FSD SERIES
ANSI Process Pumps
Installation, Operation, and Maintenance Manual
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SAFETY CONSIDERATIONS

The FSD Series ANSI Process pumps have been designed and manufactured for safe operation. In order to ensure safe operation, it is very important that this manual be read in its entirety prior to installing or operating the system. Franklin Electric shall not be liable for physical injury, damage or delays caused by a failure to observe the instructions for installation, operation and maintenance contained in this manual.

Remember that every pump has the potential to be dangerous, because of the following factors:

- Parts are rotating at high speeds
- High pressures may be present
- High temperatures may be present
- Highly corrosive and/or toxic chemicals may be present

Paying constant attention to safety is always extremely important. However, there are often situations that require special attention. These situations are indicated throughout this book by the following symbols:

**DANGER** - Immediate hazards which WILL result in severe personal injury or death.

**WARNING** – Hazards or unsafe practices which COULD result in severe personal injury or death.

**CAUTION** – Hazards or unsafe practices which COULD result in minor personal injury or product or property damage.

Maximum Lifting Speed: 15 feet/second.

If in a climate where the fluid in the system could freeze, never leave liquid in the booster system. Drain the system completely. During winter months and cold weather, the liquid could freeze and damage the system components. Always remember to drain the casing assemblies complete.

Do not run the equipment dry or start the pump without the proper prime (flooded system). Significant damage can occur to the unit if even run for a short time period without a fully filled casing assembly.

Never operate the pump(s) for more than a short interval with the discharge valve closed. The length of the interval depends on several factors including the nature of the fluid pumped and its temperature. Contact Technical Support for additional support if required.

Never operate the system with a closed suction valve.

Excessive pump noise or vibration may indicate a dangerous operating condition. The pump must be shutdown immediately.

Do not operate the pump and/or the system for an extended period of time below the recommended minimum flow.

It is absolutely essential that the rotation of the motor be checked before starting any pump in the system. Incorrect rotation of the pump(s) for even a short period of time can cause severe damage to the pumping assembly.

If the liquid is hazardous, take all necessary precautions to avoid damage and injury before emptying the pump casing.

Residual liquid may be found in the pump casing, suction and discharge manifolds. Take the necessary precautions if the liquid is hazardous, flammable, corrosive, poisonous, infected, etc.

Always lockout power to the driver before performing pump maintenance.

Never operate the pump without the coupling guard (if supplied) and all other safety devices correctly installed.

Do not apply heat to disassemble the pump or to remove the impeller. Entrapped liquid could cause an explosion.

If any external leaks are found while pumping hazardous product, immediately stop operations and repair.
PUMP IDENTIFICATION

MANUFACTURER
Franklin Electric
125 Morrison Drive
Rossville, TN 38066
United States of America

TYPE OF PUMP
FSD ANSI Process end suction pumps are a horizontal, single suction, single stage centrifugal pump.

DATE OF MANUFACTURE
The date of manufacture is indicated on the pump data plate.

INSTALLATION, OPERATION & MAINTENANCE MANUAl IDENTIFICATION
Prepared: January 1, 2018 Edition: 01
Revision: Date of Revision:

NAMEPLATE INFORMATION

WARRANTY
This product is covered by a Limited Warranty for a period of 12 months from the date of original purchase by the consumer. For complete warranty information, refer to www.franklinwater.com; or, contact Technical Support for a printed copy.

Phone: (901) 850-5115
Fax: (901) 850-5119

GENERAL INSTRUCTIONS
The pump and motor unit must be examined upon arrival to ascertain any damage caused during shipment. If damaged immediately notify the carrier and/or the sender. Check that the goods correspond exactly to the description on the shipping documents and report any differences as soon as possible to the sender. Always quote the pump type and serial number stamped on the data plate.

The pumps must be used only for applications for which the manufacturers have specified:

• The construction materials
• The operating conditions (flow, pressure, temperature, etc.)
• The field of application

In case of doubt, contact Technical Support.

Upon receipt of the pump, a visual check should be made to determine if any damage has been incurred during transit or shipment. The main areas to diligently inspect are:

• Broken or cracked castings, including the base, motor, pump feet and suction and discharge flanges
• Bent or damaged shafts
• Broken motor end bells, bent lifting eye bolts or damaged conduit boxes on the driver
• Missing parts

Parts and/or accessories are sometimes wrapped individually or fastened to the equipment. Coupling hubs are shipped in separate boxes. If any damage or loss has been incurred, promptly contact Technical Support and the freight company that delivered the equipment.

FIGURE 1 – Pump Data Plate

MODEL: Pump model designation
S/N: Pump Serial Number
PEICL: Pump Energy Index
P/N: Pump Part Number
SIZE: Discharge x Suction - # of Stages
GPM: Pump Rated Capacity
RPM: Pump Rated Speed
TDH: Pump Rated Total Dynamic Head
BHP: Pump Max HP
IMP DIA.: Impeller Trim Diameter
HANDLING AND TRANSPORT

METHOD OF TRANSPORT

The pump must be transported in the horizontal position.

INSTALLATION

During installation and maintenance, all components must be handled and transported securely by using suitable slings. Handling must be carried out by specialized personnel to avoid damage to the pump and persons. The lifting rings attached to various components should be used exclusively to lift the components for which they have been supplied.

CAUTION

Maximum lifting speed: 15 feet/second

It is important to exercise extreme care in handling and installing all parts. Certain items are precision machined for proper alignment and, if dropped, banged, sprung or mistreated in any way, misalignment and malfunction will result. Other components, such as the electrical cable, may be vulnerable to gouging or scuffing. Parts which are too heavy to be lifted from the transporting car or truck should be skidded slowly and carefully to the ground to prevent damage. Never unload by dropping parts directly from the carrier to the ground and never use shipping crates for skids.

CAUTION

For complete base mounted assemblies, NEVER lift on the pump or motor. Always lift equally at the four corners of the base assembly.

If job site conditions permit, you may be able to install directly from the truck that delivered the pump. If not, move the components to the installation area and lay them out in a clean and protected space convenient to the work location. Column pipe sections should be placed on suitable timbers to keep them out of the dirt, arranged so that the coupling ends point toward the wellhead. The motor assembly should be left on the skids until lifted for installation. The power cable and motor leads must receive special protection to avoid damage to the jacket or insulation.

If installation cannot begin within a few days after delivery, segregate and identify all components of the shipment so they won’t be confused with other equipment arriving at the job site.

Read and follow the storage instructions carefully because care of the pump during this period before installation can be as important as maintenance after operation has begun.

Check all parts against the packing list to make sure nothing is missing. It is much better to find out now than during the installation. Report any discrepancies immediately to Franklin Electric.
FIGURE 2 – Pressure-Temperature Limits By Alloy

<table>
<thead>
<tr>
<th>Designation</th>
<th>Symbol</th>
<th>ACI Designation</th>
<th>Equivalent Wrought Designation</th>
<th>ASTM Specification</th>
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<td>Carbon Steel</td>
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<td>D2</td>
<td>CF8</td>
<td>304</td>
<td>A744, Gr. CF8</td>
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<td>CZ100</td>
<td>Nickel 200</td>
<td>A744, Gr. CZ100</td>
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<tr>
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<td>DC2</td>
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</table>

*Ferralium is a registered trademark of Langley Alloys. *Hastelloy is a registered trademark of Haynes International. *Inconel and Monel are registered trademarks of International Nickel Co. Inc.

FIGURE 3 – Alloy Cross Reference Chart
Suction Pressure is limited only by the pressure temperature ratings for all open impeller pump sizes at all specific gravities and for semi-open impeller pump sizes 8x10-14, 6x8-16A, 8x10-16 and 8x10-16H through 2.0 specific gravity. RTF for specific gravities above 2.0.

**FIGURE 4 – Maximum Allowable Suction Pressures**
STORAGE

SHORT-TERM STORAGE

Normal packaging is designed to protect the pump during shipment and for dry, indoor storage for up to two months or less. If the pump is not to be installed or operated soon after delivery, store the unit in a clean, dry place, having slow changes in environmental conditions. Steps should be taken to protect the pump against moisture, dirt and foreign particulate intrusion. The procedure followed for this short-term storage is summarized below:

Standard Protection for Shipment:

a. Loose unmounted items, including, but not limited to, oilers, packing, coupling spacers, stilts and mechanical seals are packaged in a water proof plastic bag and placed under the coupling guard. Larger items are boxed and metal banded to the base plate. For pumps not mounted on a base plate, the bag and/or carton is placed inside the shipping carton. All parts bags and cartons are identified with the sales order number, the customer purchase order number and the pump item number (if applicable).

b. Inner surfaces of the bearing housing, shaft (area through bearing housing) and bearings are coated with Cortec VCI-329 rust inhibitor, or equal.

Note: Bearing housings are not filled with oil prior to shipment.

c. Regreasable bearings are packed with grease (Exxon Mobile Polyrex EM).

d. After a performance test, if required, the pump is tipped on the suction flange for drainage (some residual water may remain in the casing). Then, internal surfaces of ferrous casings, covers, flange faces and the impeller surface are sprayed with Calgon Vestal Labs RP-743m or equal. Exposed shafts are taped with Polywrap.

e. Flange faces are protected with plastic covers secured with plastic drive bolts. 3/16 in (7.8 mm) steel or 1/4 in (6.3 mm) wood covers with rubber gaskets, steel bolts and nuts are available at extra cost.

f. All assemblies are bolted to a wood skid which confines the assembly within the perimeter of the skid.

g. Assemblies with special paint are protected with a plastic wrap.

h. Bare pumps, when not mounted on base plates, are bolted to wood skids.

i. All assemblies having external piping (seal flush and cooling water plans), etc. are packaged and braced to withstand normal handling during shipment. In some cases components may be disassembled for shipment. The pump must be stored in a covered, dry location.

It is recommended that the following procedure is taken:

1. Ensure that the bearings are packed with the recommended grease (if grease lubricated) or coated with oil (if oil lubricated) to prevent moisture from entering the bearing housings.

2. Remove all glands, packing and lantern rings from the stuffing box (if packed). If the pump is supplied with a mechanical seal, remove the mechanical seal and coat it with a light film of oil.

3. Ensure that the suction and discharge flanges are covered and secured with cardboard, plastic or wood to prevent foreign objects from entering the pump.

4. If the pump is to be stored outdoors with no overhead covering, cover the unit with a tarp or other suitable covering.

LONG-TERM STORAGE

Long-term storage is defined as more than two months, but less than 12 months. The procedure Franklin Electric follows for long-term storage of pumps is given below. These procedures are in addition to the short-term procedure above.

Solid wood skids are utilized. Holes are drilled in the skid to accommodate the anchor bolt holes in the base plate or the casing and bearing housing feet holes on assemblies less base plate. Tackwrap sheeting is then placed on top of the skid and the pump assembly is placed on top of the Tackwrap. Metal bolts with washers and rubber bushings are inserted through the skid, the Tackwrap and the assembly from the bottom of the skid and are then secured with hex nuts. When the nuts are “snugged” down to the top of the base plate or casing and bearing housing feet, the rubber bushing is expanded, sealing the hole from the atmosphere. Desiccant bags are placed on the Tackwrap. The Tackwrap is drawn up around the assembly and hermetically (heat) sealed across the top. The assembly is completely sealed from the atmosphere and the desiccant will absorb any entrapped moisture. A solid wood box is then used to cover the assembly to provide protection from the elements and handling. This packaging will provide protection up to twelve months without damage to mechanical seals, bearings, lip seals, etc. due to humidity, salt laden air, dust, etc. After unpacking, protection will be the responsibility of the user. Addition of oil to the bearing housing will remove the inhibitor. If units are to be idle for extended periods after addition of lubricants, inhibitor oils and greases should be used.

Every three months, the shaft should be rotated approximately 10 revolutions.
INSTALLATION & ALIGNMENT

PREPARATION

Before installing the pump, clean the suction and discharge flanges thoroughly. Remove any protective coatings that may be on the shaft.

If the pump is coming from Short-Term or Long-Term storage and has been prepared for storage in the manner above, remove all grease and/or oil from the bearings. The bearings should be flushed with an appropriate fluid to remove any contamination prior to placing the pump into service.

PUMP LOCATION

The pump should be installed as close to the source of the liquid as the job-site allows, with the shortest and most direct suction line possible.

The pump should also be installed with future inspection and maintenance in mind. Ample space and headroom for a lifting crane or hoist sufficiently strong to lift the entire unit.

Ensure that there is suitable power available for the pump driver. You must confirm that the appropriate power is available and that it matches the requirements on the motor data plate.

FOUNDATION

The foundation should be sufficiently sized to reduce vibration and rigid enough to avoid any movement both axially and/or radially. The foundation mass should be four (4) to six (6) times the complete mass of the entire pumping assembly.

The foundation should be poured without interruption to within 0.500 in. (13 mm) to 1.500 in. (38 mm) of the finished height. The top surface of the foundation should be well scored and grooved before the concrete sets. This provides a bonding surface for the grout. Foundation bolts should be set into the concrete as shown in FIGURE 5. Allow enough bolt length for grout, shims, lower baseplate flange, nuts and washers. The foundation should be allowed to cure for several days before the baseplate is shimmed and grouted.

FACTORY PRELIMINARY ALIGNMENT PROCEDURE

The purpose of factory alignment is to ensure that the user will have full utilization of the clearance in the motor holes for final job-site alignment. To achieve this, the factory alignment procedure specifies that the pump be aligned in the horizontal plane to the motor, with the motor foot bolts centered in the motor holes. This procedure ensures that there is sufficient clearance in the motor holes for the customer to field align the motor to the pump, to zero tolerance. This philosophy requires that the customer be able to place the base in the same condition as was the case at the factory. Thus the factory alignment will be done with the base sitting in an unrestrained condition on a flat and level surface. This standard also emphasizes the need to ensure the shaft spacing is adequate to accept the specified coupling spacer. The factory alignment procedure is summarized below:

1. The base plate is placed on a flat and level work bench in a free and unstressed position.

2. The base plate is leveled as necessary. Leveling is accomplished by placing shims under the rails (or feet) of the base at the appropriate anchor bolt hole locations. Levelness is checked in both the longitudinal and lateral directions.

3. The motor and appropriate motor mounting hardware is placed on the base plate and the motor is checked for any planar soft-foot condition. If any is present it is eliminated by shimming.

4. The motor feet holes are centered around the motor mounting fasteners.

5. The motor is fastened in place by tightening the nuts on two diagonal motor mounting studs.

6. The pump is put onto the base plate and leveled. If an adjustment is necessary, we add or delete shims between the pump foot and the base plate.

7. The spacer coupling gap is verified.

8. The parallel and angular vertical alignment is made by shimming under the motor.

9. All four motor feet are tightened down.

10. The pump and motor shafts are then aligned horizontally, in both parallel and angular, by moving the pump to the fixed motor. The pump feet are tightened down.

11. Both horizontal and vertical alignment are again final checked as is the coupling spacer gap.

RECOMMENDED PROCEDURE FOR BASE PLATE INSTALLATION & FINAL FIELD ALIGNMENT

NEWLY GROUTED BASE PLATES

1. The pump foundation should be located as close to the source of the fluid to be pumped as practical. There should be adequate space for workers to install, operate and maintain the pump. The foundation should be sufficient to absorb any vibration and should provide a rigid support for the pump and motor. Recommended mass of a
concrete foundation should be four (4) to six (6) times that of the pump, motor and base. Note that foundation bolts are imbedded in the concrete inside a sleeve to allow some movement of the bolt.

