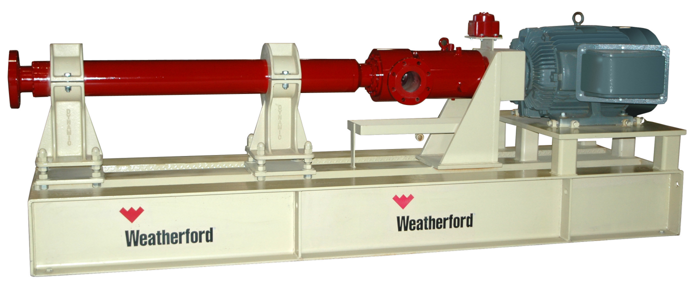
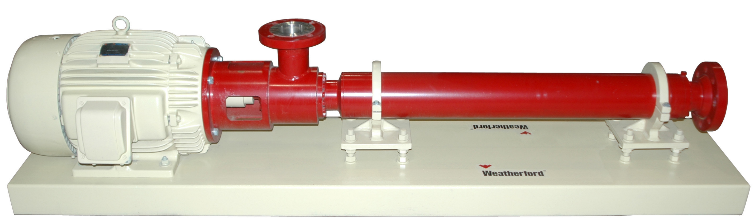
HPS FIELD SERVICE MANUAL





SECTION 1: INTRODUCTION

What Is an H.P.S. System?

An HPS System is a Horizontal Pumping System. These units consist of a motor, motor coupling, thrust chamber, intake , mechanical seal, a multi-stage centrifugal pump, pump coupling, and discharge flange, all mounted on a rigid-designed skid.

Purpose of The H.P.S. System

The purpose of an HPS System is to provide an alternative type of pump to the oil industry that is hassle free and minimize downtime. These units were built and marketed to replace the Positive Displacement pumping units that were being used at the time. Positive Displacement pumps are reciprocating plunger style pumps, which cause pulsation in flow lines that results in fatigue and created a need for the instrumentation to be calibrated often. That kind of constant maintenance and repair can lead to significant down time in the field. Compared to the PD units, the H.P.S. pumps are user friendly, cost effective, and basically maintenance free.

Applications of H.P.S. Systems

The H.P.S. system has many applications in the oil and gas industry. These applications are:

- HYDRAULIC MOTIVE POWER
- PIPELINE BOOSTER
- WATER FLOOD
- JET-PUMPING
- WATER DISPOSAL
- INDUSTRIAL FLUID TRANSFER
- DE-WATERING

Types of H.P.S. Systems

There are several different types of H.P.S. systems on the market. The most common systems are: Conventional, Electric Side Mount, Gas Driven, and the Mini unit.

Conventional

The conventional unit uses a two-poled motor coupled directly to a thrust chamber on rigid twin beam skid. This is the most common unit in the field today. These units are designed to meet the specific pressure and flow requirements given by the end user.

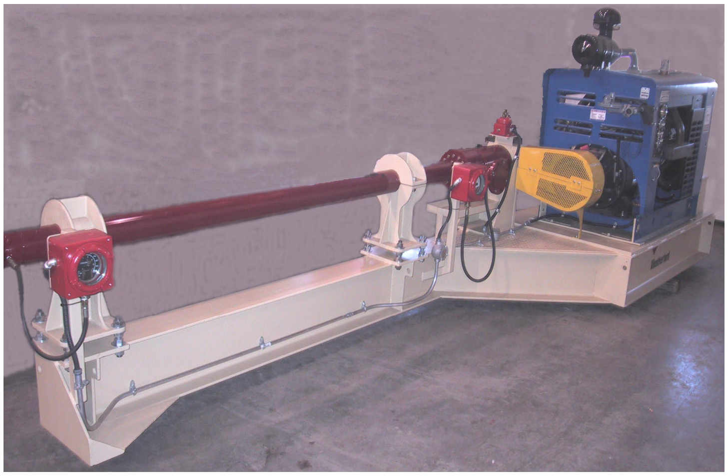
Typically these units are run at full speed, and the operating point is controlled by a pressure control valve on the discharge. Alternatively the unit can be powered with a Variable Frequency Drive (VFD) to achieve a wider range of operation.

Electric Side Mount

The electric side mount system consists of a four-pole electric motor that is mounted parallel to the thrust chamber. The motor is belt driven using taper bushing and a sprocket system. These units are best used when the customer does not know the specific pressure or flow requirements of their well or reservoir.

The advantage of this system is that the sprocket ratio can be changed in order to speed up or slow down the pump (within the motors range of horsepower). This type of unit offers a more flexible range of pressure and flow without changing any major components.

Gas Driven Side Mount



The gas driven unit has an industrial gas or diesel engine which can also be converted to run on either field gas or propane.

The engine in this type of unit is mounted on a larger base and is belt driven using sprockets, or with the larger units, a speed increaser and drive shaft assembly.

Smaller motors are mounted on the same skid as the pump whereas larger motors are mounted on separate skids to accommodate for the size and weight of the engine and to eliminate any frequency harmonics that may occur. The industrial gas engine RPM can go from 1400-2400, acting like a variable speed drive.

This unit is offered to customers when they have limited or no power available. Again, with these units, the customer has a wide range of flow and pressure options available by changing the RPM and/or changing the sprocket ratios. Before this unit was on the market, customers were using tank trucks to empty field tanks and haul to the main battery site.

The Mini Unit

The mini unit is new to the industry. This unit consists of a two-pole electric motor direct coupled to the pump without using a thrust chamber. The motor is mounted on an 18” wide channel with the pump saddles. The maximum HP range is approximately 75 horsepower and limited to 1000m3 or 1000psi. The mini unit also has very little maintenance or alignment requirements.

This unit is offered to customers to compete with the Positive Displacement pumps within the smaller HP ranges. Using fewer components, a smaller skid, and with virtually no maintenance, these units are very attractive to customers.

Basic Maintenance And Service

The maintenance and service is what sells the H.P.S units. When set up properly the H.P.S. systems are hassle free, requiring very little service. Below is an outline of the recommended maintenance that is required to ensure these systems are kept running at peek efficiency.

- The motor should be serviced once a month using motor bearing grease that is compatible with the OEM grease.

- The thrust chamber oil should be changed every three months using synthetic 46-compressor oil that is provided by the manufacturer.

- If a Grid style coupling is used: The coupling grease should be repacked every three months at the same time the thrust chamber oil is changed. However, the manufacturer may use a coupling that does not require any service.

- For electric side mounts or gas driven units every three months the belt and sprockets should be checked for wear, proper belt tension, and alignment. Belt alignment is done using a four-point alignment, which can be performed with straight edge or simply a string.

SECTION 2:
COMPONENTS

These are the components that make up a Horizontal Pumping System.

Primer Mover

The most common prime movers are:

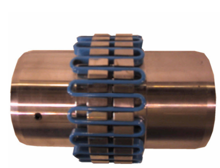
- Two pole electric motors
- Four pole electric motors (with speed-up belt drive)
- Industrial gas or diesel engine (with speed-up belt drive or speed increaser)
- Direct drive Hydraulic motor

The chosen pump curve chosen will determine the horsepower that the prime mover requires.

Motor Couplings

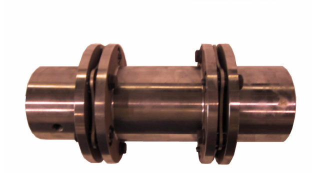
The motor coupling is what connects an electric motor to the thrust chamber and is sized based on the motors horsepower and shaft size. Types of couplings used in this application are:

- Grid style coupling which are typically used up to and including 250HP electric motors. This coupling is lubricated with grease, and should be repacked with every three months.



Grid Coupling

- Disc spacer couplings with twin disc packs and spacer spool are typically used in applications of 300HP and above. This coupling is considered lubrication and maintenance free. The disc packs can be checked for fatigue with a strobe light while the unit is running.

