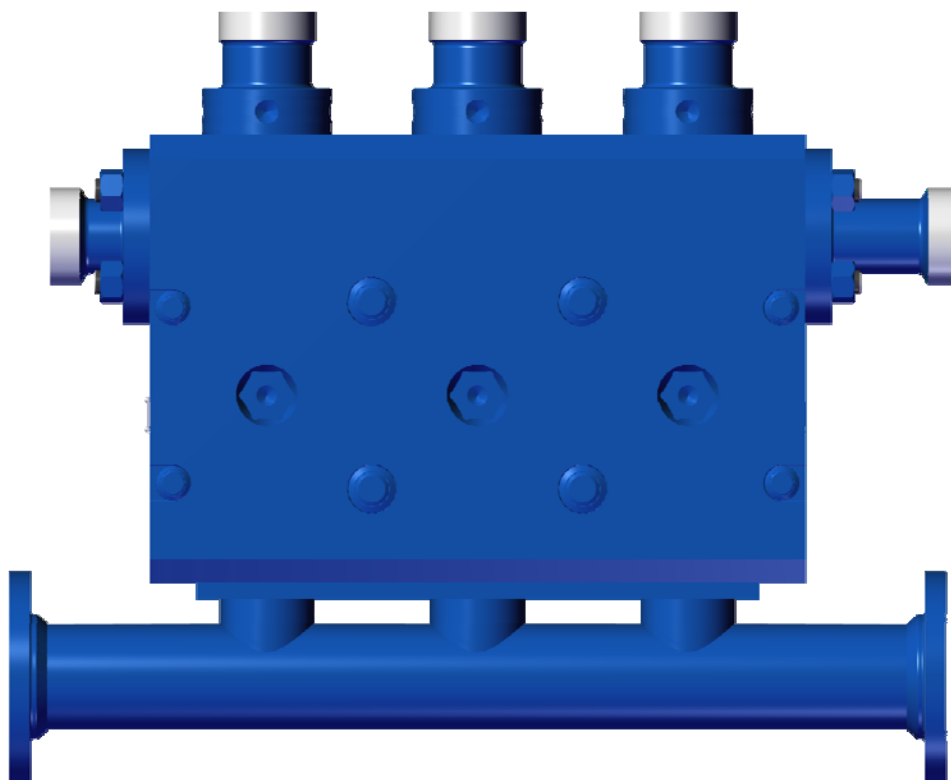




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SPM[®] PRODUCT SAFETY GUIDE FOR WELL SERVICE PUMPS

Most SPM[®] products generate, control, or direct pressurized fluids; therefore, it is critical that those who work with these products be thoroughly trained in their proper application and safe handling. It is also critical that these products be used and maintained properly!

WARNING: DO NOT HANDLE, LIFT, INSTALL, OPERATE, OR MAINTAIN THIS WELL SERVICE PUMP WITHOUT READING THIS "WELL SERVICE PLUNGER PUMP SERVICE MANUAL" THOROUGHLY. TRAINING IN THESE DOCUMENTS IS A MUST FOR PACKAGERS, OPERATIONS, AND MAINTENANCE PERSONNEL. FAILURE TO DO SO CAN LEAD TO **SERIOUS INJURY, DEATH, EQUIPMENT DAMAGE, PROPERTY DAMAGE, OR DAMAGE TO THE ENVIRONMENT.**

WARNING: MISUSE, SIDE LOADING, IMPROPER MAINTENANCE, OR DISASSEMBLY UNDER PRESSURE CAN CAUSE **SERIOUS INJURY OR DEATH.**

The following information is given in good faith and should aid in the safe use of your SPM[®] products. This information is not meant to replace existing company safety policies or practices.

Hot Surfaces: A SPM[®] well service pump is capable of pumping fluids with temperatures up to 65°C/150°F with normal trim. The power end of the pump can be operated at temperatures up to 79°C/175°F. It is the responsibility of the packager to provide adequate guarding around the fluid end as well as the inlet and discharge piping to protect against burn injury.

A SPM[®] well service pump operates at very high pressure and features some external moving parts. It is the customer's responsibility to provide adequate warning and protection for personnel for when the unit is operated.

All images and drawings shown in this document are for representation and illustration purposes only. They don't reflect the actual part/component.

The bill of materials and part numbers in this document can change without notification. For details contact Weir Oil & Gas.

Personal Responsibilities:

1. When working on the pump, safety glasses, approved safety shoes, gloves, and hard hat must be worn. Fall prevention and protection should be in place when working on the pump in raised areas. Surfaces can become slippery when servicing the pump. Hammering on any part or component may cause foreign material or steel pieces to become airborne.
2. Personnel should only hammer on the SPM[®] hammer wrench provided and never directly on the pump itself. Fractures can occur from repeated misuse. Only soft-type hammers should be used.
3. Personnel should never hammer on one of the valve retainer nuts or any other pump components when any pressure is present.
4. When servicing the pump, do not manually lift any part in excess of 40 pounds. A lift device must be used in these cases. For parts weighting 40 pounds or less, proper leg type lifts are essential. Do not lift with a back type lift.

5. It is a personal responsibility to use the proper tools when servicing the pump. Any special tools required are furnished with the pump when new, and should be kept with the pump for its routine maintenance. It is your personal responsibility to be knowledgeable and trained in the use and proper handling of these tools for all maintenance of the pump. A pump is made up of internal and external moving parts. All personnel should be located away from the pump while in operation.

On Location:

1. Each pump is clearly marked with a maximum pressure and temperature rating. This pressure must not be exceeded or **SERIOUS INJURY OR DEATH CAN OCCUR.**
2. Each pump is clearly marked with a maximum horsepower rating. This horsepower rating should not be exceeded or mechanical damage can occur, leading to **SERIOUS INJURY OR DEATH.**
3. The pump's discharge connections should be properly cleaned, and lightly oiled before the downstream piping is attached. Any worn, damaged or missing seals should be replaced before engaging the pump's drive.
4. The pump's suction connections should be properly cleaned, and lightly oiled before the supercharge hoses are attached. Any worn, damaged or missing seals should be replaced prior to pumping. Leaking connections can cause pump cavitation leading to equipment failure and subsequent **INJURY OR DEATH.**
5. Any fluid cylinder which has been pressured beyond its specified working pressure should be returned to Weir Oil & Gas for disassembly, inspection and recertification.
6. Welding, brazing, or heating any part of the pump, with the exception of driveline companion flanges, is prohibited. If accessories must be attached, consult Weir Oil & Gas factory prior to installation.
7. The SPM[®] pump suction supply flow, and pressure minimums in the pump service manual must be maintained or equipment damage will occur and can lead to **SERIOUS INJURY OR DEATH.**
8. A complete visual inspection of the pump's power end and fluid end must be made prior to each use. Any leaking seals, broken bolts, leaking hoses, or improperly tightened parts must be remedied prior to rotating the pump.
9. Any oil and other contaminants from pump should be contained during operation, and throughout the maintenance process. Improper containment can lead to serious injury, equipment damage, property damage, or damage to the environment.
10. If a pump is used in a place where permanent piping is to be attached, frame flexing or structure movements must be considered. Do not place the discharge or suction connections in a bind. Inspect all components of such piping structure, including any valves, every 90 days for wash, erosion, corrosion, etc. Replace if worn. For mobile mounted units; discharge line swivels are required.
11. SPM[®] well service pumps are to be installed and operated in a horizontal position only, as shown in the pump's service manual. Operation in an extreme inclined position could cause equipment failure, leading to injuries due to improper oil flow and/or improperly sealing valves.

12. Any repairs or service (even routine maintenance) performed on the pump must be performed by a trained service technician who is qualified to work on high pressure reciprocating plunger pumps. All such service and repairs must be supervised by qualified management personnel or returned to Weir Oil & Gas for service. Only SPM[®] replacement parts should be utilized. **Failure to do so may result in loss of warranty as well as SERIOUS INJURY OR DEATH.** Weir Oil & Gas provides a Pump Maintenance Mechanic Training School to qualify pump service mechanics.
13. SPM[®] well service pumps should never be used to pump gaseous, explosive, or uninhibited corrosive fluids. These may result in equipment failure, leading to **INJURY OR DEATH.**
14. Never place hands in area of reciprocating pony rod or plunger path. If work must be done in this area, make sure pump is disengaged from driver and isolated from suction and discharge pressure prior to initiating activity (locked out and tagged out).

Special Precautions:

1. The modifications to or unauthorized repair of any part of an SPM[®] pump, or use of components not qualified by Weir Oil & Gas, can lead to pump damage or failure and **SERIOUS INJURY OR DEATH.**
2. The pump's fluid end and related piping must always be flushed with clean water after every job. If freezing temperatures are anticipated the fluid cylinder must be completely drained of any fluid. Failure to do this may result in fluid cylinder damage from fluids which have hardened or frozen.
3. All SPM[®] threaded components are right hand threaded unless specifically designated otherwise. Any turning counterclockwise will unscrew the assembly. Always make sure any threaded component is made up properly with the proper torque.
4. All products should be properly cleaned, greased, or oiled after each use and inspected prior to each use. **Do not put oil or grease on the valve seat, or fluid end valve seat tapered area.**
5. Pressure seal (line pipe) threads are not recommended for pulsating pressure service above 10,000 PSI or where side loading or erosion are suspected. Non-pressure seal (round tubing) threads or straight integral connections are recommended under these conditions. In order to achieve the recommended Non-Shock Cold Working Pressure, power-tight make-up is required on all threaded connections. Consult the factory for any usage other than normal constant flow working conditions. Integral connections are recommended in lieu of pipe threaded connections for all pump applications.
6. Each integral union connection is clearly marked with a pressure code (i.e. "1502", 15,000 psi). This pressure must not be exceeded. This code should also be used with mating unions. Improper mating can result in failures. All integral union connections used must match (according to size, pressure rating, etc.). These connections must also match the service of the designated string they are installed in.