2. Level the pump base plate assembly. If the base plate has machined coplanar mounting surfaces, these machined surfaces are to be referenced when leveling the base plate. This may require that the pump and motor be removed from the base plate in order to reference the machined faces. If the base plate is without machined coplanar mounting surfaces, the pump and motor are to be left on the base plate. The proper surfaces to reference when leveling the pump base plate assembly are the pump suction and discharge flanges. DO NOT stress the base plate. DO NOT bolt the suction or discharge flanges of the pump to the piping until the base plate foundation is completely installed. If equipped, use leveling jackscrews to level the base plate. If jackscrews are not provided, shims and wedges should be used. See FIGURE 5. Check for levelness in both the longitudinal and lateral directions. Shims should be placed at all base anchor bolt locations, and in the middle edge of the base if the base is more than five feet long. Do not rely on the bottom of the base plate to be flat. Standard base plate bottoms are not machined, and it is not likely that the field mounting surface is flat.

3. After leveling the base plate, tighten the anchor bolts. If shims were used, make sure that the base plate was shimmed near each anchor bolt before tightening. Failure to do this may result in a torsional twist of the base plate, which could make it impossible to obtain final alignment. Check the level of the base plate to make sure that tightening the anchor bolts did not disturb the level of the base plate. If the anchor bolts did change the level, adjust the jackscrews or shims as needed to level the base plate. Continue adjusting the jackscrews or shims and tightening the anchor bolts until the base plate is level.

4. Check initial alignment. If the pump and motor were removed from the base plate proceed with step 5 first, then the pump and motor should be reinstalled onto the base plate using Franklin Electric Factory Preliminary Alignment Procedure and then continue with the following. As described above, pumps are given a preliminary alignment at the factory. This preliminary alignment is done in a way that ensures that, if the installer duplicates the factory conditions, there will be sufficient clearance between the motor hold down bolts and motor foot holes to move the motor into final alignment. If the pump and motor were properly reinstalled to the base plate or if they were not removed from the base plate and there has been no transit damage, and also if the above steps where done properly, the pump and driver should be within 0.015 in. (0.38 mm) FIM (Full Indicator Movement) parallel and 0.0025 in/in (0.0025 mm/mm) FIM angular. If this is not the case first check to see if the driver mounting fasteners are centered in the driver feet holes. If not, re-center the fasteners and perform a preliminary alignment to the above tolerances by shimming under the motor for vertical alignment and by moving the pump for horizontal alignment.

3/4” TO 1-1/2” ALLOWANCE FOR GROUT

LEVELING WEDGES OR SHIM - LEFT IN PLACE

FIGURE 5 – Base Plate Foundation

5. Grout the base plate. A non-shrinking grout should be used. Grout compensates for uneven foundation, distributes weight of unit, and prevents shifting. Use an approved, non-shrinking grout, after setting and leveling unit.

a. Build strong form around the foundation to contain grout.

b. Soak top of concrete foundation thoroughly, then remove surface water.

c. The area under an elevated motor pedestal should also be completely filled with grout.

d. After the grout has thoroughly hardened, check the foundation bolts and tighten if necessary.

e. Approximately 14 days after the grout has been poured or when the grout has thoroughly dried, apply an oil base paint to the exposed edges of the grout to prevent air and moisture from coming in contact with the grout.
Make sure that the grout fills the area under the base plate. After the grout has cured, check for voids and repair them.

6. Run piping to the suction and discharge of the pump. There should be no piping loads transmitted to the pump after connection is made. Recheck the alignment to verify that there are no significant loads.

7. Perform final alignment. Check for soft-foot under the driver. An indicator placed on the coupling, reading in the vertical direction, should not indicate more than 0.002 in (0.05 mm) movement when any driver fastener is loosened. Align the driver first in the vertical direction by shimming underneath its feet. When satisfactory alignment is obtained, the number of shims in the pack should be minimized. It is recommended that no more than five shims be used under any foot. Final horizontal alignment is made by moving the driver. Maximum pump reliability is obtained by having near perfect alignment. Franklin Electric recommends no more than 0.002 in (0.05mm) parallel and 0.0005 in/in (0.0005 mm/mm) angular misalignment.

8. Operate the pump for at least an hour or until it reaches final operating temperature. Shut the pump down and recheck alignment while the pump is hot. Piping thermal expansion may change the alignment. Realign pump as necessary.

EXISTING GROUTED BASE PLATES

When a pump is being installed on an existing grouted base plate, the procedure is somewhat different from the previous section “NEWLY GROUTED BASE PLATES.”

1. Mount the pump on the existing base plate.

2. Level the pump by putting a level on the discharge flange. If not level, add or delete shims between the pump foot and the base plate.

3. Check initial alignment. (Step 4 above)

4. Run piping to the suction and discharge flanges of the pump. (Step 6 above)

5. Perform final alignment. (Step 7 above)

6. Recheck alignment after pump is hot. (Step 8 above)

All piping must be independently supported, accurately aligned and preferably connected to the pump by a short length of flexible piping. The pump should not have to support the weight of the pipe or compensate for misalignment. It should be possible to install suction and discharge bolts through mating flanges without pulling or prying either of the flanges. All piping must be tight. Pumps may vapor-lock if air is allowed to leak into the piping. If the pump flange(s) have tapped holes, select flange fasteners with thread engagement at least equal to the fastener diameter but that do not bottom out in the tapped holes before the joint is tight.

All alignment procedures should be conducted while the unit is cold and then checked when the unit is up to operating temperature. For high temperature applications, a hot alignment must also be conducted to make sure that the thermal expansion of the entire assembly is taken into consideration.

After final alignment, the pump and driver feet can be dowel to the baseplate to make sure nothing moves while operating in service.

PIPING CONNECTION – SUCTION & DISCHARGE

When installing the pump piping, be sure to observe the following precautions:

Piping should always be run to the pump.

Do not move pump to pipe. This could make final alignment impossible.

Both the suction and discharge piping should be supported independently near the pump and properly aligned, so that no strain is transmitted to the pump when the flange bolts are tightened. Use pipe hangers or other supports at necessary intervals to provide support. When expansion joints are used in the piping system, they must be installed beyond the piping supports closest to the pump. Tie bolts should be used with expansion joints to prevent pipe strain. Do not install expansion joints next to the pump or in any way that would cause a strain on the pump resulting from system pressure changes. It is usually advisable to increase the size of both suction and discharge pipes at the pump connections to decrease the loss of head from friction.

![WARNING]

**Piping Forces: Take care during installation and operation to minimize pipe forces and/or moments on the pump casing.**

Install piping as straight as possible, avoiding unnecessary bends. Where necessary, use 45-degree or long sweep 90-degree fitting to decrease friction losses.

Make sure that all piping joints are air-tight.

Where flanged joints are used, assure that inside diameters match properly.

Remove burrs and sharp edges when making up joints.
Do not “spring” piping when making any connections.

Provide for pipe expansion when hot fluids are to be pumped.

**SUCTION PIPING**

When installing the suction piping, observe the following precautions. See FIGURE 6.

The sizing and installation of the suction piping is extremely important. It must be selected and installed so that pressure losses are minimized and sufficient liquid will flow into the pump when started and operated. Many NPSH (Net Positive Suction Head) problems can be attributed directly to improper suction piping systems.

Friction losses caused by undersized suction piping can increase the fluid’s velocity into the pump. As recommended by the Hydraulic Institute Standard ANSI/HI 1.1-1.5-1994, suction pipe velocity should not exceed the velocity in the pump suction nozzle. In some situations pipe velocity may need to be further reduced to satisfy pump NPSH requirements and to control suction line losses. Pipe friction can be reduced by using pipes that are one to two sizes larger than the pump suction nozzle in order to maintain pipe velocities less than 5 feet/second.

Suction piping should be short in length, as direct as possible, and never smaller in diameter than the pump suction opening.

If the suction pipe is short, the pipe diameter can be the same size as the suction opening. If longer suction pipe is required, pipes should be one or two sizes larger than the opening, depending on piping length.

Suction piping for horizontal double suction pumps should not be installed with an elbow close to the suction flange of the pump, except when the suction elbow is in the vertical plane.

A suction pipe of the same size as the suction nozzle, approaching at any angle other than straight up or straight down, must have the elbow located 10 pipe diameters from the suction flange of the pump. Vertical mounted pumps and other space limitations require special piping.

There is always an uneven turbulent flow around an elbow. When it is in a position other than the vertical it causes more liquid to enter one side of the impeller than the other. This results in high un-equalized thrust loads that will overheat the bearings and cause rapid wear, in addition to affecting hydraulic performance.

**FIGURE 6 – Good Piping Practices**

When operating on a suction lift, the suction pipe should slope upward to the pump nozzle. A horizontal suction line must have a gradual rise to the pump. Any high point in the pipe will become filled with air and thus prevent proper operation on the pump. When reducing the piping to the suction opening diameter, use an eccentric reducer with the eccentric side down to avoid air pockets.

*NOTE:* When operating on suction lift, never use a straight taper reducer in a horizontal suction line as it tends to form an air pocket in the top of the reducer and the pipe.

To facilitate cleaning pump liquid passage without dismantling pump, a short section of pipe (Dutchman or spool piece), so designed that it can be readily dropped out of the line, can be installed adjacent to the suction flange. With this arrangement, any matter clogging the impeller is accessible by removing the nozzle (or pipe section).

**Valves in Suction Piping**

When installing valves in the suction piping, observe the following precautions:

a. If the pump is operating under static suction lift conditions, a foot valve may be installed in the suction line to avoid the necessity of priming each time the pump is started. This valve should be of the flapper type, rather than the multiple spring type, sized to avoid excessive friction in the suction line. (Under all other conditions, a check valve, if used, should be installed in the discharge line (See “Valves in Discharge Piping” below).

b. When foot valves are used or where there are other possibilities of “water hammer,” close the discharge valve slowly before shutting down the pump.
When fluid velocity in the pipe is high, for example 10 ft/s (3 m/s) or higher, a rapidly closing discharge valve can cause a damaging pressure surge. A dampening arrangement should be provided in the piping.

Pump Insulation

On chilled water applications most pumps are insulated. As part of this practice, the pump bearing housings should not be insulated since this would tend to “trap” heat inside the housing.

This could lead to increased bearing temperatures and premature bearing failures.

PUMP AND SHAFT ALIGNMENT CHECK

After connecting piping, rotate the pump drive shaft clockwise (view from motor end) by hand several complete revolutions to be sure there is no binding and that all parts are free. Recheck shaft alignment. If piping caused unit to be out of alignment, correct piping to relieve strain on the pump.

MECHANICAL SEAL

When the pump is intended to be equipped with a mechanical seal, it is Franklin Electric standard practice to install the mechanical seal in the pump prior to shipment. Specific order requirements may specify that the seal be shipped separately, or none be supplied. It is the pump installer’s responsibility to determine if a seal was installed. If a seal was supplied but not installed, the seal and installation instructions will be shipped with the pump.

Failure to ensure that a seal is installed may result in serious leakage of the pumped fluid.

Seal and seal support system must be installed and operational as specified by the seal manufacturer.

Mechanical seals are preferred over packing on some applications because of better sealing qualities and longer service-ability.

Leakage is eliminated when a seal is properly installed and normal life is much greater than that of packing on similar applications.

Pumps containing single mechanical seals normally utilize the pumped liquid to lubricate the seal faces. This method is preferred when the pumped liquid is neither abrasive nor corrosive.

PACKING

When the pump is intended to be equipped with shaft packing, it is Franklin Electric standard practice to install the packing in the stuffing box prior to shipment. The packing is shipped with the pump. It is the pump installer’s responsibility to install the packing in the stuffing box.

c. Where two or more pumps are connected to the same suction line, install gate valves so that any pump can be isolated from the line. Gate valves should be installed on the suction side of all pumps with a positive pressure for maintenance purposes. Install gate valves with stems horizontal to avoid air pockets. Globe valves should not be used, particularly where NPSH is critical.

d. The pump must never be throttled by the use of a valve on the suction side of the pump. Suction valves should be used only to isolate the pump for maintenance purposes, and should always be installed in positions to avoid air pockets.

e. A pump drain valve should be installed in the suction piping between the isolation valve and the pump.

DISCHARGE PIPING

If the discharge piping is short, the pipe diameter can be the same as the discharge opening. If the piping is long, pipe diameter should be one or two sizes larger than the discharge opening. On long horizontal runs, it is desirable to maintain as even a grade as possible. Avoid high spots, such as loops, which will collect air and throttle the system or lead to erratic pumping.

Valves in Discharge Piping

A triple duty valve should be installed in the discharge. The triple duty valve placed on the pump protects the pump from excessive back pressure, and prevents liquid from running back through the pump in case of power failure.

When fluid velocity in the pipe is high, for example 10 ft/s (3 m/s) or higher, a rapidly closing discharge valve can cause a damaging pressure surge. A dampening arrangement should be provided in the piping.

Pressure Gauges

Properly sized pressure gauges should be installed in both the suction and discharge nozzles in the gauge taps (which are provided on request). The gauges will enable the operator to easily observe the operation of the pump and also determine if the pump is operating in conformance with the performance curve. If cavitation, vapor binding or other unstable operation should occur, widely fluctuating discharge pressure will be noted.

When fluid velocity in the pipe is high, for example 10 ft/s (3 m/s) or higher, a rapidly closing discharge valve can cause a damaging pressure surge. A dampening arrangement should be provided in the piping.
Failure to ensure that packing is installed may result in serious leakage of the pumped fluid.

**CAUTION**

If the pump has a seal support system, it is mandatory that this system be fully installed and operational before the pump is started.

**WARNING**

If packing is used:

**Packing Lubrication – Water**

Water, when compatible with the pumpage, should be introduced into the packing box at pressure 10 to 15 lbf/in² (69 to 103 kPa) above the stuffing box pressure.

The gland should be adjusted to give a flow rate of 20 to 30 drops per minute for clean fluid. For abrasive applications, the regulated flow rate should be 1-2 gpm (0.06-0.13 l/s).

**Grease lubrication**

Grease lubrication, when compatible with the pumpage, may be used. In non-abrasive applications the pumpage itself may be sufficient to lubricate the packing without need for external lines. The internal flush line should be plugged.

**Abrasive Packing Arrangement**

The installation procedures are the same as the standard packing with some exceptions. A special lip seal is installed first, followed by two lantern ring assemblies, then two of the packing rings provided.

A flush line from a clean external source should be connected to the top of the stuffing box.

**PIPING CONNECTION – SEAL/PACKING SUPPORT SYSTEM**

**PIPING CONNECTION – BEARING HOUSING COOLING SYSTEM**

Liquid at less than 90°F (32°C) should be supplied at a regulated flow rate of at least 1 gpm (0.06 l/s).
PIPING CONNECTION – SUPPORT LEG COOLING FOR CENTERLINE MOUNTING OPTION

If the casing is centerline mounted, and the process temperature is over 350°F (178°C), then the casing support legs may need to be cooled (figure 10). Cool water (less than 90°F (32°C)) should be run through the legs at a flow rate of at least 1 gpm (0.06 l/s) as shown below.