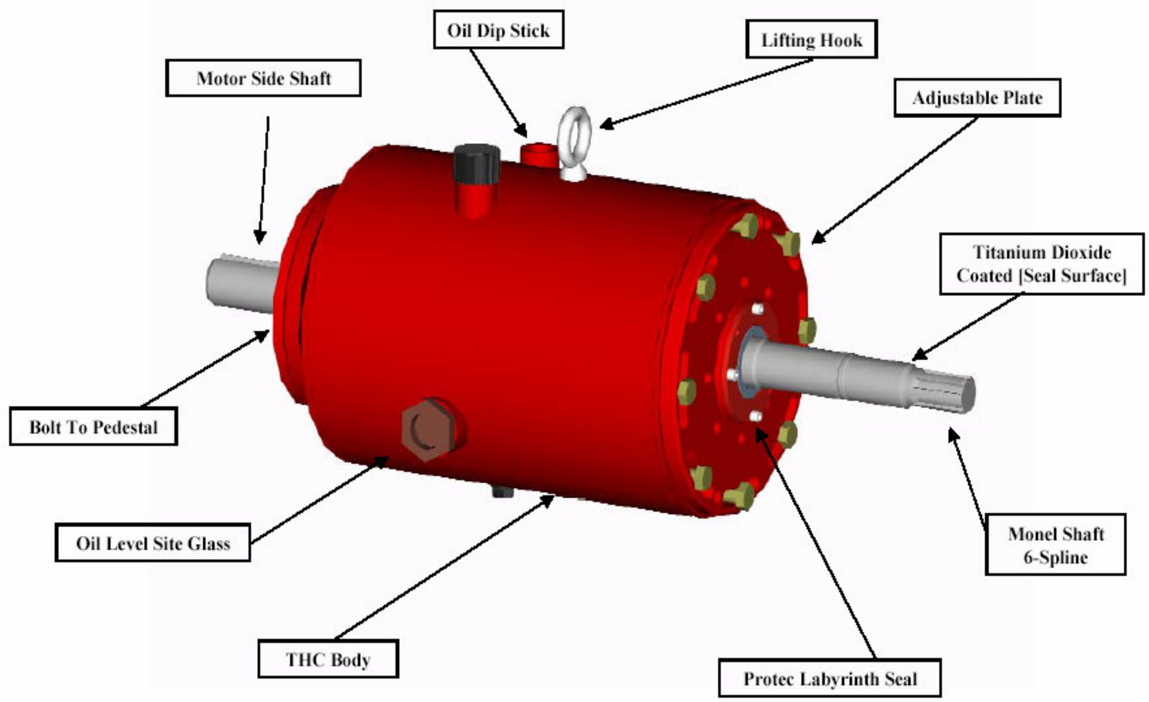


Spacer Coupling

Thrust Chamber

The thrust chamber is the most important component within the H.P.S system. It is designed to carry the thrust load developed by the multi stage pump. The modular thrust chamber is configured according to the thrust load developed by the pump.

The thrust chamber also serves another simple but very important function; it connects to the motor shaft on one end and the pump shaft on the other. This unit is filled with special oil and should be changed every three months.



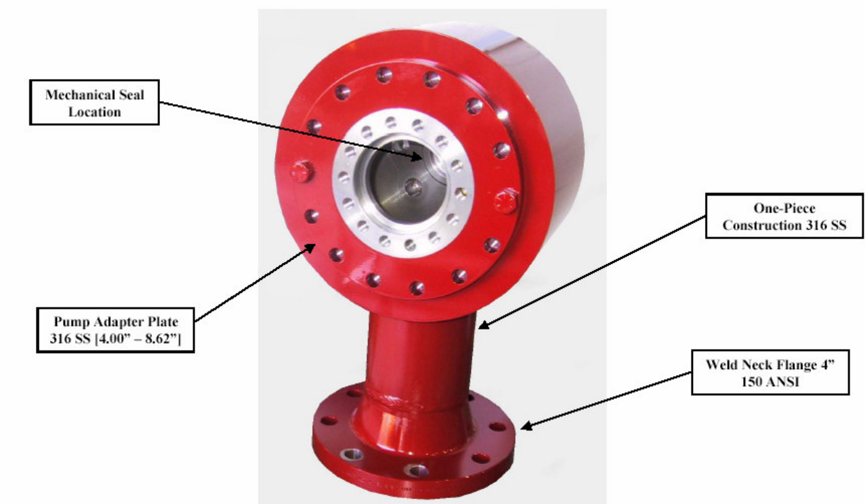
Intake, Mechanical Seal, Pump Adaptor Plate

The intake assembly is where the fluid enters the system, usually under pressure. The intake is typically fitted with standard ANSI Raised Face (RF) flanges from 3" to 6", 150RF to 300RF ratings. High pressure designs are also available that can have ratings to 2500RTJ

A mechanical seal is housed inside the intake assembly to seal the process fluid from the environment. The most commonly used mechanical seal is a Type-2 seal single seal, which is rated for 150psi. Alternatively in the same intake assembly a QBW style seal can be used which is rated up to 750psi. For higher pressure application dual cartridge seal assemblies can be used with barrier fluid to achieve intake pressures in excess of 2800psi.

Pump adapter plates are used to mate the pump flange to the intake assembly. Using pump adaptor plates allows a single intake assembly to mount to a wide range of pump series.

All wetted parts should be stainless steel including intake, mechanical seal, and pump adapter plate, as the produced fluid can be sour and corrosive.



Splined Couplings

Splined couplings are used to couple the thrust chamber shaft to the pump shaft. Also, when more than one pump is used in an assembly a splined coupling is used to couple two pumps together.

These couplings are typically an SAE six-spline coupling. This coupling spline sizes can range from 5/8" to 1.5". As the couplings are exposed to the process fluids, the couplings must be made of a corrosion resistant material such as Monel.

Pump Assembly

The pump used in all H.P.S systems is a multi-stage centrifugal pump. The pump O.D ranges from 4” to 9.5”, determined by the customer’s application based on flow and pressure. The multi-stage pump used on the majority of the H.P.S systems, are a compression style pump rather than a floater style pump.

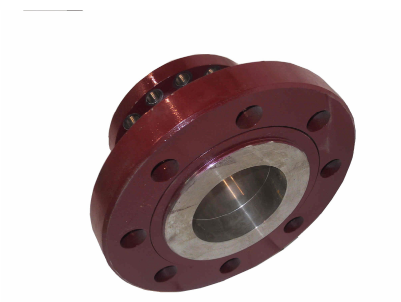
Compression pumps have all of the impellers fixed to the shaft, and when assembled the shaft and impellers move together as a complete assembly. This style of pump must be shimmed such that the pump thrust is transferred to the thrust chamber. Shims are placed behind a shaft button or in the splined coupling to achieve the desired shaft setting.

The impellers in a floater style pump float are allowed to ‘float’ on the shaft between the mating diffusers. These style of pumps usually do not require any shimming.

Discharge Flange

The discharge flange mounts on the discharge end of the final pump and converts the pump flange to a standard ANSI style flange. These flanges have a lap joint which allows the flange to rotate to match any piping configuration; there are no worries about matching any existing bolt patterns.

A wide range of flange sizes and styles are available from 2” to 6” and ANSI ratings up to 2500, RF or RTJ. The series of the pump and/or the end users requirement will dictate the size and style of the discharge flange required. The flange rating should meet or exceed the maximum working pressure of the pumps.



Skid

The H.P.S skid is a rigid designed skid containing, (in all types), these main components:

- Motor Plate
- Drip Tray
- Saddle Plates
- Pedestal
- Saddles
- Skid Base

Optional Components

The optional components are used if the customer requests them. These components are vibration switch shutdowns or vibration transducers, high and low suction switch shutdown, high and low discharge switch shutdown and expansion joints, which are connected to the intake flange. If the customer requests any of these options then they are mounted directly onto the H.P.S skid.

SECTION 3:
SPECIAL TOOLS REQUIRED

Laser Alignment Tool

This tool is used to align the motor shaft to the thrust chamber shaft. The motor alignment is the most critical alignment necessary on the H.P.S system. If this alignment is not correct it can cause increased system vibration and/or premature bearing failure in both the motor and thrust chamber. The manufacturer of the coupling will have recommend alignment tolerances. However, these are only guidelines, one should strive to achieve the best alignment possible.

Roller Jacks

Roller jacks are used to install and remove the multi-stage pump with ease. They are special built jacks that are placed on the center beam of the skid. When in place, the jacks are used to lift the pump and allow the pump to roll back and forth on the center beam for installation or removal. The pump can also be rotated on the jacks to align the pump bolt pattern on the pump to that of the pump adapter plate.

12” P.V.C. Pipe

The P.V.C pipe is used to install the mechanical seal inside the intake. The reason we use P.V.C is so we don’t damage the rotating or stationary face of the mechanical seal. These two surfaces are tungsten carbide that are lapped together for the same finish and form.

12” Metal Rulers or H-Tool

A 12” metal ruler or H-Tool is used to determine the proper shaft shimming when installing the multi-stage centrifugal pump. When installing a multi-stage compression pump correct shaft shimming is very important. If not properly shimmed, the performance and life expectance of the pump will decrease dramatically.

12” T-Handle

The 12” T-Handle comes with ¼” N.C. threaded end, which is used to install the intake plugs, after installing the 8 socket head cap screws. These plugs have O-rings on them and are used to seal the boltholes. Without these plugs the fluid under pressure would leak out the express holes (or port holes) through the threads of the 8 socket head cap screws.

Tru-Arc Snap Ring Pliers

Tru-arc snap ring pliers are used to install and remove the snap ring that retains the Type 2 seal, which is located inside the intake and on the trust chamber shaft of the H.P.S system.

Feeler Gauges

Feeler gauges are required to do a rim and face pump alignment. When aligning a pump on the H.P.S. unit the pump base flange is checked against the pump adapter plate. The tolerance for this procedure is .004” and should be checked at the 12 O’clock, 3 O’clock, 6 O’clock, and the 9 O’clock positions. This procedure will ensure proper pump alignment without stressing or bending the pump shaft. If there are tandem pumps this process is repeated between each pump base and pump head.

