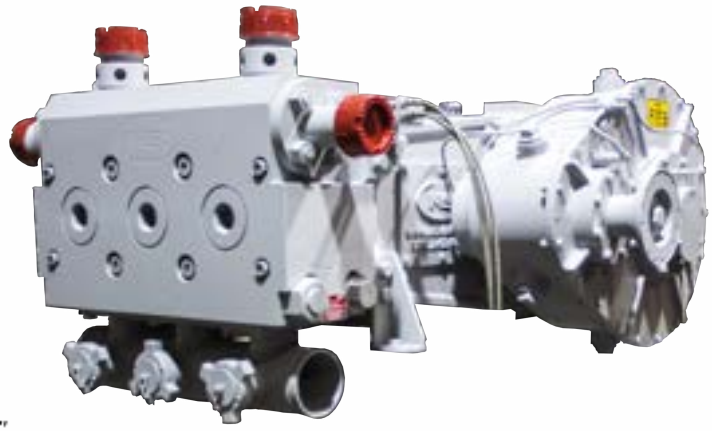
1.20 Drawings - Pump Assembly Overall Dimensions (All Plunger Sizes)

TI-600 (TRIPLEX)

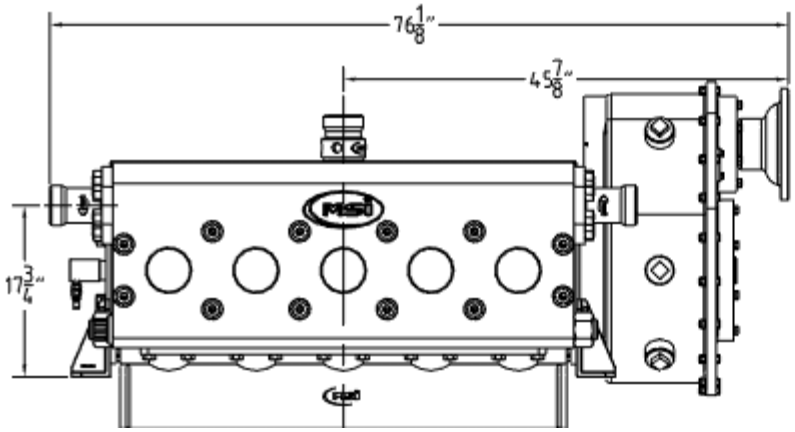


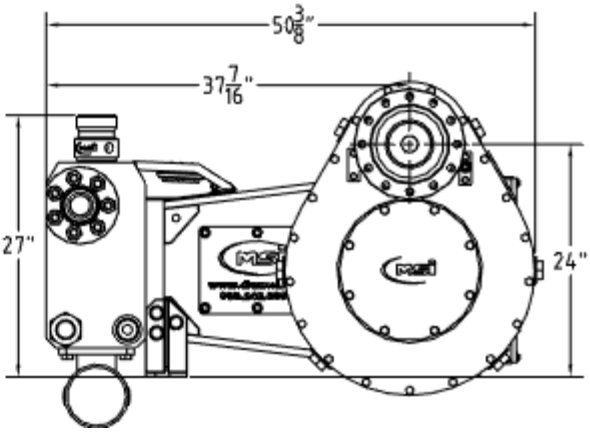


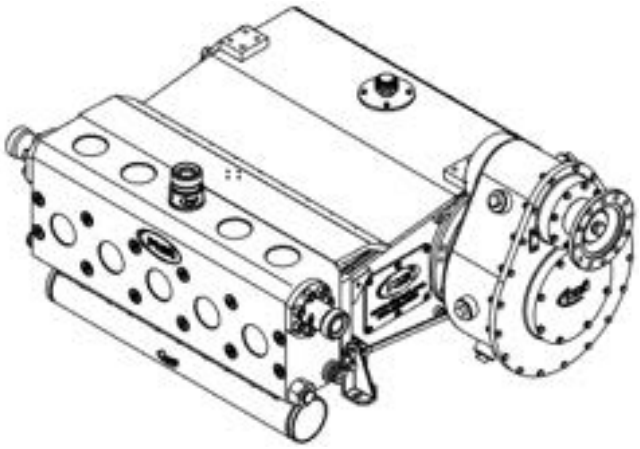


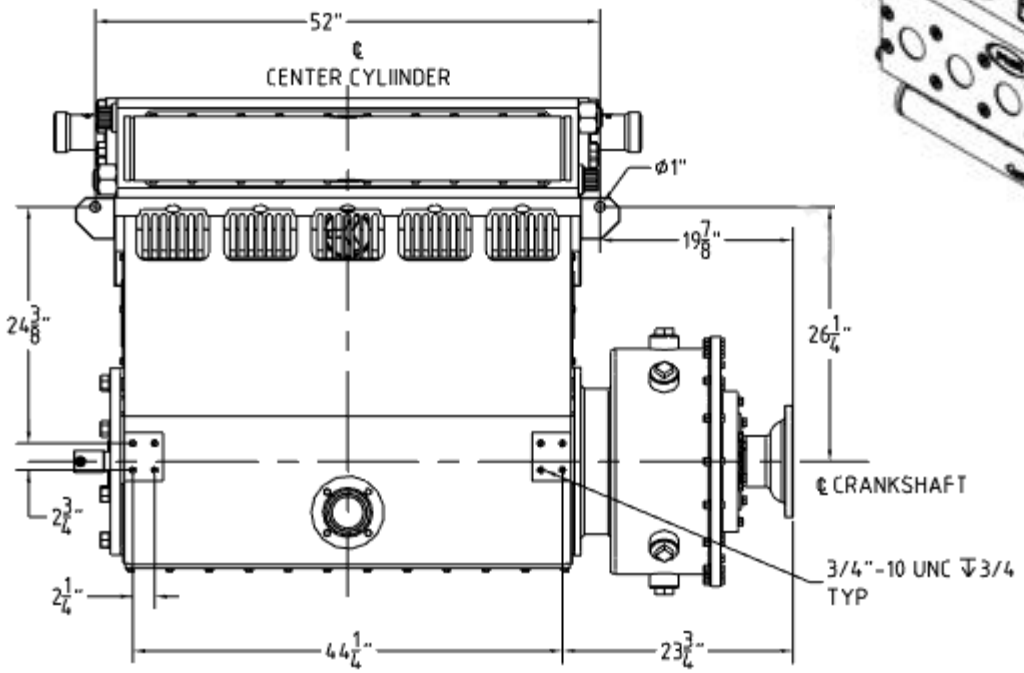


QI-1000 (QUINTUPLEX)