FIGURE 10 – Support Leg Cooling

PIPING CONNECTION – HEATING/Cooling FLUID FOR JACKETED COVER/CASING

The piping connections for jacketed covers and casings are shown below (FIGURE 11). The flow rate of the cooling water (less than 90°F (32°C)) should be at least 2 gpm (0.13 l/s).

FIGURE 11 – Seal Chamber Cooling

PIPING CONNECTION – OIL MIST LUBRICATION SYSTEM

The piping connections for an oil mist lubrication system are shown in FIGURES 12 & 13.

FIGURE 12 – Oil Mist Lubrication – Wet Sump

FIGURE 13 – Oil Mist Lubrication – Dry Sump

BEARING LUBRICATION

Grease lubricated ball bearings are packed with grease at the factory and ordinarily will require no attention before starting, provided the pump has been stored in a clean, dry place prior to its first operation. The bearings should be watched the first hour or so after the pump has been started to see that they are operating properly.

The importance of proper lubrication cannot be over emphasized. It is difficult to say how often a bearing should be greased, since that depends on the conditions of operation. It is well to add one ounce of grease at regular intervals but it is equally important to avoid adding too much grease. For average operating conditions, it is recommended that 1 oz. of grease be added at intervals of three to six months and only clean grease be used. It is always best if unit can be stopped while grease is added to avoid overloading.
COUPLING

A direction arrow is cast on the casing. Make sure the motor rotates in the same direction before coupling the motor to the Pump.

It is absolutely essential that the rotation of the motor be checked before connecting the shaft coupling. Incorrect rotation of the pump, for even a short time, can dislodge the shaft sleeves which may cause serious damage to the pump.

The coupling should be installed as advised by the coupling manufacturer. Pumps are shipped without the spacer installed. If the spacer has been installed to facilitate alignment then it must be removed prior to checking rotation. Remove protective material from the coupling and any exposed portions of the shaft before installing the coupling.

PUMP OPERATION

ROTATION CHECK

Excess grease is the most common cause of overheating.

A lithium based NLGI-2 grade grease should be used for lubricating bearings where the ambient temperature is above -20°F. Grease lubricated bearings are packed at the factory with Exxon Mobile Polyrex EM. Other recommended greases are Texaco Multifak 2, Shell Alvania 2 and Mobilux No. 2 grease. Greases made from animal or vegetable oils are not recommended due to the danger of deterioration and forming of acid. Do not use graphite. Use of an ISO VG 100 mineral base oil with rust and oxidation inhibitors is recommended.

The maximum desirable operating temperature for ball bearings is 180°F. Should the temperature of the bearing frame rise above 180°F, the pump should be shut down to determine the cause.

---

Mineral Oil | Quality mineral oil with rust and oxidation inhibitors. Mobil DTE Heavy/Medium ISO VG 68 or equivalent.
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Synthetic | Royal Purple SynFilm 68, Conoco SYNCON 68 or equivalent. Some synthetic lubricants require Viton O-rings.

Grease | Exxon Mobile Polyrex EM, Chevron SRI #2 (or compatible).

FIGURE 14 – Recommended Lubricants

<table>
<thead>
<tr>
<th>Maximum Oil Temperature</th>
<th>ISO Viscosity Grade</th>
<th>Minimum Viscosity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 160°F (71°C)</td>
<td>46</td>
<td>95</td>
</tr>
<tr>
<td>160-175°F (71°-80°C)</td>
<td>68</td>
<td>95</td>
</tr>
<tr>
<td>175-200°F (80°-94°C)</td>
<td>100</td>
<td>95</td>
</tr>
</tbody>
</table>

FIGURE 15 – Oil Viscosity Grades

<table>
<thead>
<tr>
<th>Lubricant</th>
<th>Under 60°F (71°C)</th>
<th>160-175°F (71-80°C)</th>
<th>175-200°F (80-94°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grease</td>
<td>6 mo</td>
<td>3 mo</td>
<td>1.5 mo</td>
</tr>
<tr>
<td>Mineral Oil</td>
<td>6 mo</td>
<td>3 mo</td>
<td>1.5 mo</td>
</tr>
<tr>
<td>Synthetic Oil**</td>
<td>18 mo</td>
<td>18 mo</td>
<td>18 mo</td>
</tr>
</tbody>
</table>

FIGURE 16 – Re-lubrication Intervals

It is absolutely essential that the rotation of the motor be checked before connecting the shaft coupling. Incorrect rotation of the pump, for even a short time, can dislodge and damage the shaft sleeves, impeller, casing, shaft and shaft seal.

PRE START-UP CHECKS

Prior to starting the pump it is essential that the following checks are made. These checks are all described in detail in the Maintenance Section of this booklet.

- Pump and Motor properly secured to the base plate
- Check alignment of pump and motor
- Coupling guard in place and not rubbing
- Rotation check, see above

THIS IS ABSOLUTELY ESSENTIAL

- Shaft seal and/or packing properly installed
- Seal support system operational
- Bearing lubrication
- Pump instrumentation is operational
- Pump is primed
- Rotation of shaft by hand

As a final step in preparation for operation, it is important to rotate the shaft by hand to be certain that all rotating parts move freely and that there are no foreign objects in the pump.
PRIMING

If the pump is installed with a positive head on the suction, it can be primed by opening the suction and vent valve and allowing the liquid to enter the casing. If the pump is installed with a suction lift, priming must be done by other methods such as foot valves, ejectors or by manually filling the casing and suction line.

ENSURING PROPER NPSHA

Net Positive Suction Head – Available (NPSHA) is the measure of the energy in a liquid above the vapor pressure. It is used to determine the likelihood that a fluid will vaporize in the pump. It is critical because a centrifugal pump is designed to pump a liquid, not a vapor. Vaporization in a pump will result in damage to the pump, deterioration of the Total Differential Head (TDH), and possibly a complete stopping of pumping.

Net Positive Suction Head – Required (NPSHR) is the decrease of fluid energy between the inlet of the pump and the point of lowest pressure in the pump. This decrease occurs because of friction losses and fluid accelerations in the inlet region of the pump, and particularly accelerations as the fluid enters the impeller vanes. The value for NPSHR for the specific pump purchased is given in the pump data sheet and on the pump performance curve.

For a pump to operate properly the NPSHA must be greater than the NPSHR. Good practice dictates that this margin should be at least 5 ft (1.5 m) or 20%, whichever is greater.

MINIMUM FLOW

Minimum continuous stable flow is the lowest flow at which the pump can operate and still conform to the bearing life, shaft deflection and bearing housing vibration limits of the ASME standard. Pumps may be operated at lower flows, but it must be recognized that the pump may not conform to one or more of these limits. For example, vibration may exceed the limit set by the ASME standard. The size of the pump, the energy absorbed and the liquid pumped are some of the considerations in determining the minimum flow.

Typically, limitations of 20% of the capacity at the best efficiency point (BEP) should be specified as the minimum flow. However, Franklin Electric has determined that several pumps must be limited to higher minimum flows to provide optimum service. The following are the recommended minimum flows for these specific pumps:

<table>
<thead>
<tr>
<th>Pump Size</th>
<th>60 Hz RPM</th>
<th>Minimum Flow (% of BEP)</th>
<th>50 Hz RPM</th>
<th>Minimum Flow (% of BEP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1L2x3-6</td>
<td>3500</td>
<td>25%</td>
<td>2900</td>
<td>21%</td>
</tr>
<tr>
<td>2L2x3-8</td>
<td>3500</td>
<td>25%</td>
<td>2900</td>
<td>21%</td>
</tr>
<tr>
<td>2L2x3-10</td>
<td>3500</td>
<td>33%</td>
<td>2900</td>
<td>28%</td>
</tr>
<tr>
<td>2L3x4-10</td>
<td>3500</td>
<td>33%</td>
<td>2900</td>
<td>28%</td>
</tr>
<tr>
<td>2L4x6-10</td>
<td>3500</td>
<td>50%</td>
<td>2900</td>
<td>42%</td>
</tr>
<tr>
<td>2L2x3-13</td>
<td>3500</td>
<td>50%</td>
<td>2900</td>
<td>42%</td>
</tr>
<tr>
<td>2L3x4-13</td>
<td>3500</td>
<td>50%</td>
<td>2900</td>
<td>42%</td>
</tr>
<tr>
<td>2L4x6-13</td>
<td>1750</td>
<td>50%</td>
<td>1450</td>
<td>42%</td>
</tr>
<tr>
<td>All GRP III*</td>
<td>1750</td>
<td>50%</td>
<td>1450</td>
<td>42%</td>
</tr>
</tbody>
</table>

FIGURE 17 - Minimum Continuous Safe Flow

Note: “Minimum intermittent flow” value of 50% of the “minimum continuous flow” as long as that flow is greater than the “minimum thermal flow.”

All FSD pumps also have a “Minimum Thermal Flow.” This is defined as the minimum flow that will not cause an excessive temperature rise. Minimum Thermal Flow is application dependent.

STARTING THE PUMP AND ADJUSTING FLOW

1. Open the suction valve to full open position. It is very important to leave the suction valve open while the pump is operating. Any throttling or adjusting of flow must be done through the discharge valve. Partially closing the suction valve can create serious NPSH and pump performance problems.

Never operate pump with both the suction and discharge valves closed. This could cause an explosion.
2. A standard centrifugal pump will not move liquid unless the pump is primed. A pump is said to be “primed” when the casing and the suction piping are completely filled with liquid. Open discharge valve a slight amount. This will allow any entrapped air to escape and will normally allow the pump to prime, if the suction source is above the pump. When a condition exists where the suction pressure may drop below the pump’s capability, it is advisable to add a low pressure control device to shut the pump down when the pressure drops below a predetermined minimum.

3. All cooling, heating, and flush lines must be started and regulated.

4. Start the driver (typically, the electric motor).

5. Slowly open the discharge valve until the desired flow is reached, keeping in mind the minimum flow restrictions listed above.

6. Reduced capacity
Avoid running a centrifugal pump at drastically reduced capacities or with discharge valve closed for extended periods of time. This can cause severe temperature rise and the liquid in the pump may reach its boiling point. If this occurs, the mechanical seal will be exposed to vapor, with no lubrication, and may score or seize to the stationary parts. Continued running under these conditions when the suction valve is also closed, can create an explosive condition due to the confined vapor at high pressure and temperature. Thermostats may be used to safeguard against overheating by shutting down the pump at a predetermined temperature.

Safeguards should also be taken against possible operation with a closed discharge valve, such as installing a bypass back to the suction source. The size of the bypass line and the required bypass flow rate is a function of the input horsepower and the allowable temperature rise.

8. Surging Condition
A rapidly closing discharge valve can cause a damaging pressure surge. A dampening arrangement should be provided in the piping.

OPERATION IN SUB-FREEZING CONDITIONS
When using the pump in sub-freezing conditions where the pump is periodically idle, the pump should be properly drained or protected with thermal devices which will keep the liquid in the pump from freezing. High chrome iron pumps are not recommended for applications below 0°F (−18°C).

SHUTDOWN CONSIDERATIONS
When the pump is being shutdown, the procedure should be the reverse of the start-up procedure. First, slowly close the discharge valve, shutdown the driver, then close the suction valve. Remember, closing the suction valve while the pump is running is a safety hazard and could seriously damage the pump and other equipment.

TROUBLESHOOTING
The following is a guide to troubleshooting problems with FPS pumps. Common problems are analyzed and solutions are offered. Obviously, it is impossible to cover every possible scenario. If a problem exists that is not covered by one of the examples, then contact a local Franklin Electric Sales Engineer or Distributor/Representative for assistance.

7. Reduced Head
Note that when discharge head drops, the pump’s flow rate usually increases rapidly. Check motor for temperature rise as this may cause overload. If overloading occurs, throttle the discharge.