Inspection & Testing:

1. Each pump, its drive system, and its fluid piping should be visually checked each time before operating. All worn, damaged or missing parts should be remedied before starting the pump.
2. All fluid cylinder mounting nuts must be checked routinely with a certified torque wrench. Loose fluid cylinder mounting nuts can cause the fluid end to separate from the power end resulting in **SERIOUS INJURY OR DEATH**.
3. All studs and stay rods require tightening to the proper torque. Without proper torque, the fluid end will "breathe" or flex against the power end resulting in stud failure, stay rod failure and/or even premature fatigue failure in the power or fluid end. Ensure all stay rods are not damaged, cracked, or loose. Consult Weir Oil & Gas for torque information (see assembly drawings for torque values).
4. All covers must be tight and properly torqued. Otherwise, premature fatigue and possible fluid end or component failure can result.
5. All fluid ends must be disassembled, and dimensionally inspected routinely. Any fluid cylinder or discharge flanges which exhibits any loss in wall thickness due to washing or corrosion pitting in any area must be returned to Weir Oil & Gas for repair and recertification prior to operating again.
6. All fluid cylinders in operation must be disassembled and inspected for cracks. Fluid cylinder inspection should occur on a monthly basis or every 100 hours of operation. The operation of any pump with even small surface cracks in any area of the fluid cylinder can result in equipment failure and **SERIOUS INJURY OR DEATH**.
7. All fluid cylinders should be hydrostatically tested at least twice each year by a qualified technician. Prior to any pressure testing, all air must be evacuated from the system. Failure to do so could result in **PERSONAL INJURY OR DEATH**. The maximum test pressure must not exceed the equipment's rated working pressure. The hydrostatic pressure test must be followed with an ultraviolet light/magnetic particle inspection of the internal bores prior to reinstalling and operating under pressure.
8. Once an SPM[®] fluid end assembly has been pressurized, transfer of the following components into any other fluid end assembly is prohibited:
 - Packing Nuts
 - Retainer Nuts
 - Discharge Flanges
 - Discharge Gauge Connections
 - Discharge Gauge Connection Retainer Nuts
 - Discharge Flange Studs and Nuts
 - Suction Covers
 - Discharge covers.

NOTE: It is always best practice that sealing/ soft components such as D-Rings, O-Rings, and Discharge Flange Seal Rings be replaced each time they are disassembled



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SECTION I: GENERAL INFORMATION

Useful Pump Data Formulas:

Definition of Symbols Used:

A	-	Area (sq. in.)
BHP	-	Brake horsepower
BPM	-	Barrels per minute (U.S.)
FV	-	Flow velocity (feet per second)
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	-	Pounds Per Square Inch
RL	-	Rod load (pounds)
RPM	-	Crankshaft revolutions per minute
SL	-	Stroke length (inches)
T	-	Torque (foot pounds)

Pump Data Formulas:

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

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

- To calculate the BHP input required when the volume, pressure, and mechanical efficiency are known:

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

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

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

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

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

- To calculate rod load when the plunger diameter and pressure are known:

$$PD \times PD \times .7854 \times PSI = RL$$

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

$$\frac{RL}{PD \times PD \times .7854} = PSI$$

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

$$\frac{PD \times PD \times .7854 \times SL \times NC}{231} = GPR$$

$$GPR \times RPM = GPM$$

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

$$Pipe \ I.D. \times Pipe \ I.D. \times .7854 = Internal \ Area = A$$

$$\frac{GPM \times .3208}{A} = Flow \ Velocity$$

- To calculate the size pipe of hose required to maintain a specified flow velocity when the GPM and desired flow velocity are known:

$$\frac{GPM \times .3208}{FV} = Internal \ Area \ Required$$

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

$$\frac{FV \times A}{.3208} = Max \ GPM$$

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

$$\frac{BHP \times 5252}{Pinion \ Shaft \ RPM} = Torque$$

Conversion Factors:

Multiply:	By:	To Obtain:
Barrels (U.S.)	42	Gallons (U.S.)
Gallons (U.S.)	.023809	Barrels (U.S.)
Gallons (U.S.)	231	Cubic Inches
Cubic Inches	.004329	Gallons (U.S.)
Cubic feet per second	448.831	GPM
GPM	.002228	Cubic Feet per Second
Head Feet (water)	.4331	PSI
PSI	2.309	Head Feet (water)
Kilowatts	1.341	Horsepower
Horsepower	.7457	Kilowatts

Shipping and Storage:

WARNING: DO NOT HANDLE, LIFT, INSTALL, OPERATE, OR MAINTAIN THIS WELL SERVICE PUMP WITHOUT READING THIS "OPERATION INSTRUCTION AND SERVICE MANUAL" THOROUGHLY. TRAINING WITH THESE DOCUMENTS IS A MUST FOR PACKAGERS, OPERATIONS, AND MAINTENANCE PERSONNEL. FAILURE TO DO SO CAN LEAD TO SERIOUS INJURY, DEATH, EQUIPMENT DAMAGE, PROPERTY DAMAGE, OR DAMAGE TO THE ENVIRONMENT.

All SPM® pumps are shipped dry, and must be flushed and filled with the proper lubricant before operating (refer to Installation and Operation Section). Pumps may be flushed with diesel or light oil. When pumps are shipped by ocean cargo, care should be taken to crate the pump in a watertight container and ship below deck to prevent salt-water contamination. Care should be taken to prepare the pump for possible long term storage.

New pumps are not prepared for long periods of storage and should be put in service as soon as possible. Follow the SPM® preservation guide for pump storage recommendations; SPM® document number 2P121266

CAUTION: PUMPS THAT HAVE SAT IDLE FOR ANY APPRECIABLE PERIOD OF TIME (TWO WEEKS OR MORE) MUST HAVE THE PLUNGERS AND VALVES REMOVED, COATED WITH A LIGHT LUBRICANT, AND REINSTALLED PRIOR TO OPERATING. THE ELASTOMERIC PLUNGER PACKING AND VALVE INSERTS WILL STICK TO THE MATCHING METAL PARTS AND BECOME DAMAGED UPON STARTUP IF NOT DISASSEMBLED AND LUBRICATED FIRST.

SECTION II: INSTALLATION AND OPERATION

SPM[®] TWS600S Pump Description:

The SPM TWS600S is a reciprocating, positive displacement, horizontal single-acting, triplex plunger pump that is rated at 600 Brake Horsepower input maximum. The TWS600S is designed for intermittent duty well service applications such as acidizing, cementing, fracturing, well killing, gravel packing, etc.

The TWS600S Pump consists of a Power End/Speed Reducer Assembly and a Fluid End Assembly. The Speed Reducer can be installed on either the right hand or left hand side of the pump and can be positioned in any one of 17 different input shaft locations to accommodate a number of different pumping unit drive train configurations. Two different fluid cylinders are available to accommodate several plunger sizes for a variety of pressures and volumes.

Optional packing assemblies, valve assemblies, discharge flanges, suction manifolds, etc. are available for a wide variety of unitization arrangements; for the pumping of various specific fluids; and for service in a wide range of ambient conditions. The weight of the pump will vary slightly depending on plunger size and other options but will not vary more than plus or minus 5% of the advertised weight.

The SPM TWS600S basic design and construction details are as follows:

Fluid Cylinder

Low maintenance "Valve Over Valve" monoblock design. Precision machined from high strength one-piece alloy steel forging.

Plungers

Machined from steel w/precision ground hard overlay (60 Rc) acid resistant packing surface.

Plunger Packing

"Self-adjusting" type packing assemblies. Precision molded fiber reinforced V-type pressure rings. Supported by precision machined bronze adapter rings. Various compositions available for all common well service fluid media such as hydrochloric acid, cement, frac sand slurries, hydrocarbons, toluene, etc. and a wide range of ambient temperatures and fluid temperatures.

Valve Assemblies

Wing guided well service type valves w/replaceable, or bonded urethane or neoprene inserts. Tapered well service type valve seats w/auxiliary seal ring.

Valve Springs

Long lasting coil springs engineered for a wide range of well service applications. Designed for spring rates, installed spring loads, and valve cracking pressures unique to well service pumps.

Suction Valve Keepers

Low fluid restriction type keepers located out of the high stress plane of the fluid cylinder.

Discharge Flanges

Dual outlet (RH & LH) design. Replaceable type discharge flanges precision machined from heat treated alloy steel. Available in male or female with a variety of common well service connections such as LPT and integral hammer union thread connections.

Suction Manifold

Dual inlet (RH & LH) design. Replaceable type manifold fabricated from steel, precision machined, and pressure tested. "Quick Disconnect" Victaulic grooved "ES" connections on both ends.

Fluid Seals

Precision molded high pressure acid resistant fluid seals made from a superior Polyurethane/Molydisulfide seal compound.

Packing Lubrication

Equipped for a pressurized oil base packing lube system.

Installation Highlights:

The proper installation of your SPM well service pump is a must in obtaining long life and trouble free service. Particular attention must be given to the following items:

A. Power Source:

The prime mover (usually a 2100 RPM diesel engine) should not be rated at more than 725 BHP intermittent service in order to avoid overpowering the pump.

B. Drivetrain:

The drivetrain which connects the pump to the engine should include a transmission (5 speed or more) and a mechanical driveline with universal joints and a **slip joint** in order to fully utilize the pump's wide range of pressure and flow capabilities.

A powershift type transmission with integral torque converter and automatic lock-up clutch will provide the most trouble-free means of shifting under pressure. When using an ordinary mechanical transmission with manual clutch, extreme caution must be exercised when clutching and shifting in order to avoid introducing severe shock loads to the pump's input shaft. When using any transmission with a "high gear" or "overdrive" ratio greater than 1.0:1, the "overdrive" gear range must be blocked out in order to avoid overspeeding the pump. When using a transmission with a torque converter and/or a low gear ratio of 5.0:1 or lower, extreme caution should be exercised to avoid over-pressuring the pump when operating in low gear or converter mode.

The mechanical driveline should have a "Diesel Engine Use" torque rating of approximate 1250 to 1700 ft. lbs. (6500 to 8900 ft. lbs. Short Duration) and should have no less than 1" slip capacity. The manufacturer's recommendations for maximum installed angle, maximum RPM, etc. must not be exceeded.