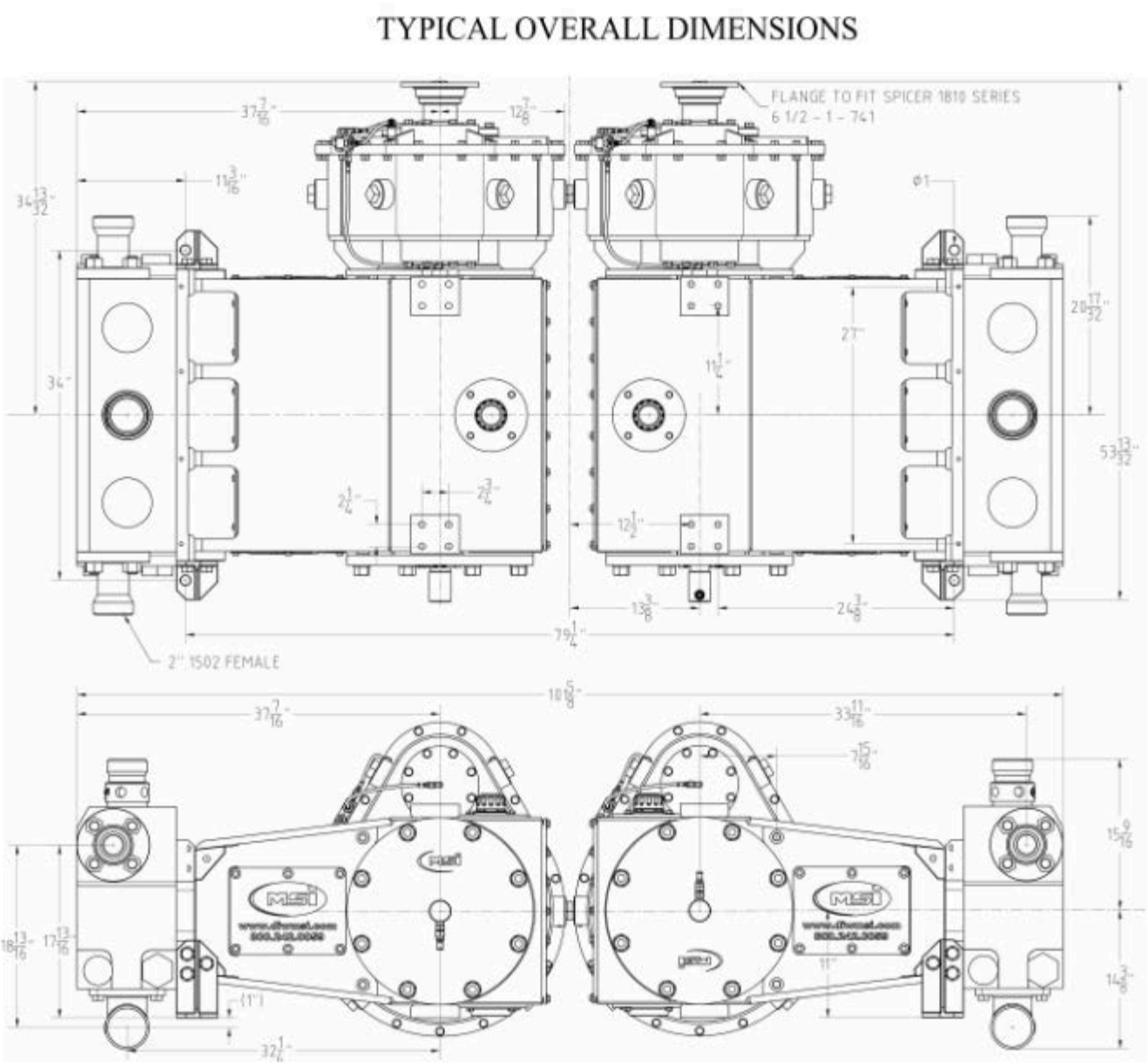




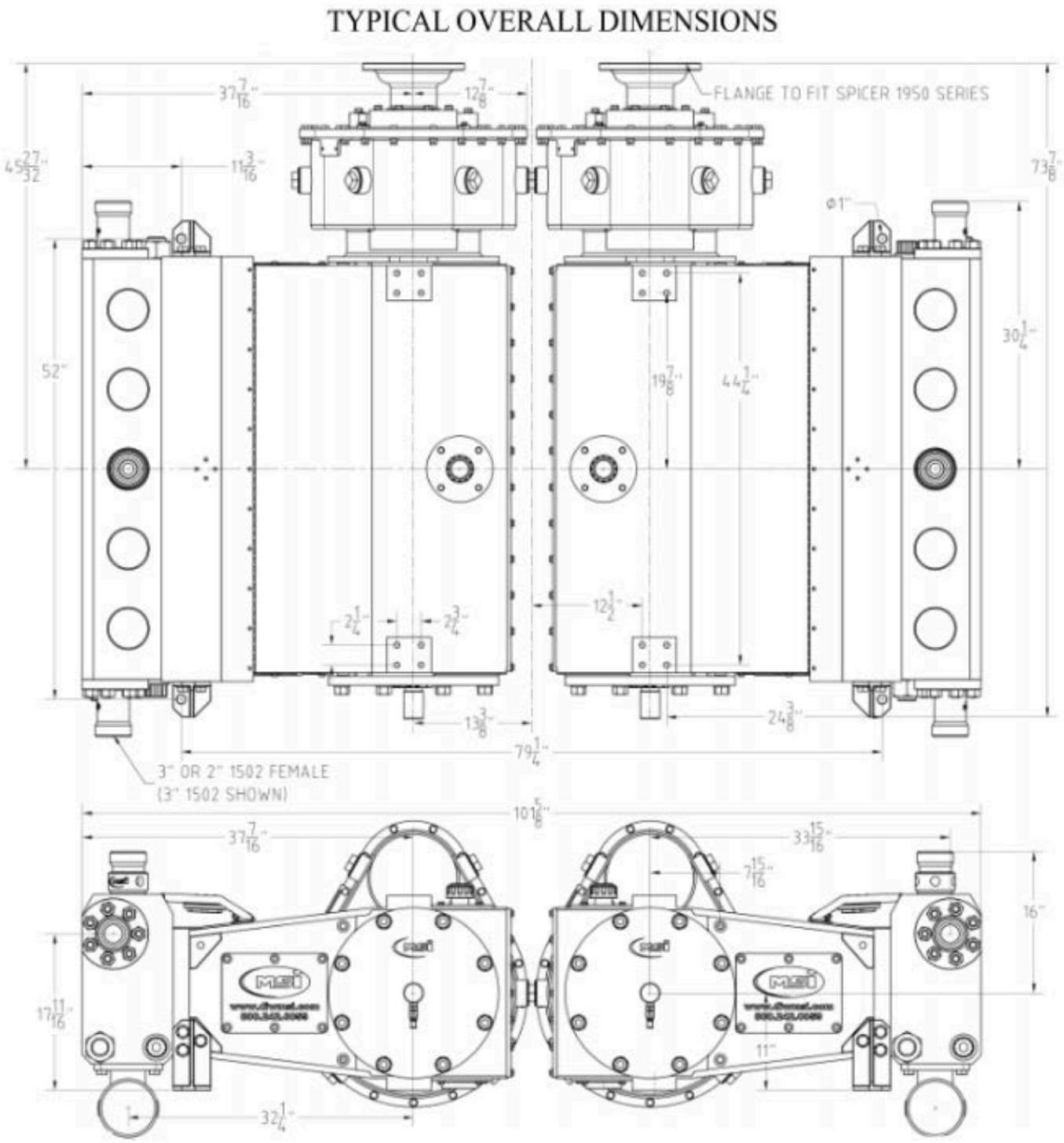


1.30 Dual Pump Assembly Overall Dimensions

1.30.1 600 HP Dual Pump Assembly Overall Dimensions

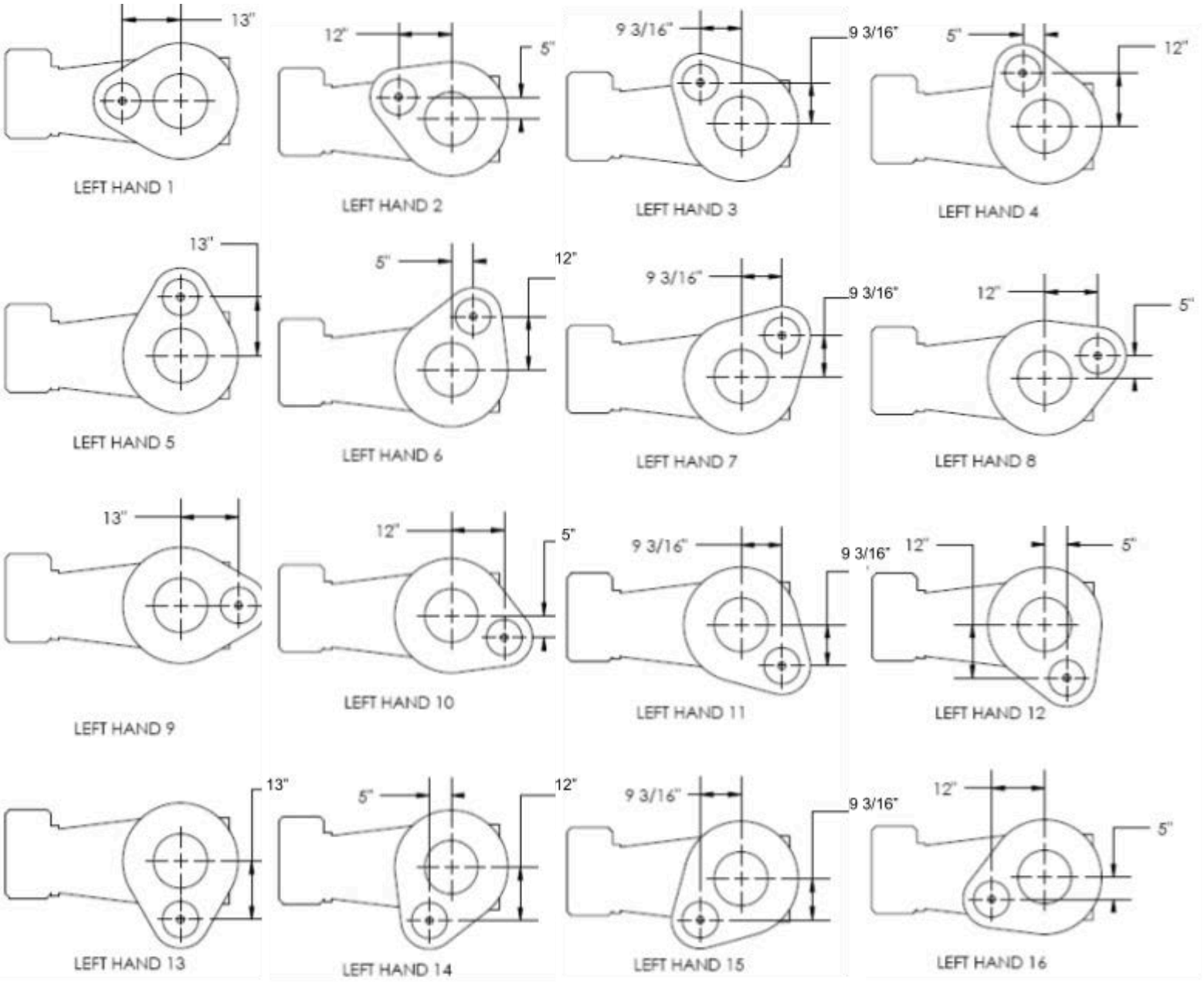


1.30.2 1000 HP Dual Pump Assembly Overall Dimensions



1.50 Drawings - Gear Reducer Installation Positions

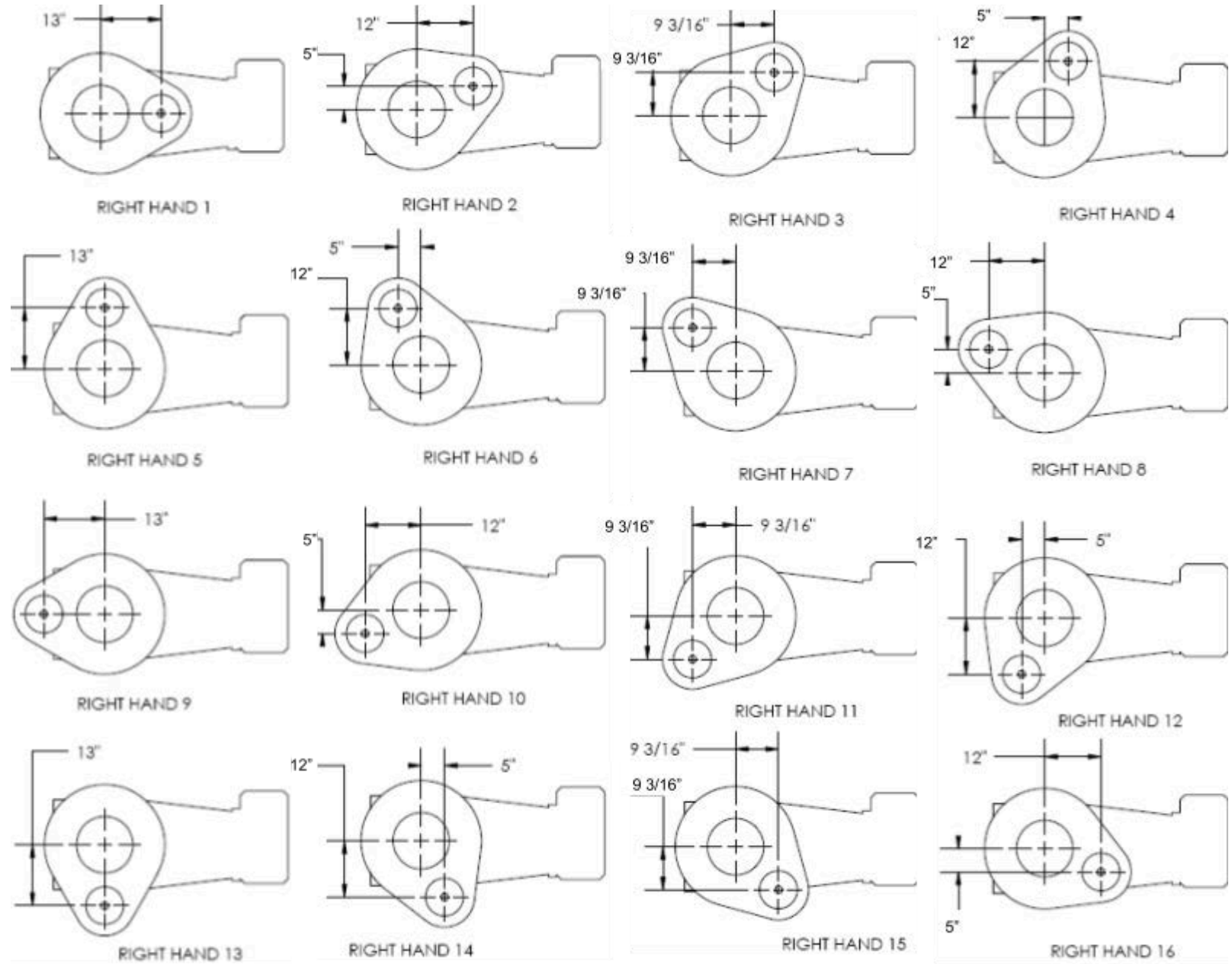
1.50.1 Gear Reducer Position-Left Hand



STANDARD GEAR REDUCER (4.61:1 REDUCTION RATIO)

*POSITION DIMENSIONS ROUNDED TO THE NEAREST 1/16"

1.50.2 Gear Reducer Position Right Hand

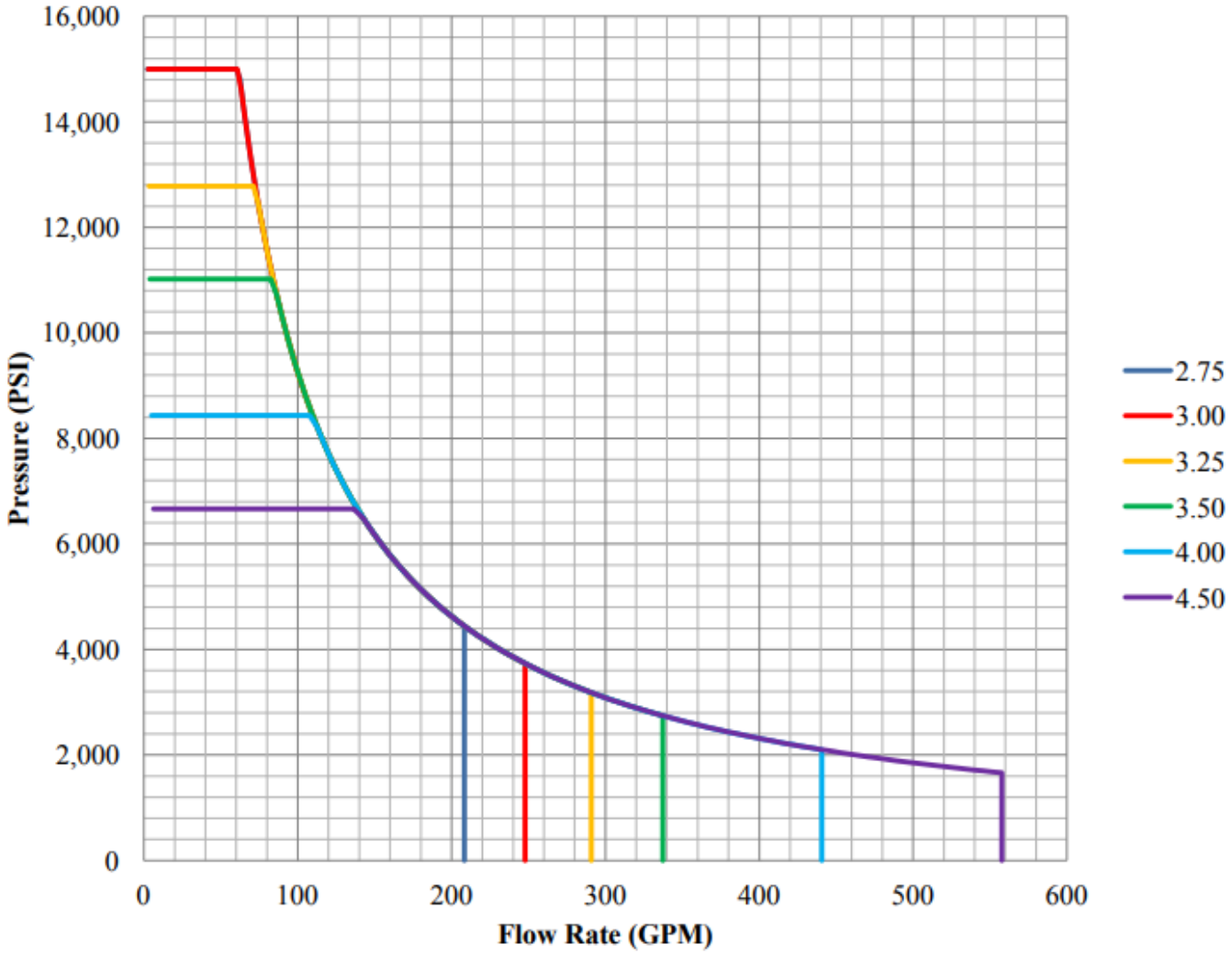


STANDARD GEAR REDUCER (4.61:1 REDUCTION RATIO)

*POSITION DIMENSIONS ROUNDED TO THE NEAREST 1/16"

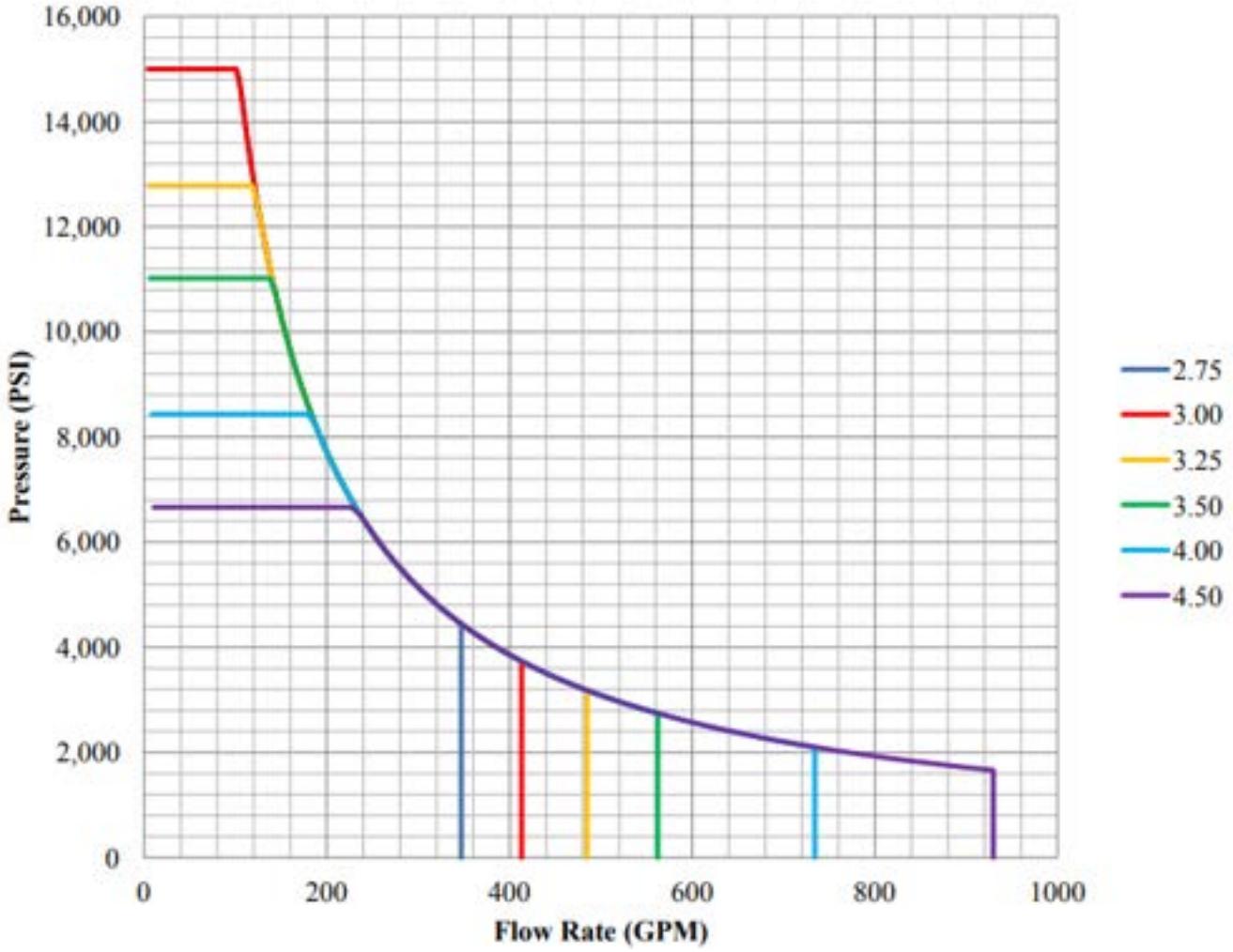
1.60 600 HP Pump Performance Data

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	
RPM	**50**	GPM	23	28	32	37	49	62	268
		PSI	15,000	15,000	11,020	11,020	8,438	6,667	
	100	GPM	46	55	65	75	98	124	536
		PSI	15,000	15,000	11,020	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	



1.70 1000 HP Pump Performance Data

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	
RPM	**50**	GPM	39	46	54	62	82	103	446
		PSI	15,000	15,000	11,020	11,020	8,438	6,667	
	100	GPM	77	92	108	125	163	207	893
		PSI	15,000	15,000	11,020	11,020	8,438	6,667	
	200	GPM	154	184	215	250	326	413	1,000
		PSI	9,999	8,402	7,159	6,173	4,726	3,734	
	300	GPM	231	275	323	375	490	620	
		PSI	6,666	5,601	4,773	4,115	3,151	2,489	
	450	GPM	347	413	485	562	734	929	
		PSI	4,444	3,734	3,182	2,744	2,100	1,660	



2.00 Operation and Maintenance

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-bore volume relief device and sufficient fluid volume will 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.

Below are the maximum relief set pressures based on plunger diameter.

Plunger Diameter	Relief Device Maximum Set Pressure
2.75"	15,000 psig
3.00"	15,000 psig
3.25"	11,020 psig
3.50"	11,020 psig
4.00"	8,438 psig
4.50"	6,667 psig

2.10 Initial Inspection

a) Check to see that all moving parts are clean and free of any shipping debris
b) Check to see that pump is securely bolted to mounting platform
c) Check to see that driveline is securely fastened to the pump's Gear Reducer input shaft with adequate slip (1 inch minimum) in the slip joint
d) Check the Fluid End bolts. Each has a mechanical indicator in the face and should be between 90 and 95 on the dial. Tighten as necessary, but do not surpass 95 on the dial. If the indicator is not working return it to MSI for immediate replacement. **Note: In order to achieve the necessary preload without damaging the bolt, DOW CORNING G-n Metal Assembly Paste must be used.**
e) Make sure the Power Frame has correct oil in its reservoir (Section 4)
f) Make sure the plunger lube system has proper type of packing oil or grease
g) Check to see that supercharge piping system is clean and all connections are tight
h) Check to see that adequate water is available to suction manifold for testing
i) Check to see that discharge piping connections are tight and all valves are open
j) Start the supercharge pump and flush the air from the system

2.20 Seating Valves

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 full open. 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. The approximate seating pressure for each plunger size is as follows:

Plunger Diameter	Rated Pressure
2.75"	14,320 PSI
3.00"	12,030 PSI
3.25"	8,840 PSI
3.50"	8,840 PSI
4.00"	6,765 PSI
4.50"	5,345 PSI

c) During this portion of the startup procedure, closely observe the plunger pump for any unusual noise, vibration, fluid leaks and oil leaks. Record all pertinent information such as elapsed time, ambient temperature, Power Frame lube oil temperature, and Power Frame lube oil pressure, supercharge pressure, etc. After returning the engine to idle and transmission to neutral, physically inspect the plunger pump before proceeding further.

3.00 Scheduled Maintenance

MSI recommends that all pumps have regular scheduled maintenance. Regular maintenance will help ensure trouble-free operation.

3.10 First 100 Hours of New Pump Operation

a) Change Power Frame lube oil filters every 25 hours
b) Thoroughly clean the Power Frame lube oil suction strainer after the first 50 hours and 100 hours of operation.
c) Change the Power Frame lube oil after the first 100 hours of operation and clean the lube oil reservoir.

3.20 Daily Preventative Maintenance

a) Check the oil level in the Power Frame lube oil reservoir.
b) Check the oil level in the plunger lube oil reservoir.
c) Check the plunger pump for oil leaks and/or fluid leaks.
d) Check the Power Frame lube oil system for leaks.
e) Check the plunger lube system for leaks.
f) Check the supercharge piping for leaks.
g) Check the Fluid End bolts. Each has a mechanical indicator in the face and should read between 90 and 95 on the dial. Tighten as necessary, but do not exceed 95 on the dial. If the indicator is not working return it to MSI for immediate replacement. Note: In order to achieve the necessary preload without damaging the bolt, use DOW CORNING G-n Metal Assembly Paste as a thread lubricant.

3.30 Weekly Preventative Maintenance

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

3.40 Every 100 hours Preventative Maintenance

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

3.50 Every 250 hours Preventative Maintenance

a) Check all items on “daily,” “weekly,” and “100 hours” list.
b) Change the Power Frame lube oil and refill with the proper grade of gear oil for upcoming ambient conditions.
c) Thoroughly clean the Power Frame lube suction strainer.
d) Remove and inspect the plungers and packing assembly components.
e) Replace all packing pressure rings and header rings.
f) Clean the plunger pump’s oil breather and the Power Frame lube oil reservoir breather.