All the tools mentioned above are only the special tools required for the assembly or repair of an H.P.S. system. A Technician will still need all the common hand tools such as wrenches, sockets, screwdrivers etc. These tools were not mentioned because most technicians or pump mechanics carry these common tools in their truck or shop.

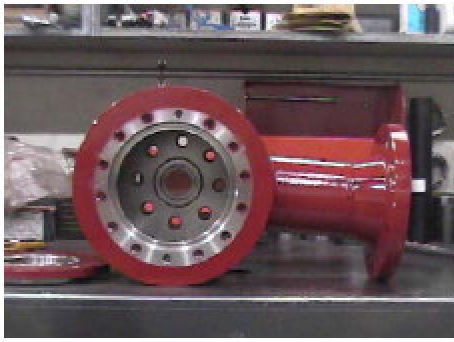
SECTION 4:
H.P.S. SKID ASSEMBLY

This skid assembly is based on a conventional skid style, which is the most common. To assemble this, you start with a bare twin beam skid and install all the saddles onto it using 1" N.C. 7" long all thread and the rest of the appropriate hardware. When all saddles are in place and in the full down position you can install the appropriate motor alignment bolts, which are located on the motor plate.

Thrust Chamber And Intake Assembly

1. Install the thrust chamber using eight ½ N.F. 2 ½ "long bolts with ½ flat and lock washers.
2. Then you lift the thrust chamber by the eyebolt and install thrust chamber against the pedestal. Install all eight bolts and tighten in a cross pattern.

3. Now you can install the coupling hub onto the thrust chamber shaft and keyway.
4. Install the intake using eight 1 ¾ socket head cap screws and high collar lock washers and tighten in a cross pattern, ensure you have proper intake or flange orientation before installing. Make sure your flange is square weather it's straight up or side-to-side, if not square you can loosen the front thrust chamber plate bolts and adjust till the flange is level or square.



5. Install eight intake plugs inside all eight boltholes in which you just install the socket head cap screws, ensure the o'rings have been installed on plugs before installing. You install these plugs using the 12" t-handle tool with the ¼ N.C threaded end.

6. Install the mechanical seal, if the seal is a type 2 John Crane seal you need to install the stationary face inside the intake, the tool needed for this is the 12" P.V.C pipe which you use to push the stationary face into place. Install the rest of the seal: first the rotating face and boot assembly, which you can lubricate with dish soap or silicon grease. Next, the spring and retainer followed by the snap ring. The snap ring is installed with the tru-arc pliers and the ring sits in the pre-determined groove on the thrust chamber shaft.

7. Install the pump adapter plate and o'ring, this plate is installed with fourteen ½ N.F bolts which are 1 ¼" long. The plate is determined by the size of pump you're using for this application.

Motor Installation And Alignment

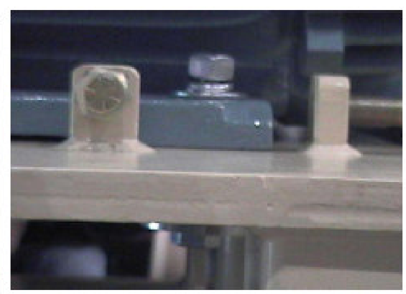
1. Install motor coupling hub on motor shaft.

2. Lift motor and remove paint and debris from motor feet.

3. Install motor on motor plate and install motor feet bolts. (Using ¾” N.C. bolts 4 ½” long with ½” thick washers which go underneath the motor plate and ¾” flat & lock washers with ¾” nuts.

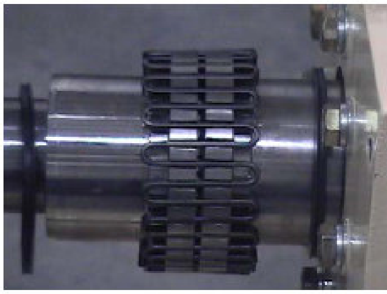
4. Lift the motor hub as close as you can to the thrust chamber hub. You do this by installing shims equally under the motor feet. With the weight of the motor on the shims, check to ensure all shim packs are tight. If you have a loose pack on one foot this means you have a soft foot, so add shims until all shim packs are tight.

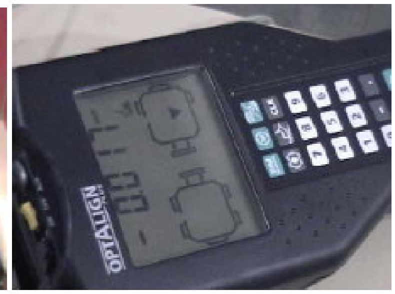




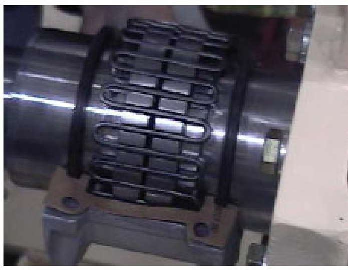
5. With everything close, using your eyes, or straight edge (up and down, side-to-side) you can now make sure you have .125” space between coupling hubs.

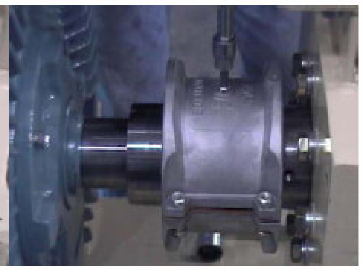
6. Install the laser alignment tool. Set your laser dot dead center on the target of the prism or moveable head. Enter the dimensions as the laser alignment asks for. Now you can do your alignment sweeps and correct the alignment as the laser tells you to.





7. Install the rest of the coupling and coupling cover guard.

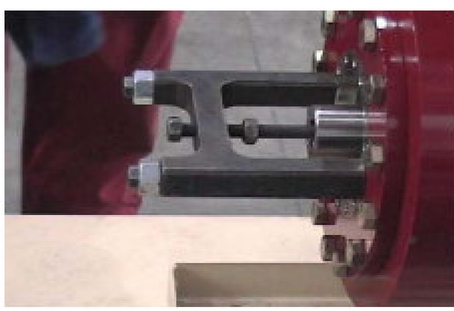




Install The Pump, Shim, And Align

1. Place the pump on your saddles, using roller jacks lift up the pump and align as close as you can to the pump adapter plate and thrust chamber shaft.

2. Measure your thrust chamber shaft (from adapter plate to shaft) using rulers or H-Tool, record. Then measure your pump shaft (in the down position) from the base flange to the shaft and record. Go to the head end of the pump and measure the shaft in the full down position and record. Measure the coupling spacer inside the coupling. You can do this by measuring the whole coupling, then measure inside each half, add these together and then subtract this number by the length of the whole coupling. This will tell you how thick the spacer is. Take the spacer number and add it to the pump shaft measurement. Now subtract from the pump adapter plate and you will know how many shims you need to fill the gap. For most compression pumps you will have to add .030-.045" more to this number.




3. Shimming is now calculated and in place, either on the shim nut, pump shaft, or inside coupling. Move the pump forward using roller jacks and align pump and coupling. Push pump base into pump adapter plate and install one bolt. Check the discharge of the pump to verify your pump shaft has moved up .030"-.045". If so, shimming is correct.

4. Using feeler gauges you can check rim face alignment between pump flange and pump adapter plate. The tolerance for this is .006", you check at the 12, 3, 6 and 9 o'clock positions. To correct the 12 and 6 o'clock positions, you use your roller jacks and lift or lower the pump. Once this is achieved, use the feeler gauges to set the back saddle into position. Now you can align the 3 and 9 o'clock positions. You can adjust this with the back saddle you just set. The roller jacks should now be in the down position out of the way. Take the back saddle and move left or right, whatever way you need to adjust. By checking with the feeler gauges you will determine when you have achieved proper alignment.

5. Set the remaining saddles into place and install all bolts in pump flange and saddles.
6. Install the pump discharge flange using the pump head bolts.

Install Vibration/Pressure Switches (If Required)

SECTION 5:
NORMAL MAINTENANCE POINTS

Mechanical Seal

The weakest link in the entire H.P.S system is the mechanical seal. The mechanical seal is located inside the intake assembly and can see a variety of pressures and fluids. The seal comes into contact with the process fluid being pumped. If there are abrasives or debris in the fluid the seal faces will be exposed to these. The abrasives or debris will come into contact with the seal faces and can cause scoring and wear which can result in seal leakage. If there is a lack of fluid or pressure then the seal may get hot because of the lack of lubrication between the two ceramic faces. A drastic change in pressure, especially high pressure, may cause the seal to fail prematurely because the seal is only rated for a certain pressure range. High pressure at the suction is usually caused by the discharge check valve failing when the unit shuts down, allowing the high line pressure to come back and hit the low pressure suction side (this is called a high pressure kick). This can shatter the two ceramic faces of the mechanical seal which results in seal failure.

Motor Coupling

A grid style motor coupling should be maintained and serviced regularly (every three months). If this coupling is not serviced properly it will start to wear and can cause premature failure. The wear points in this style of coupling are the grid and the hub slots. Without grease, the coupling will wear and the clearances will increase, the slots will wear wider and wider and the grid thinner and thinner. This coupling is traveling at 3600RPM and if wear starts to take place increased vibration will be noted due to the increase clearances.