C. Power End Mounting:

The pump must be securely bolted to the skid or vehicle at all four power end mounting hold locations (Refer to pump installation drawing).

D. Power End Lubrication:

SPM[®] well service plunger pumps are shipped dry, do not include an integral oil pump, and are designed for a pressure lubricated dry sump system. An auxiliary oil reservoir and engine driven oil pump must be provided for proper lubrication. More information pertaining to the power end lube system and power end lube oils is included in this manual.

E. Plunger Lubrication:

SPM[®] well service plunger pumps require a force fed oil plunger lube system. The unit is internally and externally plumbed so that the correct oil source provided by the customer will supply lube to all appropriate surfaces.

SPM[®] supplied hosing (both internal and external) is normally medium pressure Teflon with a stainless steel outer braid. This type hose has the following ratings:

Size	Working	Burst
1/4"	3000 psi	12000 psi
5/16"	2500 psi	10000 psi
3/8"	2000 psi	8000 psi
1/2"	1750 psi	7000 psi
3/4"	1000 psi	4000 psi

More information pertaining to the plunger lube system and plunger lube oils is included in this manual.

Lifting Requirements:

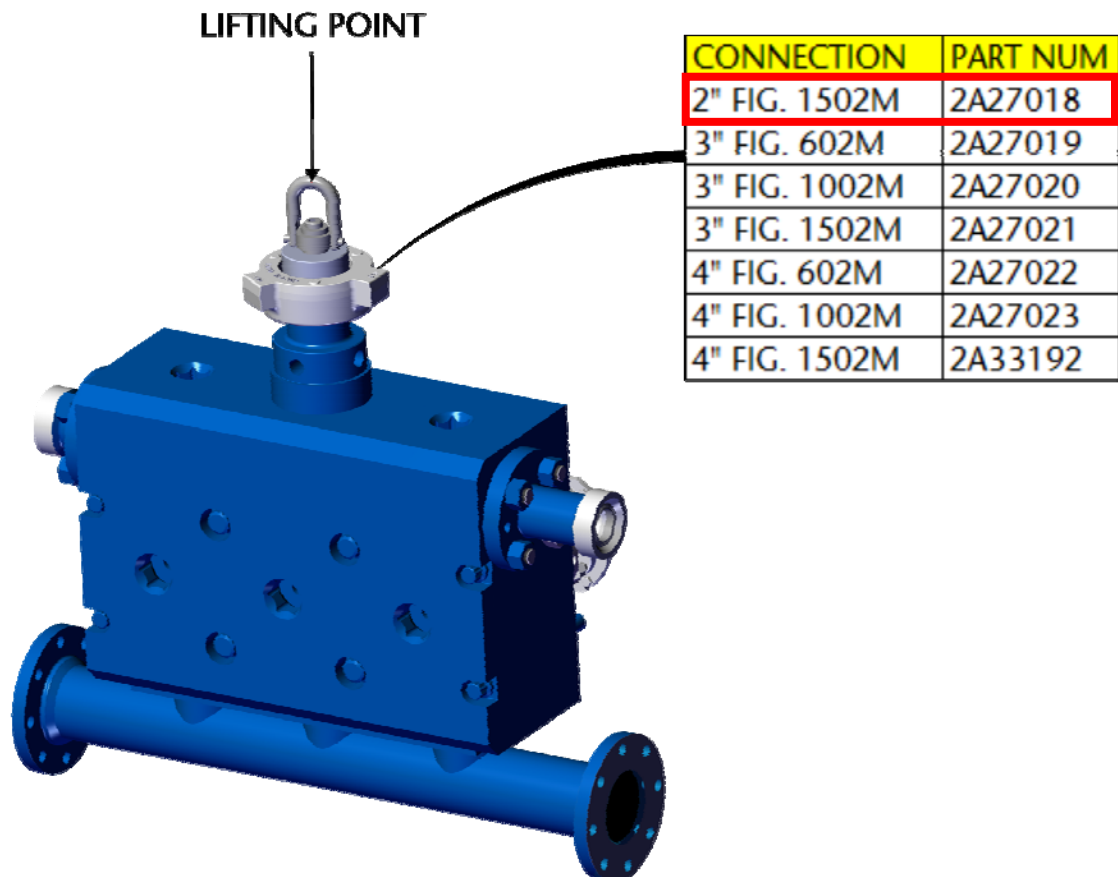
The SPM® TWS600S fluid end assembly with suction manifold weighs approximately 1,700 Lbs./ 771 Kg.

CAUTION: DO NOT MOUNT THE PUMP ON AN INCLINE OR VERTICALLY.

WARNING: LIFTING THE SPM® TWS600S PUMP AND/OR FLUID END WITHOUT USING EQUIPMENT RATED FOR THIS LOAD CAN CAUSE EQUIPMENT DAMAGE, PERSONAL INJURY OR DEATH.

WARNING: DO NOT HANDLE, LIFT, INSTALL, OPERATE OR MAINTAIN THIS FLUID CYLINDER WITHOUT READING THIS "OPERATION INSTRUCTION AND SERVICE MANUAL" THOROUGHLY. TRAINING IN THESE DOCUMENTS IS A MUST FOR PACKAGERS, OPERATIONS AND MAINTENANCE PERSONNEL. FAILURE TO DO SO CAN LEAD TO SERIOUS INJURY, DEATH, EQUIPMENT DAMAGE, PROPERTY DAMAGE OR DAMAGE TO THE ENVIRONMENT.

NOTE: A LIFTING PLUG ASSEMBLY IS REQUIRED TO LIFT THE FLUID END. SEE TABLE BELOW FOR PART



Plunger Lube System Requirements:

SPM[®] well service plunger pumps are designed for packing lubrication with oil rather than grease. Exceptionally long packing life can be expected providing proper lubrication is supplied to the plunger packing lube port above each stuffing box. Ample plunger and packing lubrication can be achieved with an inexpensive relatively trouble-free low-pressure air operated “lubricant pump” type system. Mechanically driven plunger lubricators are not recommended due to the well service pump’s extreme variations in pump speeds. A properly designed packing lube system will meet the following specifications:

1. Oil Reservoir:

- Should be a minimum of 15 gallon capacity.
- Should be equipped for the vertical installation of an air-operated pump.
- Should be equipped with a sight glass or dipstick.
- Should be equipped with a breather/filler cap that has a built-in strainer to prevent trash from entering the reservoir.

2. Air Operated Lubricant Pump:

- Vertical air operated 12 oz. per minute / 150 PSI / 40:1 ratio lubricant pump.
- Must be equipped with a 1/4” adjustable air pressure regulator in order to adjust the pump speed and packing lubricant flow rate.
- Should be installed so that the bottom of the pump is no closer than 1” to the bottom of the reservoir.

3. Packing Lubricant Flow Lines:

- Should be 1/4” I.D./1250 PSI minimum/fiber or wire reinforced hose to prevent crimping.
- Should be a common line from the lubricant pump to the plunger pump at which point it will branch off to each individual packing lube port.

4. Flow Control Needle Valves:

- Should be a 1/4” needle valve which can be locked at any given setting after adjustment.
- Must be installed in each lubricant flow line which leads to the individual packing lube ports in the plunger pump fluid cylinder.

5. High Pressure Check Valves:

- Must be rated at or above the- well service plunger pump’s maximum pressure rating.
- Must be installed in the packing lube port so that the direction of flow is into the fluid cylinder.

6. Packing Lube System Flow Requirements/Adjustments:

- After filling with the proper grade of rock drill packing oil, and before rotating the well service plunger pump, the lube system should be adjusted to supply oil to each plunger and packing assembly.
- Weir Oil & Gas recommends a minimum of 1 pint per plunger per hour for adequate packing lubrication. Results from SPM[®] internal tests support this although variables in packaging and field operations may result in higher consumption rates.

Minimum consumption rate 1.0 pint per plunger per hour

- Rates as high as 3 times the minimum recommended have been reported, and this should be considered when sizing the lube reservoir.

Recommended Plunger Lube Oils:

Selecting the proper plunger lube oil is very important to obtaining long life from the pumps plungers and packing assemblies. The use of a superior plunger lubricant will also reduce horsepower robbing friction, reduce fuel consumption, and increase the net amount of hydraulic horsepower delivered by the pump. Weir Oil & Gas highly recommends the use of a modern "Rock Drill" for improved lubrication of the plungers and packing. If "Rock Drill" is not available, a suitable "Way Oil" may be substituted.

Weir Oil & Gas recommends the use of Rock Drill or Way Oil that meet the following specifications:

ISO Grade	68	100
API Gravity	29.4	28.2
Viscosity, Kinematics		
cSt at 40°C	70	104
cSt at 100°C	9	12
Viscosity, Saybolt		
SUS at 100°F	362	556
Viscosity Index	103	99
Flash Point, C(F)	248 (478)	254 (489)
Pour Point, C(F)	-27 (-17)	-24(-11)

The following types of plunger lube Rock Drill oil are recommended for use in various ambient conditions as shown:

General Service – for ambient conditions above 32 degrees F:

- "Rock Drill 100" or equivalent

Cold Temperature Service – for ambient conditions below 32 degrees F:

- "Rock Drill 68" or equivalent

NOTE: LUBRICANTS WHICH DIFFER SIGNIFICANTLY FROM THOSE SHOWN ABOVE ARE UNACCEPTABLE AND MAY RESULT IN A MUCH SHORTER PLUNGER AND PACKING LIFE OR PREMATURE FAILURE OF THESE COMPONENTS.

NOTE: STARTUP IS A CRITICAL TIME FOR PLUNGER PACKING. LUBRICATION SHOULD FLOW FREELY TO PLUNGERS/PACKING PRIOR TO STROKING THE PUMP. STROKING DRY PLUNGERS CAN CAUSE THE HEADER RING, PACKING, AND ELASTOMERS TO TEAR AND FAIL.