3.60 Yearly or as Required Preventative Maintenance

a) Replace worn plungers and packing brass.
b) Replace worn or corroded valve covers, suction valve stops, packing nuts, discharge flanges, pump tools, etc.
c) Replace all discharge flange seals and suction manifold seals.
d) Replace any defective gauges and instruments.

3.70 Inspection of Bearings and Gears

a) Inspection of the gears, bearings, and journal bearings should be made every 500 hours. Look in the oil filter for telltale clues such as flaking metal. Also check for end play on pinion shaft. This is easily checked by placing a dial indicator on face of Spicer flange and pulling on the Spicer flange. There should be no movement on the Spicer flange. If end play is noted see Section 7.10 paragraph (k).
b) Remember: Pitting, spalling, and other surface defects are an indication of impending failure. Replace as necessary.

4.00 LUBRICATION REQUIREMENTS: POWER TRAIN AND PLUNGERS

4.1 Lubrication Capacity Requirements

The MSI 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 Well Service Pump greatly reduces the 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 4.8**. A valve installed at the lowest point in the tank is recommended to allow for accumulated water to be removed.

The MSI 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 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.

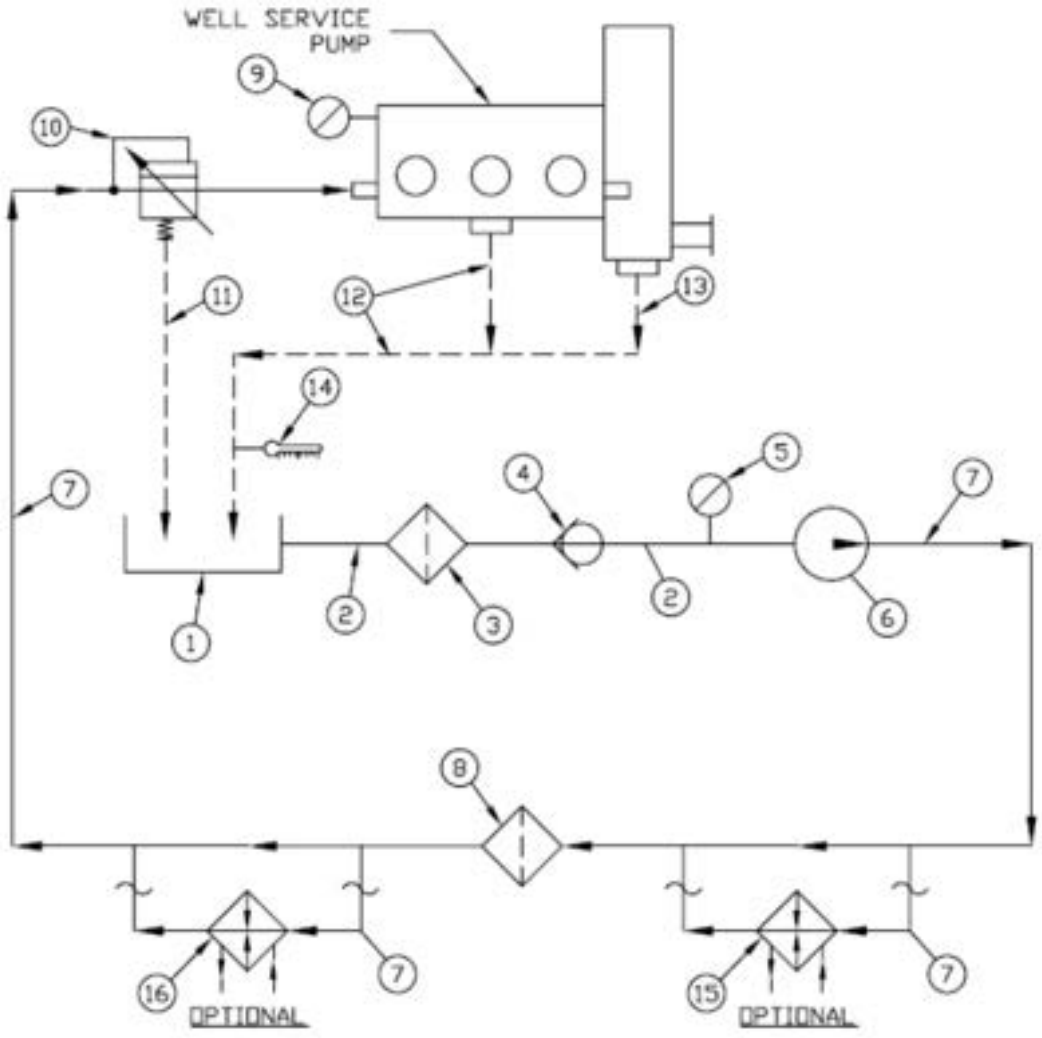
It is important to mount the lubrication pump as low as possible so that the pump does not cavitate as a result of having to lift the fluid from the reservoir. If at all possible, the pump should be mounted below the outlet of the reservoir.

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 Well Service Pump power end lubrication inlet. (This pressure limitation does not apply to the fluid end plunger lubrication system.)

4.2 Typical Lubrication Schematic

A typical power end and gear reducer lubrication oil schematic is shown below.

ITEM #	DESCRIPTION
1	RESERVOIR, VENTED 50 GALLON MIN CAPACITY
2	SUCTION LINE, PIPE OR HOSE, 1 1/2” ID MINIMUM
3	SUCTION STRAINER, 50 GPM MIN. 300 SQ IN MIN. 40-100 MESH w/3-5 PSI RELIEF
4	CHECK VALVE, SWING, 1 1/2” ID MINIMUM
5	VACUUM GAUGE, LIQUID FILLE, 0-30” Hg
6	PUMP, GEAR TYPE, 20 GPM, 300 PSI MIN. ENGINE OR TRANSMISSION DRIVEN
7	PRESSURE LINE, PIPE OR HOSE, 3/4” ID MINIMUM
8	FILTER, 50 GPM/200 PSI MIN. 25-33 MICRON ELEMENTS, w/ 15-25 PSI RELIEF
9	PRESSURE GAUGE, LIQUID FILLED, 0-200 PSI
10	RELIEF VALVE, ADJUSTABLE, 60-200 PSI, 3/4” ID 20-25 GPM MINIMUM
11	RELIEF RETURN LINE, PIPE OR HOSE, 3/4” ID
12	POSER FRAME DRAIN LINE, PIPE OR HOSE, 3” NPT
13	GEAR REDUCER DRAIN, PIPE OR HOSE, 2”NPT
14	TEMPERATURE TRANSDUCER/ GAUGE, 0-250°F
15	OPTIONAL HEAT EXCHANGER
16	OPTIONAL OIL COOLER



4.3 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:

- TI-600: 46 ft^2
- QI-1000: 60 ft^2

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%.

4.4 Lubrication Relief Valve

A relief valve should be part of any MSI 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.

4.5 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 Well Service Pump is designed to prevent migration of well service fluids into the lubrication system. However, even with the MSI 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.

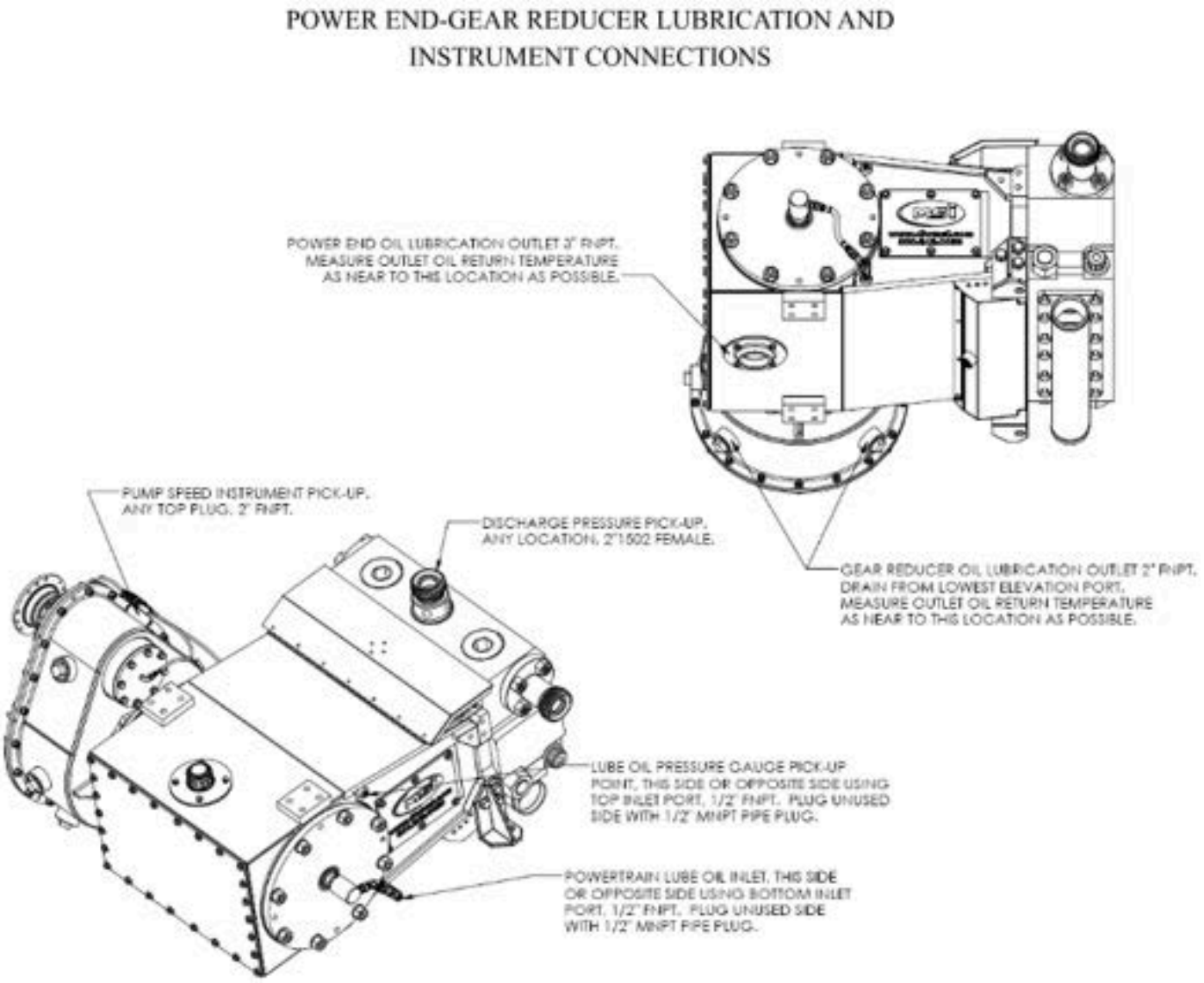
It is highly recommended that you use filters with a built in bypass valve rated for 15 to 25 PSI so that oil will still reach the moving parts inside the pump in case of a filter clog.

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.

4.6 Lubrication Attachment Points

See images below showing lubrication inlet and outlet locations.



4.7 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.

4.8 Oil Change and Oil Types

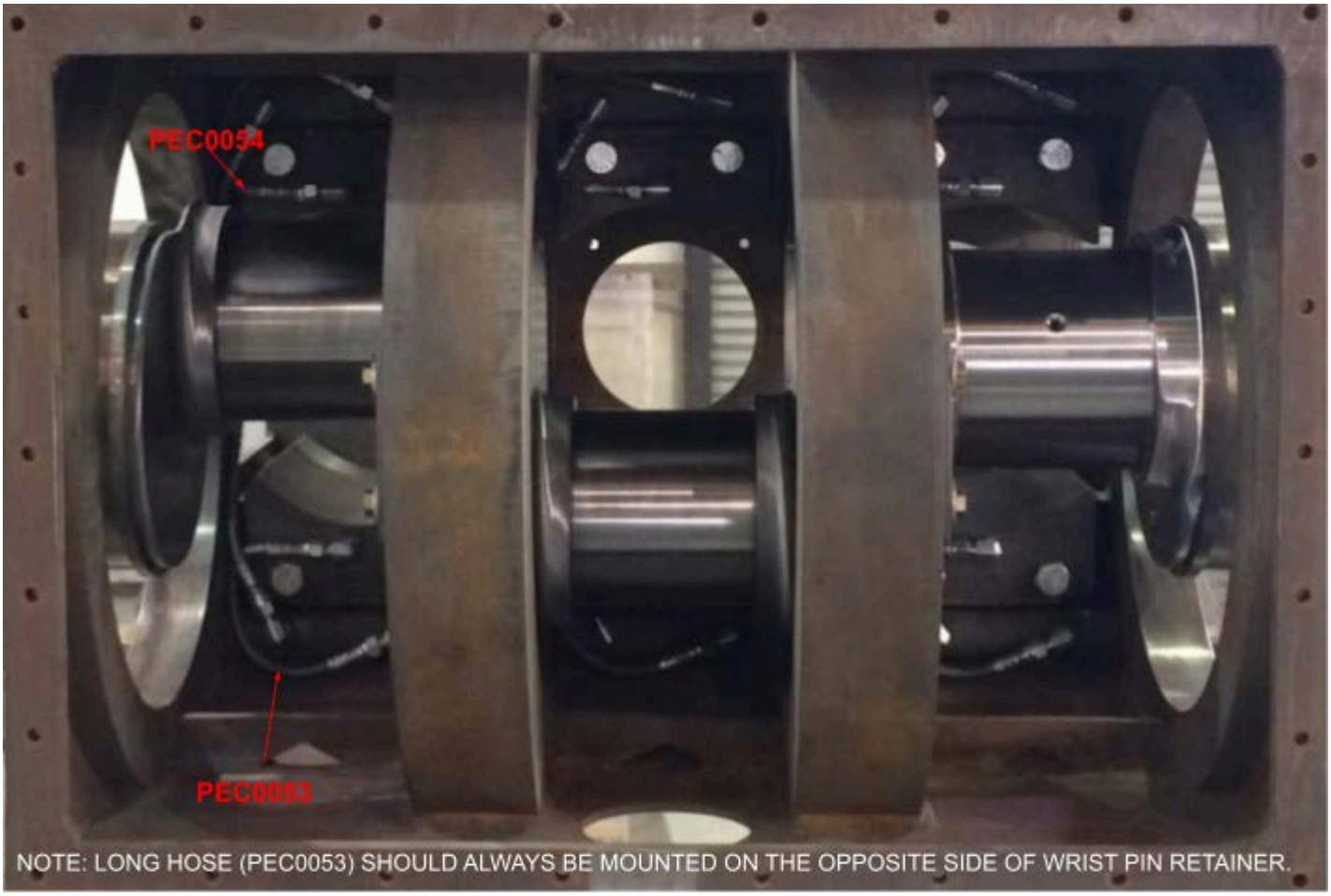
API Service Classification GL-5 Extreme Pressure (EP) gear oils are required for lubrication of the power end and gear reducer. These oils contain additives that allow sustained high loads and prevent oxidation, rust, and foaming. The oil viscosity should be selected based on the anticipated ambient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

4.9 Cleaning Plunger Lubrication Drip Pan

The drip pan is intended to collect plunger lubricant that bypasses the sealing element. To clean the pan remove the screws and slide the pan out from below the pump. Clean then reinstall it.