The other common coupling used is the disc style spacer coupling. These couplings consist of two hubs that are bolted together with a drop out spacer spool in the middle. The spacer spool has a disc pack on each end, which fits between the two hubs. This style of coupling does not require lubrication. The only maintenance required is to check the disc pack for cracks and fatigue using a strobe light. If the disc packs are showing signs of fatigue, the spacer spool should be remove and fitted with new and disc packs.

Thrust Chamber

The Thrust Chamber is the main rotating piece of equipment. If it is serviced properly and regularly, it will be hassle free. However, if neglected, premature failure may happen, and in the process other system components could be damaged as well such as the motor bearings, mechanical seals, or the pump bushings. The maintenance and alignment on both ends of the Thrust Chamber is critical for proper life.

The Thrust Chamber will also wear if periodic maintenance is not done. The additives in the oil will start to break down and will not provide the bearings with sufficient lubrication. When servicing the

Thrust Chamber, ensure that the proper oil is used (as per specs) and that the proper level is maintained. Do not overfill the Thrust Chamber, or the Thrust Chamber may run hot or the oil seals may leak.

Electric Motor

The service points on an electric motor are the motor bearings, and sometimes, the windings. Motor bearings should be greased once a month with the proper grease. (Check the nameplate or motor spec or manual for proper type). If the motor bearings start to go you will notice excessive vibration. If the motor runs too long in this condition, it could damage other components in the system such as the radial bearing of the Thrust Chamber.

Windings failure in most cases is caused by excessive heat within the motor. This could be because the motor and the V.S.D. are not compatible, or the wrong carrier is being used within the variable speed drive, or it could just be a manufacturer defect. To monitor the motor windings, R.T.D.'s are used, especially on larger horsepower motors.

To prevent the motor from getting too hot, a periodic maintenance check should be done. The fan cover can be removed from the motor and any dust or debris cleaned out. Also, it is important to ensure that the motor has proper fresh air ventilation and that there are no blockages of airflow around the motor. It is also important to ensure the motor fan rotation is suitable for the pump rotation.

Pump

The multi-stage centrifugal pump requires little to no maintenance. There are three main checks required to maintain a H.P.S. pump. First of all, anytime suction filters or the mechanical seal is changed air is introduced into the system. Once the unit is put back together, and before starting up, the air should be purged from the system. Opening the suction valve to flood the system with fluid should do this, and then the air should be purged from some point on the discharge end of the pump. The purge point should be the highest point in the discharge line. This will prevent the pump from cavitating, or an air lock in the pump causing the pump not to produce. This will result in the excessive heat generation within the pump which may cause the bushings and bearings to seize to the pump shaft, and in extreme cases, shaft failure. Cavitation is one of the main failures of an H.P.S. Pump.

Once the unit is running, ensure the discharge pressure and flow match the pump curve, and ensure these values are within the min and max performance range from the pump curve. Verify suction and discharge switch settings are set within the performance curve. If the switches are not reading properly, remove the instrumentation line from the switch to ensure there is no air in it, as air in the line can cause false readings.

Trouble Shooting

The following chart lists most of the troubles that can be encountered during HPS operation, probable causes, and recommended remedies.

TROUBLE	*SYMPTOMS*	*REMEDY*
Hot Bearings	Inadequate lubricant	Verify proper lubricant
	Contaminated oil or grease	Drain and clean oil reservoir, refill with clean oil or grease.
	Defective bearings	Repair or replace
Excessive mechanical seal leakage	Worn internal parts	Replace or repair seal
Reduced flow or low discharge pressure	Air leaks in suction	Check suction line for leaks
	Speed too low	Check motor speed
	NPSH too low	Check suction side of HPS for flow restrictions, air leaks.
	Clogged suction line	Clean out suction line strainer.
	Clogged impellers	If unable to clear chemically, return pump for disassembly or repair.
	Impellers damaged	Return pump for disassembly or repair.
	Wrong rotation	Check motor rotation.
	Worn pump	Return pump for repair.
No Flow or Low Flow	Pump not primed	Prime pump.
	Speed too low	Check motor speed.

	Plugged Impellers	If unable to clear chemically, return pump for disassembly or repair.
	Clogged suction strainer	Clean out suction line strainer
	Damaged Impellers	Return pump for repair.
	Wrong rotation	Check motor rotation.
	Discharge valve is shut	Check valves setting.
Pump Vibration Excessive	Clogged impellers	If unable to clear chemically, return pump for disassembly or repair.
	Damaged Impellers	Return pump for repair.
	Misalignment	Check motor-to-pump alignment.

SECTION 6: BASIC START-UP AND COMMISIONING

Basic Operational Checklist

1. Pre-Commissioning

a. Safety
Ensure correct PPE and Tools

b. Foundation
Ensure equipment is properly supported and anchored without distortion.
Level skid in both planes and shim as required.

c. Piping
Verify piping line class ratings are acceptable for the intended equipment/ service conditions.
Verify proper valving: Isolation, Check, Throttling, Control, Relief, Strainers, are supplied in the system and are installed correctly and in the proper places.

d. Electrical Instruments
Verify rotation for motor.
Pre-Set instrument shutdown set points, high and low intake and discharge pressure. Check alignment of Motor and Thrust Chamber.

e. Lubricants
Ensure the Thrust Chamber is filled to the proper levels with the correct grade of lubricants.

f. Filling/Purging
With discharge and drain valves closed, open suction valve and flood. Vent instruments and piping/pump at high points.

2. Operational

a. Verify Pump is Operating according to the desired and specified design conditions. Record.

b. Adjust set points on instruments as required. Record.
Ex: Measure voltage and amp draw. Ensure current trip limits are set and within range of the operating conditions and equipment provided. Record.

c. Perform baseline vibration reading for entire drive train in both vertical and horizontal axis for all operating frequencies. Vibration should not exceed .156ips or .28rms. Record.

d. Observe Thrust Chamber Oil Temps. Record.

Preliminary Check

There are several points that require checking prior to the initial start-up and whenever the system has been shutdown for more than an hour.

- Check the sight glass window on the Thrust Chamber for sufficient oil level.
- Check the security of all bolts, piping connections, and wiring.
- Check all gauges, valves, and instrumentation for proper working order.
- Never operate the HPS unless the suction valve is fully open.
- Check to ensure the discharge valve is open to fully fill the pump with liquid and purge all air out of the pump. It may be necessary to adjust the backpressure to meet the system requirements.
- Do not operate the equipment with the coupling guard removed.
- The HPS may start and stop automatically. A warning sign should be placed on or near the equipment to warn personnel that the HPS can start automatically without warning.
- If being serviced, open the services disconnect and lockout the power to prevent automatic starting.

Pump

Pumps that are shut down during periods of freezing weather should be drained and glycol with rust inhibiter should be added.

- Insure that the intake line valves are open and that water is available from the boost pump, tank, or pipeline.
- Bleed any air from the intake line, pump intake, and pump.
- Insure that discharge valves are open and downstream equipment is ready to receive fluid. With most pumps, adequate backpressure must be present to insure that the pump does not experience excessive up-thrust wear during flow stabilization.

To prevent overheating, excessive wear or damage to the pump, do not operate under the following conditions:

- Operation outside the design parameters.
- Extended operation at the minimum flow rate.
- When pump runs dry.
- When pump liquid contains excessive gas or air.
- When the pumped fluid contains sand or other abrasives. Small amounts will have no immediate effect, but eventually they will damage the pump’s rotating parts
- Check the Thrust Chamber oil level in the sight glass and add oil if necessary.

- (Oil level should be within the middle of the site glass.) The Thrust Chamber contains bearings that absorb any down-thrust forces from the pump shaft. The oil level should be checked while the equipment is running and warm.

- Insure that the coupling guard, and other safety equipment are in place prior to start-up.

- The motor is usually a two-pole or four-pole winding design with either anti-friction ball bearings or oil lubricated journal bearings on each end of the shaft. It should not be operated beyond the speed limits set by the manufacturer. Follow lubrication instructions on the motor nameplate.

Operating Check

As soon as possible after the pumping operation begins, repeat the applicable preliminary check above, being certain that all gauges and instruments indicate as specified and that pump speed is also as specified. If trouble occurs, immediately shutdown the system and refer to the trouble-shooting section.

Variable Speed Driver

Optional. Refer to the manufacturers operating manual for details of operation.

Shutdown

- The following sequence is suggested when stopping the unit:
- Stop the driver at the control panel.
- Make sure the flow line and check valve is functional.
- When the pump shaft stops rotating, close the suction valve.

Instrumentation

Switches and/or sight glasses provide monitoring functions for the HPS. These may include vibration, temperature, fluid levels, and pressures. Refer to the appropriate manual included in this section for proper operation and maintenance.