NOTE: PROPER LUBRICATION IS CRITICAL TO DURING THE STARTUP OF THE PLUNGER PUMP. THE PLUNGER LUBRICANT MUST BEGIN TO FLOW FREELY TO THE STUFFING BOX LUBE INLET PRIOR TO THE PUMP'S STARTUP AND STROKING OF THE PLUNGERS.

CAUTION: PUMPS WHICH HAVE SAT IDLE FOR ANY APPRECIABLE PERIOD OF TIME (TWO WEEKS OR MORE) MUST HAVE THE PLUNGERS REMOVED, BE HAND COATED WITH PLUNGER LUBE OIL, AND REINSTALLED PRIOR TO OPERATION UNDER POWER. THE ELASTOMERIC PACKING RINGS WILL EVENTUALLY STICK TO THE PLUNGER SURFACE AND WILL BECOME DAMAGED UPON STARTUP IF NOT RE-LUBRICATED AS NOTED ABOVE.

When using a SPM[®] air operated plunger lube system, the audible sound of the air operated lubricant pump stroking once every one to two seconds will be an indicator of satisfactory plunger and packing lubrication.

For all styles of packing, the plunger lube is absolutely critical for good packing and plunger life. Failure to provide adequate or appropriate lube will cause the packing to fail and cause damage to mating components.

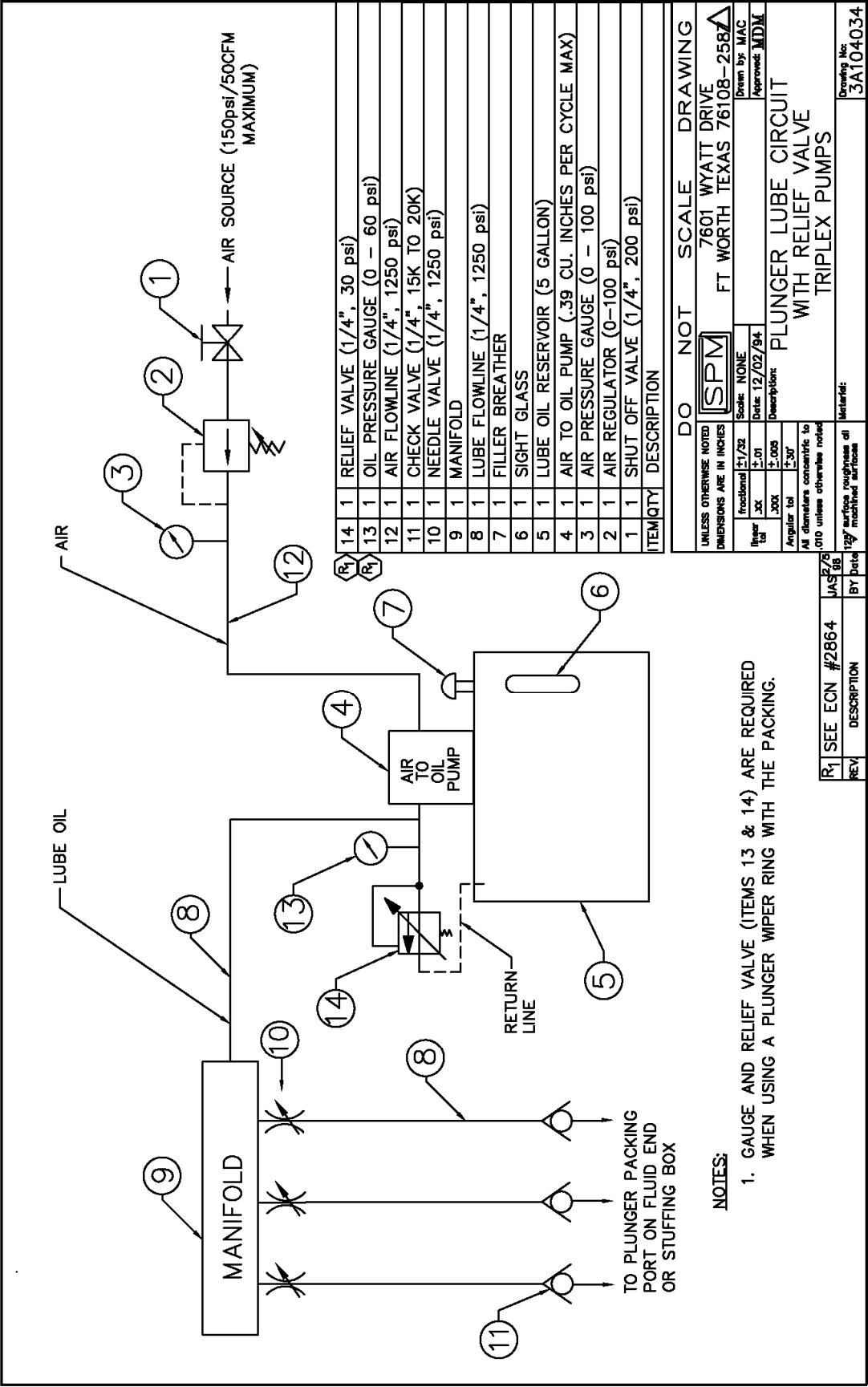
NOTE: LUBRICANTS THAT FAIL TO MEET THE PACKING LUBRICATION SPECIFICATIONS, AND ESPECIALLY "USED CRANKCASE OILS", ARE UNACCEPTABLE.

Recommended Plunger Grease Lube System:

If the end-user is going to modify the lubrication system to use grease, at their discretion, the plunger packing wiper ring **MUST** be flipped in the packing nut to allow a path for the excess grease to escape the packing bore chamber. Weir Oil & Gas recommends the use of a double or triple "ought" grease, 00 or 000.



Plunger Lube Circuit Diagram:



NOTES:
1. GAUGE AND RELIEF VALVE (ITEMS 13 & 14) ARE REQUIRED WHEN USING A PLUNGER WIPER RING WITH THE PACKING.

Supercharging System Requirements:

Due to the high-speed design characteristics associated with well service plunger pumps, supercharging the SPM[®] well service pump is necessary. The nature of well service operations (extreme variations in flow rates coupled with the pumping of heavy slurries) requires a well-designed supercharge system. The supercharging system must deliver an adequate supply of fluid to the plunger pump's suction manifold at high enough pressures and flow velocities to prevent the pump from starving for fluid while at the same time, maintaining fluid flow velocities high enough to keep solids suspended in the fluid slurry. A well designed supercharging system is extremely important in avoiding the harmful effects of cavitation and ensuring trouble-free service of the SPM[®] well service pump. A well-designed supercharging system will meet the following guidelines:

Primary Suction Piping and Hoses:

These are defined as the piping where the fluid first begins to flow from its source through gravity flow or atmospheric pressure only. This portion of the system is usually a pipe or hose that connects the fluid reservoir to the charge pump or blender suction pump. The flow velocity (based on the plunger pump's maximum flow rating with the size plunger being used) in this portion of the system must not exceed 4 feet per second in order to flow freely under atmospheric pressure or gravity flow. Other guidelines are as follows:

- Hoses must be oil and chemical resistant wire reinforced combination vacuum/discharge hose rated at 305inHg/150 PSI minimum.
- If steel piping is used; all piping runs must be installed so that they are level or progressively higher toward the plunger pump in order to prevent air traps in the system. When used, reducer fittings should be of the eccentric type and installed "belly down" in order to prevent air traps. All welded connections must be air and fluid tight.
- All piping or hoses in this portion of the system should be kept as short as possible (10 feet or less and should be free of excessive bends and turns).

Centrifugal Supercharge Pump/Mixing Pump:

Some well servicing operations require the use of two centrifugals - one for mixing a slurry and the other for supercharging the plunger pump. When two centrifugals are used, they must both meet the following guidelines:

- Must be capable of delivering the rated maximum flow of the plunger pump while **maintaining 80 PSI (185 feet head) minimum at the plunger pump suction inlet during all phases of the well service job.** Must be sized appropriately to overcome any friction losses in the piping between the centrifugal's discharge and the SPM[®] plunger pump's suction inlet. For example, depending on the length and the layout of the piping, the centrifugal may have to be sized to deliver the required flow at higher pressures at its discharge in order to maintain 80 PSI (185 feet head) at its discharge in order to maintain 80 PSI (185 feet head) at the plunger pump suction inlet.
- Must be operated at a speed which will deliver the required flow within the upper 25% of its efficiency range in order to assure adequate fluid acceleration on demand from the plunger pump.
- Must be adequately powered to deliver the plunger pump's fluid requirements based on volume, pressure, and the specific gravity of the fluid or slurry.

Secondary Suction Piping and Hoses:

These are defined as the piping that carries fluid under pressure from the discharge of the centrifugal pump to another point in the system. This is the piping which connects the centrifugal charge pump to the SPM[®] plunger pump suction inlet and can also be the piping which connects the centrifugal mixing pump's discharge to a mixing tub inlet. The flow velocity in this portion of the system (based on the plunger being used) should range from 8 to 12 feet per second. Other guidelines are as follows:

- Hoses must be oil and chemical resistant wire reinforced combination vacuum/discharge hose rated at 203inHg/100 PSI minimum.
- If steel piping is used; all piping runs must be installed so that they are level or progressively higher toward the plunger pump in order to prevent air traps in the system. When used, reducer fittings should be of the eccentric type and installed "belly down" in order to prevent air traps. All welded connections must be air and fluid tight.
- All piping and hoses in this portion of the system should be kept as short as possible (10 feet or less) and should be free of excessive bends and turns.

Suction Pulsation Dampener (when a suction stabilizer dampening manifold is not used):

Due to the plunger pump's positive displacement design, a naturally occurring fluid rhythm is generated in the supercharge system as the fluid stops and starts at each suction valve. The varying pressure signal created by this fluid rhythm reduces the effectiveness of the charge pump and the SPM[®] pump unless the pressure signal is dampened out of the system. A suction pulsation dampener is necessary to ensure adequate fluid acceleration when each suction valve opens, which will help prevent cavitation, and will result in a much smoother operating pump and longer lasting expendables. Guidelines for using a suction pulsation dampener are as follows:

- A pulsation dampener of the nitrogen charged bladder type should be rated at 150 PSI minimum, or a closed cell foam style dampener.
- Should be installed above the fluid flow path or in line with the fluid flow path so that solids in the fluid cannot settle and pack around the bladder.
- Should be installed as close to the plunger pump's suction manifold inlet side, or if not possible as close as possible to the suction inlet for maximum effectiveness.
- Must be pre-charged according to the manufacturer's recommendations (usually 60% to 80% of the anticipated supercharge pressure).