4.10 Power Frame Lube Lines- Dual Lube Pipe

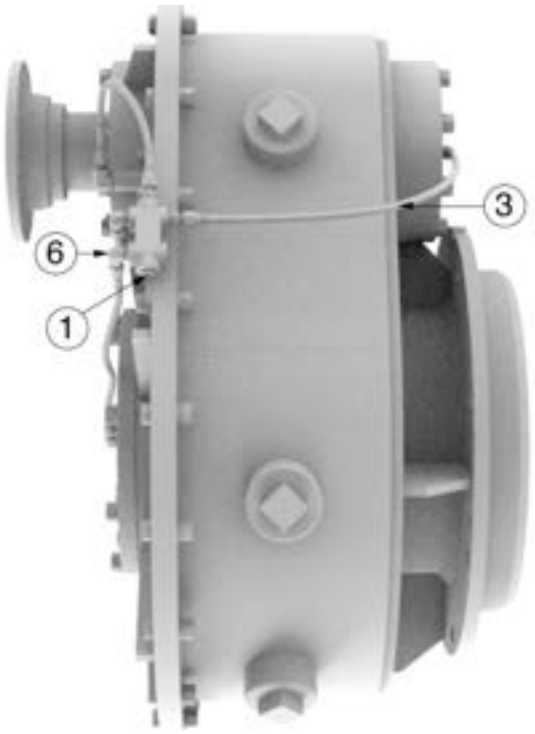
QTY.	PART NUMBER	DESCRIPTION
1	FC0146	NIPPLE, 1/2”NPT HEX x 02”
1	PEC0051	HOSE ASSEMBLY, LUBRICATOR x 12”
1	PEC0052	ROTOSEAL, LUBRICATOR
3	PEC0053	HOSE ASSEMBLY, LUBRICATOR INTERNAL x 16.50”
6	PEC0054	HOSE ASSEMBLY, LUBRICATOR INTERNAL x 9.50”
1	TC0094	TEE BODY, 1/2”NPT FFF



PEC0050 IS THE COMPLETE LUBE ASSEMBLY

4.20 Gear Reducer Lube Lines

ITEM NUMBER	QTY.	PART NUMBER	DESCRIPTION
1	1	UC0301	BLANK PLUG, 1/4" NPT SOCKET TYPE HIGH PRESS (5000psi)
2	1	GRC0028	HOSE ASSEMBLY, LUBE PIPE (600HP) x 7.5"
3	1	GRC0029	HOSE ASSEMBLY, PINION CAP (600HP) x 15.75"
4	1	GRC0030	HOSE ASSEMBLY, PINION RETAINER (600HP) x 6"
5	1	GRC0031	HOSE ASSEMBLY, BEARING COVER (600HP) x 11.5"
6	1	GRC0158	MANIFOLD BLOCK, ¼" NPT x 6 (600HP & 1000HP) CASTING



COMPLETE LUBE ASSEMBLY AS GRC0019

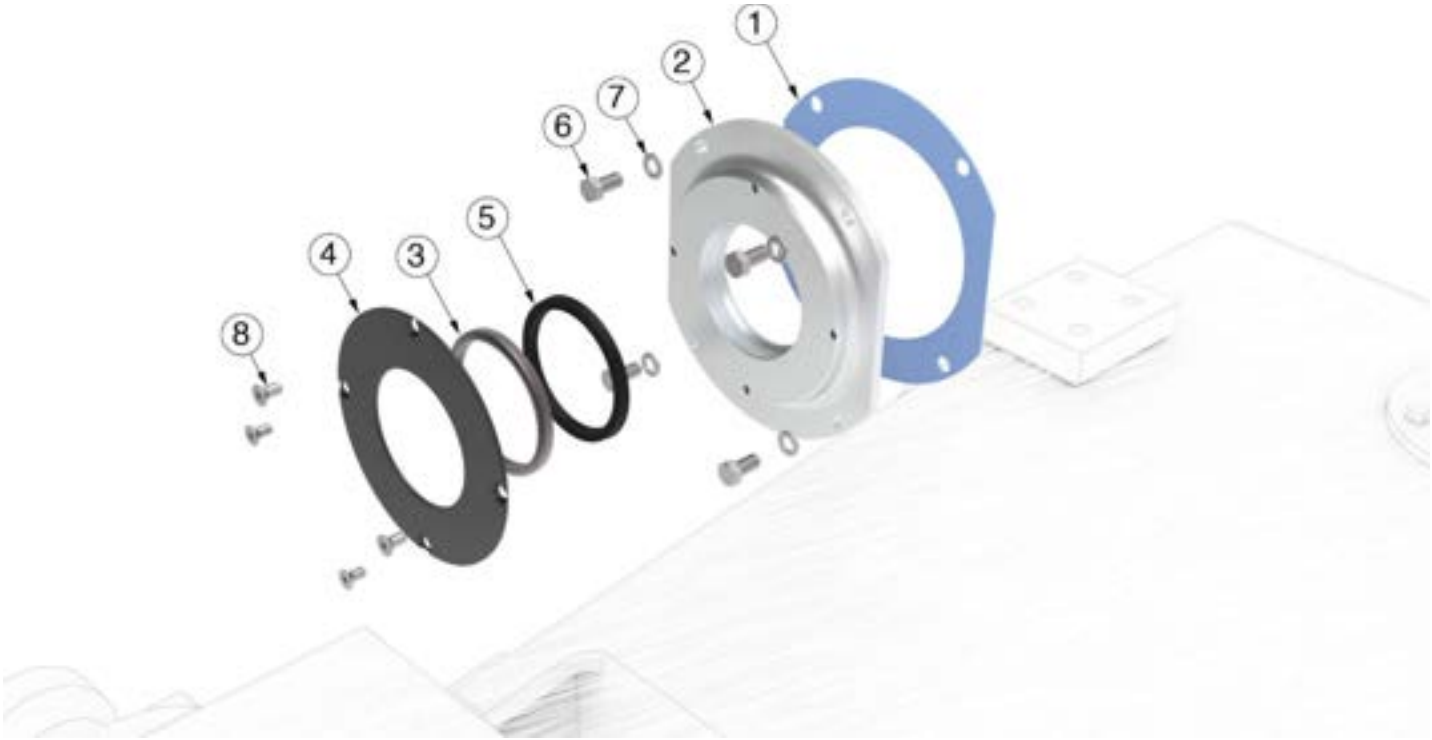
5.00 Power Frame Repair Procedures

Due to the complexity of the task and the need for special tools and training, MSI does not recommend the complete disassembly of the Power Frame in the field. If extensive Power Frame repairs are required, the pump should be returned to Dixie Iron Works, Ltd. where expert service can be obtained on an expedited emergency basis, if needed. When field repairs are required, they should be performed in a clean, well-equipped shop by a trained well service pump technician.

5.10 Power Frame Assembly- Exploded View and Reference Drawings

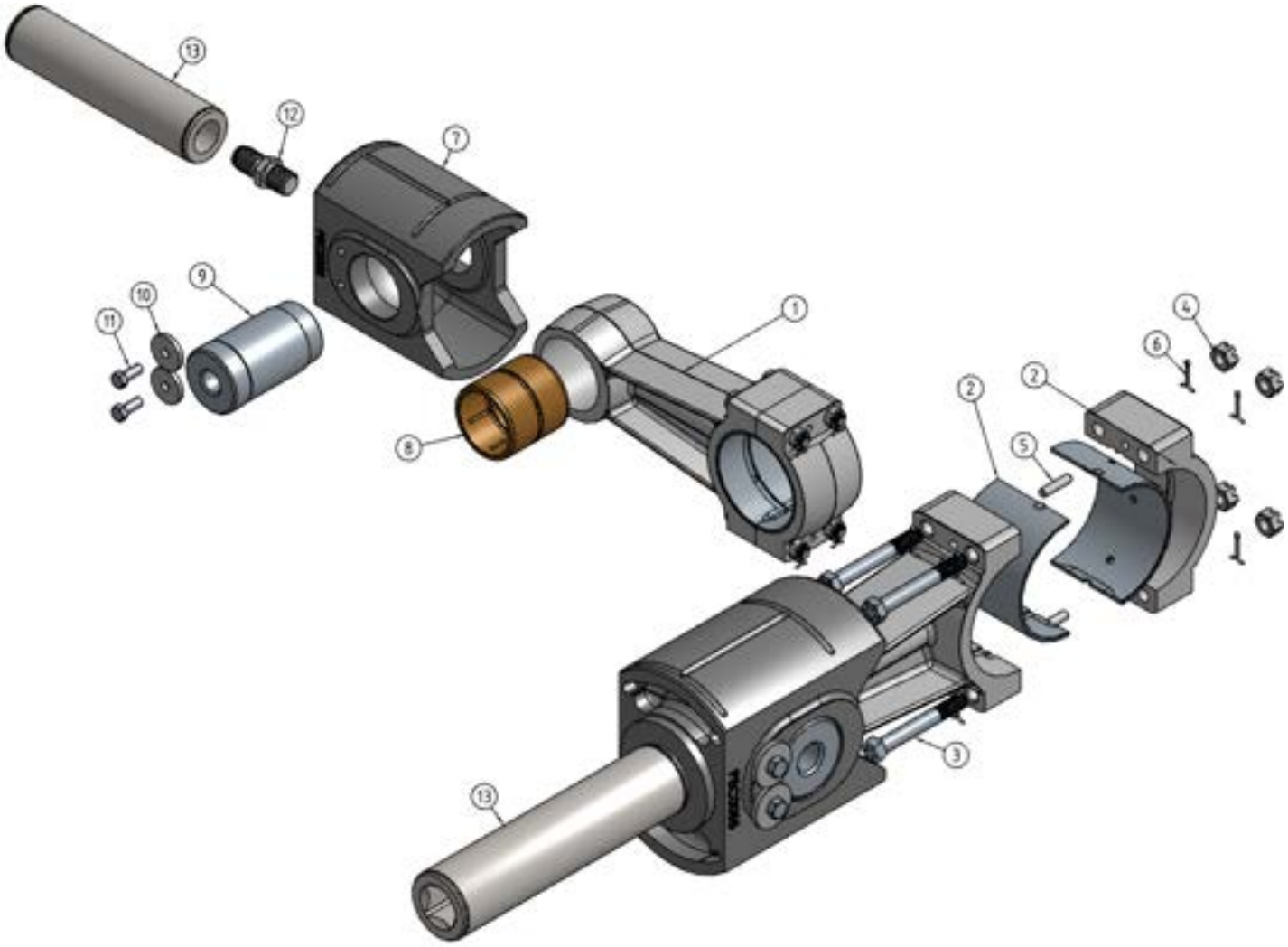
5.10.1 Power End Plunger Seals

ITEM NUMBER	QTY.	PART NUMBER						DESCRIPTION
		2.75”	3.00”	3.25”	3.50”	4.00”	4.50”	
1	1	PEC0237						DIAPHRAGM PLATE GASKET
2	1	FEC0064	FEC0007	FEC0253	FEC0043	FEC0042	FEC0035	DIAPHRAGM PLATE
3	1	FEC0067	FEC0022	FEC0254	FEC0045	FEC0044	FEC0041	WIPER-SCRAPER
4	1	FEC0070	FEC0046	FEC0255	FEC0047	FEC0048	FEC0049	SEAL RETAINER PLATE
5	1	FEC0174	FEC0166	FEC0262	FEC0175	FEC0176	FEC0177	FLUID SEAL
6	4	HC0004						HEX HD, 3/8”-16 x 0.75”
7	4	HC0099						LOCK WASHER, 3/8”
8	4	HC0122						FLAT SOC HD, 1/4”-20 x 0.50”



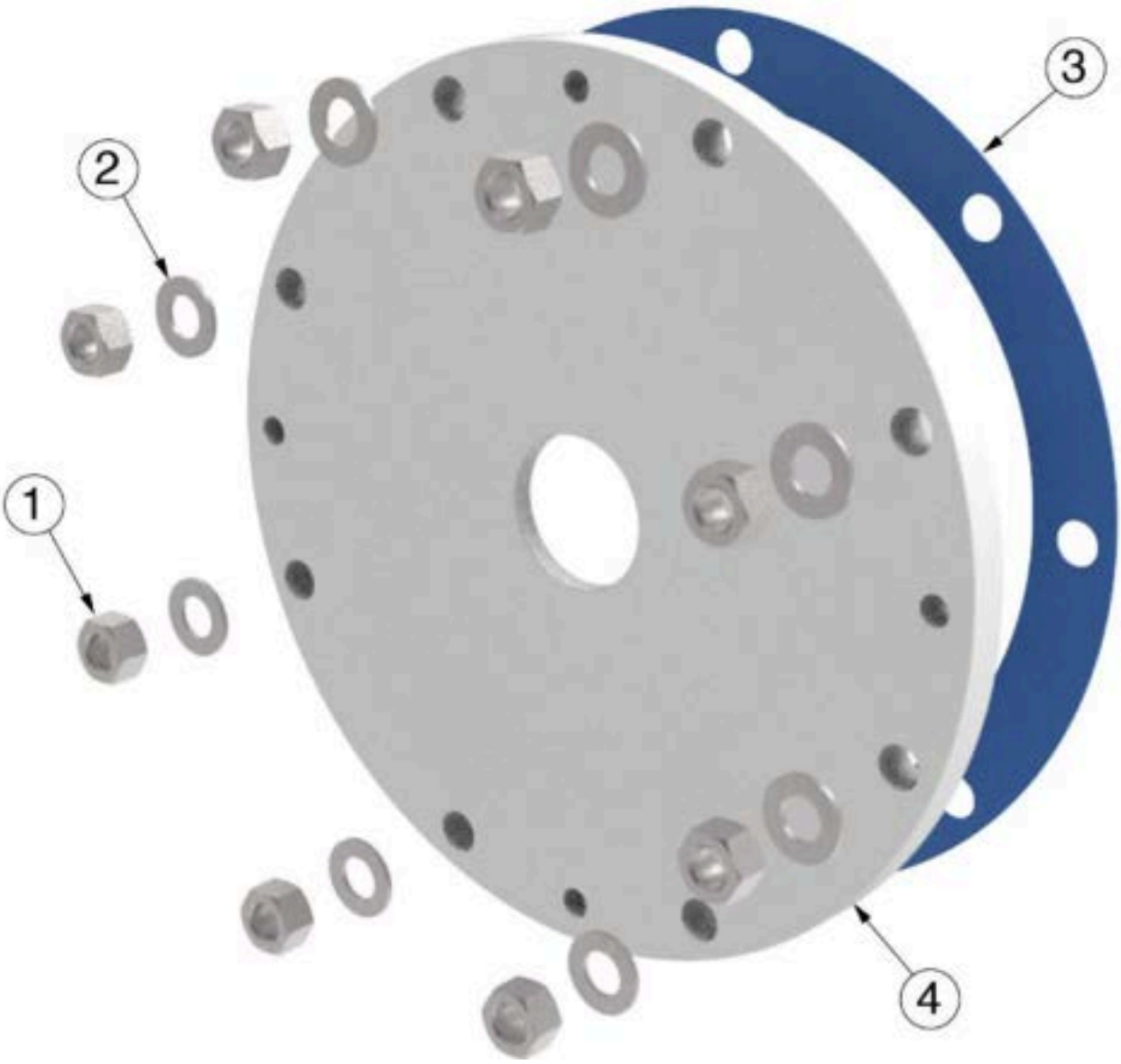
5.10.2 Reciprocating Assembly- Exploded

ITEM #	DESCRIPTION	PART#
1	CONNECTING ROD	PEC0057
2	CONNECTING ROD BEARING	PEC0044
3	CONNECTING ROD BOLT	PEC0048
4	CONNECTING ROD NUT	HC0086
5	CONNECTING ROD PIN	HC0105
6	COTTER PIN	HC0088
7	CROSSHEAD	PEC0055
8	CROSSHEAD BEARING	PEC0029
9	CROSSHEAD PIN	PEC0013
10	CROSSHEAD RETAINER	HC1117
11	CROSS HEAD RETAINER BOLT	HC0024
12	PONY ROD STUD	FEC0004
13	PLUNGER	See Section 6.10 and 6.20



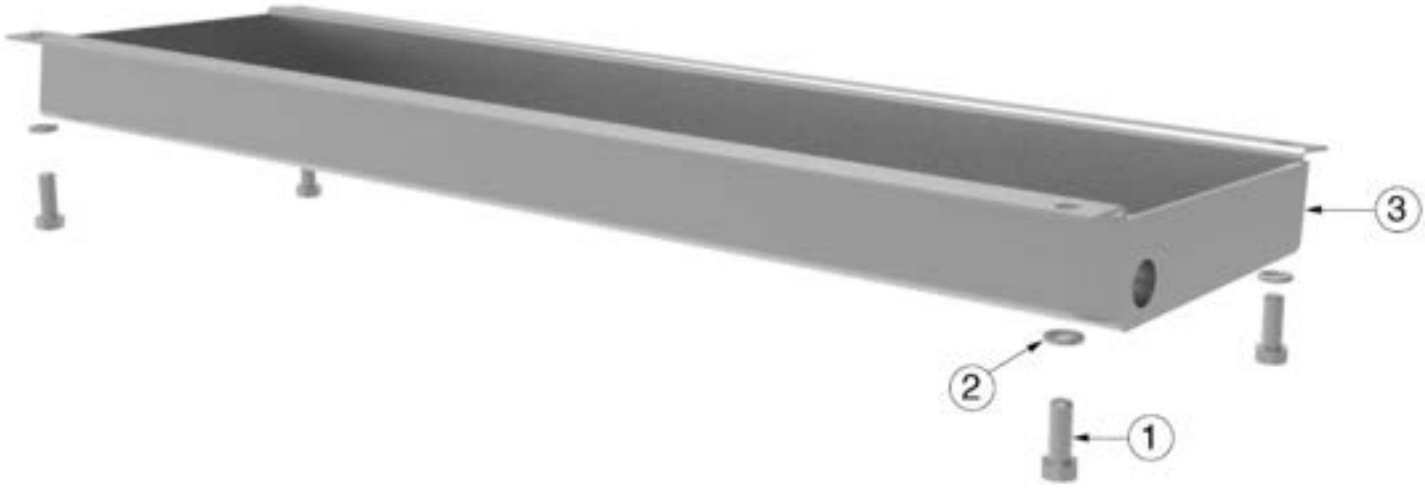
5.10.3 Power Frame Assembly - Main Bearing Assembly

ITEM NUMBER	QTY.	PART NUMBER	DESCRIPTION
1	8	HC0085	HEX NUT, 7/8"-9
2	8	HC0087	FLAT WASHER, 7/8" HARDENED
3	1	PEC0031	GASKET, MAIN BEARING HOUSING (600/1000HP)
4	1	PEC0063	MAIN BEARING HOUSING, (600/1000HP)