Start-up Equipment

The basic start-up equipment and instrumentation needed is as follows:

- Charge pump
- Soft starter or switchboard
- Low and high suction switches
- Low and high discharge switch

- Vibration switch
- Flow meter
- Backpressure valve

Start-Up Sequence

The basic start-up sequence for an H.P.S unit with the basic controls is:

- Once the unit is purged and there is no air left in the system it is ready for the start command.
- On start command the backpressure valve should be open approximately 30%
- The charge pump should then start-up
- If the low suction switch is satisfied then the H.P.S motor will start (if there is a low discharge pressure shutdown this will have to be bypassed for start-up, and if there is a low flow shutdown it will also have to be bypassed for start-up)
- Once the unit is running all switches should be off bypass and in normal operation, all shutdowns should be active
- Check all pressure gauges and flow meter to ensure the pump is running within it's operating parameters
- After unit has been running for 30-60 minutes and has stabilized, a vibration check should be performed as per the vibration worksheet
- All shutdowns and equipment information should be recorded on the H.P.S run sheet shown below.

Run Data Sheet

Customer:________________________ Date: ____________
Location:________________________
Field: ________________________ Service Tech: ____________

SKID Model:_______________ Serial No:__________ Part No.:_________________

EQUIPMENT CHANGED OUT

Motor S/N:___________ HP:_________Volts:_______Amps:_______Mfg:_______________
Pump S/N:___________ Type:_______Stages:______Hsg:________P/N:________
Thrust: ____________
Pump S/N:___________ Type:_______Stages: ______Hsg:________P/N:________
Thrust: ____________
T/C Model No: ____________ S/N:______________ P/N: ____________

Comments:____

EQUIPMENT INSTALLED

Motor S/N:___________HP:_________Volts:_______Amps: ____________Mfg:_______________
S.F:_________Frame: __________________ Encl:

T/C Model No: __________________S/N:____________________P/N:______________
Intake Jacket-Material:______________STD:______________High Pres:__________Rating:_____________

Pump S/N:___________Type:_______Stg:_________Hsg:__ P/N:_________
Thrust:______________Trim:_______Head:________Base:________Hsg:_________
Pump S/N:___________Type:_______Stg:_________Hsg:_________P/N:_________
Thrust:______________Trim:_______Head:________Base:________Hsg:_________

Discharge Flange:_________________Size: ____________Rating:_____________Material:_____
Intake-Piped in Solid:______________Expansion Joint Used:____________ Size:________

Pressure Switch Mfg: ___________________
Intake Setting-Low:______________________Intake Setting-High:______________
Discharge Setting-Low: ___________________Discharge Setting –High:________________

Motor Control Mfg:______________________Model No: _________Amps: ______Volts: ______

START UP INFORMATION

Supply Pressure:__________________Discharge Pressure: _______________________________
Specific Gravity:__________________Amperage:________________Production Rate:___________

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Artificial Lift Systems

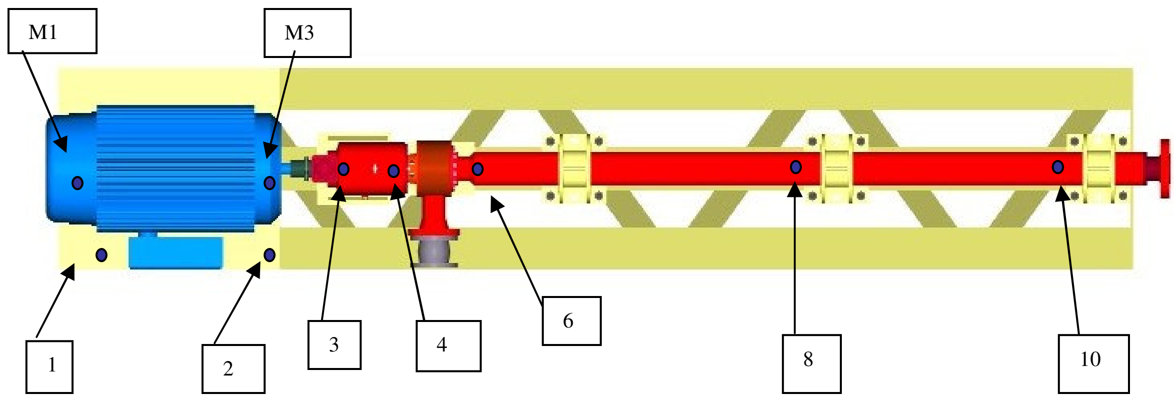
HPS PRODUCT LINE

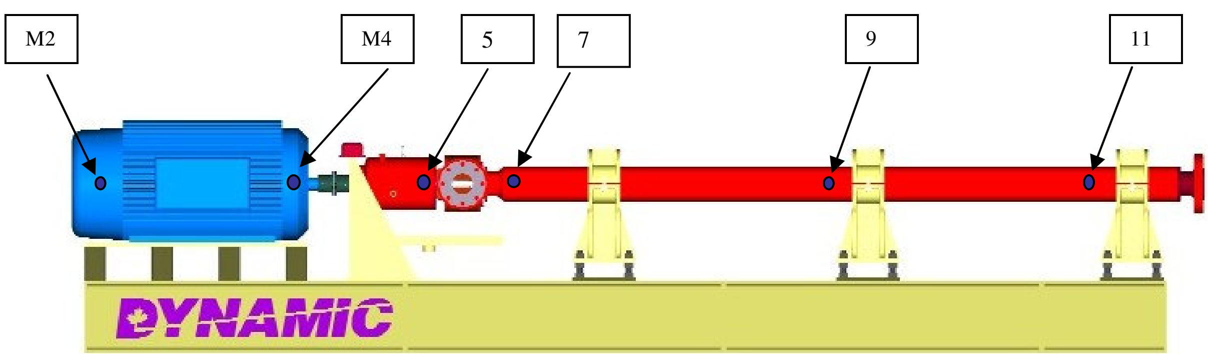
VIBRATION DATA REPORT
TK81 VIBRATION TEST

POINT	1x (in/sec)	2x (in/sec)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
POINT	1x (in/sec)	2x (in/sec)
M1		
M2		
M3		
M4		

SO No.	Date:
Customer:	
Company Rep:	
City/Town:	
Location:	Unit No.
Motor:	Serial No.
Pump:	Serial No.
Pump:	Serial No.
THC:	Serial No.
Mtr Coupling:	PSI (Suction):
HPS Serial No.	PSI (Discharge):
Flow Rate:	
COMMENTS:	
SO No.	Date:

Velocity Severity		Vibration Severity
in/sec	cm/sec	Remarks
0.042	0.107	Smooth
0.057	0.145	Very Good
0.099	0.251	Good
0.156	0.396	Fair
0.255	0.648	Slightly Rough
0.396	1.006	Rough


M1
M3
1
2
3
4
6
8
10


M2
M4
5
7
9
11
DYNAMIC

SECTION 7:
H.P.S. SIZING

PUMP FORMULAS

Head = squared (eg) new Hz ÷ old hz^2 45÷ 60 =. 75 x .75 =. 56 x 60 Hz head = new head @ 45 Hz

Horsepower = cubed (eg) new Hz ÷ old hz^3 45 ÷ 60 = .75 x .75 x .75 = .42 x 60Hz horsepower = new horsepower @ 45 Hz

Flow = proportional (eg) new Hz ÷ old Hz 45 ÷ 60 = .75 x 60 Hz flow

CONVERSIONS YOU NEED TO KNOW

Barrels to Cubic Meters = 6.289
PSI to KPA = 6.895
Feet to Meters = 3.281
Head Feet to Pressure ÷ 2.31 or x .433
Barrels Per Day (BPD) to Gallons per Minute (GPM) = 34.4
BAR to PSI = 14.5

To size an H.P.S system five basic design parameters are needed from the customer.

1. FLOW RATE
2. DISCHARGE PRESSURE
3. SUCTION PRESSURE
4. SPECIFIC GRAVITY
5. PPM'S OF SOLIDS IN FLUID

With these design parameters an H.P.S system can be sized that will best suit the customers' needs. First, the appropriate pump type and size that will accommodate the desired flow rate should be selected. After the pump size and type have been established the number of stages necessary to achieve the desired discharge pressure can be calculated, remembering to take into account the specific gravity of the fluid. The suction pressure must also be considered to ensure the proper discharge pressure is achieved.

The amount of abrasive solids in the fluid will dictate the bearing combination required for the internal pump make up.

The NPSHa should also be checked to ensure that the pump will not cavitate. The NPSHa should be at least 30% higher or 5-10 higher than the NPSHr (whichever is greater).

EXAMPLE:

1. FLOW RATE = 10,000 BPD
2. DISCHARGE PRESSURE = 1100 PSI
3. SUCTION PRESSURE = 50 PSI
4. SPECIFIC GRAVITY = 1
5. PPM'S OF SOLIDS IN FLUID = 50

This is the design parameter from the customer. First the appropriate pump must be selected for the specified flow rate.