DANGER
It is important that the discharge valve be opened within a short interval after starting the driver. Failure to do this could cause a dangerous build up of heat and possibly an explosion.
<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>No liquid delivered</th>
<th>Not enough liquid delivered</th>
<th>Not enough discharge pressure</th>
<th>Loss of liquid after starting</th>
<th>Pump operating for a short time, then stops</th>
<th>Pump is pulling high horsepower</th>
<th>Driver running hot</th>
<th>Excessive vibration</th>
<th>Cavitation noise from pump</th>
<th>Pump bearings running hot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump not primed/lack of prime/incomplete priming</td>
<td></td>
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<tr>
<td>Loss of prime</td>
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<td></td>
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<tr>
<td>Suction lift too high</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Discharge head too high</td>
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<tr>
<td>Rotational speed too low</td>
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<tr>
<td>Incorrect direction of rotation</td>
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<tr>
<td>Impeller plugged/impeller partially blocked by debris</td>
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<tr>
<td>Air leak in suction line</td>
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<tr>
<td>Air leak in discharge line</td>
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<tr>
<td>Insufficient Net Positive Suction Pressure Available (NPSH&lt;sub&gt;A&lt;/sub&gt;)</td>
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<tr>
<td>Damaged impeller</td>
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<tr>
<td>Defective packing</td>
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<td></td>
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<tr>
<td>Foot valve too small or partially blocked</td>
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<tr>
<td>Inlet pipe not submerged enough</td>
<td></td>
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<td></td>
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<tr>
<td>Impeller diameter too small</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Obstruction in water passageways</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Entrained air or gas in liquid</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Discharge head lower than previously thought</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Specific gravity of liquid higher than previously thought</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Viscosity of liquid higher than previously thought</td>
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<tr>
<td>Bent or damaged shaft</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROBLEM</td>
<td>No liquid delivered</td>
<td>Not enough liquid delivered</td>
<td>Not enough discharge pressure</td>
<td>Loss of liquid after starting</td>
<td>Pump operating for a short time, then stops</td>
<td>Pump is pulling high horsepower</td>
<td>Driver running hot</td>
<td>Excessive vibration</td>
<td>Cavitation noise from pump</td>
<td>Pump bearings running hot</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>---------------------</td>
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<td>Bearings worn</td>
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<td>Misalignment of pump and driver</td>
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<td>Defect in driver</td>
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<td>Voltage and/or frequency lower than previously thought</td>
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<td>Rotational speed too high</td>
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<td>Foundation not rigid enough</td>
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<td>Lubrication grease and/or oil dirty &amp; contaminated</td>
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<td>PROBLEM</td>
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<tr>
<td>Problem #1</td>
<td>Pump not reaching design flow rate.</td>
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<tr>
<td>1.1</td>
<td>Insufficient NPSHA. (Noise may not be present)</td>
<td>Recalculate NPSH available. It must be greater than the NPSH required by pump at desired flow. If not, redesign suction piping, holding number of elbows and number of planes to a minimum to avoid adverse flow rotation as it approaches the impeller.</td>
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<td>1.2</td>
<td>System head greater than anticipated.</td>
<td>Reduce system head by increasing pipe size and/ or reducing number of fittings. Increase impeller diameter. <strong>NOTE:</strong> Increasing impeller diameter may require use of a larger motor.</td>
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<td>1.3</td>
<td>Entrained air.</td>
<td>Air leak from atmosphere on suction side. 1. Check suction line gaskets and threads for tightness. 2. If vortex formation is observed in suction tank, install vortex breaker. 3. Check for minimum submergence.</td>
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<td>1.4</td>
<td>Entrained gas from process.</td>
<td>Process generated gases may require larger pumps.</td>
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<td>1.5</td>
<td>Speed too low.</td>
<td>Check motor speed against design speed.</td>
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<td>1.6</td>
<td>Direction of rotation wrong.</td>
<td>After confirming wrong rotation, reverse any two of three leads on a three phase motor. The pump should be disassembled and inspected before it is restarted.</td>
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<td>1.7</td>
<td>Impeller too small.</td>
<td>Replace with proper diameter impeller. <strong>NOTE:</strong> Increasing impeller diameter may require use of a larger motor.</td>
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<td>1.8</td>
<td>Impeller clearance too large.</td>
<td>Replace impeller and/or case wear rings.</td>
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<td>1.9</td>
<td>Plugged impeller, suction line or casing which may be due to a product or large solids.</td>
<td>1. Reduce length of fiber when possible. 2. Reduce solids in the process fluid when possible. 3. Consider larger pump.</td>
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<td>1.10</td>
<td>Wet end parts (casing cover, impeller) worn, corroded or missing.</td>
<td>Replace part or parts.</td>
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<tr>
<td>Problem #2.0</td>
<td>Pump not reaching design head (TDH).</td>
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<td>2.1</td>
<td>Refer to possible causes under Problem #1.0.</td>
<td>Refer to remedies listed under Problem #1.0 and #3.0.</td>
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<tr>
<td>Problem #3.0</td>
<td>No discharge or flow</td>
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<td>3.1</td>
<td>Not properly primed.</td>
<td>Repeat priming operation, recheck instructions. If pump has run dry, disassemble and inspect the pump before operation.</td>
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<td>PROBLEM</td>
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<td>Cont. Problem #3.0</td>
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<tr>
<td>No discharge or flow</td>
<td>3.2 Direction of rotation wrong.</td>
<td>After confirming wrong rotation, reverse any two of three leads on a three phase motor. The pump should be disassembled and inspected before operation.</td>
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<td></td>
<td>3.3 Entrained air.</td>
<td>Air leak from atmosphere on suction side. Refer to recommended remedy under Problem #1.0, Item #1.3.</td>
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<td>3.4 Plugged impeller, suction line or casing which may be due to a fibrous product or large solids.</td>
<td>Refer to recommended remedy under Problem #1.0, Item #1.9.</td>
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<td>3.5 Damaged pump shaft, impeller.</td>
<td>Replace damaged parts.</td>
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<td>Problem #4.0</td>
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<td>Pump operates for short period, then loses prime.</td>
<td>4.1 Insufficient NPSH.</td>
<td>Refer to recommended remedy under Problem #1.0, Item #1.1.</td>
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<td></td>
<td>4.2 Entrained air.</td>
<td>Air leak from atmosphere on suction side. Refer to recommended remedy under Problem #1.0, Item #1.1.</td>
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<td>Problem #5.0</td>
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<tr>
<td>Excessive noise from wet end.</td>
<td>5.1 Cavitation - insufficient NPSH available.</td>
<td>Refer to recommended remedy under Problem #1.0, Item #1.1.</td>
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<td>5.2 Abnormal fluid rotation due to complex suction piping.</td>
<td>Redesign suction piping, holder number of elbows and number of planes to a minimum to avoid adverse fluid rotation as it approaches the impeller.</td>
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<td></td>
<td>5.3 Impeller rubbing.</td>
<td>1. Replace impeller and/or case wear rings. 2. Check outboard bearing assembly for axial end play.</td>
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<td>Problem #6.0</td>
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<td>Excessive noise from bearings.</td>
<td>6.1 Bearing contamination appearing on the raceways as scoring, pitting, scratching, or rusting caused by adverse environment and entrance of abrasive contaminants from atmosphere.</td>
<td>1. Work with clean tools in clean surroundings. 2. Remove all outside dirt from housing before exposing bearings. 3. Handle with clean dry hands. 4. Treat a used bearing as carefully as a new one. 5. Use clean solvent and flushing oil. 6. Protect disassembled bearing from dirt and moisture. 7. Keep bearings wrapped in paper or clean cloth while not in use. 8. Clean inside of housing before replacing bearings. 9. Check oil seals and replace as required. 10. Check all plugs and tapped openings to make sure that they are tight.</td>
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<td>PROBLEM</td>
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<td>Cont. Problem #6.0 Excessive noise from bearings.</td>
<td>6.2 Brinelling of bearing identified by indentation on the ball races, usually caused by incorrectly applied forces in assembling the bearing or by shock loading such as hitting the bearing or drive shaft with a hammer.</td>
<td>When mounting the bearing on the out-board end use a proper size ring and apply the pressure against the inner ring only. Be sure when mounting a bearing to apply the mounting pressure slowly and evenly.</td>
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<td>6.3 False brinelling of bearing identified again by either axial or circumferential indentations usually caused by vibration of the balls between the races in a stationary bearing.</td>
<td>1. Correct the source of vibration. 2. Where bearings are oil lubricated and employed in units that may be out of service for extended periods, the drive shaft should be turned over periodically to re-lubricate all bearing surfaces at intervals of one-to three months.</td>
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<td>6.4 Thrust overload on bearing identified by flaking ball path on one side of the outer race or in the case of maximum capacity bearings, may appear as a spalling of the races in the vicinity of the loading slot. (Please note: maximum capacity bearings are not recommended in FSD pumps.) These thrust failures are caused by improper mounting of the bearing or excessive thrust loads.</td>
<td>1. Follow correct mounting procedures for bearings.</td>
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<td>6.5 Misalignment identified by fracture of ball retainer or a wide ball path on the inner race and a narrower cocked ball path on the outer race. Misalignment is caused by poor mounting practices or defective drive shaft. For example bearing not square with the centerline or possibly a bent shaft due to improper handling.</td>
<td>Handle parts carefully and follow recommended mounting procedures. Check all parts for proper fit and alignment.</td>
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<td>6.6 Bearing damaged by electric arcing identified as electro-etching of both inner and outer ring as a pitting or cratering. Electrical arcing is caused by a static electrical charge emanating from belt drives, electrical leakage or short circuiting.</td>
<td>1. Where current shunting through the bearing cannot be corrected, a shunt in the form of a slip ring assembly should be incorporated. 2. Check all wiring, insulation and rotor windings to be sure that they are sound and all connections are properly made. 3. Where pumps are belt driven, consider the elimination of static charges by proper grounding or consider belt material that is less generative.</td>
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<td>Cont. Problem #6.0 Excessive noise from bearings.</td>
<td>6.7 Bearing damage due to improper lubrication, identified by one or more of the following: 1. Abnormal bearing temperature rise. 2. A stiff cracked grease appearance. 3. A brown or bluish discoloration of the bearing races.</td>
<td>1. Be sure the lubricant is clean. 2. Be sure proper amount of lubricant is used. The constant level oiler supplied with FSD pumps will maintain the proper oil level if it is installed and operating properly. In the case of greased lubricated bearings, be sure that there is space adjacent to the bearing into which it can rid itself of excessive lubricant, otherwise the bearing may overheat and fail prematurely. 3. Be sure the proper grade of lubricant is used.</td>
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### MAINTENANCE

#### PREVENTIVE MAINTENANCE

The following sections of this manual give instructions on how to perform a complete maintenance overhaul. However, it is also important to periodically repeat the “Pre start-up checks” listed on page 18. These checks will help extend pump life as well as the length of time between major overhauls.

#### NEED FOR MAINTENANCE RECORDS

A procedure for keeping accurate maintenance records is a critical part of any program to improve pump reliability. There are many variables that can contribute to pump failures. Often long term and repetitive problems can only be solved by analyzing these variables through pump maintenance records.

#### NEED FOR CLEANLINESS

One of the major causes of pump failure is the presence of contaminants in the bearing housing. This contamination can be in the form of moisture, dust, dirt and other solid particles such as metal chips. Contamination can also be harmful to the mechanical seal (especially the seal faces) as well as other parts of the pumps. For example, dirt in the shaft threads could cause the impeller to not be seated properly against the shaft sleeve. This, in turn, could cause a series of other problems. For these reasons, it is very important that proper cleanliness be maintained. Some guidelines are listed below.

If it is contaminated, determine the cause and correct. The work area should be clean and free from dust, dirt, oil, grease, etc. Hands and gloves should be clean. Only clean towels, rags, and tools should be used.

### MAINTENANCE OF PUMP DUE TO FLOOD DAMAGE

The servicing of centrifugal pumps after a flooded condition is a comparatively simple matter under normal conditions.

Bearings are a primary concern on pumping units. First, dismantle the bearings, clean and inspect them for any rusted or badly worn surfaces. If bearings are free from rust and wear, re-assemble and re-lubricate them with one of the recommended pump lubricants. Depending on the length of time the pump has remained in the flooded area, it is unlikely that bearing replacement is necessary, however, in the event that rust or worn surfaces appear, it may be necessary to replace the bearings.

Next, inspect the stuffing box and clean out any foreign matter that might clog the box. Mechanical seals should be cleaned and thoroughly flushed.

Couplings should be dismantled and thoroughly cleaned.

Any pump that is properly sealed at all joints and connected to both the suction and discharge should exclude outside liquid.

Therefore, it should not be necessary to go beyond the bearings, stuffing box, and coupling when servicing the pump.
### ROUTINE MAINTENANCE CHART

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Maintenance Tasks</th>
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<tbody>
<tr>
<td>Every Week</td>
<td>Visually check for leaks&lt;br&gt;Check for lubrication&lt;br&gt;Adjust glands as necessary to&lt;br&gt;maintain proper leakage&lt;br&gt;Hand test bearing housing for any sign of temperature rise</td>
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<tr>
<td>Every Month</td>
<td>Check bearing temperature with a thermometer</td>
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<tr>
<td>Every 6 Months</td>
<td>Check the packing and replace if necessary&lt;br&gt;Check alignment of the pump and motor&lt;br&gt;Check holding down bolts for tightness&lt;br&gt;Check coupling for wear</td>
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<tr>
<td>Every Year</td>
<td>Check rotating element for wear&lt;br&gt;Check wear ring clearances&lt;br&gt;Check and regrease bearings&lt;br&gt;Measure total dynamic suction and discharge head</td>
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</table>

### DISASSEMBLY

Refer to the parts list shown in FIGURES 45, 46 & 47 for item number references used throughout this section.

**FSD MODELS**

1. Before performing any maintenance, disconnect the driver from its power supply and lock it off line.

2. Close the discharge and suction valves and drain all liquid from the pump.

3. Close all valves on auxiliary equipment and piping, then disconnect all auxiliary piping.

4. Decontaminate the pump as necessary. If FPS pumps contain dangerous chemicals, it is important to follow plant safety guidelines to avoid personal injury or death.

5. Remove the coupling guard.

6. Remove the spacer from the coupling (if supplied).

7. Remove casing fasteners (#544A).

8. Remove the fasteners holding the bearing housing foot (#820) to the base plate.

9. Move the power frame (#356) and rear cover (#008) assembly away from the casing (#179). Discard the casing/cover gasket (#364A).

**DANGER**

The power frame and rear cover assembly is heavy. It is important to follow plant safety guidelines when lifting it.

10. Inspect the casing (#179) and the case wear ring (#676A) for damage. If the casing (#179) shows any signs of damage, replace it.

11. Transport the back pull-out assembly to the maintenance shop.

12. Remove the coupling hub from the pump shaft (#728).

13. Loosen and remove the impeller (#444) from the shaft (#728). Discard the impeller gasket (#364).

**CAUTION**

Do not apply heat to the impeller. If liquid is entrapped in the hub, an explosion could occur.

14. Loosen and remove the gland nuts (#544G).

15. If a cartridge type mechanical seal is used, loosen the set screws which lock the unit to the shaft and remove the complete seal assembly. If the seal is to be reused, the spacing clips or tabs should be reinstalled prior to loosening the set screws. This will ensure that the proper seal compression is maintained.

16. If a component type outside mechanical seal is used, remove the gland (#372GM) and the stationary seat from the rear cover (#008). Once the rear cover (#008) has been removed, remove the stationary seat from the gland (#372GM). Loosen the set screws in the rotating unit and remove it. Discard all O-rings and gaskets.
17. Remove rear cover nuts (#544B) and carefully remove the rear cover (#008) from the power frame (#356).

18. If packing (#372P) is used, remove it and the lantern ring (#676L). Remove the gland (#372).

19. Remove the shaft sleeve (#756) from the shaft (#728).

20. If the power frame (#356) is oil lubricated, remove the drain plug (#600) and drain the oil from the bearing housing (#356).

21. Remove the shaft deflector (#764).

22. Remove the adapter cap screws (#708A). Remove the adapter cap (#069N). Remove and discard the adapter o-ring (#364C). Remove and discard the adapter oil lip seal (#364P). If bearing isolators are used, refer to Appendix B. If magnetic seals are used, maintain the seals as specified by the manufacturer.

23. Remove the outboard bearing cap screws (#708B). Remove the outboard bearing carrier (#164N). Remove and discard the bearing carrier o-rings (#364B). Remove and discard the outboard bearing carrier oil lip seal (#364N). If bearing isolators are used, refer to Appendix B. If magnetic seals are used, maintain the seals as specified by the manufacturer.

24. Press the shaft assembly (consisting of the shaft (#728), the inboard bearing (#164P), the outboard bearing (#164N) and bearing carrier (#164N) out of the bearing housing (#356).

25. Remove bearing carrier snap ring (#676S). An arbor or hydraulic press may be used to remove the bearings (#164N and #164P) from the shaft (#728). It is extremely important to apply even pressure to the inner bearing race only. Never apply pressure to the outer race as this exerts excess load on the balls and causes damage.

26. If present, the Trico oiler should be removed from the bearing housing.

27. The sight gage should be removed from the bearing housing.

---

**CLEANING/INSPECTION**

All parts should now be thoroughly cleaned and inspected. New bearings, O-rings, gaskets, and lip seals should be used. Any parts that show wear or corrosion should be replaced with new genuine Franklin Electric parts.

**WARNING**

*It is important that only non-flammable, non-contaminated cleaning fluids are used. These fluids must comply with plant safety and environmental guidelines.*

**ASSEMBLY**

Note: Refer to FIGURE 19 for all bolt torque information.

It is very important that all pipe threads be sealed properly. PTFE tape provides a very reliable seal over a wide range of fluids but it has a serious shortcoming if not used properly. If, during application to the threads, the tape is wrapped over the end of the male thread, strings of the tape will be formed off when threaded into the female fitting. This string can then tear away and lodge in the piping system. If this occurs in the seal flush system, small orifices can become blocked effectively shutting off flow. For this reason, Franklin Electric does not recommend the use of PTFE tape as a thread sealant.

Franklin Electric has investigated and tested alternate sealants and has identified two that provide an effective seal, have the same chemical resistance as the tape and will not plug flush systems. These are Laco SlicTite and Bakerseal. Both products contain finely ground PTFE particles in an oil based carrier. They are supplied in a paste form which is brushed on the male pipe threads. Franklin Electric recommends using one of these paste sealants.