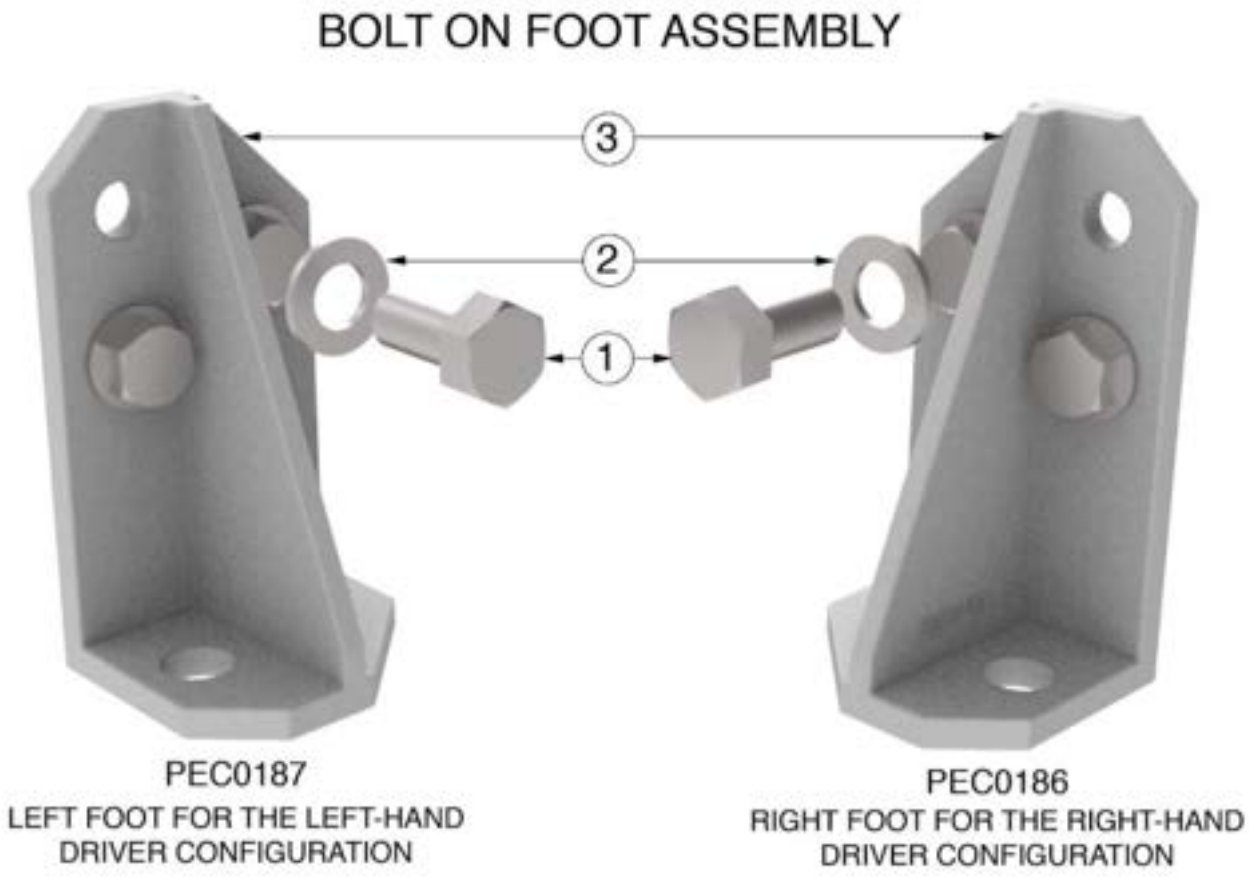
5.10.4 Power Frame Assembly-Oil Pan Collector

ITEM NUMBER	QTY	600 HP PART#	600 HP PART #	DESCRIPTION
1	4	HC0015	HC0015	HEX HD, 3/8”-16 x1.00”
2	4	HC0099	HC0099	LOCK WASHER, 3/8” STD
3	1	PEC0065	PEC0099	OIL COLLECTOR ASSEMBLY



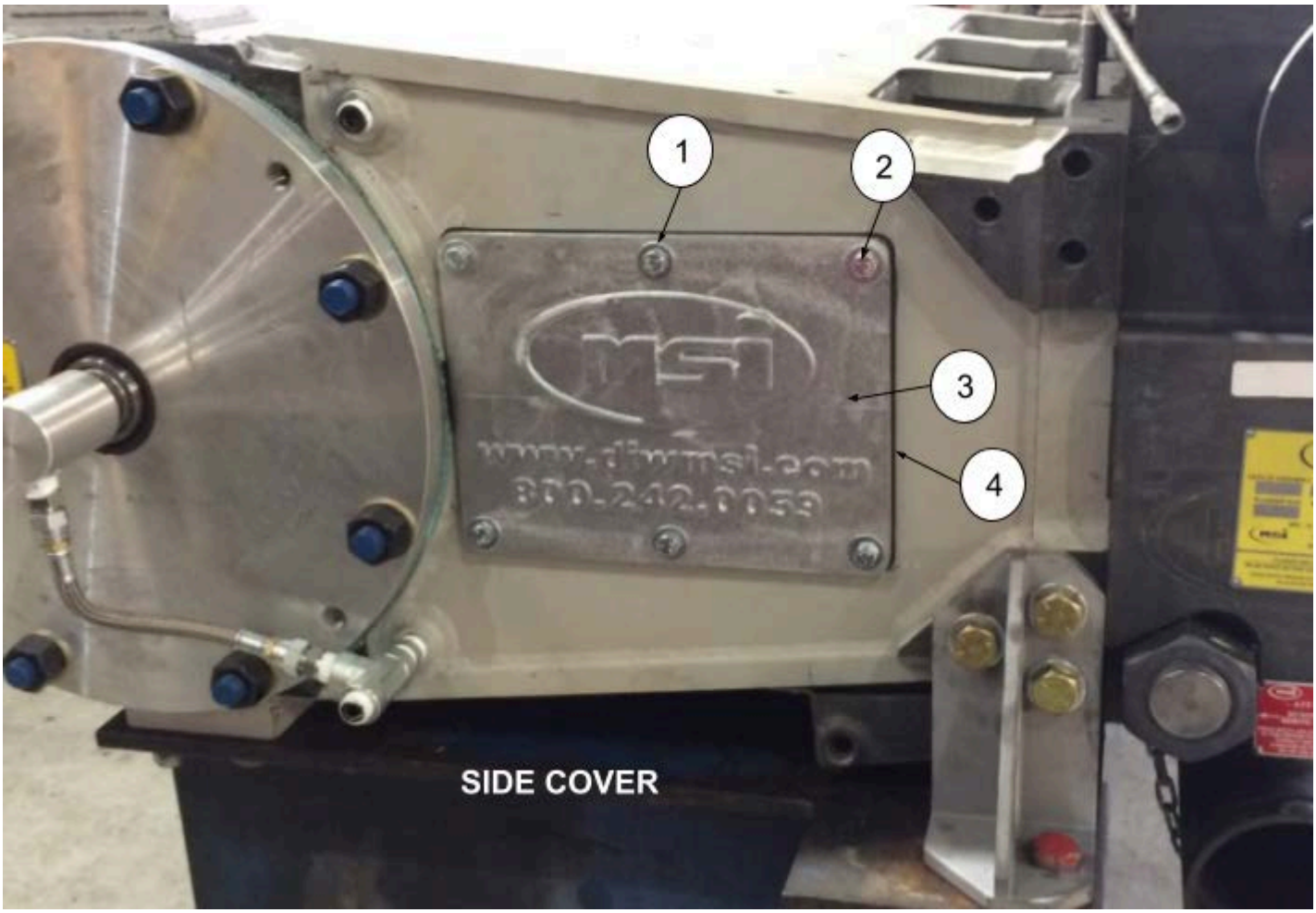
5.10.5 Power Frame Assembly - Foot Assembly

ITEM NUMBER	QTY.	PART #		DESCRIPTION
		LEFT	RIGHT	
1	3	HC0108		HEX HD, 3/4"-10 x 1.50"
2	3	HC0134		FLAT WASHER, 3/4" SAE "N" UNDERSIZED
3	1	PEC0187	PEC0186	FRONT FOOT, (600/1000HP) CENTERED RIB



5.10.6 Power Frame Assembly - Side Cover

ITEM NUMBER	QTY.	PART NUMBER	DESCRIPTION
1	6	HC0002	FLAT WASHER, 3/8” STD
2	6	HC0004	HEX HD, 3/8"-16 x 0.75"
3	1	PEC0078	SIDE COVER
4	1	PEC0079	GASKET

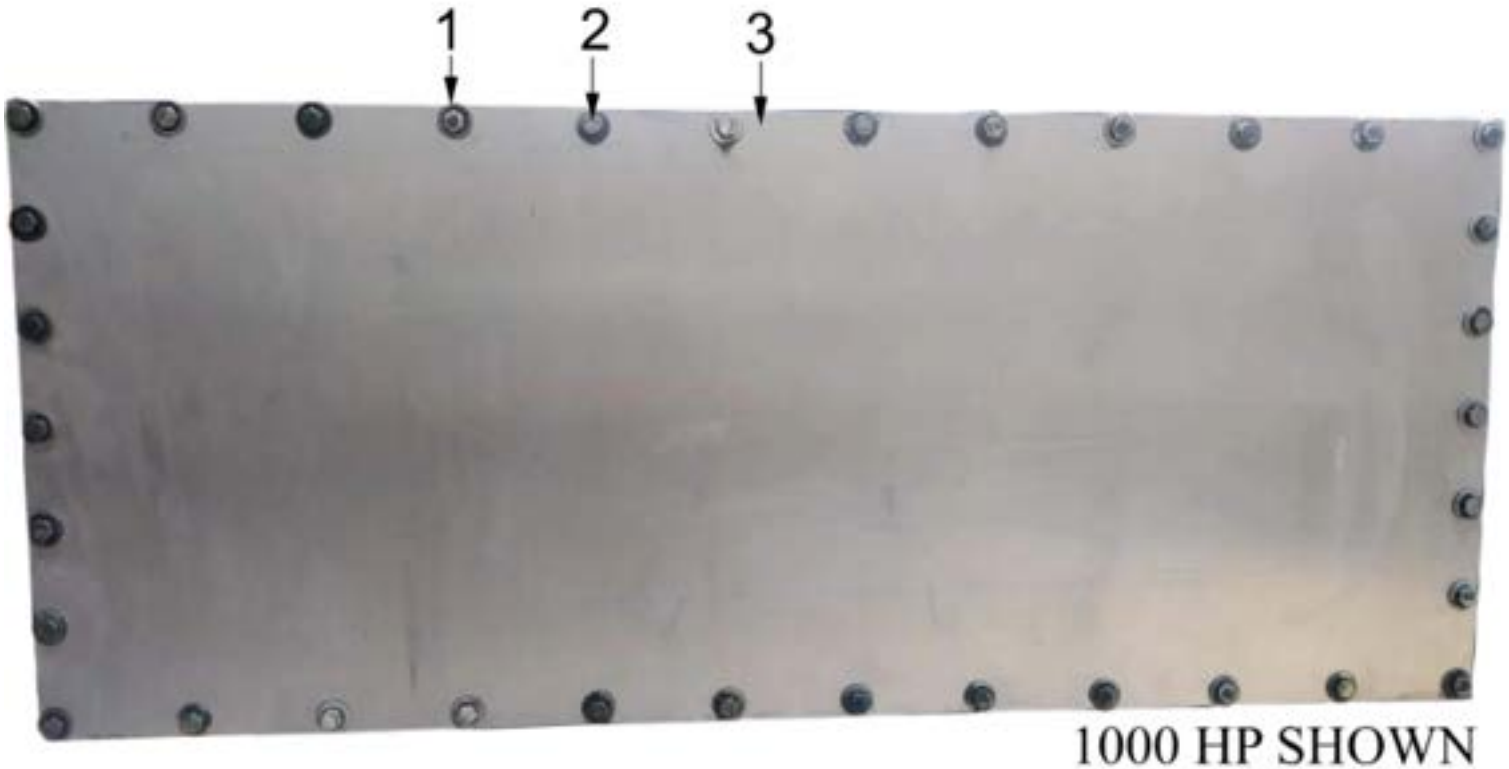


5.10.7 Power Frame Assembly-Breather/Drain Port Assembly

ITEM NUMBER	QTY.	PART NUMBER	DESCRIPTION
1	8	HC0015	HEX HD, 3/8”-16 x 1.00”
2	1	PEC0190	BREATHER
3	2	PEC0083	GASKET
4	1	PEC0189	BREATHER PORT
5	1	PEC0085	DRAIN PORT

5.10.8 Power Frame Assembly - Rear Cover

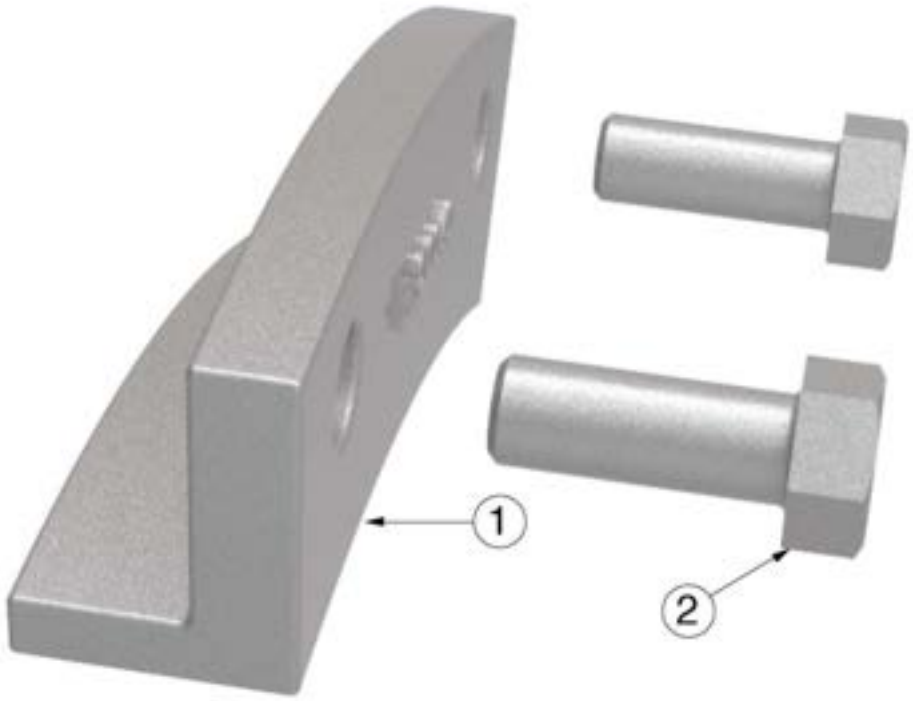
ITEM NUMBER	600 HP		1000 HP		DESCRIPTION
	QTY	PART#	QTY.	PART #	
1	26	HC0002	34	HC0002	FLAT WASHER, 3/8” STD
2	26	HC0004	34	HC0004	HEX HD, 3/8”-16 x 0.75”
3	1	PEC0077	1	PEC0095	REAR COVER
4	1	PEC0080	1	PEC0096	GASKET



1000 HP SHOWN
ITEM 4 NOT SHOWN

5.10.9 Power Frame Assembly - Bearing Retainer

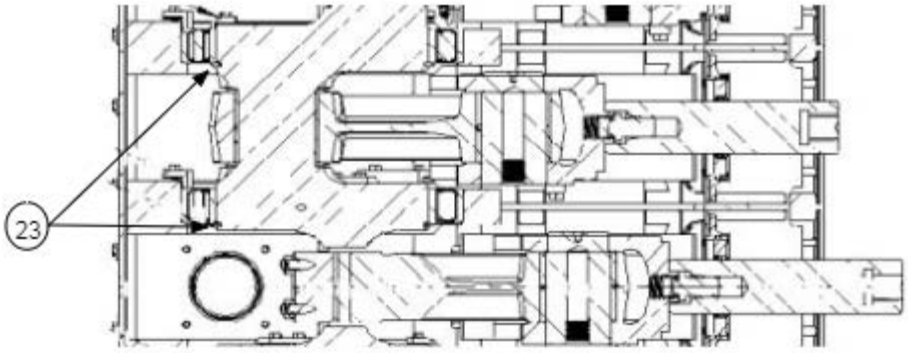
ITEM NUMBER	QTY.	PART #	DESCRIPTION
1	1	PEC0060	BEARING RETAINER
2	2	HC0015	HEX HD, 3/8”-16 x 1.00”