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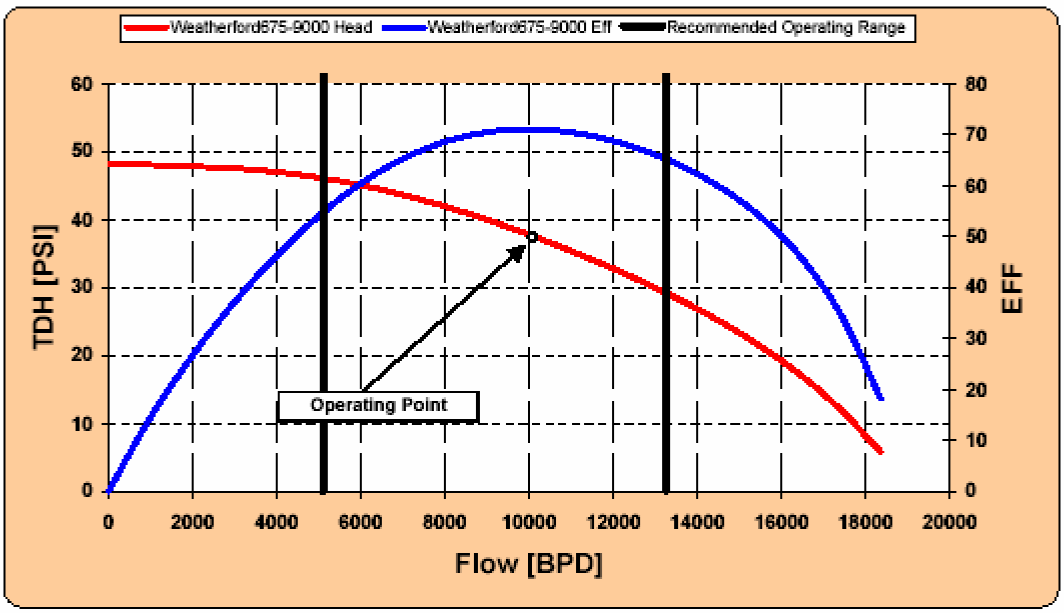
Performance Curves

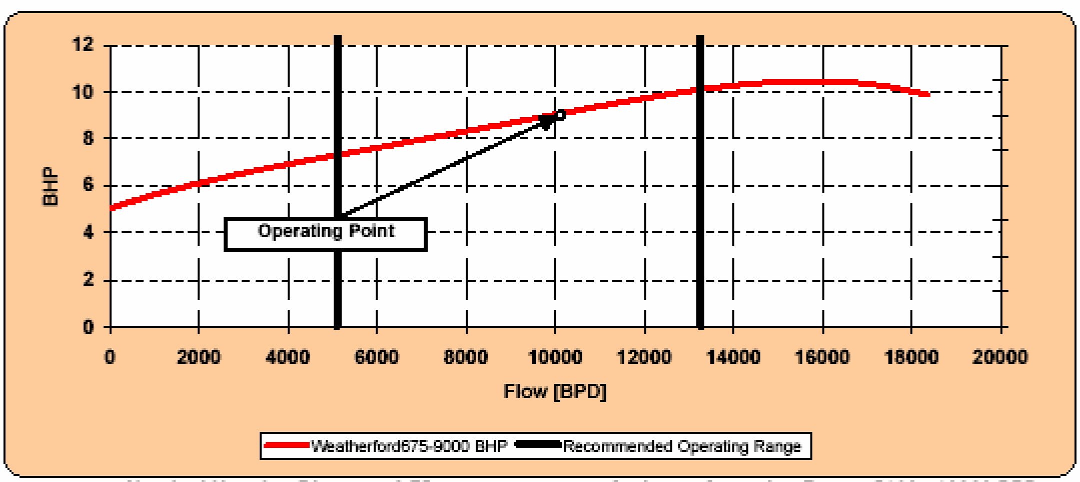
Pump Selection

Single Frequency Data

Manufacturer	Series	Pump
Weatherford	675	-9000

Weatherford675-9000	RPM	3570	Stages	1	S.G.	1





Nominal Housing Diameter	6.75	Optimum Operating Range	5100 - 13260 BPD
Shaft Diameter	1.187"	BHP	8.74
Shaft Cross Sectional Area	#VALUE!	Housing Burst Pres. [Standard]	n/a
Shaft Brake HP Limit [Standard]	649.74	Maximum Discharge Pressure	46psi
% Shaft Loading	2%	Minimum Casing I.D. Drift	8.625
BEP	70.71	TDH	48PSI

The 675-9000 is the best pump for this flow rate. This pump will produce 10,000 BPD at its best efficiency point. When looking at the pump curve it is noted that at 10,000 BPD the pump has 38psi head per stage, so in order to achieve 1100psi, 29 stages will be required (1100psi/38psi).

Next the system horsepower can be calculated from the horsepower per stage curve. The horsepower per stage is 9hp, so 29 stages will require 261HP (29 * 9). The pump and motor sizing would be 675-9000 29stg requiring 261 HP. The system motor HP is selected as the next available size motor, in this case a 300HP motor would be used.

The pump make-up for 50 PPM would only need enhanced head and base bearing design, ni-resist bushings and regular compression stages. If the customer is using a VFD, the multi frequency curve can be used to show the wide range of flow and pressure capability of the pump. The flow range will go from 3500 BPD to 13500 BPD and pressure ranging from 400psi to 1400psi with frequency ranging from 42 Hz to 62 Hz. This gives the customer a great variety of options.