Full thread length engagement is required for all fasteners.
### FSD POWER FRAME ASSEMBLY

#### BEARING INSTALLATION

Mounting of bearings on shafts must be done in a clean environment. Bearing and power end life can be drastically reduced if even very small foreign particles work their way into the bearings.

Bearings should be removed from their protective packaging only immediately before assembly to limit exposure to possible contamination. After removing the packaging they should only come in contact with clean hands, fixtures, tools and work surfaces.

The chart shown in FIGURE 22 gives the SKF part numbers for bearings in FPS FSD pumps. Note that the term “inboard bearing” refers to the bearing nearest to the impeller. “Outboard bearing” refers to the bearing nearest to the motor.

1. Install the inboard bearing (#069P) on the shaft (#728). The inboard bearing (#069P) must be positioned against the shaft (#728) shoulder. If the power end is equipped with single shield re-greaseable bearings, the shields should be placed next to the shaft shoulder. Both bearings have a slight interference fit which requires that they be pressed on the shaft with an arbor or hydraulic press. Even force should be applied to the inner race only. Never press on the outer race, as the force will damage the balls and races. An alternate method of installing bearings is to heat the bearings to 200°F (93°C) in an oven or induction heater. Then place them quickly in position on the shaft.

2. Using clean gloves, install the outboard bearing (#069N) firmly against the shaft (#728) shoulder as shown in FIGURE 20. If hot bearing mounting techniques are used, steps must be taken to ensure the outboard bearing (#069N) is firmly positioned against the shaft (#728) shoulder. The outboard bearing (#069N), while still hot, is to be positioned against the shaft (#728) shoulder. After the bearing (#069N) has cooled below 100°F (38°C) the bearing should be pressed against the shaft (#728) shoulder. An approximate press force needed to seat the bearing is listed in FIGURE 23. This value may be used if the press has load measuring capability. It must be understood that fixtures and equipment used to press the bearing must be designed so no load is ever transmitted through the bearing balls. This would damage the bearing.

The locknut (#124) and lock washer (#125) should be installed. The locknut should be torqued to the value shown in FIGURE 21. At this point the lock washer tang must be bent into the locknut.

The FSD design has an optional oil slinger. If the slinger was removed during disassembly, install a new slinger (#676P).

---

**FIGURE 19** - Bolt & Cap Screw Torque Ratings

<table>
<thead>
<tr>
<th>BOLT SIZE</th>
<th>TIGHTENING TORQUE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Metric Lbf ft Nm</td>
</tr>
<tr>
<td>4 mm</td>
<td>5/32” 2.7 3.6</td>
</tr>
<tr>
<td>5 mm</td>
<td>3/16” 5.2 7.0</td>
</tr>
<tr>
<td>6 mm</td>
<td>1/4” 8.9 12.0</td>
</tr>
<tr>
<td>7 mm</td>
<td>9/32” 14.6 19.8</td>
</tr>
<tr>
<td>8 mm</td>
<td>5/16” 21.8 29.6</td>
</tr>
<tr>
<td>9 mm</td>
<td>11/32” 28.0 38.0</td>
</tr>
<tr>
<td>10 mm</td>
<td>3/8” 38.7 52.5</td>
</tr>
<tr>
<td>12 mm</td>
<td>1/2” 65.6 89.0</td>
</tr>
<tr>
<td>14 mm</td>
<td>9/16” 99.6 135</td>
</tr>
<tr>
<td>16 mm</td>
<td>5/8” 151 205</td>
</tr>
<tr>
<td>18 mm</td>
<td>11/16” 190 257</td>
</tr>
<tr>
<td>20 mm</td>
<td>3/4” 264 358</td>
</tr>
<tr>
<td>22 mm</td>
<td>7/8” 321 435</td>
</tr>
<tr>
<td>24 mm</td>
<td>15/16” 411 557</td>
</tr>
</tbody>
</table>

---

**FIGURE 20** – Typical Shaft Arrangement

---

**CAUTION**

Never heat the bearings above 230°F (110°C). To do so will likely cause the bearing fits to permanently change, leading to early failure.

---

**CAUTION**

Never heat the bearings above 230°F (110°C). To do so will likely cause the bearing fits to permanently change, leading to early failure.
SHIELDED BEARING INSTALLATION

Mounting of bearings on shafts must be done in a clean environment. Bearing and power end life can be drastically reduced if even very small foreign particles work their way into the bearings.

Bearings should be removed from their protective packaging only immediately before assembly to limit exposure to possible contamination. After removing the packaging they should only come in contact with clean hands, fixtures, tools and work surfaces.

The chart shown in FIGURE 22 gives the SKF part numbers for bearings in FPS FSD pumps. Note that the term “inboard bearing” refers to the bearing nearest to the casing. “Outboard bearing” refers to the bearing nearest to the motor.

1. Install the inboard bearing (#069P) on the shaft (#728). The inboard bearing must be positioned against the shoulder as shown in FIGURE 20. If the power end is equipped with single shield re-greaseable bearings, the shields should be oriented as shown in FIGURE 21.

<table>
<thead>
<tr>
<th>Module</th>
<th>Type of Bearings</th>
<th>Inboard Single Row, Deep Groove</th>
<th>Outboard Single Deep Groove</th>
<th>Optional Outboard Duplex Angular Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oil bath/mist – Open</td>
<td>6207-C3 6207-2ZC3 6207-2ZC3 6207-2RSIC3</td>
<td>5306-AC3 5306-AZC3 5306-A2ZC3 5306-A2RSC3</td>
<td>7306-BECBY</td>
</tr>
<tr>
<td></td>
<td>Regreasable – Single Shielded</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Greased for life – Double Shielded</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sealed for life – Double Sealed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Oil bath/mist – Open</td>
<td>6310-C3 6310-ZC3 6310-ZC3 6310-2ZC3 6310-2RSIC3</td>
<td>5310-AC3 5310-AZC3 5310-A2ZC3 5310-A2RSC3</td>
<td>7310-BECBY</td>
</tr>
<tr>
<td></td>
<td>Regreasable – Single Shielded</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Greased for life – Double Shielded</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sealed for life – Double Sealed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Oil bath/mist – Open</td>
<td>6314-C3 6314-ZC3 6314-ZC3 6314-2ZC3 6314-2RSIC3</td>
<td>5314-AC3 5314-AZC3 5314-A2ZC3 5314-A2RSC3</td>
<td>7314-BECBY</td>
</tr>
<tr>
<td></td>
<td>Regreasable – Single Shielded</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Greased for life – Double Shielded</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sealed for life – Double Sealed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FIGURE 22 – FPS-Pumps FSD Bearings

1. These bearings are open on both sides. They are lubricated by oil bath or oil mist.
2. These bearings are pre-greased by Franklin Electric. Replacement bearings will generally not be pre-greased, so grease must be applied by the user. They have a single shield, which is located on the side next to the grease buffer, or reservoir. The bearings draw grease from the reservoir as it is needed. The shield protects the bearing from getting too much grease, which would generate heat. The grease reservoir is initially filled with grease by Franklin Electric. Lubrication fittings are provided, to allow the customer to periodically replenish the grease, as recommended by the bearing and/or grease manufacturer.
3. These bearings are shielded on both sides. They come pre-greased by the bearing manufacturer. The user does not need to re-grease these bearings. The shields do not actually contact the bearing race, so no heat is generated.
4. These bearings are sealed on both sides. They come pre-greased by the bearing manufacturer. The user does not need to re-grease these bearings. The seals physically contact and rub against the bearing race, which generates heat. These bearings are not recommended at speeds above 1750 RPM.
5. The codes shown are SKF codes. Inboard and outboard bearings have the C3, greater than “Normal” clearance. These clearances are recommended by SKF to maximize bearing life.
6. Re-greasable – Single Shielded bearings are not available in the duplex configuration; however, open oil bath-type bearings can be used for the re-greasable configuration. These bearings must be pre-greased during assembly. Lubrication fittings are provided, to allow the user to periodically replenish the grease, as recommended by the bearing and/or grease manufacturer.
7. Not available.
<table>
<thead>
<tr>
<th>Pump</th>
<th>Press Force lbf (N)</th>
<th>Locknut Torque ft-lbf (N•m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>1300 (5,780)</td>
<td>20 +5/-0 (27 +4/-0)</td>
</tr>
<tr>
<td>Group 2</td>
<td>2500 (11,100)</td>
<td>0 +5/-0 (54 +7/-0)</td>
</tr>
<tr>
<td>Group 3</td>
<td>4500 (20,000)</td>
<td>70 +5/-0 (95 +7/-0)</td>
</tr>
</tbody>
</table>

FIGURE 23 – Bearing Press Force

Both bearings have a slight interference fit which requires that they be pressed on the shaft with an arbor or hydraulic press. Never press on the outer race, as the force will damage the balls and races. An alternate method of installing bearings is to heat the bearings to 200°F (93°C) in an oven or induction heater. Then place them quickly in position on the shaft.

**CAUTION**

Never heat the bearings above 230°F (110°C). To do so will likely cause the bearing fits to permanently change, leading to early failure.

4. If the outboard bearing is cold pressed against the shaft shoulder, it should be secured with the lock washer and locknut torqued with the “locknut torque” value listed in FIGURE 23. The lockwasher tang must then be bent into the locknut.

5. Duplex angular contact bearings must be mounted back to back with the wider thrust sides of the outer races in contact with each other. Only bearings designed for universal mounting should be used. SKF’s designation is “BECB”. NTN’s designation is “G”.

Note: A special shaft is required when using duplex angular contact bearings.

**LIP SEALS**

5. If oil lip seals (#364N & 364P) were used, install new lip seals (#364N & 364P) in the bearing carrier (#164N) and adapter (#028).

6. Bolt the adapter (#028) to the bearing housing (#356) remembering to install new inboard and outboard bearing housing cap gaskets (#364B & 364C).

**LABYRINTH SEALS**

Refer to Appendix A.

**MAGNETIC SEALS**

Follow the installation instructions provided by the manufacturer.

7. Install a sight gage (#624) and or oil eye into the bearing housing (#356).

8. If one was present, install a Trico oiler into the bearing housing. If not used, install a plug into the hole. When using a Trico oiler it is very important that a vent/breather be installed in the tapped hole on top of the bearing housing. See Appendix C.

9. Install a drain plug (#600) into the bearing housing (#356). Be sure to install the optional magnetic drain plug, if appropriate.

10. Install the shaft deflector (#764).
11. Install a new impeller gasket (#364). Place the shaft sleeve (#756) onto the shaft (#728).

**FSD WET END ASSEMBLY**

Refer to the appropriate section according to construction details (FIGURES 46, 47 & 48).

**INTERNAL COMPONENT MECHANICAL SEALS**

1. Press the stationary part of the mechanical seal (#372M) into the rear cover (#008) taking care not to damage the mechanical seal (#372M).

2. Install the rear cover (#008) to the bearing housing (#356) using studs (#808B) and nuts (#544B).

3. Install the rotating part of the mechanical seal (#372M) onto the shaft sleeve (#756) using a seal guide following the seal manufacturer’s instructions.

4. Install the impeller (#444) onto the shaft (#728). Install a new impeller gasket (#364). Tighten the impeller (#444) to lock into place.

**CARTRIDGE MECHANICAL SEALS**

5. Slide the cartridge seal onto the shaft (#728) using a seal guide until it lightly touches the bearing housing.

6. Install the rear cover (#008). Tighten the rear cover (#008) to the bearing housing (#356). Install the cartridge seal gland to the rear cover plate (#008) using studs (#808G), nuts (#544G) and washers (#908G). Tighten set screws on the seal to lock the rotating unit to the shaft. Finally, remove centering clips from the seal.

**EXTERNAL COMPONENT TYPE MECHANICAL SEAL**

7. Install the rear cover (#008) to the bearing housing (#356).

8. Put blueing on the shaft in the area near the face of the rear cover (#008). Scribe a mark on the shaft (#728) at the face of the seal chamber (#008). Now the location of the seal (#372M) can be determined by referring to the seal drawing supplied by the seal manufacturer.

9. Remove the rear cover (#008).

10. Install the mechanical seal gland (#372GM) and stationary seal components following the seal manufacturer's instructions. Slide the gland (#372GM) and stationary seal components onto the shaft (#728) until it lightly touches the bearing housing (#356) or rear cover (#008). Install the gland gasket (#364G) into the gland.

11. Install the rotating part of the mechanical seal (#372M) onto the shaft sleeve (#756) using a seal guide following the seal manufacturer’s instructions.

12. Install the rear cover (#008) to the bearing housing (#356). Now, install the mechanical seal gland (#372GM) to the rear cover (#008) using studs (#808G), nuts (#544G) and washers (#908G).

13. Install the impeller (#444) onto the shaft (#728). Install a new impeller gasket (#364). Tighten the impeller (#444) to lock into place.

**PACKING WITH SPLIT GLAND**

14. Install the rear cover plate (#008) to the bearing housing (#356) using studs (#808B) and nuts (#544B).

15. Install the impeller (#444) onto the shaft (#728). Install a new impeller gasket (#364). Tighten the impeller (#444) to lock into place.

16. Install the packing rings (#372P) and lantern ring (#676L) into the rear cover (#008). Always stagger the end gaps 90° to ensure a better seal. To speed installation of each ring, have an assistant turn the pump shaft in one direction. This movement of the shaft will tend to draw the rings into the stuffing box. A split gland (#372GP) is an assembly of two matched gland halves that are bolted together. Unbolt the gland halves and install the gland halves around the shaft. Bolt the halves together to form a gland assembly (#372GP). Now, install the gland assembly (#372) using studs (#808G), nuts (#544G) and washers (#908G). Lightly snug up the gland (#372GP). Final adjustments must be made after the pump has begun operation.

**PACKING WITH ONE PIECE GLAND**

17. Slip gland (#372GP) over shaft (#728) and slide back to the bearing housing (#356).

18. Install the rear cover plate (#008) to the bearing housing (#356) using studs (#808B) and nuts (#544B).

19. Install the impeller (#444) onto the shaft (#728). Install a new impeller gasket (#364). Tighten the impeller (#444) to lock into place.

20. Install the packing rings (#372P) and lantern ring (#676L) into the rear cover (#008). Always stagger the end gaps 90° to ensure a better seal. To speed installation of each ring, have an assistant turn the pump shaft in one direction. This movement of the shaft will tend to draw the
rings into the stuffing box. Now, attach the gland (#372GP) to the rear cover (#008) using studs (#808G), nuts (#544G) and washers (#908G). Lightly snug up the gland (#372GP). Final adjustments must be made after the pump has begun operation.

**Impeller installation and clearance setting**

Install the impeller (#444) as instructed in Appendix D, if reverse vane, or Appendix E, if a front vane open style impeller. Care should be taken in the handling of high chrome iron impellers.

**BEARING LUBRICATION**

**OIL BATH**

The standard bearing housing bearings are oil bath lubricated and are not lubricated by Franklin Electric. Before operating the pump, fill the bearing housing to the center of the oil sight glass (#624) with the proper type oil. (See FIGURE 25 for approximate amount of oil required – do not overfill.) The oil level in the bearing housing must be maintained at ±1/8 in (±3 mm) from the center of the sight glass. The sight glass (#624) has a 1/4 in (6 mm) hole in the center of its reflector. The bearing housing oil level must be within the circumference of the center hole to ensure adequate lubrication of the bearings.