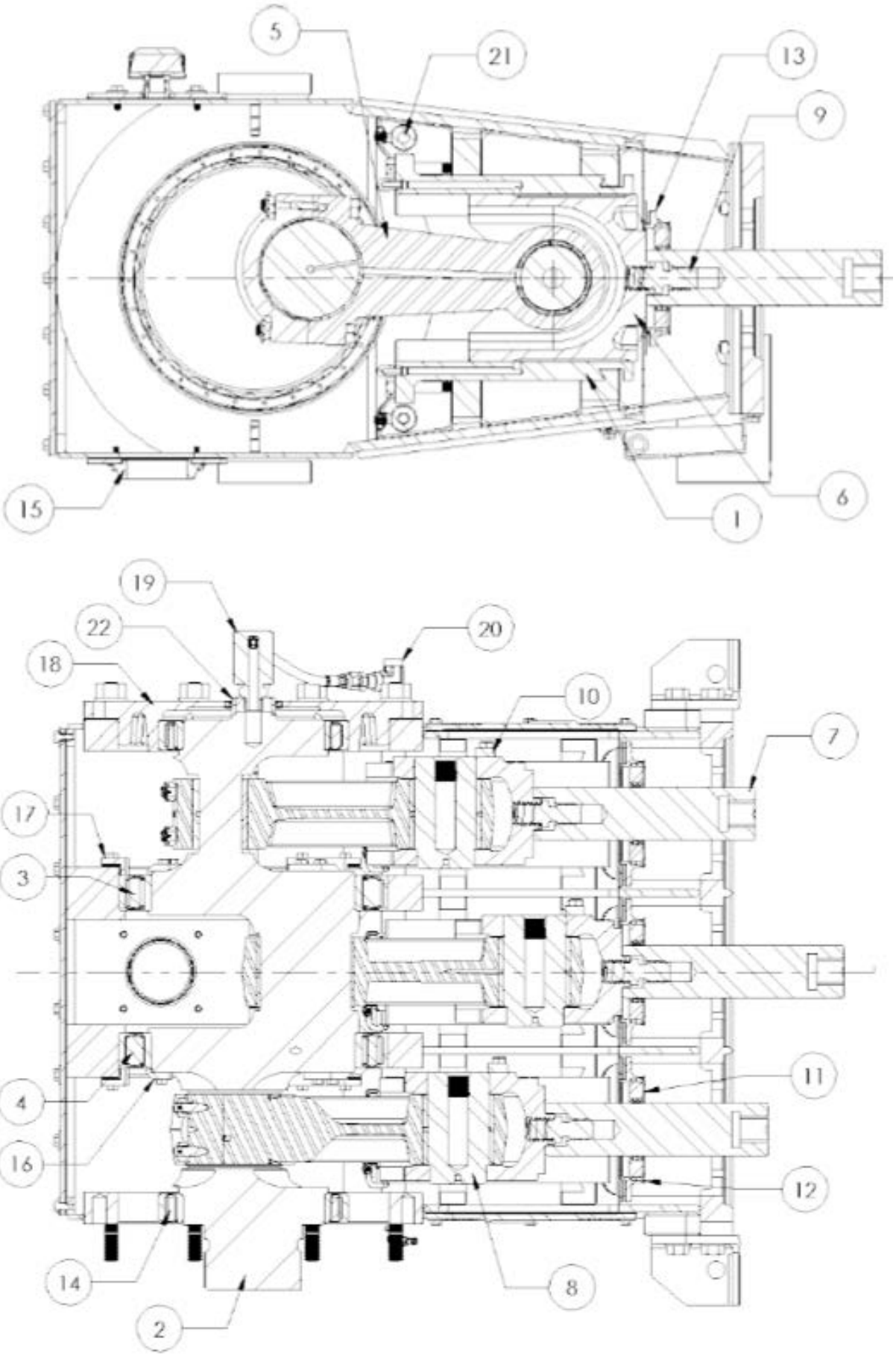
5.20 Power Frame Assembly-Section View

ITEM NUMBER	600HP		1000HP		DESCRIPTION
	QTY.	PART #	QTY.	PART #	
1	6	PEC0056	10	PEC0056	CROSSHEAD GUIDE
2	1	PEC0062	1	PEC0088	CRANKSHAFT
3	1	PEC0046	1	PEC0046	BEARING, INSIDE MAIN BEARING, FIXED
4	1	PEC0047	1	PEC0047	BEARING, INSIDE MAIN BEARING, FLOAT
5	3	PEC0057	5	PEC0057	CONNECTING ROD ASSEMBLY
6	3	PEC0055	5	PEC0086	CROSSHEAD
7	3	FEC0002	5	FEC0002	3” PLUNGER
8	3	PEC0013	5	PEC0013	CROSSHEAD PIN
9	3	FEC0004	5	FEC0004	PONY ROD STUD
10	3	HC1117	5	HC1117	WASHER, WRIST PIN RETAINER
11	3	SEE 5.10.1	5	SEE 5.10.1	DIAPHRAGM SEAL RETAINER
12	12		20		SOC HD, 1/4”-20 x 0.5” FLAT HEAD
13	3		5		DIAPHRAGM SEAL HOUSING
14	2	PEC0239	2	PEC0239	BEARING, OUTSIDE MAIN
15	1	PEC0009	1	PEC0009	LUBE DRAIN, 3” NPT TANK FLANGE
16	6	PEC0027	12	PEC0027	BEARING RETAINER, INNER RACE
17	6	PEC0060	12	PEC0060	BEARING RETAINER
18	1	PEC0063	1	PEC0063	MAIN BEARING HOUSING
19	1	PEC0052	1	PEC0052	ROTOSEAL, LUBRICATOR
20	1	TC0094	1	TC0094	TEE BODY, 1/2” NPT FFF
21	2	UC0050	2	UC0050	BANK PLUG, 1/2” NPT STD (SOCKET)
22	1	PEC0064	1	PEC0064	SPACER
23	-	-	2	PEC1000	SPIRAL RETAINER RING, PUMP

(See next page for a cross section of a 600 HP pump)



ITEM 23 ONLY USED IN 1000 HP PUMP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5.30 Removing the Crankshaft, Connecting Rods, and Crossheads

a) Remove the Gear Reducer assembly (see Section 7.10.)

b) Remove the plunger and seal retainers (see Section 6.30.)

c) Using a 9/16" wrench, remove the 3/8" cap screws, which secure the side and rear covers to the Power Frame housing.

d) Remove the 1/8" cotter pin from the each of the connecting rod bolts. Using a 15/16" wrench, remove the slotted 5/8" hex nuts from each of the connecting rod bolts. Remove the connecting rod caps taking care to avoid damaging the rod bearing half trapped inside each cap. Shove each connecting rod/crosshead assembly all the way forward taking care to avoid damaging the rod bearing half trapped inside each connecting rod.

e) Using a ¾" wrench, remove the ½" cap screws which secure the washers to the crosshead. Using a slide hammer with 1- ¼" UNC puller thread, pull the wrist pin from the crosshead. Remove the connecting rod from the crosshead, and take it out of the Power Frame. Rotate the crosshead 90 degrees and remove it through the side of the Power Frame. The remaining crossheads should be removed in the same manner.

f) Reattach each match-marked connecting rod cap to the rod from which it was removed. Note: If the connecting rod bearing halves are to be removed and re-used, they must be tagged so that they can be reinstalled in the same connecting rod or cap.

g) Using a 9/16" wrench, remove the 3/8" cap screws, which secure the tach drive housing to the Power Frame. Remove the tach drive assembly. **If required.

h) Using a 1 7/16" wrench, remove the eight 7/8" nuts, which secure the main bearing housing to the Power Frame. Remove the main bearing housing and inspect the bearing for wear.

i) Turn the Power Frame housing over on its side so that the crankshaft extension is pointed straight up. The Power Frame must be blocked up so that is rests level. Using a 9/16" wrench, remove the 3/8" cap screws, which secure the three bearing retainers against the top inner main bearing's outer race. Lift the crankshaft from the Power Frame.

j) Using a 9/16" wrench, disconnect all six lube oil hoses from the fittings at the rear of each crosshead guide. Using a 15/16" wrench, remove the two 5/8" cap screws, which secure each see section crosshead guide to the Power Frame housing. Remove all six crosshead guides and inspect them for wear.

k) Reassembly of the Power Frame should be performed in the reverse order of the disassembly instructions shown above.

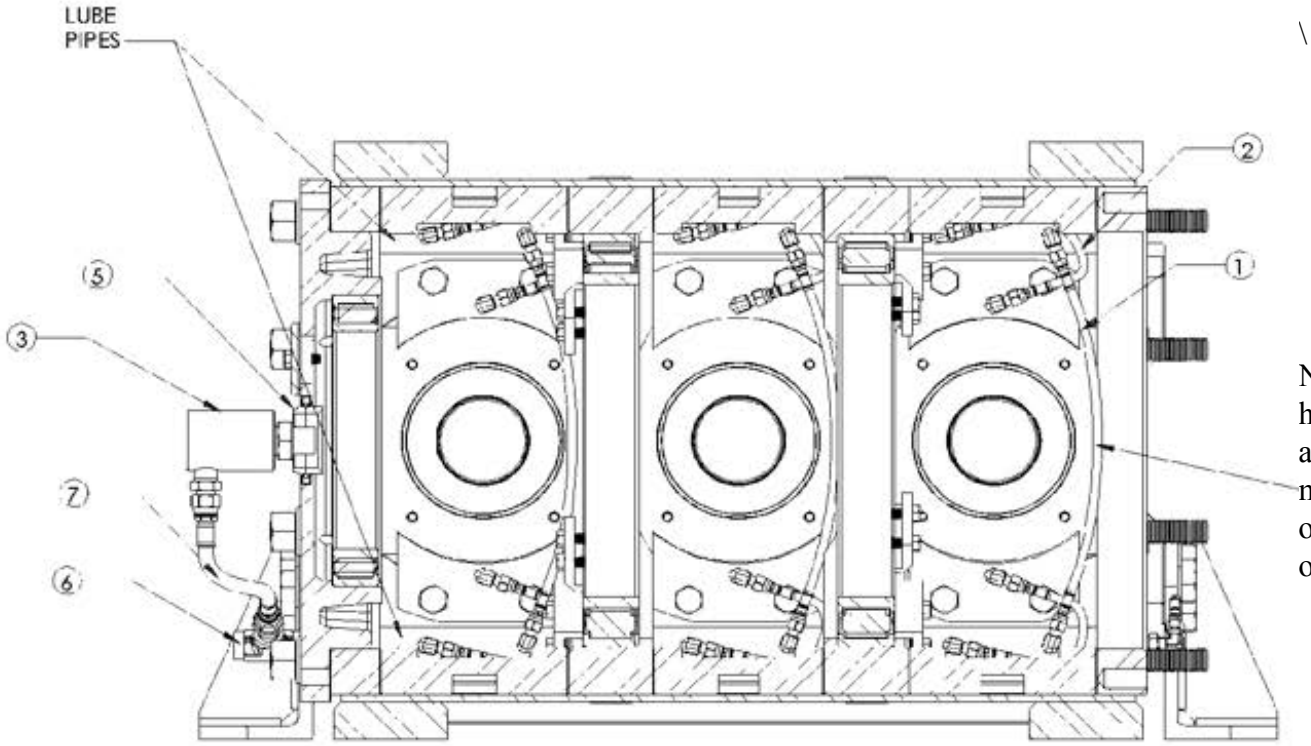
Note: Prior to reassembling the Power Frame, all lubrication hoses and lube passages should be flushed and cleaned thoroughly.

When reinstalling the crosshead slides, care must be taken to avoid excessive torque on the 5/8" cap screws to more than 50 ft-lbs. torque. Excessive torque can distort the surface of the slide causing crosshead misalignment.

All cap screws, nuts, etc. must have the proper amount of torque upon reassembly (see Torque Table in Appendix).

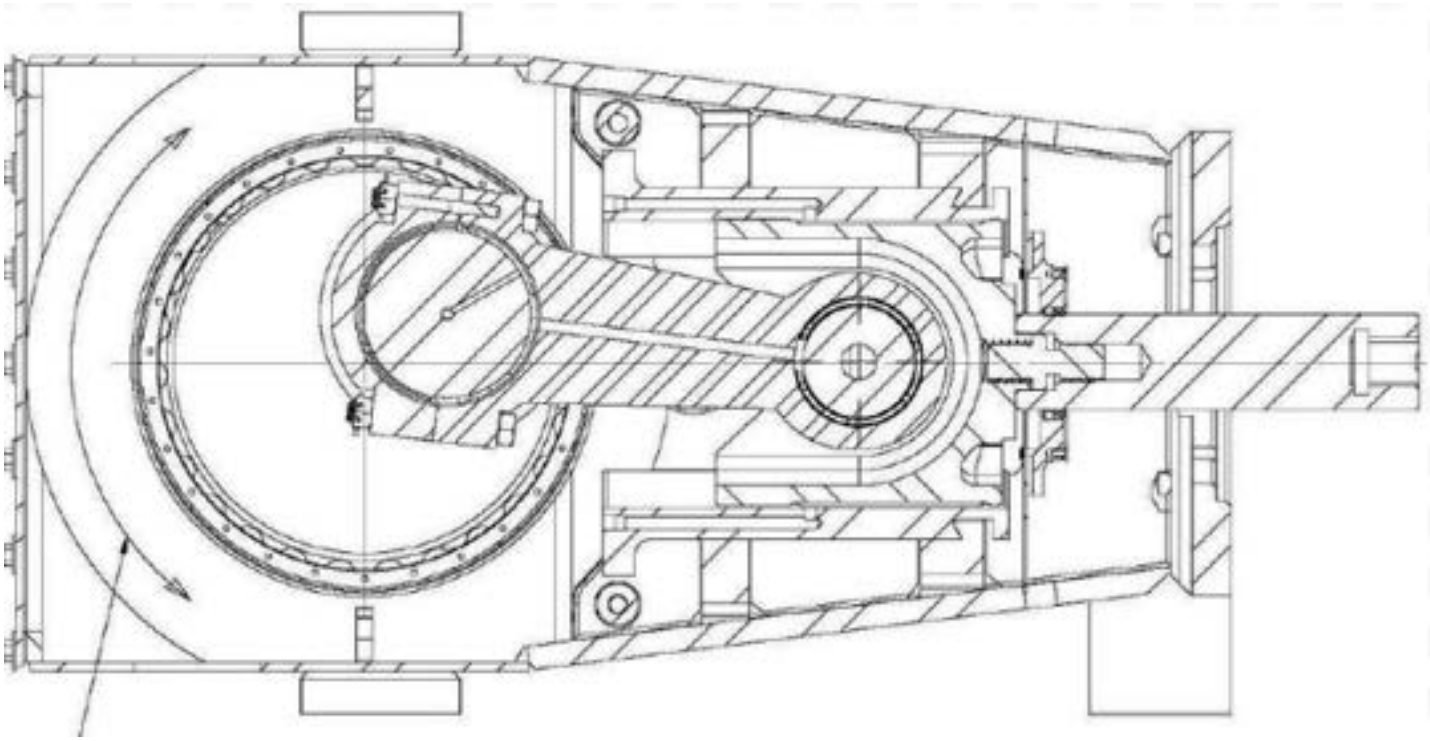
5.40 Power Frame Lube Lines- Dual Lube Pipe

ITEM NUMBER	600HP		1000HP		DESCRIPTION
	QTY.	PART #	QTY.	PART #	
1	3	PEC0053	1	PEC0053	HOSE ASSEMBLY, LUBRICATOR (600HP) INTERNAL x 16.50”
2	6	PEC0054	1	PEC0054	HOSE ASSEMBLY, LUBRICATOR (600HP) INTERNAL 9.50”
3	1	PEC0052	1	PEC0052	ROTOSEAL, LUBRICATOR (600HP & 1000HP)
4	2	UC0050	2	UC0050	BLANK PLUG, 1/2” NPT STD (SOCKET)
5	1	PEC0064	1	PEC0064	SPACER, CRANKSHAFT MSI 600 & 1000
6	1	TC0094	1	TC0094	TEE BODY, 1/2” NPT FFF
7	1	PEC0051	1	PEC0051	HOSE ASSEMBLY, LUBRICATOR (600HP) x 12”



Note: Long hoses should always be mounted on the opposite side of washers.

5.50 Power Frame Crank Rotation



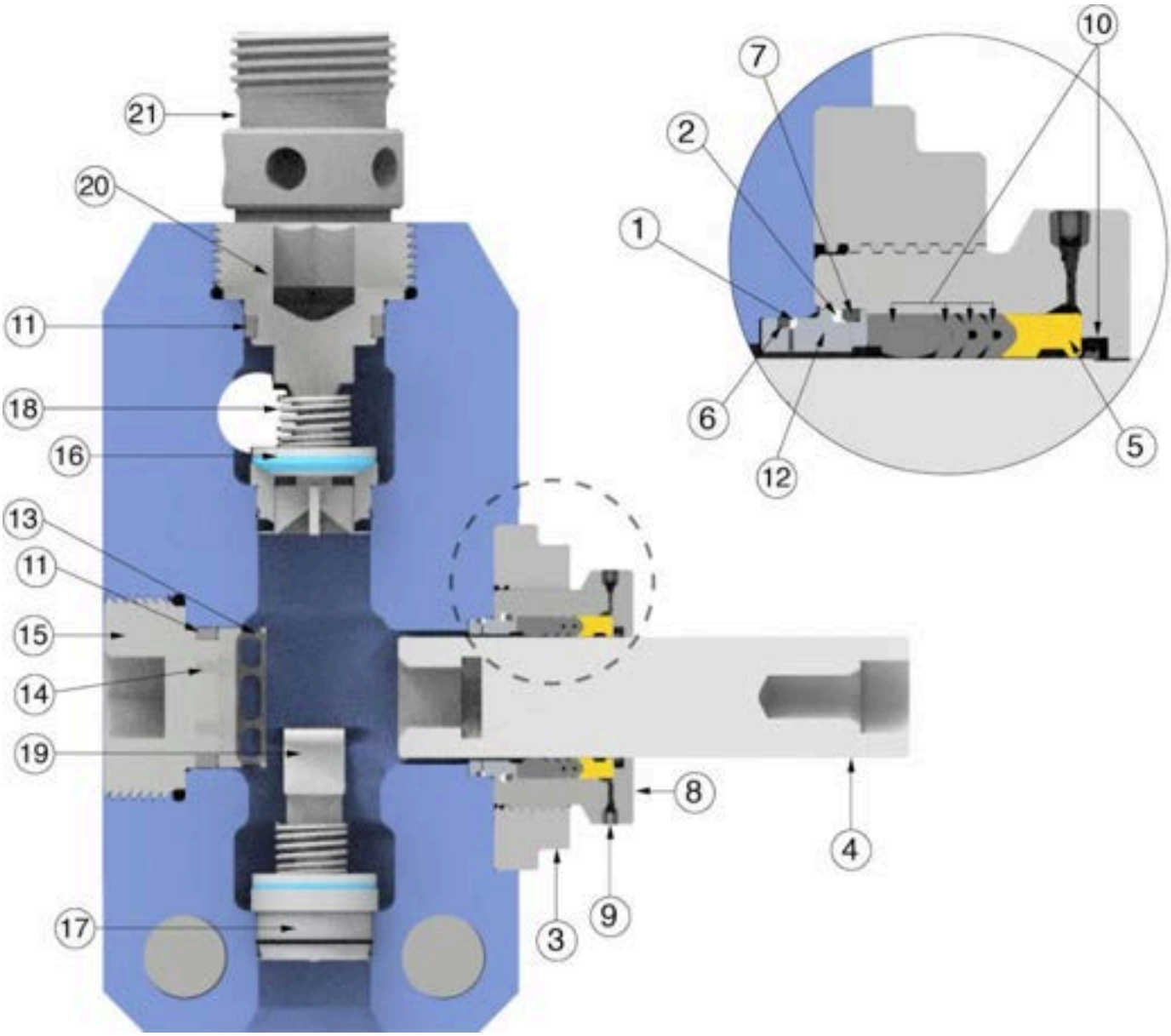
NOTE: Crank Rotation can either be clockwise or counterclockwise.