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Artificial Lift Systems

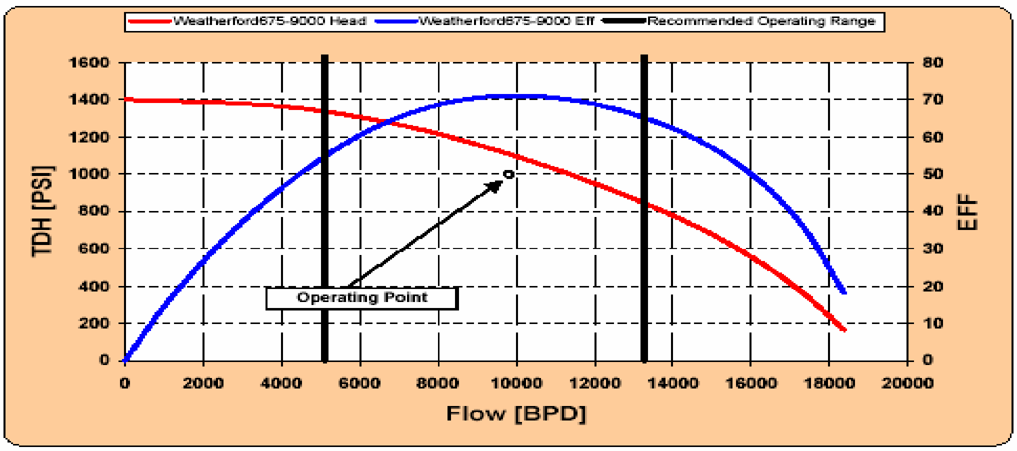
Performance Curves

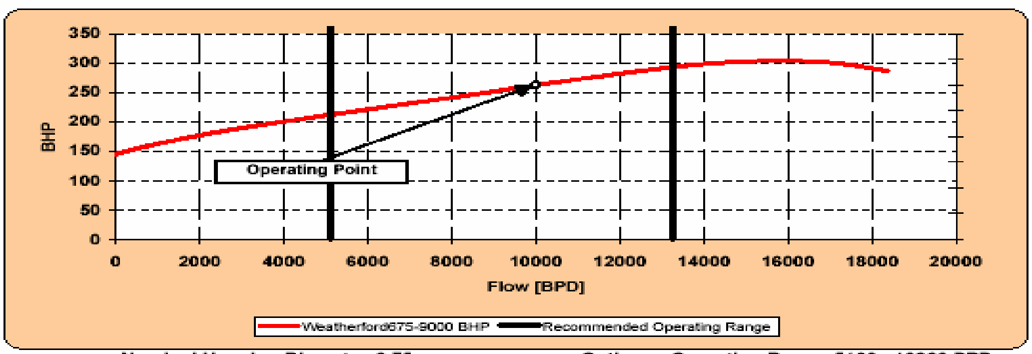
Pump Selection

Single Frequency Data

Manufacturer	Series	Pump
Weatherford	675	-9000

Weatherford675-9000 RPM 3570 Stages 29 S.G. 1





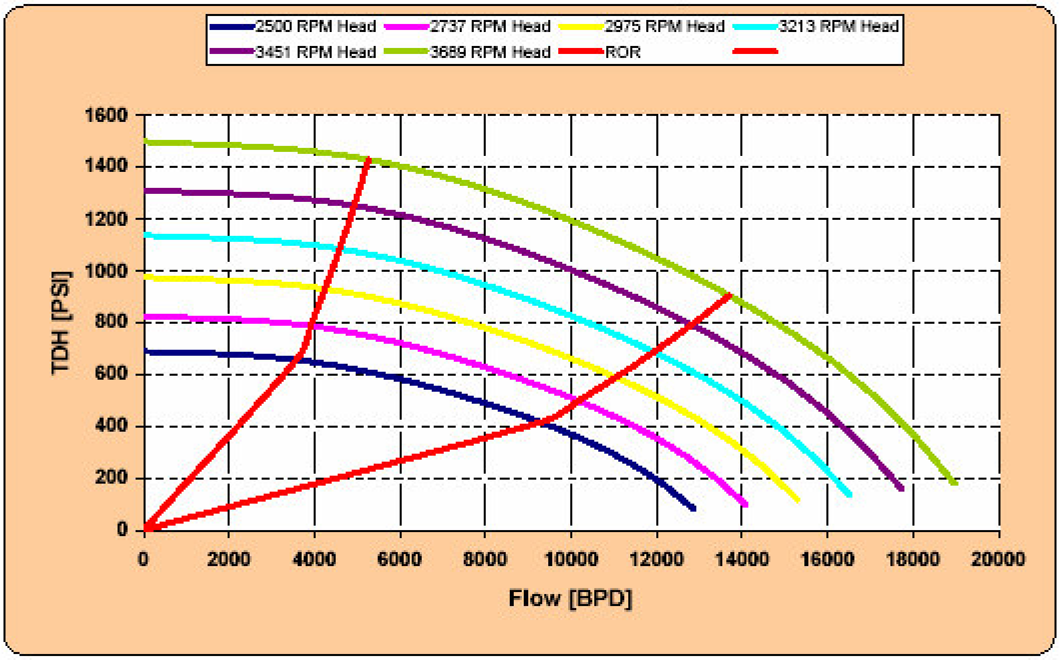
Nominal Housing Diameter	6.75	Optimum Operating Range	5100 - 13260 BPD
Shaft Diameter	1.187"	BHP	253.56
Shaft Cross Sectional Area	#VALUE!	Housing Burst Pres. [Standard]	n/a
Shaft Brake HP Limit [Standard]	649.74	Maximum Discharge Pressure	1342psi
% Shaft Loading	47%	Minimum Casing I.D. Drift	8.625
BEP	70.71	TDH	1400PSI

Performance Curves

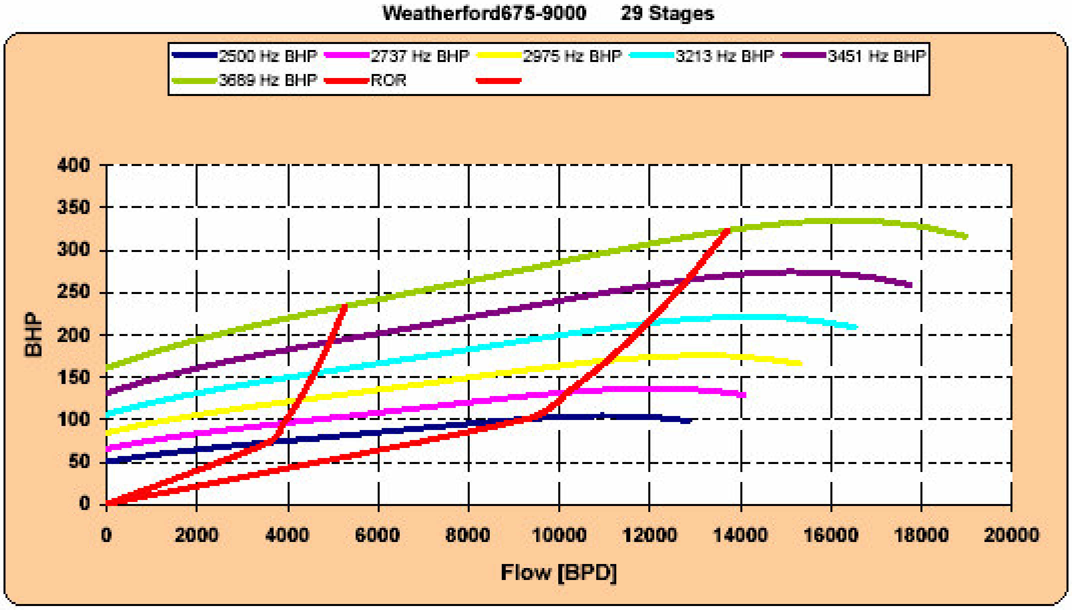
Multi-Frequency Data [3570rpm=60Hz]

Speed 1	2500 RPM	42Hz		Speed 4	3213 RPM	54hz	
Speed 2	2737 RPM	46hz		Speed 5	3451 RPM	58hz	
Speed 3	2975 RPM	50hz		Speed 6	3689 RPM	62hz	

Weatherford675-9000 29 Stages



Weatherford675-9000 29 Stages



The next step is to calculate the thrust load that the pump can develop. This is calculated at zero flow, because the pump will develop the highest thrust load at the dead head condition. Thrust load is required to properly size the thrust chamber-bearing configuration. The thrust load for a 675-9000 is 118lbs per stage x 29stgs = 3422lbs of thrust.

To select the proper discharge flange maximum pressure (at zero flow) must be know. In this application the max discharge pressure would be 1400psi at 60 Hz so the correct flange is 4"-900 ANSI, 900 ANSI is rated for 2160 psi.

Standard Discharge Flanges

400 Series	538 Series	675 Series	862 Series	950 Series
2" 600 ANSI RF	3" 600 ANSI RF	4" 600 ANSI RF	6" 600 ANSI RF	6" 600 ANSI RF
2" 900 ANSI RF	3" 900 ANSI RF	4" 900 ANSI RF	6" 900 ANSI RF	6" 900 ANSI RF
2" 1500 ANSI RF	3" 1500 ANSI RF	4" 1500 ANSI RF	6" 1500 ANSI RF	6" 1500 ANSI RF
2" 1500 ANSI RTJ	3" 1500 ANSI RTJ	4" 1500 ANSI RTJ		
2" 2500 ANSI RTJ	3" 2500 ANSI RTJ	4" 2500 ANSI RTJ		
ANSI: Rating x 2.4 = Maximum working pressure (Ex. 600 x 2.4 = 1440)				
RF: Raised Face Flange				
RTJ: Ring Type Flange				

Thrust Chambers

Bearing Combination	Thrust Chamber	
2 Bearing	4000 lbs	
3 Bearing	7500 lbs	
4 Bearing	10,000 lbs	Circulating Reservoir Cooler

The 400 through 675 series pumps require a 4”- 150 psi intake unless the customer specs 6” because of the existing piping, 4” piping is sufficient for these lower flow rates.

For 862 or 950 series 6” intakes are required. When the technical sizing is done all that is left to determine the overall length of the skid to suit the equipment. To determine the skid length the length of the pump, motor, Thrust Chamber, intake assembly, coupling and discharge flange must be considered.

The pump length can be found in the pump catalogue. The catalogue will tell you the length of the pump, in this case 675-9000 29stg pump is 13’-7”. From the pump length, the number of saddles required can be determined. For the over-all skid length the length of the motor, thrust chamber, intake and motor coupling will also have to be added to the pump length.

Once all this information is determined it can be sent to the engineer to do the complete drawing. The quote with the dimensional drawing and sizing is provided to the customer.

Weatherford
Artificial Lift Systems

Quotation **DF-50617**

4436 - 50 Avenue, Calmar, Alberta, T0C 0V0 Ph: 780-985-2232 Fax: 780-985-3707 Email: hps@weatherford.com

EQUIPMENT QUOTATION

Customer

Example Customer

Rock Springs, Wyoming

Date	19-Aug-05
Customer Rep	
Rep	
FOB	Calmar, AB

Qty	Description	Unit Price	TOTAL
	PROJECT: HPS Training Pump		
1	Complete HPS System, each consisting of the following:		
	DESIGN PARAMETERS		
	Flow Rate: 10,000 BPD @ 1,100psi Pump Boost Pressure		
	Intake (Suction) Pressure: 50 PSI		
	Fluid Properties: 50ppm Specific Gravity 1.0		
1	Pump - 29stage 675-9000, 400 Series, CMP, AR/SS Head & Base, 13' 7" Compression-Style, Abrasion Resistant Bearings Head&Base		
1	Motor - 30HP 3/60/460v, 3570rpm, 286TSC, TEFC, Premium Efficiency, Continuous Duty, Class F Insulation, Nema Design B, SF: 1.15		
1	Thrust Chamber - Model DFSI-02, Modular Bearing Design, CS		
1	Motor Coupling - 1070 FALK		
1	Motor Coupling Guard		
1	HPS Pump Bench - Model DFSI-HM, Length 19.7', 3 Saddles		
1	Intake - 4" 150RF ANSI Class, SS w/ Type 2 John Crane Seal 150psi		
1	Pressure Switch - Hi/Low Intake 0-100 PSI Ex-Proof		
1	Discharge Head - 4" 900RF ANSI Class, SS		
1	Pressure Switch - Hi/Low Discharge 0-2000 PSI Ex-Proof		
1	Switch - Vibration Shut-Down, Ex-Proof CSA		
1	Manuals - Operating & Maintenance		
	FOB Point: Calmar, Alberta	SubTotal	
		Shipping & Handling	
	Equipment Delivery: 4-6 weeks from receipt of order		
		TOTAL	