CAUTION: BLADDER OR CLOSED CELL FOAM TYPE UNITS ARE NOT RECOMMENDED FOR CO₂ SERVICE. CHECK BLADDER COMPATIBILITY TO THE FRAC FLUID BEING PUMPED.

WARNING: FOR CO₂ SERVICE, USE AN SPM[®] CO₂ APPROVED SUCTION MANIFOLD WITHOUT A SUCTION STABILIZER. USING NON-RATED EQUIPMENT CAN RESULT IN PRESSURE VESSEL FAILURE DUE TO THERMAL SHOCK. **INJURY OR DEATH** CAN RESULT FROM USING EQUIPMENT NOT RATED FOR CO₂ SERVICE. NO VIC GROOVE END CONNECTIONS, HAMMER UNION ONLY.

Supercharge Pressure Gauge:

Supercharge pressure gauge should always be used in the system and should meet the following guidelines:

- Should be a liquid filled 0 to 150 PSI pressure gauge.
- Should be installed as close to the plunger pump suction inlet as possible for maximum accuracy.
- Should be used with a gauge snubber or a needle valve which can be adjusted to act as a snubber.

Supercharging System Operational Parameters:

- The recommended Supercharge Pressure at the plunger pump suction inlet is **80 PSI (185 feet head) minimum to 100 PSI (230 feet head) maximum.**

NOTE: THE SUPERCHARGE PRESSURE MUST ALWAYS BE GREATER THAN THE VAPOR PRESSURE OF THE FLUID BEING PUMPED.

CAUTION: ALLOWING VELOCITIES IN THE PRESSURIZED PORTION OF THE SYSTEM TO FALL BELOW 8 FEET/SECOND IN WATER WILL RESULT IN THE FRAC SAND NOT REMAINING IN SUSPENSION AND CAN RESULT IN SAND-OFF AND EQUIPMENT DAMAGE.

- Number of 4" suction hoses required to maintain 4 feet per second maximum fluid velocity in "gravity feed" portion of the system:

	GPM FLOW	BPM FLOW	NUMBER OF 4" HOSES REQ'D
Up to:	157	3.7	One
Up to:	313	7.5	Two
Up to:	470	11.2	Three
Up to:	626	14.9	Four
Up to:	783	18.6	Five
Up to:	940	22.4	Six
Up to:	1096	26.1	Seven
Up to:	1253	29.8	Eight
Up to:	1409	33.5	Nine
Up to:	1566	37.3	Ten

- Steel pipe size required to maintain 4 feet per second maximum fluid velocity in "gravity feed" portion of the system:

	GPM FLOW	BPM FLOW	PIPE SIZE REQ'D
Up to:	156	3.7	4" I.D.
Up to:	250	5.9	5" I.D.
Up to:	353	8.4	6" I.D.
Up to:	626	14.9	8" I.D.
Up to:	979	23.3	10" I.D.
Up to:	1410	33.6	12" I.D.
Up to:	1719	40.9	14" I.D.

- Number of 4" suction hoses required to maintain 12 feet per second maximum fluid velocity in the "pressurized" portion of the system:

	GPM FLOW	BPM FLOW	NUMBER OF 4" HOSES REQ'D
Up to:	470	11.1	One
Up to:	940	22.3	Two
Up to:	1409	33.5	Three
Up to:	1879	44.7	Four

- Steel pipe size required to maintain 12 feet per second maximum fluid velocity in the "pressurized" portion of the system.

	GPM FLOW	BPM FLOW	PIPE SIZE REQ'D
Up to:	264	6.2	3" I.D.
Up to:	470	11.1	4" I.D.
Up to:	734	17.4	5" I.D.
Up to:	1057	25.2	6" I.D.
Up to:	1880	44.8	8" I.D.



Recommended Practice for Pump Packing:

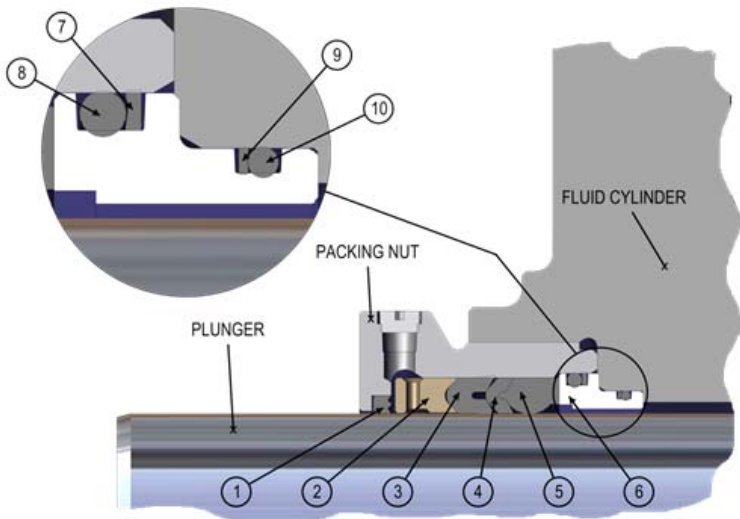
SPM® Well Service Pump Packing

For use in the SPM® TWS 600S and QWS 1000S pumps for cementing, acidizing, and other well service applications. This offering is rated up to 15,000 psi.

- General Service - Standard header and pressure rings for basic applications
- Enhanced General Service - Pairs enhanced header rings with standard pressure rings for extended performance

NOTE: The HD Service offering is ONLY for use in SPM® TWS 600S HD and QWS 1000S HD pumps or in models of the TWS 600S and QWS 1000S that have been retrofitted with SPM® HD retrofit kits.

WELL SERVICE (CEMENT)



Item	Qty	Description	Complete Set	Soft Packing Set
1	1	Wiper Ring	X	X
2	1	Lantern Ring	X	
3	1	Tall Pressure Ring	X	X
4	1	Pressure Ring	X	X
5	1	Header Ring	X	X
6	1	Seal Ring	X	
7	1	Backup Ring	X	X
8	1	O-Ring	X	X
9	1	Backup Ring	X	X
10	1	O-Ring	X	X

*Note position of items
7 & 9

Size	General Service		Enhanced Service	
	Soft Set	Complete Set	Soft Set	Complete Set
2-1/2"	P139815	2A140366	P139827	2A140367
2-3/4"	P139817	2A140369	P139829	2A140370
3"	P139819	2A140372	P139831	2A140373
3-1/2"	P139821	2S140375	P139816	2A140376
4"	P139823	2A140378	P139818	2A140379
4-1/2"	P139825	2A140381	P139820	2A140382





Tach Drive/Rate Meter Calibration Specifications:

PLUNGER DIAMETER IN (MM)	*FLUID DISPLACEMENT					
	PER TACH DRIVE REVOLUTION @95% V.E.			PER TACH DRIVE REVOLUTION @100% V.E.		
	GPR	BPR	LPR	GPR	BPR	LPR
2 1/2 (63.5)	0.0727	0.00173	0.2751	0.0765	0.00182	0.2896
2 3/4 (69.9)	0.0879	0.00209	0.3328	0.0926	0.00220	0.3504
3 (76.2)	0.1047	0.00249	0.3961	0.1102	0.00262	0.4170
3 1/2 (88.9)	0.1424	0.00339	0.5391	0.1499	0.00357	0.5675
4 (101.6)	0.1860	0.00443	0.7042	0.1958	0.00466	0.7413
4 1/2 (114.3)	0.2355	0.00561	0.8912	0.2479	0.00590	0.9381

NOTE: THE VOLUMETRIC EFFICIENCY AND RESULTING DISPLACEMENT WILL VARY SLIGHTLY DUE TO OPERATIONAL FACTORS SUCH AS PUMP SPEED, SUPERCHARGE CONDITIONS, AND THE SPECIFIC GRAVITY OF THE FLUID BEING PUMPED.

V.E. = VOLUMETRIC EFFICIENCY OF PUMP
GPR = U.S. GALLONS PER REVOLUTION
BPR = U.S. BARRELS PER REVOLUTION
LPR = LITER PER REVOLUTION



Startup and Break-In Procedure:

Each new pump must undergo a brief but thorough startup and break-in procedure in order to verify the field worthiness of the unitized pumping system and in order to allow a gradual “wearing in” of various mating parts in the pump itself. The following guidelines have been established by SPM to minimize startup problems and insure maximum service from the plunger pump:

A. Inspection Prior to Starting Engine:

1. Check to see that all masking tape, rust preventative, etc. has been removed from moving parts such as plungers, pinion shaft, etc.
2. Check to see that the plunger pump is securely bolted to skid or truck frame.
3. Check to see that the driveline is securely fastened to the plunger pump's input shaft and that adequate slip is present in the driveline's slip joint.
4. Check to see that the power end lube oil reservoir was flushed and drained then filled with the proper type of gear oil.
5. Check to see that the plunger lube oil reservoir was flushed and drained then filled with the proper type of rock drill oil.
6. Check to see that the supercharge piping system has been completely flushed and all piping connections are tight.
7. Check to see that the power end lube system startup adjustments and plunger lube system startup adjustments were performed.
8. Check to see that the suction pulsation dampener has been precharged properly.
9. Check to see that the primary suction piping is connected to an adequate supply of cool clean water for testing.
10. Check to see that the plunger pump's discharge piping is safely installed all the way back to the water reservoir. Check to see that all connections are tight and all valves are open.
11. Start the supercharge pump and flush all air from the entire system.
12. Follow the engine manufacturer's recommendations for engine startup and warmup.