<table>
<thead>
<tr>
<th>Pump</th>
<th>FSD Oil Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>8.5 oz (251 ml)</td>
</tr>
<tr>
<td>Group 2</td>
<td>32 oz (946 ml)</td>
</tr>
<tr>
<td>Group 3</td>
<td>48 oz (1419 ml)</td>
</tr>
</tbody>
</table>

FIGURE 25 – Approximate Amount Of Oil Required

<table>
<thead>
<tr>
<th>Mineral Oil</th>
<th>Quality mineral oil with rust and oxidation inhibitors. Mobil DTE Heavy/Medium ISO VG 68 or equivalent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synthetic</td>
<td>Royal Purple SynFilm 68, Conoco SYCON 68 or equivalent. Some synthetic lubricants require Viton O-rings.</td>
</tr>
<tr>
<td>Grease</td>
<td>Exxon Mobile Polyrex EM, Chevron SRI #2 (or compatible)</td>
</tr>
</tbody>
</table>

FIGURE 26 – Recommended Lubricants

<table>
<thead>
<tr>
<th>Maximum Oil Temperature</th>
<th>ISO Viscosity Grade</th>
<th>Minimum Viscosity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 160°F (71°C)</td>
<td>46</td>
<td>95</td>
</tr>
<tr>
<td>160-175°F (71°-80°C)</td>
<td>68</td>
<td>95</td>
</tr>
<tr>
<td>175-200°F (80°-94°C)</td>
<td>100</td>
<td>95</td>
</tr>
</tbody>
</table>

FIGURE 27 – Oil Viscosity Grades

See FIGURE 26 for recommended lubricants. DO NOT USE DETERGENT OILS. The oil must be free of water, sediment, resin, soaps, acid and fillers of any kind. It should contain rust and oxidation inhibitors. The proper oil viscosity is determined by the bearing housing operating temperature as given in FIGURE 27. To add oil to the housing, clean and then remove the vent plug at the top of the bearing housing, pour in oil until it is visually half way up in the sight glass (#624). Fill the constant level oiler bottle (Trico), if used, and return it to its position. The correct oil level is obtained with the constant level oiler in its lowest position, which results in the oil level being at the top of the oil inlet pipe nipple, or half way up in the sight glass window. Oil must be visible in the bottle at all times. As stated above, proper oil level is the center of the “bull’s eye” sight glass.

<table>
<thead>
<tr>
<th>Lubrication</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil bath</td>
<td>180°F* (82°C)</td>
</tr>
<tr>
<td>Grease</td>
<td>200°F* (94°C)</td>
</tr>
</tbody>
</table>

* Assuming good maintenance and operation practices, and no contamination.

FIGURE 28 – Maximum External Housing Temperature

In many pumping applications lubricating oil becomes contaminated before it loses its lubricating qualities or breaks down. For this reason it is recommended that the first oil change take place after approximately 160 hours of operation, at which time, the used oil should be examined carefully for contaminants. During the initial operating period monitor the bearing housing operating temperature. Record the external bearing housing temperature. See FIGURE 28 for maximum acceptable temperatures. The normal oil change interval is based on temperature and is shown in FIGURE 29.

**GREASE**

**Single shielded re-greasable bearings**

When the grease lubrication option is specified, single shielded bearings, grease fittings and vent pipe plugs are installed inboard and outboard. The bearings are packed with Exxon Mobile Polyrex EM grease prior to assembly. For initial lubrication, apply grease through the fittings until it comes out of the vent holes, then reinstall the pipe plugs. For re-lubrication, a grease with the same type base (non-soap polyureide) and oil (mineral) should be used. To re-grease, remove the
pipe plug from both the inboard and outboard bearing location.

**WARNING**

To re-grease bearings under coupling guard, stop pump, lock the motor, remove coupling guard, then re-grease the bearings.

---

<table>
<thead>
<tr>
<th>Lubricant</th>
<th>Under 60°F (71°C)</th>
<th>160-175°F (71-80°C)</th>
<th>175-200°F (80-94°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grease</td>
<td>6 mo</td>
<td>3 mo</td>
<td>1.5 mo</td>
</tr>
<tr>
<td>Mineral Oil</td>
<td>6 mo</td>
<td>3 mo</td>
<td>1.5 mo</td>
</tr>
<tr>
<td>Synthetic Oil**</td>
<td>18 mo</td>
<td>18 mo</td>
<td>18 mo</td>
</tr>
</tbody>
</table>

**FIGURE 29 – Re-lubrication Intervals**

---

**CAUTION**

Do not fill the housing with oil when greased bearings are used. The oil will leach the grease out of the bearings and the life of the bearings may be drastically reduced.

Double shielded or double sealed bearings

These bearings are packed with grease by the bearing manufacturer and should not be re-lubricated. Maintenance intervals for these bearings are greatly affected by their operating temperature and pump speed. However, the shielded bearing typically operates cooler, thus extending its life.

---

**FIGURE 30 – Re-greaseable Configuration**

---

**FIGURE 32 – Amount of Grease Required**

Notes:

1. Exxon Mobile Polyrex EM grease density = 0.92 g/cm³.
2. Grams to ounces conversion: g * 0.035 = oz.
3. Typical tube of grease holds 14 oz (397 g).
4. Grease reservoirs should be cleaned out every 18 months and new initial lube amount applied.

---

**OIL MIST**

When optional oil mist lubricated bearings are specified, the bearing housing is furnished with a plugged 1/2 in NPT top inlet for connection to the user’s oil mist supply system, a vent fitting in the bearing carrier, and a plugged 1/4 in NPT bottom drain. See Oil Mist Lubrication System on Page 16.

Do not allow oil level to remain above the center of the bearing housing sight glass window with purge mist (wet sump) systems.

The optional oil slinger must not be used with an oil mist system.

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**REINSTALLATION**

The pump is now ready to be returned to service. It should be reinstalled as described in the installation section.

---

**PUMP REINSTALLATION**

The pump is now ready to be returned to service. It should be reinstalled as described in the installation section.
SPARE PARTS

RECOMMENDED SPARE PARTS – STANDARD FSD PUMP

The decision on what spare parts to stock varies greatly depending on many factors such as the criticality of the application, the time required to buy and receive new spares, the erosive/corrosive nature of the application and the cost of the spare part. FIGURES 45, 46 & 47 give the parts list for a typical FSD pumps.

HOW TO ORDER SPARE PARTS

Spare parts can be ordered from the local Franklin Electric Engineer or from the Franklin Electric Distributor or Representative. The pump size and type can be found on the name plate on the bearing housing. See FIGURE 1. Please provide the item number, description, and alloy for the part(s) to be ordered.

APPENDIX A

CRITICAL MEASUREMENTS AND TOLERANCES FOR MAXIMIZING MTBPM

PARAMETERS THAT SHOULD BE CHECKED BY USERS

Franklin Electric recommends that the user check the following measurements and tolerances whenever pump maintenance is performed. Each of these measurements is described in more detail on the following pages.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Suggested By Major Seal Vendors in (mm)</th>
<th>Suggested And/Or Provided By FPS in (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft Diameter tolerance, under bearings</td>
<td>0.0002 (0.005)</td>
<td></td>
</tr>
<tr>
<td>Impeller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance</td>
<td></td>
<td>See Note 1</td>
</tr>
<tr>
<td>Bearing Housing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter (ID) tolerance at bearings</td>
<td>0.0005 (0.013)</td>
<td></td>
</tr>
<tr>
<td>Power End Assembly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaft Runout</td>
<td>0.001 (0.03)</td>
<td>0.001 (0.03)</td>
</tr>
<tr>
<td>Shaft Sleeve Runout</td>
<td>0.002 (0.05)</td>
<td>0.002 (0.05)</td>
</tr>
<tr>
<td>Radial Deflection - Static</td>
<td>0.003 (0.076)</td>
<td>0.002 (0.05)</td>
</tr>
<tr>
<td>Shaft Endplay</td>
<td>0.002 (0.05)</td>
<td>0.002 (0.05)</td>
</tr>
<tr>
<td>Seal Chamber</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Face Squareness to Shaft</td>
<td>0.001 (0.03)</td>
<td>0.003 (0.08)</td>
</tr>
<tr>
<td>Register Concentricity</td>
<td>0.005 (0.13)</td>
<td>0.005 (0.13)</td>
</tr>
<tr>
<td>Complete Pump</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaft movement caused by pipe strain</td>
<td>0.002 (0.05)</td>
<td>0.002 (0.05)</td>
</tr>
<tr>
<td>Alignment</td>
<td></td>
<td>See Note 2</td>
</tr>
<tr>
<td>Vibration at bearing housing</td>
<td></td>
<td>See Note 3</td>
</tr>
</tbody>
</table>

FIGURE 33 - Measurements

N.S. = Not specified

Note 1: The maximum values of acceptable unbalance are: 1800 rpm: 0.021 oz•in/lb (1500 rpm: 0.01 oz•in/lb) parallel F.I.M. and 0.0011 oz•in/lb of mass. Franklin Electric performs a single plane spin balance on most impellers. All balancing, whether single or two plane, is performed to the ISO 1940 Grade 6.3 tolerance criteria.

Note 2: Franklin Electric recommends that the pump and motor shafts be aligned to within 0.002 in (0.05 mm) parallel F.I.M. and 0.0005 in/in (0.0005 mm/mm) angular F.I.M. Closer alignment will extend MTBPM. For a detailed discussion of this subject see the Alignment section of this IOM.

Note 3: Franklin Electric recommends the following peak velocities, in in/s (mm/second): 25A/25B & 35 = 0.1 (2.5), 45 & 55 = 0.19 (3.8), 60 & 70 = 0.25 (6.3).
ADDITIONAL PARAMETERS CHECKS
The parameters listed below are somewhat more difficult to measure and/or may require specialized equipment. For this reason, they are not typically checked by our customers, although they are monitored by Franklin Electric during the manufacturing and/or design process. These parameters are described at the end of this appendix.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Suggested By Major Seal Vendors</th>
<th>Suggested And/Or Provided By FPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft - Maximum roughness at seal chamber</td>
<td>16µin (0.40 µm)</td>
<td></td>
</tr>
<tr>
<td>Bearing Housing - Bore Concentricity</td>
<td>0.001 in (0.025 mm)</td>
<td></td>
</tr>
<tr>
<td>Complete Pump – Dynamic Shaft Deflection*</td>
<td>0.002 in (0.05 mm)</td>
<td>0.002 in (0.05 mm)</td>
</tr>
</tbody>
</table>

FIGURE 34 – Specialized Measurements

The ASME standard recommends 0.005 in (0.13 mm) max deflection at the impeller, while Franklin Electric provides 0.002 in (0.05 mm) max deflection at the mechanical seal. The two recommendations are essentially equivalent.

IMPELLER BALANCING
Shaft whip is deflection where the centerline of the impeller is moving around the true axis of the pump. It is not caused by hydraulic force but rather by an imbalance with the rotating element. Shaft whip is very hard on the mechanical seal because the faces must flex with each revolution in order to maintain contact. To minimize shaft whip it is imperative that the impeller is balanced. All impellers manufactured by Franklin Electric are balanced after they are trimmed. If for any reason, a customer trims an impeller, it must be re-balanced.

The maximum values of acceptable unbalance are:
1800 rpm: 0.021 oz•in/lb (1500 rpm: 40 g•mm/kg) of mass
3600 rpm: 0.011 oz•in/lb (2900 rpm: 20 g•mm/kg) of mass
The OD of the bearings should also be checked and should conform to the min/max values given above.

POWER END ASSEMBLY
Shaft/Shaft Sleeve Runout
Shaft runout is the amount the shaft is “out of true” when rotated in the pump. It is measured by attaching a dial indicator to a stationary part of the pump so that its contact point indicates the radial movement of the shaft surface as the shaft is rotated slowly. If a shaft sleeve is used then shaft sleeve runout must be checked. It is analogous to shaft runout.

Measurement of shaft runout/shaft sleeve runout will disclose any out of roundness of the shaft, any eccentricity between the shaft and the sleeve, any permanent bend in the shaft, and/or any eccentricity in the way the shaft or bearings are mounted in the bearing housing.

Shaft runout can shorten the life of the bearings and the mechanical seal. The following diagram shows how to measure shaft/shaft sleeve runout. Note that both ends need to be checked. The runout should be 0.001 in (0.025 mm) FIM or less.

Radial Deflection – Static
Radial movement of the shaft can be caused by a loose fit between the shaft and the bearing and/or the bearing and the housing. This movement is measured by attempting to displace the shaft vertically by applying an upward force of approximately ten pounds to the impeller end of the shaft. While applying this force, the movement of an indicator is observed as shown in the following diagram. The movement should be checked at a point as near as possible to the location of the seal faces. A movement of more than 0.002 in (0.05 mm) is not acceptable.

Shaft Endplay
The maximum amount of axial shaft movement, or endplay, on an FPS pump should be 0.001 in (0.03 mm) and is measured as shown below. Observe indicator movement while tapping the shaft from each end in turn with a soft mallet. Shaft endplay can cause several problems. It can cause fretting or wear at the point of contact between the shaft and the secondary sealing element. It can also cause seal overloading or under-loading and possibly chipping of the seal faces. It can also cause the faces to separate if significant axial vibration occurs.

SEAL CHAMBER
Face Squareness to Shaft
Also referred to as “Seal Chamber Face Run-Out.” This runout occurs when the seal chamber face is not perpendicular to the shaft axis. This will cause the gland to cock, which causes the stationary seal to be cocked, which causes the seal to wobble. This runout should be less than 0.003 in (0.08 mm).

Register Concentricity
An eccentric seal chamber bore or gland register can interfere with the piloting and centering of the seal components and alter the hydraulic loading of the seal faces, resulting in reduction of seal life and performance. The seal chamber register concentricity should be less than 0.005 in (0.13 mm).

COMPLETE PUMP
Shaft Movement Caused by Pipe Strain
Pipe strain is any force put on the pump casing by the piping. Pipe strain should be measured as shown below. Install the indicators as shown before attaching the piping to the pump. The suction and discharge flanges should now be bolted to the piping separately while continuously observing the indicators. Indicator movement should not exceed 0.002 in (0.05 mm).
**Alignment**
Misalignment of the pump and motor shafts can cause the following problems:
- Failure of the mechanical seal
- Failure of the motor and/or pump bearings
- Failure of the coupling
- Excessive vibration/noise

The schematics below show the technique for a typical rim and face alignment using a dial indicator. It is important that this alignment be done after the flanges are loaded, and at typical operating temperatures. If proper alignment cannot be maintained a C-flange motor adapter and/or stiff/spring mounting should be considered.

Many companies today are using laser alignment which is a more sophisticated and accurate technique. With this method a laser and sensor measure misalignment. This is fed to a computer with a graphic display which shows the required adjustment for each of the motor feet.