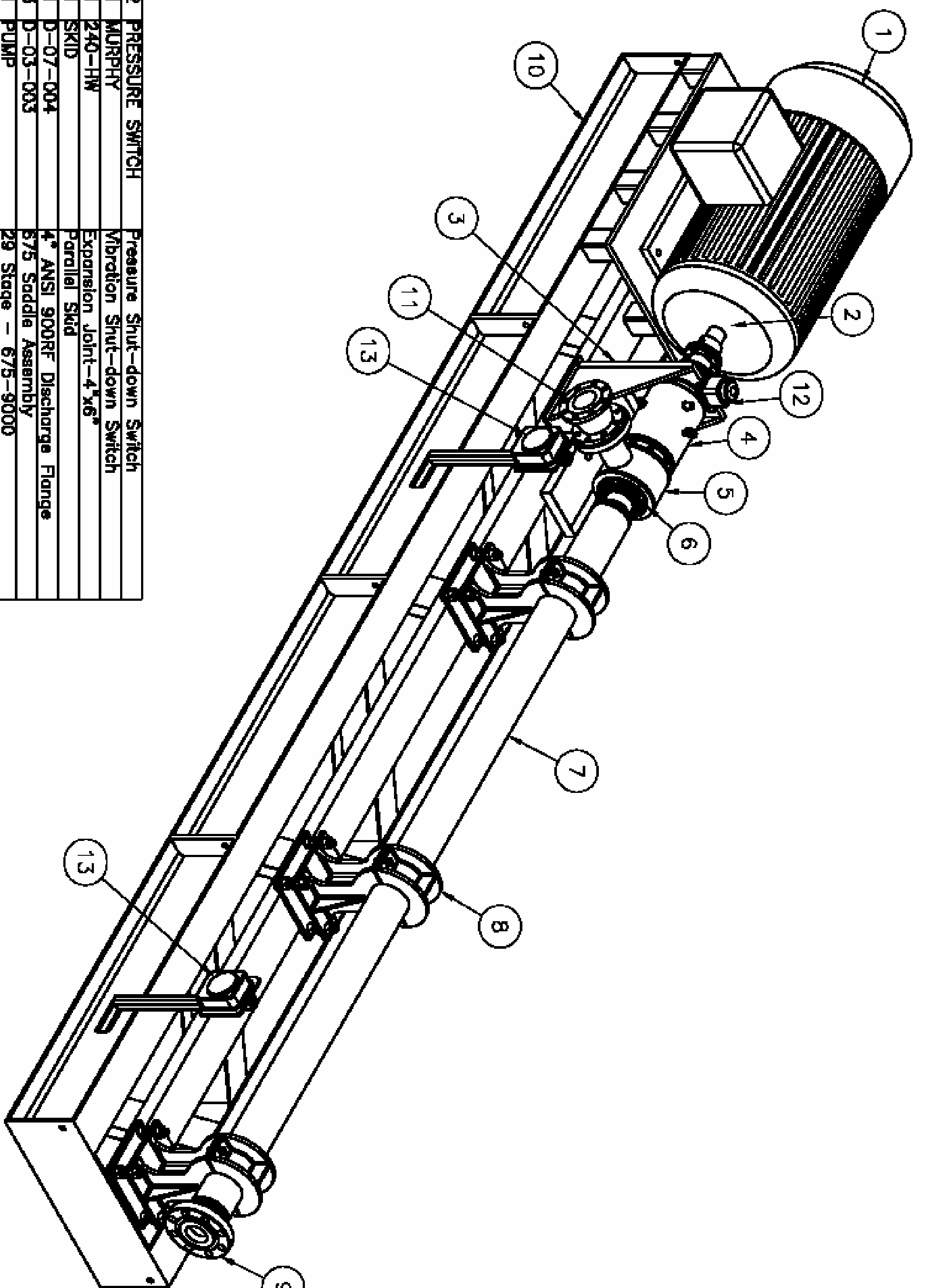
GST No. 89713 4110 RT0001
WCB No. 44931254756

Accepted By:

ORDER ACCEPTANCE SUBJECT TO CREDIT APPROVAL

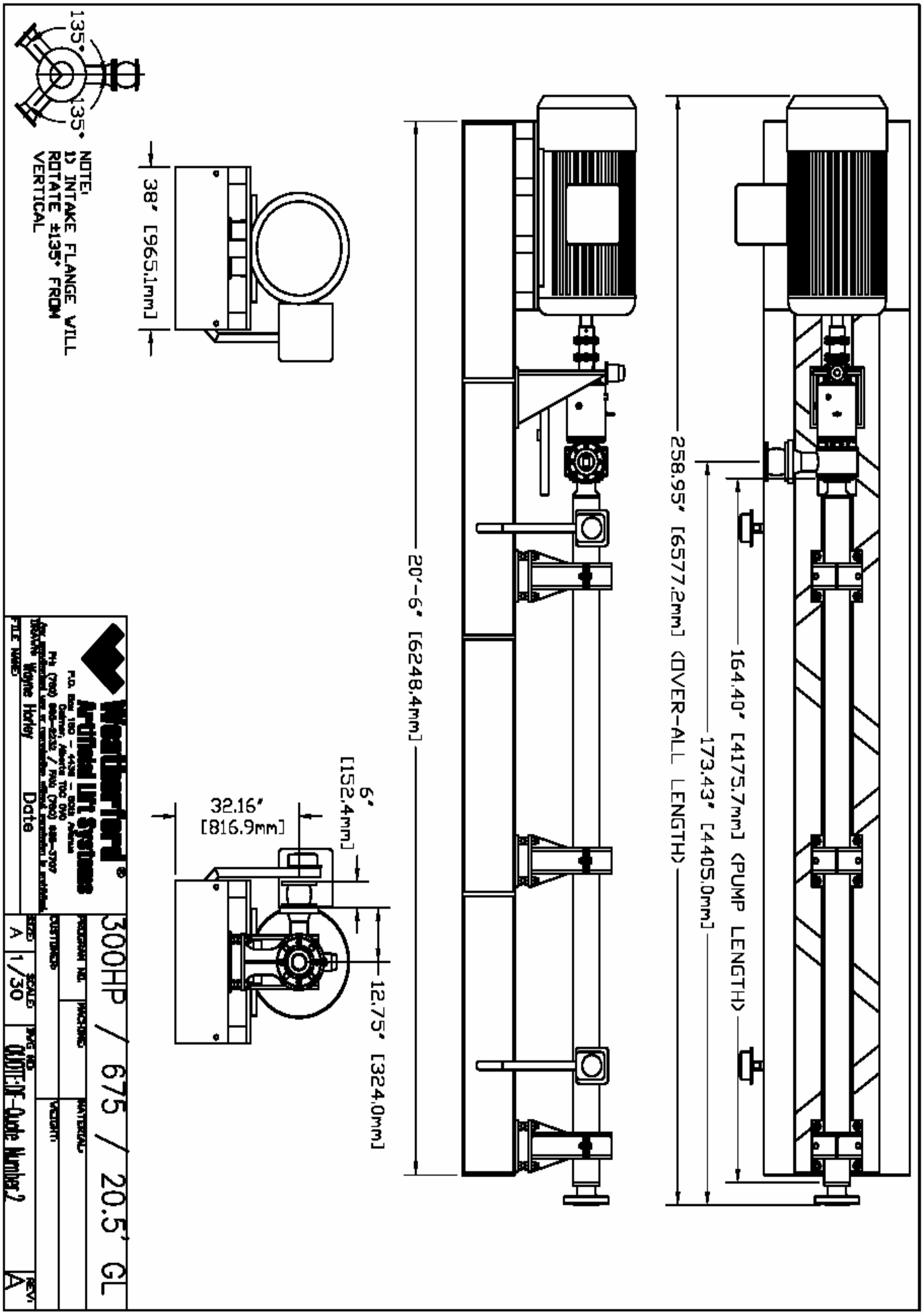
QUOTATION PRICES - VALID FOR 60 DAYS

Thank You for Choosing Weatherford HPS



ITEM	QTY	NAME	DESCRIPTION
13	2	PRESSURE SWITCH	Pressure Shut-down Switch
12	1	MURPHY	Vibration Shut-down Switch
11	1	240-HW	Expansion Joint-4"x6"
10	1	SKID	Parallel Skid
9	1	D-07-004	4" ANSI 900RF Discharge Flange
8	3	D-03-003	675 Saddle Assembly
7	1	PUMP	29 Stage – 675-9000
6	1	D-06-002	675 Intake Adaptor Plate
5	1	D-06-006	Intake Assembly – 4"-150RF
4	1	D-05-001	Thrust Chamber Assembly
3	1	D-04-001	Thrust Chamber Pedestal
2	1	SX-158-6	Disc Spacer Coupling
1	1	5009A	300HP 460V 3570RPM TEFC Motor

Parts List


135°
135°
NOTE:
1) INTAKE FLANGE WILL ROTATE ±135° FROM VERTICAL
38" [965.1mm]
20'-6" [6248.4mm]
258.95" [6577.2mm] (OVER-ALL LENGTH)
164.40" [4175.7mm] (PUMP LENGTH)
173.43" [4405.0mm]
32.16" [816.9mm]
6" [152.4mm]
12.75" [324.0mm]
Weatherford
Artificial Lift Systems
Wayne Harley
Date
300HP / 675 / 20.5' GL
A
1/30
QUOTE-DF-Quote Number2
A