B. Warmup Procedure Prior to Rotating the Plunger Pump:

1. While operating the engine at idle and transmission in neutral, check the power end lube pump vacuum reading, the power end lube oil pressure, and the power end lube oil temperature. If the lube pump vacuum reading is less than 10" Hg, gradually increase the engine RPM to determine whether full engine RPM can be reached without exceeding 10" Hg at the power end lube pump suction inlet.
2. Continue running the engine at or below 10" Hg lube pump vacuum as necessary to warm and thin the power end lube oil. The plunger pump should not be rotated until full engine RPM can be achieved without exceeding 10" Hg at the lube pump suction inlet or until the power end lube oil temperature reaches 60F minimum.

C. Plunger Pump Valve Seating Procedure:

1. In order to protect the fluid cylinder from washing before sustained pumping begins, the tapered valve seats must be pressured up and fully seated creating a positive fluid seal.
2. Adjust the test choke for high pressure/low pump RPM. Shift the transmission to 1st gear and slowly increase the throttle setting, to achieve the values in the table below, for 2 to 3 minutes or until a series of audible popping noises are heard. This indicates the seats have properly set in the taper. The desired pressure for each plunger size is as follows:

PLUNGER DIAMETER IN (MM)		SEATING PRESSURE PSI (MPA)	
2 1/2	(63.5)	9,400	(64.8)
2 3/4	(69.9)	9,400	(64.8)
3	(76.2)	9,400	(64.8)
3 1/2	(88.9)	4,600	(31.7)
4	(101.6)	4,600	(31.7)
4 1/2	(114.3)	4,600	(31.7)

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 end lube oil temperature, power end lube oil pressure, supercharge pressure, etc. After returning the engine to idle and transmission to neutral, physically inspect the plunger pump before proceeding further.

D. Break-In Procedure:

1. Adjust the test choke, engine, and transmission according to the values below. These settings should be approximately as follows:

PLUNGER DIAMETER IN (MM)		INPUT SPEED PINION PUMP RPM		POWER BHP KW		PRESSURE PSI MPA		FLOW RATE GPM BPM LPM		
2 1/2	(63.5)	1400	304	270	201.3	3586	24.7	116	2.8	440
2 3/4	(69.9)					2963	20.4	141	3.3	532
3	(76.2)					2490	17.2	167	4.0	633
3 1/2	(88.9)					1829	12.6	228	5.4	862
4	(101.6)					1401	9.7	297	7.1	1126
4 1/2	(114.3)					1107	7.6	376	9.0	1425

Run the plunger pump at this setting for one hour. During this time, 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 end lube oil temperature, power end lube oil pressure, supercharge pressure, etc. After returning the engine to idle and the transmission to neutral, physically inspect the plunger pump before proceeding further.

2. Adjust the test choke, engine, and transmission according to the values below. These settings should be approximately as follows:

PLUNGER DIAMETER IN (MM)	INPUT SPEED PINION PUMP RPM	POWER		PRESSURE		FLOW RATE		
		BHP	KW	PSI	MPA	GPM	BPM	LPM
2 1/2 (63.5)	1105 240	305	227.4	5129	35.4	92	2.2	347
2 3/4 (69.9)		331	247.0	4604	31.7	111	2.6	420
3 (76.2)		360	268.5	4204	29.0	132	3.1	500
3 1/2 (88.9)		380	283.4	3261	22.5	180	4.3	680
4 (101.6)				2496	17.2	235	5.6	889
4 1/2 (114.3)				1972	13.6	297	7.1	1125

Run the plunger pump at this setting for one hour. During this time, 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 end lube oil temperature, power end lube oil pressure, supercharge pressure, etc. After returning the engine to idle and the transmission to neutral, physically inspect the plunger pump before proceeding further.

3. Adjust the test choke, engine, and transmission according to the values below. These settings should be approximately as follows:

PLUNGER DIAMETER IN (MM)	INPUT SPEED PINION PUMP RPM	POWER		PRESSURE		FLOW RATE		
		BHP	KW	PSI	MPA	GPM	BPM	LPM
2 1/2 (63.5)	811 176	340	253.5	7795	53.7	67	1.6	255
2 3/4 (69.9)		392	292.7	7437	51.3	81	1.9	308
3 (76.2)		450	335.6	7164	49.4	97	2.3	367
3 1/2 (88.9)		490	365.4	5731	39.5	132	3.1	499
4 (101.6)				4388	30.3	172	4.1	652
4 1/2 (114.3)				3467	23.9	218	5.2	825

Run the pump at this setting for 30 minutes. During this time, 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 end lube oil temperature, power end lube oil pressure, supercharge pressure, etc. After returning the engine to idle and the transmission to neutral, physically inspect the plunger pump before proceeding further.

4. Adjust the test choke, engine, and transmission according to the values below. These settings should be approximately as follows:

PLUNGER DIAMETER IN (MM)	INPUT SPEED PINION PUMP RPM	POWER		PRESSURE		FLOW RATE		
		BHP	KW	PSI	MPA	GPM	BPM	LPM
2 1/2 (63.5)	516 112	375	279.6	13500	93.1	43	1.0	162
2 3/4 (69.9)		454	338.4	13500	93.1	52	1.2	196
3 (76.2)		540	402.7	13500	93.1	62	1.5	234
3 1/2 (88.9)		600	447.4	11020	76.0	84	2.0	318
4 (101.6)				8438	58.2	110	2.6	415
4 1/2 (114.3)				6667	46.0	139	3.3	525

Run the pump at this setting for 30 minutes. During this time, 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 end lube oil temperature, power end lube oil pressure, supercharge pressure, etc. Return the engine to idle, the transmission to neutral, and kill the engine.

5. Visually inspect the power end for oil leaks around the plunger seals, pinion seal, lubrication hoses, lube drain hoses, covers, etc.

Visually inspect the fluid end for fluid leaks around the suction covers, discharge covers, discharge flanges, stuffing boxes, and suction manifold. Visually inspect the plungers for any signs of heating or scoring.

Remove the power end lube system magnet and inspect for any unusually large particles of metal. Change the lube oil filters.

* Pressure is limited to 15,000 PSI due to discharge flange and plunger configuration. For higher pressure, contact Weir Oil & Gas engineering department.

SECTION III: MAINTENANCE AND REPAIR:

Routine Preventative Maintenance:

Maximum service and trouble-free operation can be obtained from the SPM[®] well service plunger pump by establishing a thorough preventive maintenance program as follows:

During The First 100 Hours of New Pump Operation:

- Thoroughly clean the power end lube oil suction strainer after the first 50 hours and 100 hours operation.
- Change the power end lube oil after the first 100 hours operation and clean the lube oil reservoir.
- Change the power end lube filters.

Daily Preventive Maintenance:

- Check the oil level in the power end lube oil reservoir.
- Check the oil level in the plunger lube oil reservoir.
- Check the plunger pump for oil leaks and/or fluid leaks.
- Check the power end lube oil system for leaks.
- Check the plunger lube system for leaks.
- Check the supercharge piping for leaks.
- Visually check for loose fasteners in the following locations:
 - Power End mounting bolts.
 - Stay Rods, and fluid end attachment nuts.
 - Discharge Flanges.
 - Companion Flange.
 - Packing Nuts.
 - Retainer and Discharge Nuts.
 - If the suction stabilizer has a nitrogen filled bladder, check the nitrogen charge pressure and correct as needed. Follow the manufacturer's charging pressure recommendations, usually 60%-80% of suction inlet pressure.

Weekly Preventive Maintenance:

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

Monthly (or every 200 hours) Preventive Maintenance:

- Check all items on "daily" and "weekly" lists.
- Check all fluid cylinder mounting bolts to insure that they are tight with a torque wrench.
- Check all plunger pump-mounting bolts to insure that they are tight.
- Change power end lube oil filters.
- 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.
- Check condition of valve springs; check weight and tension.

Quarterly (or every 600 hours) Preventive Maintenance:

- Check all items on "daily", "weekly", and "monthly" list.
- Change the power end lube oil and refill with the proper grade of gear oil for upcoming ambient conditions.
- Thoroughly clean the power end lube oil suction strainer.

Quarterly (or every 600 hours) Preventive Maintenance (Cont.):

- Change power end filters.
- Remove and inspect the plungers and packing assembly components. Replace all packing pressure rings and header rings.
- Clean the plunger pump's oil breather and the power end lube oil reservoir breather.
- Replace fluid end valve springs.

Yearly (or as required) Preventive Maintenance:

- Replace worn 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.
- Inspect (and rebuild if necessary) the power end lube oil pump.
- Replace the shell bearings. Retorque connecting rod housing bolts to correct torque values.

It is difficult to assess wear and tear on a pump based solely on hours operated, due to the variations in duty cycle and types of service. However, roller bearings, rod bearings and gearing may need replacing after approximately 1200 to 3000 hours. With either component, signs of extensive wear will generally show up as spalling, or flaking off, of material causing pitting or scoring on the working surfaces. A small amount of this is tolerable on gear faces, but any spalling on a bearing surface is an indication to replace that item as quickly as feasible.

Failure of a main bearing can quite often lead to power frame, crankshaft, or other serious damage.

Close observation of the lube oil filters during routine maintenance will generally indicate the condition of roller bearings, gears, and journal bearings. A routine of pulling the inspection covers and inspecting the condition of the bearings and gears every **1000** hours is recommended.

Expendable Components:

A. Expendable life improvement techniques:

a. Valves and valve seats

Valves and valve seats wear out faster than any other expendable due to valve seat damage from frac sand and cavitation corrosion pitting. Valve life can be extended by keeping valve-flow-through velocities below 12 feet/sec and by using a properly sized, correct style and properly installed pulsation suction stabilizer.

WARNING: VALVES AND VALVE SEATS MUST BE REPLACED PRIOR TO FAILURE. FAILURE OF A DISCHARGE AND SUCTION VALVE IN THE SAME PLUNGER PRESSURE CHAMBER CAN RESULT IN DISCHARGE (WELL BORE) PRESSURE ENTERING THE SUCTION MANIFOLD. FAILURE OF THE SUCTION MANIFOLD, SUCTION FLOW LINES OR HOSES CAN RESULT. INJURY, DEATH OR ENVIRONMENTAL DAMAGE CAN OCCUR. USE OF A CHECK VALVE IN THE FLOW LINE IS RECOMMENDED.