**Vibration Analysis**
Vibration Analysis is a type of condition monitoring where a pump’s vibration “signature” is monitored on a regular, periodic basis. The primary goal of vibration analysis is extension on MTBPM. By using this tool, Franklin Electric can often determine not only the existence of a problem before it becomes serious, but also the root cause and possible solution. Modern vibration analysis equipment not only detects if a vibration problem exists, but can also suggest the cause of the problem. On a centrifugal pump, these causes can include the following: unbalance, misalignment, defective bearings, resonance, hydraulic forces, cavitation, and recirculation. Once identified, the problem can be corrected, leading to increased MTBPM for the pump.

Franklin Electric does not make vibration analysis equipment, however Franklin Electric strongly urges customers to work with an equipment supplier or consultant to establish an on-going vibration analysis program. The ASME standard for vibration at the bearing housing is 0.25 inches/second (6.35 mm/sec) peak velocity or 0.0025 inches (0.064 mm) peak-to-peak displacement. Franklin Electric recommends the following peak velocities:

<table>
<thead>
<tr>
<th>Group</th>
<th>Peak Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1 in/s (2.5 mm/s)</td>
</tr>
<tr>
<td>2</td>
<td>0.15 in/s (3.8 mm/s)</td>
</tr>
<tr>
<td>3</td>
<td>0.25 in/s (6.4 mm/s)</td>
</tr>
</tbody>
</table>

for best practice of a properly installed and operated pump.

**SPECIAL PARAMETERS CHECKED**

**SHAFT – MAXIMUM ROUGHNESS AT SEAL CHAMBER**
FPS shafts do not exceed 16 µin (0.4 µm) at these areas. Franklin Electric audits smoothness by using a profilometer surface finish gauge.

**BEARING HOUSING – BORE CONCENTRICITY**
If the bore for holding the bearing is eccentric, the bearing will be shifted off center. This will contribute to shaft runout. Franklin Electric measures this concentricity by using computerized measuring equipment. The concentricity should not exceed 0.001 in (0.03 mm).

**COMPLETE PUMP – DYNAMIC SHAFT DEFLECTION**
In regards to pump operation, a very important factor for maximizing pump MTBPM is the avoidance of off-design pump operation. In order to maximize the life of the seal and bearings, a process pump should be run as close as possible to its Best Efficiency Point (BEP).

Dynamic shaft deflection is a deflection of the shaft caused by unbalanced hydraulic forces acting on the impeller. Dynamic shaft deflection will change as the pump is operated on various points along the curve. When the pump is operated at BEP, the shaft deflection is zero. This deflection is very difficult to measure.

At a given point on the curve, the shaft deflection is constant and is constantly in the same direction. The centerline of the impeller, though bent from parallel, does not move. For this reason, in many cases, shaft deflection is not particularly hard on mechanical seals. It is, however, hard on bearings, since the force which causes shaft deflection can be a tremendous load on them. The amount of deflection depends on three factors: how the shaft is supported, the strength of the shaft and the amount of unbalanced hydraulic force experienced by the shaft/impeller. If there seems to be a shaft deflection problem, refer to Technical Support for a detailed discussion on how to calculate deflection.

**APPENDIX B**

**XA MAINTENANCE INSTRUCTIONS BEARING HOUSING OIL SEALS (LABYRINTH TYPE) INPRO/SEAL® VBXX BEARING ISOLATORS**

**INTRODUCTION**
Franklin Electric provides pumps fitted with a variety of labyrinth oil seals. While these instructions are written specifically for the Inpro/Seal VBXX labyrinth, they also apply to seals of other manufacturers. Specific installation instructions included with the seal, regardless of manufacturer, should be observed.

The Inpro “VBXX” Bearing Isolator is a labyrinth type seal which isolates the bearings from the environment (uncontaminated), and retains the oil in the bearing housing. The bearing isolator consists of a rotor and a stator. The rotor revolves with the shaft, driven by a close fitted drive ring that rotates with the shaft. The stator is a stationary component that fits into the housing bore with a press fit (nominal 0.002 in (0.05 mm) interference) and with an “O” ring gasket seal. The two pieces are assembled as a single unit, and are axially locked together by an “O” ring. There is no mechanical contact between the rotor and stator when the isolator is running.
The VBXX is not intended to be separated from the bearing arm unless being replaced.

1. If the VBXX is removed from the housing, for any reason, it must be replaced with a new VBXX to ensure a perfect seal with the housing bore.

2. Repair or replacement of the seals is only necessary when excessive oil leakage is evident. However, if for any other reason, the bearing housing is to be disassembled or the pump shaft removed, it is recommended that the rotor “O” rings (which seal on the shaft) be replaced. Spare or replacement “O” rings may be obtained from “Inpro” distributors.

The “Inpro” VBXX bearing isolator is a one piece assembly. The rotor must not pull out of the stator. If the rotor can be removed, the complete seal assembly must be replaced.

3. If the bearing arm with bronze VBXX seals is washed or cleaned using a caustic type bath, the bronze material may discolor (turn black). If this happens, the complete seal assembly must be replaced. Note: This may occur if the housing is left in a caustic bath over a long period of time (more than 8 hours).

4. To remove the VBXX bearing isolator:
   A. Remove the pump shaft as described in the pump disassembly instructions.
   B. From the inside of the bearing arm (#86N & 86P), place a bar (made from a soft material such as wood or plastic) against the inside face of the seal. Push the seal out by tapping the bar with a soft mallet or an arbor press.

5. To install a new VBXX bearing isolator, in the outboard or inboard bearing arm:
   A. Position the outboard seal in the bore of the bearing arm (#86N & 86P) with the single expulsion port at the 6 o’clock position, (carefully keep aligned with the bore).
   B. The seal stator O.D. press fits into the bore. Use an arbor press. Place a block or bar (large enough to protect the rotor flange) between the arbor press ram and seal face. Press the seal down into the bore stop ping at the shoulder on the stator O.D.

The elastomer “O” ring acts as a gasket to ensure damming up of small imperfections in the housing bore. The “O” ring is designed to be compressed to the point of overfilling its groove. The overfilled material is sheared off during assembly. Remove any sheared “O” ring material which may extrude from the bore.

APPENDIX C

BEARING HOUSING TRICO CONSTANT LEVEL OILERS

INTRODUCTION

Constant level oilers provide a visible and proven way to supply oil to both bearing housings. Read and follow the below instructions to ensure proper operation of the oiler.

1. Prior to installing the Opto-Matic Oiler, shaft rotation direction must be determined, typically indicated by an arrow on the casting of the equipment. Install oiler on the side of the equipment facing the direction of shaft rotation to prevent misfeeding of the oiler (FIGURE 36A).

2. Determine proper oil level, which may be indicated on the equipment with an arrow. If that is not the case, engineering drawings or the equipment’s operator manual can provide the information. Indicate proper oil level on equipment using a marking device such as; a marker, scribe, paint, etc.

3. Loosen set screws on reservoir assembly. Remove reservoir assembly from lower casting.

4. Be sure all connecting hardware is free from contaminants (burrs, chips, dirt, etc.) to prevent clogging or damage to the equipment to be lubricated.

5. Connect lower casting to bearing chamber either through the side connection, Type E and EH oilers (FIGURE 36B) or the bottom connection, Type EB and EHB oilers (FIGURE 36C). Use thread compound on threaded areas.

6. Verify the lower casting is level and parallel with desired oil level (FIGURE 36B and 36C). Make necessary adjustments if needed until lower casting is level.
7. From the oil level mark indicated on the equipment, use a level to put a mark on the outside of the Opto-Matic lower casting to indicate where the oil level should be (FIGURE 36D).

8. Measure the distance between Opto-Matic Oiler casting edge and top edge of spout angle (FIGURE 36E). Mark this distance above the original line made in step 7 on the outside of the Opto-Matic lower casting (FIGURE 36F). Now the bottom of the reservoir assembly can be used as an indicator of oil level.

9. Fill the equipment bearing chamber through the lower casting until the oil level reaches just below the mark made in step 7 on the lower casting. DO NOT fill at or above this mark as it will cause your equipment to have a high oil level.

10. Use a funnel to fill the reservoir assembly 2/3rds with the recommended oil.

11. Place thumb over reservoir spout, invert, and insert on lower casting assembly at the point where the bottom edge of the reservoir assembly is at the level “X” mark from step 8. Quickly tighten set screws on the side of the reservoir assembly.

12. Start up equipment to verify proper oil level is being maintained.

FIGURE 36 – Trico Oiler
APPENDIX D

INSTALLATION/CLEARANCE SETTING FOR REVERSE VANE IMPELLER

Install the impeller (#444) by screwing it onto the shaft (use heavy gloves) until it firmly seats against the shaft shoulder.

The impeller could have sharp edges which could cause an injury. It is very important to wear heavy gloves.

CAUTION

Do not attempt to tighten the impeller on the shaft by hitting the impeller with a hammer or any other object or by inserting a pry bar between the impeller vanes. Serious damage to the impeller may result from such actions.

CAUTION

It is recommended that two people install a Group 3 impeller. The weight of a Group 3 impeller greatly increases the chance of thread damage and subsequent lock-up concerns.

Determine how far to rotate the bearing carrier by dividing the desired impeller clearance by 0.004 (one indicator pattern). Tightening the set screws (#708B) will cause the impeller to move 0.002 in (0.05 mm) closer to the rear cover because of the internal looseness in the bearing carrier threads. This must be considered when setting the impeller clearance. Rotate the bearing carrier clockwise the required amount to get the desired clearance to the cover. Lastly, tighten the set screws (#708B) to lock the bearing carrier in place.

<table>
<thead>
<tr>
<th>Temperature – °F (°C)</th>
<th>Clearance to cover – in (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;200 (93)</td>
<td>0.018 ± 0.003 (0.46 ± 0.08)</td>
</tr>
<tr>
<td>200 to 250 (93 to 121)</td>
<td>0.021 (0.53)</td>
</tr>
<tr>
<td>251 to 300 (122 to 149)</td>
<td>0.024 (0.61)</td>
</tr>
<tr>
<td>301 to 350 (150 to 176)</td>
<td>0.027 (0.69)</td>
</tr>
<tr>
<td>351 to 400 (177 to 204)</td>
<td>0.030 (0.76)</td>
</tr>
<tr>
<td>401 to 450 (205 to 232)</td>
<td>0.033 (0.84)</td>
</tr>
<tr>
<td>&gt;450 (232)</td>
<td>0.036 (0.91)</td>
</tr>
</tbody>
</table>

FIGURE 38 – Impeller Clearance Settings

Notes

1. For 1.5x3-13 and 2x3-13 at 3500 rpm add 0.003 in (0.08 mm).
2. Rotation of bearing carrier from center of one lug to center of next results in axial shaft movement of 0.004 in (0.1 mm).
3. Reverse vane impeller set to cover, open impeller to casing.

Example: For an impeller setting of 0.020 in (0.5 mm) off the rear cover plate, it is necessary to add 0.002 in (0.05 mm) for the movement caused by tightening the set screws; therefore, an adjustment of 0.022 in (0.56 mm) is needed. First, turn the bearing carrier counterclockwise until the impeller comes into light rubbing contact with the rear cover. Now rotate the bearing carrier clockwise 5-1/2 indicator patterns to get the 0.022 in (0.56 mm) clearance (0.004 x 5-1/2 = 0.022). Franklin Electric suggests that a felt tip pen be used to mark an initial reference point on the bearing housing and the bearing carrier as shown in Figure D-5. Then make a second mark on the bearing carrier 5-1/2 indicator patterns counterclockwise from the initial reference point. Now rotate the bearing carrier clockwise until the second mark on the bearing carrier lines up with the initial reference point mark on the bearing housing. The impeller is now set correctly.
APPENDIX E

INSTALLATION/CLEARANCE SETTING FOR FRONT VANE SEMI-OPEN IMPELLER

Install the impeller (#444) by screwing it onto the shaft (use heavy gloves) until it firmly seats against the shaft shoulder.

**WARNING**

The impeller could have sharp edges which could cause an injury. It is very important to wear heavy gloves.

**CAUTION**

Do not attempt to tighten the impeller on the shaft by hitting the impeller with a hammer or any other object or by inserting a pry bar between the impeller vanes. Serious damage to the impeller may result from such actions.

**FIGURE 39 – Micro-Millimeter Adjustment**

Like all front vane open style impellers, the FPS semi-open impeller clearance must be set off the casing. The casing must be present to accurately set the impeller clearance. (Realizing that this can be very difficult, Franklin Electric strongly promotes the use of reverse vane impellers, which do not require the presence of the casing to be properly set.)

Attach the power end/rear cover plate assembly to the casing. Now set the impeller clearance by loosening the set screws (#708B) and rotating the bearing carrier (#164N) to obtain the proper clearance. Turn the bearing carrier clockwise until the impeller comes into light rubbing contact with the casing. Rotating the shaft at the same time will accurately determine this zero setting. Now, rotate the bearing carrier counterclockwise to get the proper clearance. Refer to FIGURE 40 for the proper impeller clearance. Rotating the bearing carrier the width of one of the indicator patterns cast into the bearing carrier moves the impeller axially 0.004 in (0.1 mm).

Determine how far to rotate the bearing carrier by dividing the desired impeller clearance by 0.004 in (0.1 mm) (one indicator pattern). Tightening the set screws (#708B) will cause the impeller to move 0.002 in (0.05 mm) away from the casing because of the internal looseness in the bearing carrier threads. This must be considered when setting the impeller clearance. Rotate the bearing carrier counterclockwise the required amount to get the desired clearance to the casing. Lastly, tighten the set screws (#708B) to lock the bearing carrier in place.

### Temperature – °F (°C) | Clearance to cover – in (mm)
--- | ---
<200 (93) | 0.018 ± 0.003 (0.46 ± 0.08)
200 to 250 (93 to 121) | 0.021 (0.53)
251 to 300 (122 to 149) | 0.024 (0.61)
301 to 350 (150 to 176) | 0.027 (0.69)
351 to 400 (177 to 204) | 0.030 (0.76)
401 to 450 (205 to 232) | 0.033 (0.84)
>450 (232) | 0.036 (0.91)

**FIGURE 40 – Impeller Clearance Settings**

**Notes**

1. For 1.5x3-13 and 2x3-13 at 3500 rpm add 0.003 in (0.08 mm).
2. Rotation of bearing carrier from center of one lug to center of next results in axial shaft movement of 0.004 in (0.1 mm).
3. Reverse vane impeller set to cover, open impeller to casing.

**Example:** For an impeller setting of 0.020 in (0.5 mm) off the casing, it is necessary to subtract 0.002 in (0.05 mm) for the movement caused by tightening the set screws; therefore, an adjustment of 0.018 in (0.46 mm) is needed. First, turn the bearing carrier clockwise until the impeller comes into light rubbing contact with the casing. Now rotate the bearing carrier counterclockwise 4-1/2 indicator patterns to get the 0.018 in (0.46 mm) clearance (0.004 x 4-1/2 = 0.018). Franklin Electric suggests that a felt tip pen be used to mark an initial reference point on the bearing housing and the bearing carrier as shown in Figure E-5. Then make a second mark on the bearing carrier 4-1/2 indicator patterns clockwise from the initial reference point. Now rotate the bearing carrier counterclockwise until the second mark on the bearing carrier lines up with the initial reference point mark on the bearing housing. At that point, the setting will be 0.018 in (0.46 mm). Tightening the set screws will cause a 0.002 in (0.05 mm) draw of the bearing carrier threads, which will give the final setting of 0.020 in (0.5 mm).