6.00 Fluid End Repair Procedures

Exercise care while working on the Fluid End. Errant dings on the sealing surfaces of the Fluid End may cause leaks.

6.10 Fluid End Assembly- 2.75”-3.00”

ITEM #	DESCRIPTION	PART NUMBER		ITEM #	DESCRIPTION	PART NUMBER	
		2.75”	3.00”			2.75”	3.00”
1	BACK-UP RING, SB FE SIDE	OC0077		12	STUFFING BOX ADAPTER	FEC0066	FEC0010
2	BACK-UP RING, SB PE SIDE	OC0077	OC0064	13	SUCTION COVER CAGE	FEC0252	
3	FLUID END ADAPTER	FEC0090		14	SUCTION COVER CAGE NUT	HC0132	
4	FLUID END PLUNGER	FEC0063	FEC0002	15	SUCTION COVER NUT	FEC0088	
5	LANTERN RING	FEC0068	FEC0032	16	VALVE	FEC0504	
6	O-RING, SB FE SIDE	OC0076		17	VALVE SEAT	FEC0453	
7	O-RING, SB PE SIDE	OC0076	OC0085	18	VALVE SPRING	FEC0093	
8	PACKING NUT	FEC0065	FEC0008	19	VALVE STOP ASSEMBLY	FEC0094	
9	PACKING NUT LUBE PLUG	UC0486		ITEM#	DESCRIPTION	TRIPLEX	QUINTUPLEX
10	PACKING SET	FEC0069	FEC0033	20	DISCHARGE COVER NUT	FEC0089	FEC0149
11	SEAL, SUCTION/DISCHARGE COVER	FEC0095		21	GAUGE CONNECTION	FEC0556	FEC0582

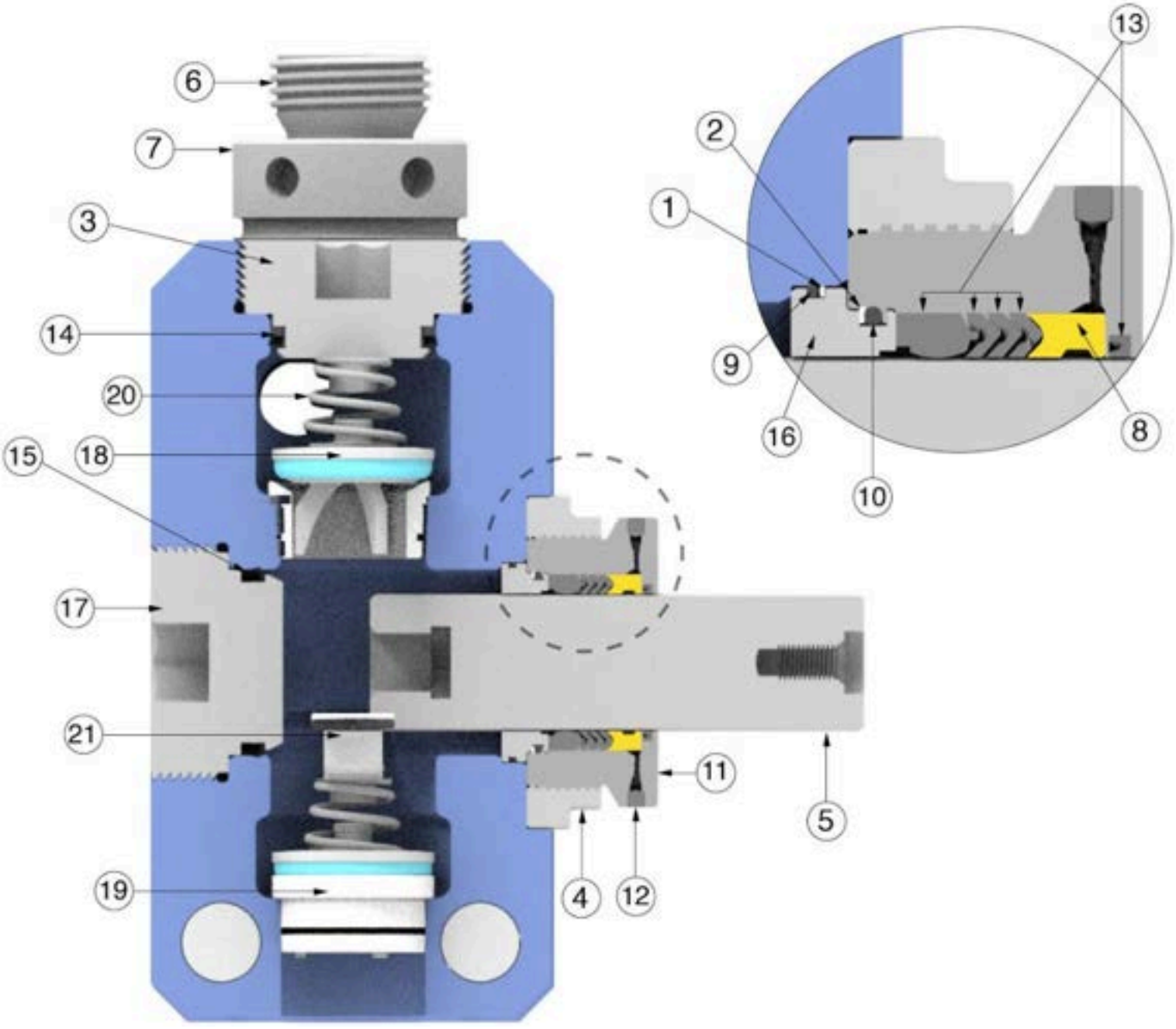


6.20 Fluid End Assembly- 3.25” -4.50”

ITEM #	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	OC0067	OC0070	OC0072
3	DISCHARGE COVER NUT	FEC0005			
4	FLUID END ADAPTER	FEC0009			
5	FLUID END PLUNGER	FEC0259	FEC0056	FEC0057	FEC0021
6	GAGE CONNECTION	FEC0583			
7	GAGE CONNECTION NUT	NOT USED WITH FEC0583			
8	LANTERN RING	FEC0256	FEC0050	FEC0051	FEC0039
9	O-RING, SB FE SIDE	OC0065			
10	O-RING, SB PE SIDE	OC0138	OC0067	OC0069	OC0071
11	PACKING NUT	FEC0257	FEC0052	FEC0053	FEC0037
12	PACKING NUT LUBE PLUG	UC0486			
13	PACKING SET	FEC0258	FEC0054	FEC0055	FEC0040
14	SEAL, DISCHARGE COVER	FEC0015			
15	SEAL, SUCTION COVER	FEC0013			
16	STUFFING BOX ADAPTER	FEC0260	FEC0058	FEC0059	FEC0036
17	SUCTION COVER NUT	FEC0006			
18	VALVE	FEC0472			
19	VALVE SEAT	FEC0473			
20	VALVE SPRING	FEC0003			
21	VALVE STOP ASSEMBLY	FEC0019			

(Fluid End Assembly image on next page)

Fluid End Assembly- 3.25” -4.50”, continued



6.30 Removing Plungers and Packing

a) Remove the plunger lube fitting from each packing nut.

b) Using the MSI packing nut tool (FEC0027), loosen each of the packing nuts at least one full turn.

c) Remove the suction covers using MSI Wrench (FEC0024).

d) Using the MSI plunger wrench (FEC0023), unscrew the plunger from the crosshead and pull each plunger out of the fluid cylinder through the suction cover bore. Care must be taken to keep contaminants from entering the Power Frame section once the plunger is removed.

e) When removing the plunger packing, try to keep the Stuffing Box Adapter (Seal Ring) in the Fluid End using MSI Adapter Stuffing Box Retaining Tool (FEC0115,-116,-117,-118,-119). Keeping the Stuffing Box Adapter (FEC0066,-10,-58,-59,-36) in the Fluid End will make the removal easier. Once the packing nut is removed, the Stuffing Box Adapter (FEC0066,-10,-58,-59,-36) may then be removed from the cylinder. Label each packing nut on removal to ensure that they are installed back into the same bore. Note that the packing nuts are numbered to their corresponding cylinders.

f) Inspect each plunger for wear, scoring, and corrosion on the hard surface area and damage to the face which mates with the crosshead.

g) Inspect each ring of packing brass for excessive wear and scoring.

h) Blow air through the lube port on each packing nut to ensure that the lube passage is unobstructed.

i) Each packing bore, both inside the packing nut and inside the fluid cylinder, must be thoroughly cleaned and lightly hand polished with a 220 to 240-grit Emery cloth prior to packing reinstallation.

j) Using new packing header rings and new packing pressure rings, reinstall the packing assembly one piece at a time (refer to the Packing Assembly diagram included in this manual). Each ring should be installed with a coating of light oil only. Care must be taken to avoid damaging the internal and external sealing lips of each packing ring.

k) Replace the o-rings and back up rings in the seal rings and dress the seal ring seal areas in both the fluid cylinder and packing nut with 220 to 240 grit Emery cloth. Reinstall the seal rings as shown in the packing assembly diagram.

l) Reinstall each packing nut into its proper cylinder, screwing it all the way in until tight, then backing it off one to two turns.

m) Coat the hard surface area of each plunger with a light oil and insert it into the packing. Using MSI Plunger Wrench and 10 lb. hammer, bump the plunger into the packing while holding it as straight as possible with the packing bore centerline. Continue bumping the plunger through the packing until the threaded bore approaches the crosshead stud. Carefully align the plunger and crosshead threads then rotate the plunger clockwise until the plunger is fully seated on the crosshead.

n) Tighten the plunger to the crosshead with the MSI plunger wrench to achieve 300 ft*lbs of torque.

o) Using the MSI packing nut wrench, tighten each Packing Nut until it stops.

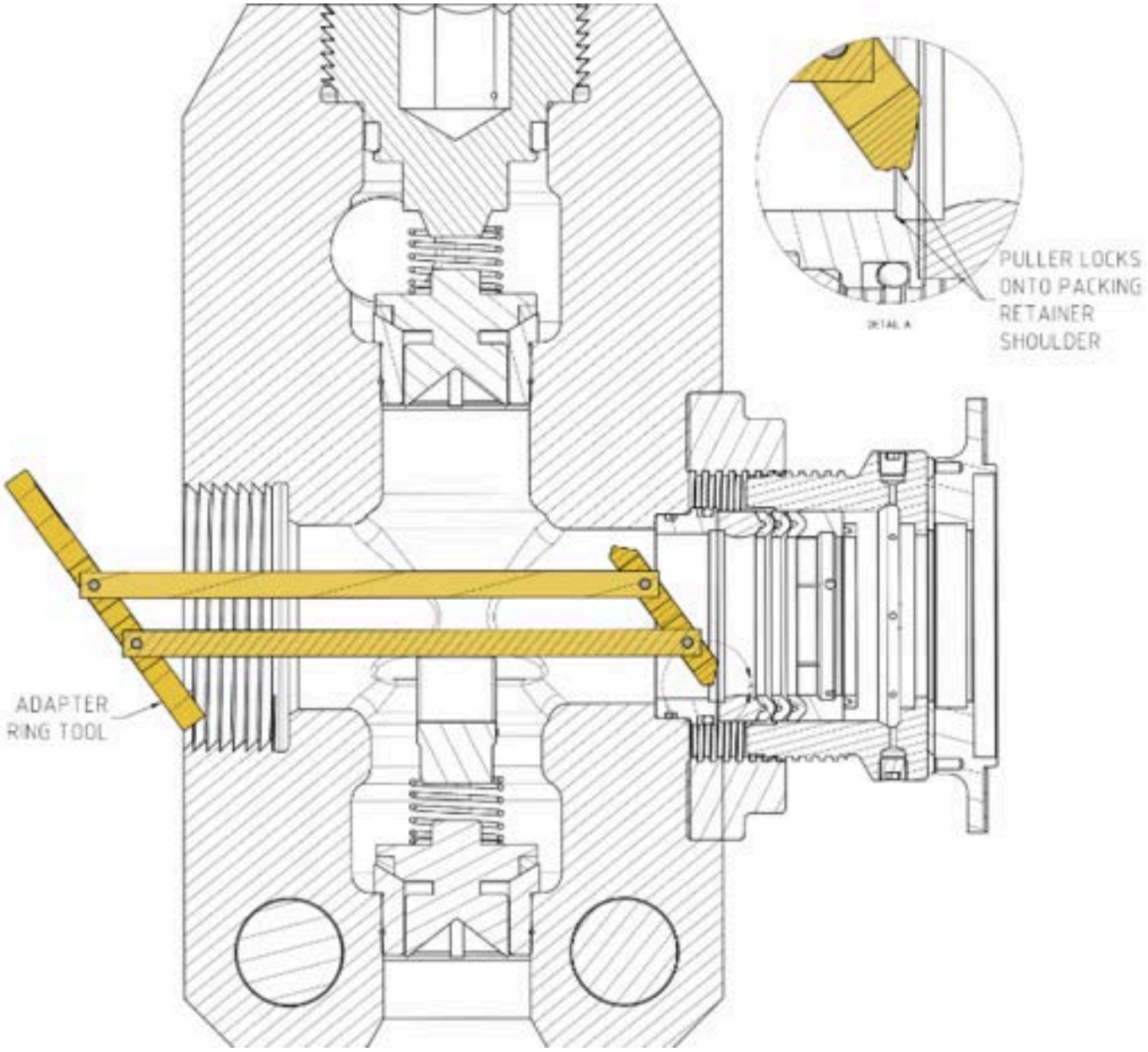
NOTE: The packing nut will need to be retightened only once after the pump is reassembled and run under pressure for a few revolutions. After that, the packing is completely self-adjusting.

p) Reinstall the check valve and lube fittings into the packing nut.

q) Reinstall the suction covers as outlined earlier.

6.40 Packing Tool Remover in Fluid End

PUMP SIZE	PART #	DESCRIPTION
2.75”	FEC0115	TOOL, ADAPTER RING RETAINER 600 - 2.75"
3.00”	FEC0116	TOOL, ADAPTER RING RETAINER 600 - 3.00"
3.50”	FEC0117	TOOL, ADAPTER RING RETAINER 600 - 3.50"
4.00”	FEC0118	TOOL, ADAPTER RING RETAINER 600 - 4.00"
4.50”	FEC0119	TOOL, ADAPTER RING RETAINER 600 - 4.50"



6.50 Removing the Valves and Seats

a) Using the MSI 2" hex cover wrench (MSI Wrench FEC0024) and a 10 lb. hammer, remove the suction covers and discharge covers from the fluid cylinder.

b) Turn the suction valve stop until it stops approximately 90 degrees and remove the valve stops from the fluid cylinder along with the valve springs underneath them.

c) Remove the valve from the Fluid End. Follow the valve manufacturer's recommendation of removing the insert from the valve.

d) Remove the discharge valve springs and discharge valves from the fluid cylinder.

e) Using an MSI seat puller assembly (FEC0113,-114), remove each of the discharge valve seats and suction valve seats.

f) The tapered valve seat bore in the fluid cylinder must be thoroughly cleaned and lightly hand polished with 220 to 240 grit Emery cloth prior to installing new valve seats.

g) Always install a new o-ring seal when reinstalling a valve seat. Do not use any grease, sealer, etc.-the valve seat must be installed dry. Upon installing the valve seat hand tight, install the valve in the seat and using a heavy steel bar with Teflon or wood pad, hammer the valve seat into the taper.

h) When reinstalling the valves, do not mix one manufacturer's valve with another manufacturer's valve seat. Likewise, do not mix one manufacturer's valve insert with another's valve.

i) When reinstalling the suction valve stop, make certain it is turned perpendicular to the plunger and securely seated in the groove in the cylinder.

j) Before reinstalling the discharge and suction covers, remove the seals from each, clean the covers thoroughly, and install new seals in the same direction that the old ones came off. Each cover bore in the fluid cylinder must be cleaned thoroughly and lightly hand polished with 220 to 240 grit Emery cloth prior to cover installation.

k) Upon installing the threaded suction and discharge covers with a coating of oil or very light grease, tighten them securely with the 2" hex cover wrench and a 10 lb. hammer.

6.60 Removing Discharge Flanges

a) Using a 1 5/8" wrench, remove the four 1" nuts from each of the two discharge flanges.

b) Remove each discharge flange from the fluid cylinder. Remove the fluid seals from both the inlet side and outlet side of each discharge flange. Closely inspect each discharge flange for internal erosion and corrosion. Inspect the discharge flange threads for wear and damage. The discharge flange seal surfaces should be thoroughly cleaned and lightly hand polished with a 220 and 240 grit Emery cloth prior to reinstallation.

c) Inspect the fluid cylinder discharge flange bores for erosion and corrosion. Thoroughly clean and lightly hand polish each bore with a 220 to 240-grit Emery cloth prior to reinstalling the discharge flanges.

d) Using a new fluid seals and a coating of light oil. Install seals into Fluid End bores lip end first. Carefully install the Discharge Connection so as not to damage the seal. Reinstall the four 1" hex nuts on each flange and evenly tighten them to the proper torque (Appendix 10.20).

6.70 Removing the Suction Manifold

a) Using a 1-1/8" wrench, remove the ¾" cap screws which secure the suction manifold to the fluid cylinder, and drop the suction manifold away from the fluid cylinder.

b) Inspect the suction manifold for internal erosion and corrosion. Remove the three suction manifold o-ring seals and inspect the seal grooves in the manifold for erosion and corrosion. Inspect the face and O.D. of the pipe at each end of the manifold for erosion and corrosion. Note: The MSI manifold incorporates a Victaulic "ES" type connection at each end which will accept either a Victaulic "End Seal Cut Groove: gasket or a Victaulic "Standard Cut Groove" gasket.

c) The condition of the pipe face at each end of the manifold is important for sealing purposes only when the "End Seal" (ES) gasket is used.

d) Inspect the bottom face of the fluid cylinder for erosion and corrosion. Thoroughly clean and lightly hand polish the bottom face of the fluid cylinder with a 220 to 240 grit Emery cloth prior to reinstalling the suction manifold.

e) Using new o-ring seals, reinstall the suction manifold. Reinstall the twelve ¾" cap screws and evenly tighten them to the proper torque (Appendix 9.20).

6.80 Removing the Fluid End

a) Remove Plungers and Packing as outlined in Section 6.30.

b) Remove the four (4) 1" bolts and the four (4) 1 3/8" bolts, which secure the fluid cylinder to the Power Frame. Remove the fluid cylinder from the Power Frame. *Note that the fluid cylinder is only secured by these 8 bolts and must be supported before the bolts are removed.

c) Examine the mating surfaces of the fluid cylinder and nose plate for signs of damage. Examine mounting bolt threads for signs of damage. Repair or replace as necessary.

d) Clean and lubricate the fluid cylinder mounting bolt threads with DOW CORNING G-n Metal Assembly Paste.

e) Reconnect all hose and piping connections and tighten plunger to crosshead to torque of 300 ft-lbs.

7.00 Gear Reducer Repair Procedures

Due to the complexity of the task and the need for special tools and training, MSI does not recommend the complete disassembly of the Gear Reducer in the field. If extensive Gear Reducer repairs are required, the pump should be returned to the Dixie Iron Works, Ltd. where expert service can be obtained on an expedited emergency basis if needed. When field repairs are required, they should be performed in a clean well equipped shop by a trained well service pump technician.

7.10 Removing and Disassembling the Gear Reducer

The Gear Reducer assembly may be removed from the Power Frame without being disassembled by using a 1-7/16" wrench to remove the eight 7/8" hex nuts, which secure the Gear Reducer to the Power Frame. MSI highly recommends removing the Gear Reducer intact when at all possible. When Gear Reducer internal repairs are required, follow the procedure below to inspect or replace the bull gear, pinion shaft, or roller bearings:

a. Remove the unit's mechanical driveline from the pump's input shaft.
b. Remove the lubrication hoses from the Gear Reducer and remove the Gear Reducer as a complete assembly from the Power Frame. Lay the Gear Reducer down on its mounting flange face with the input shaft facing up.
c. Using a 1 ½" wrench, remove the 1" cap screw which secures the companion flange to the input shaft. Remove the companion flange and inspect it for wear.
d. Using a ¾" wrench, remove the eight ½" cap screws, which hold the pinion seal retainer to the Gear Reducer housing. Remove the pinion seal retainer and shims from the Gear Reducer, remove the oil seal from the retainer, and scrape all old silicone sealer from the retainer.
e. Using a punch and hammer, drive the three ½" dowel pins from the outer flange of the Gear Reducer housing. Using a ¾" wrench, remove the nineteen ½" cap screws, nuts, and washers, which secure the Gear Reducer, cover plate to the housing. Remove the eight ½" cap screws which secure the bearing cover to the Gear Reducer. Remove the bearing cover and shims. Lift the cover plate away. Scrape all old silicone sealer from the Gear Reducer cover and from the flange on the housing. Using a brass punch and hammer, drive both bearing cups (outer races) from the cover plate and inspect them for wear or damage.
f. Remove the bull gear from the pump and inspect the gear teeth and both tapered roller bearing cones for wear and damage.
g. Remove the pinion shaft from the Gear Reducer and inspect both tapered roller bearing cones for wear and damage. If the bearing needs to be removed from the shaft, do so by carefully heating them with an acetylene torch until they will slip off the shaft. Care must be taken to avoid overheating the shaft itself. Inspect the shaft for wear and damage to the gear teeth, and bearing journals.
h. Using a ¾" wrench, remove the eight ½" cap screws which hold the rear pinion-bearing cap on the Gear Reducer housing. Remove the bearing cap and scrape all old silicone sealer from it.
i. Turn the Gear Reducer housing over on the opposite face. Using a brass punch and hammer, drive the tapered roller bearing cups (outer races) out of the Gear Reducer housing and inspect them for wear and damage.
j. Reassembly of the Gear Reducer should be performed in the reverse order of the disassembly instructions above. Installation of new tapered roller bearing cones on the pinion shaft or bull gear can be performed by pressing them on or by heating the cone assembly through any one of several methods. A temperature controlled heating plate, hot oil bath unit, hot air cabinet, or induction heating

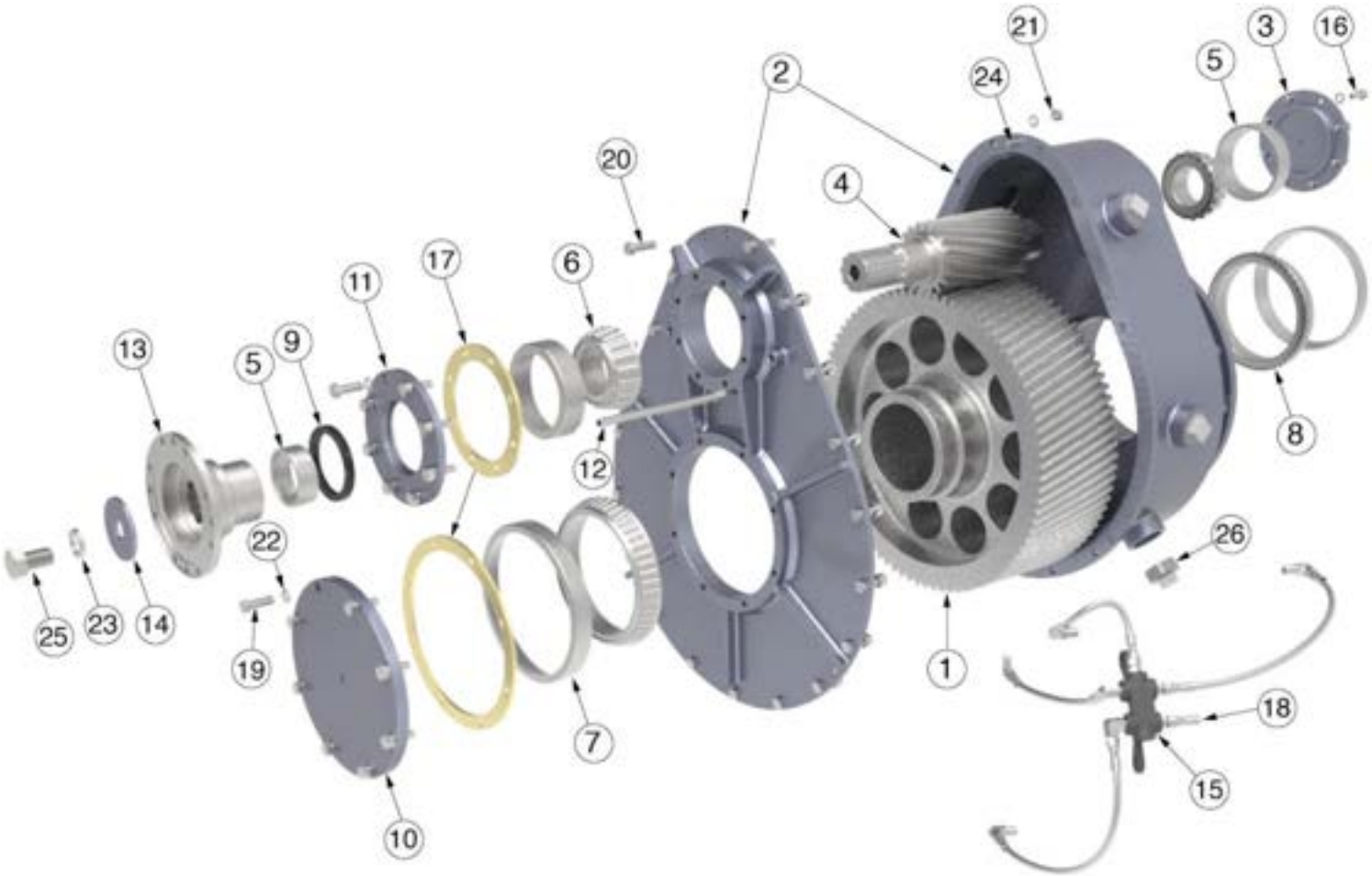
unit can be used to safely heat the bearings. When heating a bearing for installation, the temperature must not exceed 250 degrees Fahrenheit (121 degrees Celsius). Installation of new tapered roller bearing cups in the housing should be performed by tapping them into the housing with a soft metal bar or by pressing them into the housing.

k. Upon reinstallation of the bull gear and pinion shaft, it is extremely important to establish the proper bearing "pre-load" (.003" to .005") before operating the pump. This "pre-load" must be accomplished by obtaining endplay readings with a dial indicator and removing the appropriate thickness of bearing adjustment shims. If for example there is 0.010" of axial "play", a total of 0.013"-0.015" of shim stock thickness shall be removed from the shim set. Silicone liquid gasket material should not be applied to the bearing retainer until after the bearing pre-load has been set properly.

7.20 Gear Reducer, 4.61:1 Ratio Standard- Exploded View

ITEM	QTY	PART	DESCRIPTION
1	1	GRC0001	LARGE GEAR
2	1	GRC0002	GEAR CASE
3	1	GRC0020	PINION CAP
4	1	GRC0021	PINION SHAFT
5	2	GRC0023	BEARING CUP, PINION
6	2	GRC0024	BEARING CONE
7	2	GRC0025	BEARING CUP, GEAR
8	1	GRC0026	BEARING CONE, GEAR
9	1	GRC0027	OIL SEAL, PIN SHAFT
10	1	GRC0033	BEARING COVER, MAIN GEAR
11	1	GRC0034	RETAINER, PINION BEARING
12	1	GRC0037	SPRAY PIPE ASSY
13	1	GRC0041	SPICER FLANGE, PINION SHAFT

ITEM	QTY	PART #	DESCRIPTION
14	1	GRC0042	RETAINER WASHER
15	1	GRC0158	MANIF. BLOCK, 1/4"NPT x 6
16	8	HC0024	HEX HD, ½”-13 x 1.25”
17	1	HC0032	SHIM SET
18	1	HC0054	SOC HD, 3/8"-16 x 0.75"
19	16	HC0096	HEX HD, 1/2"-13 x 1.50"
20	19	HC0097	HEX HD, 1/2"-13 x 1.75"
21	19	HC0098	HEX NUT, 1/2"-13
22	43	HC0100	LOCK WASHER, 1/2"
23	1	HC0101	LOCK WASHER, 1"
24	3	HC0102	DOWEL PIN, 1/2" x 1"
25	1	HC0103	HEX HD, 1"-14 x 1.50"
26	6	UC0371	BLANK PLUG, 2"NPT



8.00 Charge Pump Intake

Unless careful attention is put into the design of the suction supply system, the well service pump can experience cavitations. 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 cavitations 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 need to be sized according the 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 cavitations 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.

Appendix

9.00 Pump Formulas

Definition of Symbols Used:

A	-	Area (sq. in.)
BHP	-	Brake horsepower
BPM	-	Barrels per minute (U.S.)
FV	-	Flow velocity (ft./sec.)
GPM	-	Gallons per minute (U.S.)
GPR	-	Gallons per revolution (U.S.)
HHP	-	Hydraulic horsepower
ID	-	Inside diameter (inches)
ME	-	Mechanical efficiency
NC	-	Number of cylinders (per pump)
PD	-	Plunger diameter (inches)
PSI	-	Lbs./sq. in.
RL	-	Rod load (lbs.)
RPM	-	Crankshaft revolutions per minute
SL	-	Stroke length (inches)
T	-	Torque (ft. lbs.)

Pump Formulas

1. To calculate the HHP output when the volume and pressure are known:

$$\frac{GPM \; x \; PSI}{1714} = HHP$$

2. To calculate the BHP input required when the volume, pressure, and mechanical efficiency are know:

$$\frac{GPM \; x \; PSI}{(1714 \; x \; ME)} = BHP$$

3. To calculate the maximum possible pressure when the BHP, flow, and ME are known:

$$\frac{BHP \; x \; (1714 \; x \; ME)}{GPM} = PSI$$

4. To calculate the maximum possible flow when the BHP, PSI, and ME are known:

$$\frac{BHP \; x \; (1714 \; x \; ME)}{PSI} = GPM$$

5. To calculate rod load when the plunger diameter, and pressure are known:

$$PD \; x \; PD \; x \; 0.7854 \; x \; PSI = RL$$

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

$$\frac{RL}{PD \; x \; PD \; x \; 0.7854} = PSI$$

7. To calculate the flow in gal/rev or GPR when the plunger diameter, stroke length, and number of cylinders is known:

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

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

$$Pipe \; I.D. \; x \; Pipe \; I.D. \; x \; 0.7854 = Internal \; Area \; (A)$$

$$\frac{GPM \; x \; 0.3208}{A} = Flow \; Velocity \; (FV)$$

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

$$\frac{GPM \; x \, 0.3208}{FV} = Internal \; Area \; Required \; (A_R)$$

10. 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:

$$\frac{FV \; x \; A_R}{0.3208} = GPM_{MAX}$$

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

$$\frac{BHP \; x \, 5252}{INPUT \; RPM} = Torque(T)$$

9.10 Recommended Torques

GENERAL TORQUE TABLE				
	Cap screws, nuts & bolts		Alloy Steel Studs & Nuts	
	SAE GRADE 5		SAE GRADE 7	
Thread Dia & Thread Pitch	Dry Threads Torque (ft*lbs)	Lubricated Thrds. Torque (ft*lbs)	Dry Threads Torque (ft*lbs)	Lubricated Thrds. Torque (ft*lbs)
1/4-20 UNC	6.7	5.1		
5/16-18 UNC	13.9	10.4		
3/8-16 UNC	24.7	16.5		
7/16-14 UNC	39.4	29.6		
1/2-13 UNC	60.3	45.2		
5/8-11 UNC	110	80		
3/4-10 UNC	212	159		
7/8-9 UNC	315	236	425	318
1-8 UNC	472	354	635	477
1-1/8- 7 UNC	633	475	900	675
1-1/4- 7 UNC	900	675	1270	955
1-3/8-8 UN			1660	1245
1-5/8-8 UN				2300
1-3/4-8 UN				2400

Connecting Rod Cap Nuts: Install 5/8”-11 castellated nuts using Loctite® Threadlocker Blue and torque to 150 ft-lbs of torque.

Crosshead Slide Bolts: Install 5/8”-11 bolts using Loctite® Threadlocker Blue and torque to 50 ft-lbs of torque.

Fluid End Plungers: Install FEC0004 pony stud using Loctite® Threadlocker Blue and torque to 360 ft-lbs of torque. Install plungers using anti-seize compound and torque to 300 ft-lbs of torque.

Note: There is no specified torque for the Fluid End bolts. The indicator in the face measures the preload on the bolt, torque as necessary to achieve proper readings. MSI strongly recommends using DOW CORNING G-n Metal Assembly Paste as a lubricant. Other lubricants will damage the bolt threads before required preload is achieved. Each has a mechanical indicator in the face and should read between 90 and 95 on the dial. Tighten as necessary, but do not exceed 95 on the dial. If the indicator is not working return it to MSI for immediate replacement.