Expendable Components (Cont.):

b. Fluid End

Fluid Ends commonly fail by cracking in the crossbore. The time of failure can be extended by a properly sized suction stabilizer. If it is a nitrogen bladder type, check the charge pressure before each job.

NOTE: WHEN CHANGING VALVES USE A MIRROR AND FLASHLIGHT TO CHECK FLUID CYLINDER FOR CRACKS, AND WIPE ALL SURFACES CLEAN.

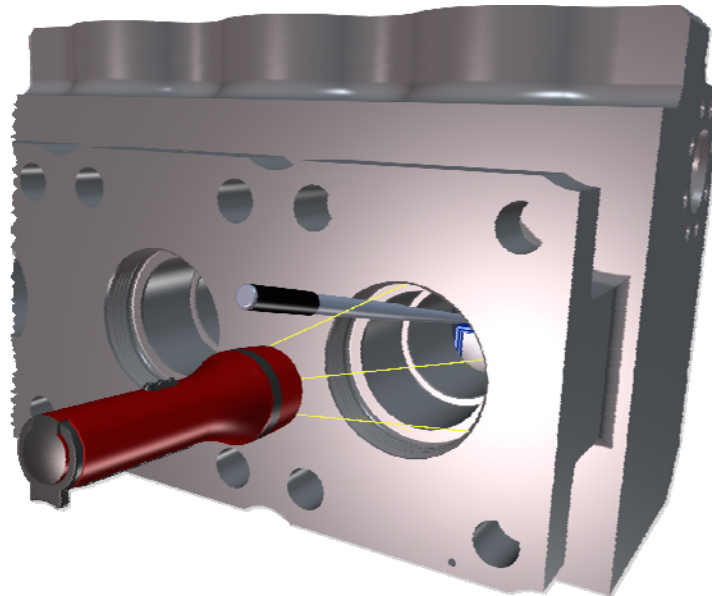
c. Plungers

Plungers should be replaced if the hard coating is worn, if they have dents or dings, spalling of the plunger coating, or grooving.

d. Packing

Packing should be replaced prior to failure. Packing failure can lead to washout of the packing gland. Between stages, check to see that all packing nuts are tight.

CAUTION: FAILURE TO PROPERLY MAINTAIN PACKING OR ALLOWING THE PACKING NUT TO LOOSEN CAN RESULT IN ENVIRONMENTAL DAMAGE.



Troubleshooting Guide:

TROUBLE SYMPTOM:	PROBABLE CAUSE:
A.) Abnormally high vacuum at power end lube pump suction inlet (may or may not be accompanied by abnormally low oil pressure).	1. Extremely cold ambient temperature/dangerously high oil viscosity. 2. Clogged lube system suction strainer. 3. Kinked or collapsed lube system suction hose. 4. Clogged oil reservoir breather. 5. Erroneous gauge reading. 6. Closed tank valve.
B.) Abnormally low power end lube oil pressure with normal to low vacuum reading at lube pump suction (may or may not be accompanied by high oil temperature).	1. Leak in lube pump suction piping, which allows air to be drawn into the system. 2. Worn or damaged lube pump. 3. Leak in lube pump pressure piping. 4. Low oil level in reservoir. 5. Clogged oil filter element. 6. Faulty lube system relief valve. 7. Extremely hot lube oil temperature/dangerously low oil viscosity. 8. Erroneous gauge reading.
C.) Abnormally high power end lube oil temperature (may or may not be accompanied by low oil pressure).	1. Extremely warm ambient temperature/dangerously low oil viscosity/incorrect grade of gear oil. 2. Gear oil contaminated with water, trash, or air bubbles. 3. Plunger pump has been operated continuously for too long a period of time at or near its maximum horsepower or torque rating. 4. Heat exchanger or oil cooler malfunction. 5. Erroneous gauge reading. 6. Internal power end damage or power end wear. 7. Thermostatic valve malfunction.
D.) Leaking power end oil seals.	1. Extremely cold ambient temperature/high oil viscosity. 2. Damaged seal surface on mating parts. 3. Clogged oil breather/high crankcase pressure. 4. Worn or damaged seal. 5. Contaminated lube oil. 6. Loose inspection cover bolts, torn inspection cover gaskets, or sealing bonded inspection cover bolt washers.
E.) Leaking lube lines.	1. Loose fittings, damaged hoses, or fittings.
F.) Leaking fluid end seals.	1. Seal installed improperly. 2. Seal cut or pinched on installation. 3. Mating seal surface not cleaned properly prior to seal installation. 4. Damaged or corroded mating seal surface. 5. Sealing part not properly tightened.



TROUBLE SYMPTOM:	PROBABLE CAUSE:
G.) Plunger and/or packing fluid leak.	1. Packing nut not tightened properly. 2. Worn or damaged packing. 3. Packing installed improperly. 4. Mating seal surface not cleaned properly prior to packing installation. 5. Damaged or corroded mating seal surface. 7. Fluid being pumped is incompatible with the style packing being used. 8. Wiper ring damaged or installed improperly.
H.) Fluid knock or hammer.	1. Air entering supercharge system through loose, worn or damaged connections. 2. Air entering supercharge system through leaking charge pump seals. 3. Fluid being pumped contains gas or vapor. 4. Insufficient supercharge flow or pressure. 5. Valve cocked open/broken valve spring or valve stop. 6. Worn or damaged valve, valve insert, or valve seat. 7. Improperly charged or ineffective suction pulsation dampener.
I.) Low discharge pressure/rough running pump.	1. Worn or damaged valve assemblies. 2. Insufficient supercharge flow or pressure. 3. Air, gas, or vapor in fluid being pumped. 4. Improperly charged or ineffective suction pulsation dampener. 5. Two or more plunger pumps being supercharged by a common charge pump and getting "in phase" with each other. 6. Pump has not been primed properly.

SPM® TWS600S Fluid End Repair Procedures:

To remove Valves and Seats:

1. Using the SPM® 2" hex cover wrench and a 10lb. hammer, remove the suction covers and discharge covers from the fluid cylinder.
2. Turn the suction valve stops approximately 90 degrees and remove them from the fluid cylinder along with the valve springs underneath them.
3. Using an SPM® magnetic valve removal tool, cock each suction valve to one side in order to drain any fluid standing over it, and remove the valve from the fluid cylinder. Follow the valve manufacturer's recommendation of removing the insert from the valve.
4. Remove the discharge valve springs and discharge valves from the fluid cylinder.
5. Using an SPM® hydraulic seat puller assembly, remove each of the discharge valve seats and suction valve seats.
6. The tapered valve seat bore in the fluid cylinder must be thoroughly cleaned and lightly hand polished with a 220 to 240 grit emory cloth prior to installing new valve seats.
7. Always install a new o-ring seal when reinstalling a valve seat. Do not use any type of 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, hammer the valve seat into the taper.
8. 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.
9. When reinstalling the suction valve stop, make certain it is turned perpendicular to the plunger and securely seated in the groove in the cylinder. **Note also the orientation of the valve stop. If the wings on the stop are not symmetrical, they must be pointed towards the suction cover and away from the plunger. (See Engineering Bulletin 1003 for more detail).**
10. 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 a 220 to 240 grit emory cloth prior to cover installation.
11. 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.



To Change Plungers and Packing:

1. Remove the plunger lube fitting from each packing nut.
2. Using the SPM[®] packing nut tool, loosen each of the packing nuts at least one full turn.
3. Remove the suction covers as outlined earlier in "To Remove Valves & Seats".
4. Using the SPM[®] plunger wrench, 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 end section once the plunger is removed.
5. After securing the seal ring with the SPM[®] seal ring retainer or another suitable tool, completely remove each packing nut from the packing gland thread bore. The seal ring must remain in the cylinder while the packing nut is being removed. Once the packing nut is removed, the seal ring may then be removed from the cylinder. Label each packing nut on removal to ensure that they are installed back into the same bore.
6. Inspect each plunger for wear, scoring, and corrosion on the hard surface area and damage to the face which mates with the crosshead.
7. Inspect each ring of packing brass for excessive wear and scoring.
8. Blow air through the lube port on each packing nut to ensure that the lube passage is unobstructed.
9. 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 emory cloth prior to packing reinstallation.
10. 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.
11. 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 emory cloth. Reinstall the seal ring as shown in the packing assembly diagram.
12. Reinstall each packing nut into its proper cylinder, screwing it all the way in until tight, then backing it off one to two turns.
13. Coat the hard surface area of each plunger with a light oil and insert it into the packing. Using an aluminum bar and 12 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; or for solid studded plungers, until the stud approaches the crosshead threads. Carefully align the plunger and crosshead and gently bump the plunger up against the crosshead.
14. Tighten the plunger to the crosshead with the SPM plunger wrench to achieve torque as shown in the installation illustrations.
15. Using the SPM[®] packing nut wrench, packing tighten each nut as tight as possible.

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.

16. Reinstall the packing lube fitting into the packing nut.
17. Reinstall the suction covers as outlined earlier in "To Remove Valves and Seats".

To Remove Discharge Flanges:

1. Using a 1 $\frac{5}{8}$ " wrench, remove the four 1" nuts from each of the two discharge flanges.
2. 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 to 240 grit emory cloth prior to reinstallation.
3. 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 emory cloth prior to reinstalling the discharge flanges.
4. Using new fluid seals and a coating of light oil, reinstall each discharge flange being careful to avoid damaging the seal on the inlet side of the flange. Reinstall the four 1" hex nuts on each flange and evenly tighten them to the proper torque (refer to the Torque Table included in this manual).

To Remove the Suction Manifold:

1. Using a 1 $\frac{1}{8}$ " wrench, remove the twelve 3/4" capscrews which secure the suction manifold to the fluid cylinder, and drop the suction manifold away from the fluid cylinder.
2. 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 SPM[®] 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. 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.
3. 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 emory cloth prior to reinstalling the suction manifold.
4. Using new o-ring seals, reinstall the suction manifold. Reinstall the twelve 3/4" capscrews and evenly tighten them to the proper torque (refer to the Torque Table included in this manual).