The above procedure is fairly straightforward when doing the final setting of the impeller. However, it can be quite laborious when doing the preliminary setting in order to establish the location of the mechanical seal. For this reason, some companies will take the following shortcut. Before the pump is taken out of service, they adjust the impeller until it touches the casing. The impeller is then backed off by 0.020 in (0.5 mm), or whatever is the desired clearance. Now, the impeller is adjusted all the way back to the rear cover, and this distance is recorded. The pump is now removed from the casing and taken to the shop for maintenance. When it is time to set the seal, the impeller...
is simply set off the rear cover by the same distance recorded earlier.

Note that if the casing, cover, impeller or shaft need to be replaced this shortcut method will not work.

APPENDIX F

REMOVAL/INSTALLATION OF SEALS WITH FMI SEAL CHAMBER

REMOVAL

After removing the impeller, slide the hook sleeve off the shaft. Remove the rotating unit from the sleeve. Remove cover. Remove the stationary seat from the seal chamber counterbore.

INSTALLATION

1. Set the impeller as instructed in Appendix D or E.
2. Remove the impeller.
3. Install stationary seat into seal chamber counterbore.
4. Refer to FIGURE 41. Measure distance $TL$ from the seal face on the stationary seat to the end of the hook sleeve.
5. The seal working length, $WL$, is determined from the seal drawing provided by the seal manufacturer. Subtract the seal working length $WL$ from $TL$.
6. The distance remaining, $RL$, is the distance from the end of the hook sleeve to the rotating unit. Install the rotating unit at this location.
7. Install the hook sleeve onto the shaft.
8. Install the impeller to the shaft, locking the hook sleeve into position.

FIGURE 41 – FMI Seal Chamber
The allowable nozzle loads listed in Figure 52 may be applied to any FSD Standard Horizontal and Lo-Flo pumps in Ductile cast iron, Carbon Steel, 316 Stainless Steel, Cd4MCu, Monel, and Inconel. The allowable loads must be multiplied by 0.70 for pumps made of nickel, titanium, zirconium and high chrome iron.

The loads listed in FIGURE 42 are the combined values resolved to the center of the pump, except for the Fr + Mr/3 limits, which apply to the separate suction and discharge flanges. Some piping analysis programs calculate forces and moments on each flange, and do not translate them to a common point at the center of the pump. The formulas in FIGURE 44 can be used to translate the forces and moments on each flange to the common center point.

<table>
<thead>
<tr>
<th>Pump Nozzle Sizes</th>
<th>Combined Loading at Center of Pump</th>
<th>Flange Loading</th>
<th>Loading Flange</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Forc e (lbf)</td>
<td>Moments (lbf •ft)</td>
<td>Frs+M r/S/3</td>
</tr>
<tr>
<td></td>
<td>Fx</td>
<td>Fy</td>
<td>Fz</td>
</tr>
<tr>
<td>1 x 1.5</td>
<td>120</td>
<td>295</td>
<td>235</td>
</tr>
<tr>
<td>1.5 x 1.5</td>
<td>120</td>
<td>295</td>
<td>235</td>
</tr>
<tr>
<td>1 x 2</td>
<td>145</td>
<td>365</td>
<td>285</td>
</tr>
<tr>
<td>1.5 x 2</td>
<td>165</td>
<td>405</td>
<td>325</td>
</tr>
<tr>
<td>2 x 2</td>
<td>175</td>
<td>435</td>
<td>350</td>
</tr>
<tr>
<td>1.5 x 3</td>
<td>220</td>
<td>545</td>
<td>435</td>
</tr>
<tr>
<td>2 x 3</td>
<td>235</td>
<td>590</td>
<td>470</td>
</tr>
<tr>
<td>3 x 3</td>
<td>260</td>
<td>650</td>
<td>520</td>
</tr>
<tr>
<td>3 x 4</td>
<td>325</td>
<td>815</td>
<td>650</td>
</tr>
<tr>
<td>4 x 6</td>
<td>470</td>
<td>1170</td>
<td>940</td>
</tr>
<tr>
<td>6 x 8</td>
<td>610</td>
<td>1520</td>
<td>1215</td>
</tr>
<tr>
<td>8 x 10</td>
<td>670</td>
<td>1670</td>
<td>1335</td>
</tr>
</tbody>
</table>

FIGURE 42 – Forc e & Moments (US Units)
### FIGURE 43 – Forces & Moments (Metric Units)

**Formula for all pumps**

\[
\begin{align*}
    F_x &= F_{xs} + F_{xd} \\
    F_y &= F_{ys} + F_{yd} \\
    F_z &= F_{zs} + F_{zd} \\
    M_x &= M_{xs} + M_{xd} + (F_{zd} \cdot H) + (F_{zs} \cdot M) \\
    M_y &= M_{ys} + M_{yd} + (-F_{zs} \cdot L) \\
    M_z &= M_{zs} + M_{zd} + (F_{ys} \cdot L) - (F_{xd} \cdot H) - (F_{xs} \cdot M)
\end{align*}
\]

\[
\begin{align*}
    F_{rs} &= \sqrt{(F_{xs}^2 + F_{ys}^2 + F_{zs}^2)} \\
    M_{rs} &= \sqrt{(M_{xs}^2 + M_{ys}^2 + M_{zs}^2)} \\
    F_{rd} &= \sqrt{(F_{xd}^2 + F_{yd}^2 + F_{zd}^2)} \\
    M_{rd} &= \sqrt{(M_{xd}^2 + M_{yd}^2 + M_{zd}^2)}
\end{align*}
\]

Suction Loading (US Customary) = \( F_{rs} + M_{rs}/3 \)
Discharge Loading (US Customary) = \( F_{rd} + M_{rd}/3 \)
Suction Loading (Metric) = \( F_{rs} + M_{rs}\ast 1.09 \)
Discharge Loading (Metric) = \( F_{rd} + M_{rd}\ast 1.09 \)

<table>
<thead>
<tr>
<th>Pump Nozzle Sizes</th>
<th>Combined Loading at Center of Pump</th>
<th>Flange Suction</th>
<th>Loading Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Forces (N)</td>
<td>Moments (N•m)</td>
<td>Frs + Mrs\ast 1.098</td>
</tr>
<tr>
<td></td>
<td>( F_x )</td>
<td>( F_y )</td>
<td>( F_z )</td>
</tr>
<tr>
<td>1 x 1.5</td>
<td>534</td>
<td>1313</td>
<td>1046</td>
</tr>
<tr>
<td>1.5 x 1.5</td>
<td>534</td>
<td>1313</td>
<td>1046</td>
</tr>
<tr>
<td>1 x 2</td>
<td>645</td>
<td>1624</td>
<td>1268</td>
</tr>
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<td>1.5 x 2</td>
<td>734</td>
<td>1802</td>
<td>1446</td>
</tr>
<tr>
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<td>779</td>
<td>1936</td>
<td>1558</td>
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<td>1.5 x 3</td>
<td>979</td>
<td>2425</td>
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<td>2893</td>
<td>2314</td>
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<td>8 x 10</td>
<td>2982</td>
<td>7432</td>
<td>5941</td>
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</table>

**FIGURE 44 – Load Translation Formula**

Where:

- Forces are expressed lbf or N and moments are expressed in lbf•ft or N•m.
- Forces and Moments are positive in the directions shown on Figure 50.
- \( F_{xs} \) = Force in the x direction applied to the suction nozzle.
- \( F_{xd} \) = Force in the x direction applied to the discharge nozzle.
- \( M_{xs} \) = Moment about the x-axis applied to the suction.
- \( M_{xd} \) = Moment about the x-axis applied to the discharge.
- \( H \) = Vertical distance from the centerline of the pump to the top of the discharge flange.
- \( L \) = Horizontal distance from the centerline of the discharge to the front of the suction flange.
**FIGURE 45**

**FSD ANSI PUMP**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
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</thead>
<tbody>
<tr>
<td>008</td>
<td>REAR COVER</td>
</tr>
<tr>
<td>069N</td>
<td>BEARING, OUTBOARD</td>
</tr>
<tr>
<td>069P</td>
<td>BEARING, INBOARD</td>
</tr>
<tr>
<td>164N</td>
<td>BEARING CARRIER</td>
</tr>
<tr>
<td>179</td>
<td>CASING</td>
</tr>
<tr>
<td>356</td>
<td>POWER FRAME</td>
</tr>
<tr>
<td>364</td>
<td>O-RING, IMPELLER</td>
</tr>
<tr>
<td>364A</td>
<td>O-RING, CASING</td>
</tr>
<tr>
<td>364B</td>
<td>O-RING, BEARING CAP</td>
</tr>
<tr>
<td>364G</td>
<td>GASKET, GLAND</td>
</tr>
<tr>
<td>364N</td>
<td>OIL LIP SEAL</td>
</tr>
<tr>
<td>364P</td>
<td>OIL LIP SEAL</td>
</tr>
<tr>
<td>372G</td>
<td>GLAND, PACKING</td>
</tr>
<tr>
<td>372GM</td>
<td>GLAND, MECHANICAL SEAL</td>
</tr>
<tr>
<td>372M</td>
<td>MECHANICAL SEAL</td>
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</table>

<table>
<thead>
<tr>
<th>ITEM</th>
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<tbody>
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<tr>
<td>444</td>
<td>IMPELLER</td>
</tr>
<tr>
<td>472B</td>
<td>KEY, COUPLING</td>
</tr>
<tr>
<td>544A</td>
<td>NUT, CASING</td>
</tr>
<tr>
<td>544B</td>
<td>NUT, CASING</td>
</tr>
<tr>
<td>544G</td>
<td>NUT, PACKING GLAND</td>
</tr>
<tr>
<td>544N</td>
<td>BEARING LOCKNUT</td>
</tr>
<tr>
<td>600</td>
<td>PLUG, DRAIN</td>
</tr>
<tr>
<td>624</td>
<td>OIL LEVEL SIGHT GLASS</td>
</tr>
<tr>
<td>676L</td>
<td>LANTERN RING</td>
</tr>
<tr>
<td>676S</td>
<td>SNAP RING</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>708B</td>
<td>CAPSCREW, BEARING CARRIER</td>
</tr>
<tr>
<td>708F</td>
<td>CAPSCREW, FOOT</td>
</tr>
<tr>
<td>708N</td>
<td>BEARING LOCKWASHER</td>
</tr>
<tr>
<td>728</td>
<td>SHAFT</td>
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</table>

<table>
<thead>
<tr>
<th>ITEM</th>
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<tbody>
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</tr>
<tr>
<td>808G</td>
<td>STUD, PACKING GLAND</td>
</tr>
<tr>
<td>820</td>
<td>POWER FRAME FOOT</td>
</tr>
<tr>
<td>908G</td>
<td>GLAND STUD WASHER</td>
</tr>
<tr>
<td>995</td>
<td>POWER FRAME BREATHER</td>
</tr>
</tbody>
</table>

**NOTE:** Recommended spare parts are in BOLD.
### FIGURE 46
FSD ANSI PUMP

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>O08</td>
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</tr>
<tr>
<td>O28</td>
<td>CASING ADAPTER</td>
</tr>
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<td>BEARING, OUTBOARD</td>
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<tr>
<td>069P</td>
<td>BEARING, INBOARD</td>
</tr>
<tr>
<td>164N</td>
<td>BEARING CAP, OUTBOARD</td>
</tr>
<tr>
<td>179</td>
<td>CASING</td>
</tr>
<tr>
<td>356</td>
<td>POWER FRAME</td>
</tr>
<tr>
<td>364</td>
<td>IMPELLER, CASING</td>
</tr>
<tr>
<td>364A</td>
<td>O-RING, CASING</td>
</tr>
<tr>
<td>364B</td>
<td>O-RING, BEARING CAP</td>
</tr>
<tr>
<td>364C</td>
<td>ADAPTER O-RING</td>
</tr>
<tr>
<td>364G</td>
<td>GASKET, GLAND</td>
</tr>
<tr>
<td>364N</td>
<td>OIL LIP SEAL</td>
</tr>
<tr>
<td>364P</td>
<td>OIL LIP SEAL</td>
</tr>
<tr>
<td>372M</td>
<td>MECHANICAL SEAL</td>
</tr>
<tr>
<td>372GP</td>
<td>GLAND, PACKING</td>
</tr>
<tr>
<td>372GM</td>
<td>GLAND, MECHANICAL SEAL</td>
</tr>
<tr>
<td>372P</td>
<td>PACKING</td>
</tr>
<tr>
<td>444</td>
<td>IMPELLER</td>
</tr>
<tr>
<td>472B</td>
<td>KEY, COUPLING</td>
</tr>
<tr>
<td>544A</td>
<td>NUT, CASING</td>
</tr>
<tr>
<td>544B</td>
<td>NUT, CASING</td>
</tr>
<tr>
<td>544C</td>
<td>NUT, PACKING GLAND</td>
</tr>
<tr>
<td>544N</td>
<td>BEARING LOCKNUT</td>
</tr>
<tr>
<td>600</td>
<td>PLUG, DRAIN</td>
</tr>
<tr>
<td>624</td>
<td>OIL LEVEL SIGHT GLASS</td>
</tr>
<tr>
<td>676L</td>
<td>LANTERN Ring</td>
</tr>
<tr>
<td>676P</td>
<td>OIL RING</td>
</tr>
<tr>
<td>676S</td>
<td>SNAP RING</td>
</tr>
<tr>
<td>708A</td>
<td>CAPSCREW, BEARING CAP</td>
</tr>
</tbody>
</table>

### NOTE: Recommended spare parts are in BOLD.
FIGURE 47
FSD ANSI PUMP

ITEM | DESCRIPTION
---|---
008 | REAR COVER
028 | CASING ADAPTER
069N | BEARING, OUTBOARD
069P | BEARING, INBOARD
164A | BEARING ADAPTER
164N | BEARING CAP, OUTBOARD
179 | CASING
356 | POWER FRAME
364 | IMPELLER, CASING
364A | IMPELLER, BEARING CARRIER
364B | ADAPTER O-RING
364C | ADAPTER O-RING
364G | GASKET, GLAND
364N | OIL LIP SEAL
364P | OIL LIP SEAL
364G | NUT, PACKING GLAND
364A | BEARING LOCKWASHER
444 | POWER FRAME FOOT
472B | SHAFT
544N | BEARING LOCKNUT
544G | GASKET, GLAND
600 | PLUG, DRAIN
624 | OIL LEVEL SIGHT GLASS
676L | LANTERN RING
676P | OIL RING
676S | SNAP RING
708A | CAPSCREW, BEARING CAP
708B | CAPSCREW, BEARING CARRIER
708F | CAPSCREW, FOOT
708N | BEARING LOCKWASHER
728 | SHAFT
756 | SHAFT SLEEVE
764 | WATER SLINGER
808A | STUD, CASING
808B | STUD, CASING
808G | STUD, PACKING GLAND
820 | POWER FRAME FOOT
995 | POWER FRAME BREATHER

NOTE: Recommended spare parts are in BOLD.