To Remove The Fluid End:

1. Disconnect the plunger from the crosshead using the SPM[®] plunger wrench as outlined earlier in Section B "To Change Plunger and Packing".
2. Disconnect the plunger lube hoses and whatever discharge piping connections and suction piping connections are necessary for fluid end removal.
3. Support the fluid cylinder, and then remove the four (4) 1" bolts & the four (4) 1³/₈" bolts which secure the fluid cylinder to the power end.
4. 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.
5. Clean and lubricate the fluid cylinder mounting bolt threads, and hand tighten the (8) bolts. Using a torque wrench, tighten the four (4) 1" bolts to 500 ft-lbs, and the four (4) 1³/₈" bolts to 1300 ft-lbs.
6. Reconnect all hose and piping connections and tighten plunger to crosshead to torque of 250 to 350 ft-lbs.

Suction Valve Stop Installation for Grooved Fluid Ends:

1. To insert valves, valve seats, and springs; Follow instructions in the “To remove valves and seats” section of this manual.
2. Insert valve stop and turn valve stop approximately 90 degrees. Ensure that it is properly seated in the grooves in the cylinder and that it is turned perpendicular to the plunger. (Fig. 6)

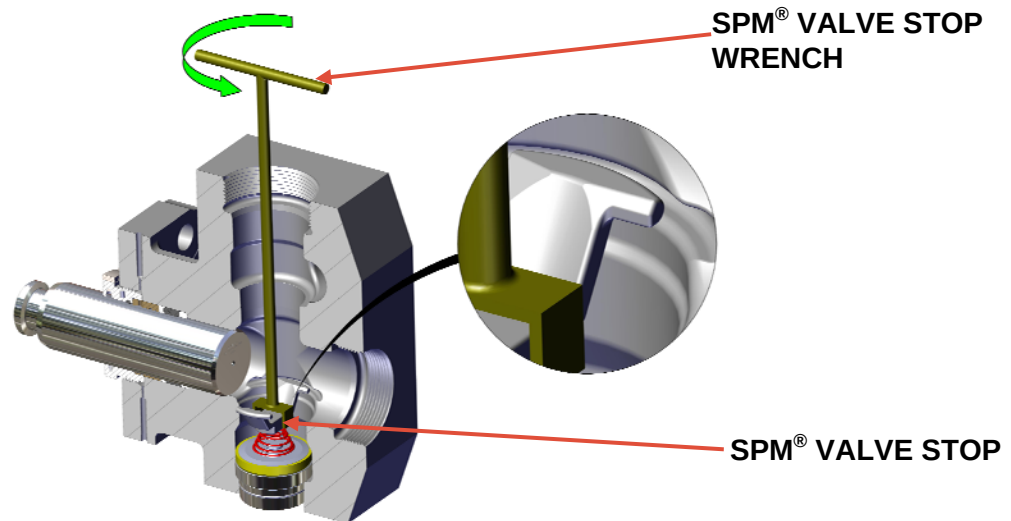


Figure 6

3. Follow “To remove valves and seats” section of this manual for prepping covers and fluid cylinder for installation.
4. Reinstall the discharge covers and suction covers using the SPM® slide hammer. Care must be taken to keep the discharge valve springs aligned properly while installing the discharge covers. (Fig. 7)

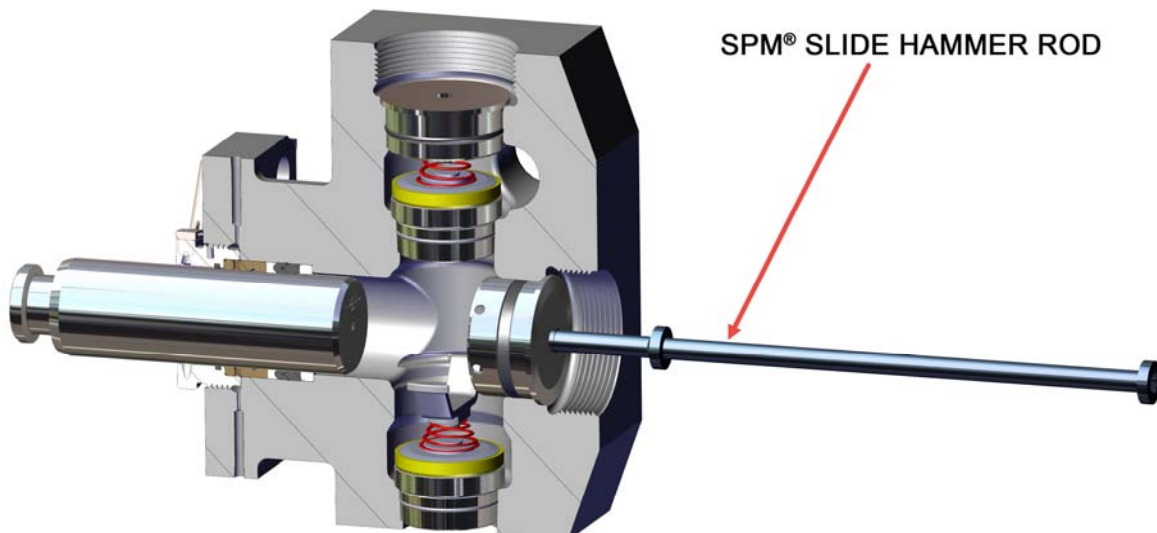


Figure 7

5. Using the SPM[®] hex cover wrench and 6 pound hammer, reinstall the discharge and suction cover retainer nuts per instructions in the “to remove valves and seats” section of this manual. (Typically two or three blows with the hammer will seat the cap and nut). (Fig. 8)

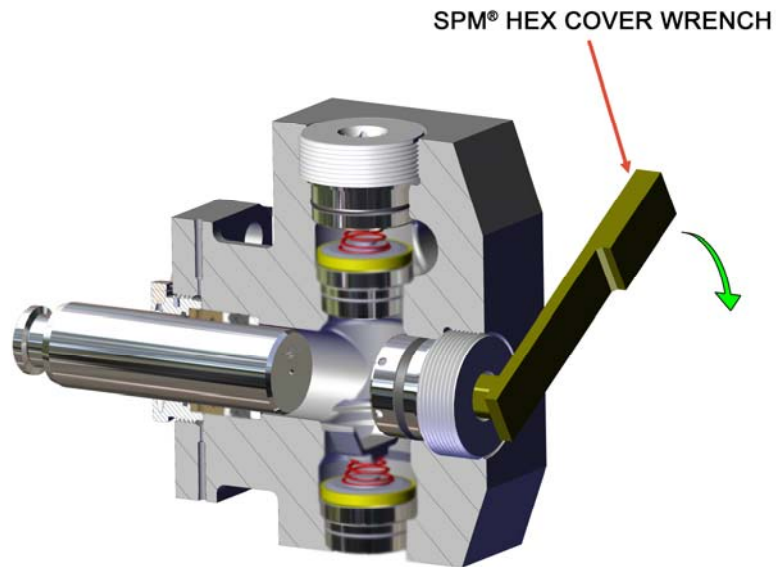


Figure 8



SECTION IV: SERVICE AND SUPPORT

General Information:

Weir Oil & Gas stocks a large inventory of genuine original equipment replacement parts for each of its pumps. In order to expedite a parts order and avoid any delays, please provide the following information with your order:

1. The part number and description (refer to drawings and parts lists in this section) of each item ordered.
2. The quantity of each part, kit, or assembly ordered.
3. The model number and serial number of the pump (see identification tags on the fluid end and power end).
4. Your purchase order number.
5. Specify method of shipment, complete shipping address, complete billing address and telephone number at the destination of the shipment.

There is a 25 percent restocking charge for any returned, undamaged parts. Returned parts must include a SPM® issued "Return Authorization Number" on the shipping label and packing list. Parts must be returned within 90 days of the original shipping date. Returned parts must be shipped prepaid, to the appropriate address, including a copy of the original invoice or delivery ticket.

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Spare Parts and Usages

Item	Description	Quantity	Replacement
1	Insert, Valve	90	24 Days
2	Valve	90	24 Days or AR
3	Seat	90	24 Days or AR
4	Seal, O-ring for seat	12	As Required
5	Spring, Valve	12	180 Days
6	Packing, Complete	6	As Required
7	Packing, Soft Set	24	45 Days or AR
8	Plunger	6	As Required
9	Stud, Plunger	6	As Required
10	Seal, D ring, Suction Cover	72	15 Days or AR
11	Seal, D ring, Discharge Cover	72	15 Days or AR
12	Seal, D ring, Discharge Flange	4	Quarterly or AR
13	Seal Ring, 2 inch	16	60 Days or AR
14	Seal, O-ring for Suction Manifold	12	90 Days or AR
15	Seal, Oil, Diaphragm	24	45 Days or AR
16	Gasket, Seal, Oil, Diaphragm	24	45 Days or AR
17	Ring, Deflector	24	45 Days or AR
18	O-ring, Ring, Deflector	24	45 Days or AR
19	Stop, Valve	3	365 Days or AR
20	Packing Nut	1	As Required
21	Cover, Suction	1	As Required
22	Cover, Discharge	1	As Required
23	Gauge Port Connection	1	As Required
24	Nut, Retainer	1	As Required
25	Flange, Discharge, 2 inch 1502	1	As Required
26	Seal, Oil, Input, Gearbox	2	180 Days or AR
27	Oil Breather, Power End	1	As Required
28	Seat Puller	1	As Required
29	Lifter, Valve	1	As Required
30	Lifter, Valve	1	As Required
31	Valve Stop Tool	1	As Required
32	Tool Kit	1	As Required

Notes:

- AR = As Required
- Part numbers can vary from model to model, the are not referenced in this document.
- Replacement times are recommended replacement times. Actual operation conditions can alter these times, depending on usage and other operational conditions.



Fluid End Drawings: