FLOWISE®

Pumps For Professionals Only

Installation, Operation, and Maintenance Manual For Submersible Turbine Pumps

www.flowisewater.com

Table of Contents

Introduction

Thank you for purchasing a FloWise product. Our pumps are designed for safe operation, long life, and ease of service. This manual is intended to provide instructions to install, operate, and maintain FloWise submersible vertical turbine pumps. The procedures shown in this manual cover all our submersible turbine pump models.

It is necessary that you read and understand this manual in its entirety before installation or maintenance of the FloWise submersible turbine pump. Following the instructions and service procedures as noted herein will help extend the life of the pump and ensure trouble-free operation.

Note: FloWise shall not be liable for physical injury, death, damage, or delays caused by a failure to observe the instructions for installation, operation, and maintenance contained in this manual.

Specific Pump Information

Pump Model:_____

Pump Serial: _____

Motor Model: _____

Motor Serial: _____

Contact Name: _____

Contact Phone: _____

Purchase Date: _____

Install Date: _____

Warranty

FloWise pumps are warranted to be free from defects in material and workmanship for a period of one year from the date of shipment. This warranty does not include wear parts or consumables such as seals, gaskets, elastomers, coatings, bearings, etc. Warranty void on items damaged due to misuse or improper handling by others.

Safety

This product is a rotating piece of machinery typically coupled to an electric motor. It is important that you follow all safety instructions within this manual and on the pump to avoid serious or fatal personal injury. While safety must always be observed while working with this product, we have noted specific situations throughout this manual which require additional attention. These situations will be denoted as follows:

Hazards marked by this symbol are immediate and will cause personal injury, death, or result in major property damage.

Hazards marked by this symbol are severe and may cause serious personal injury, death, or result in major property damage.

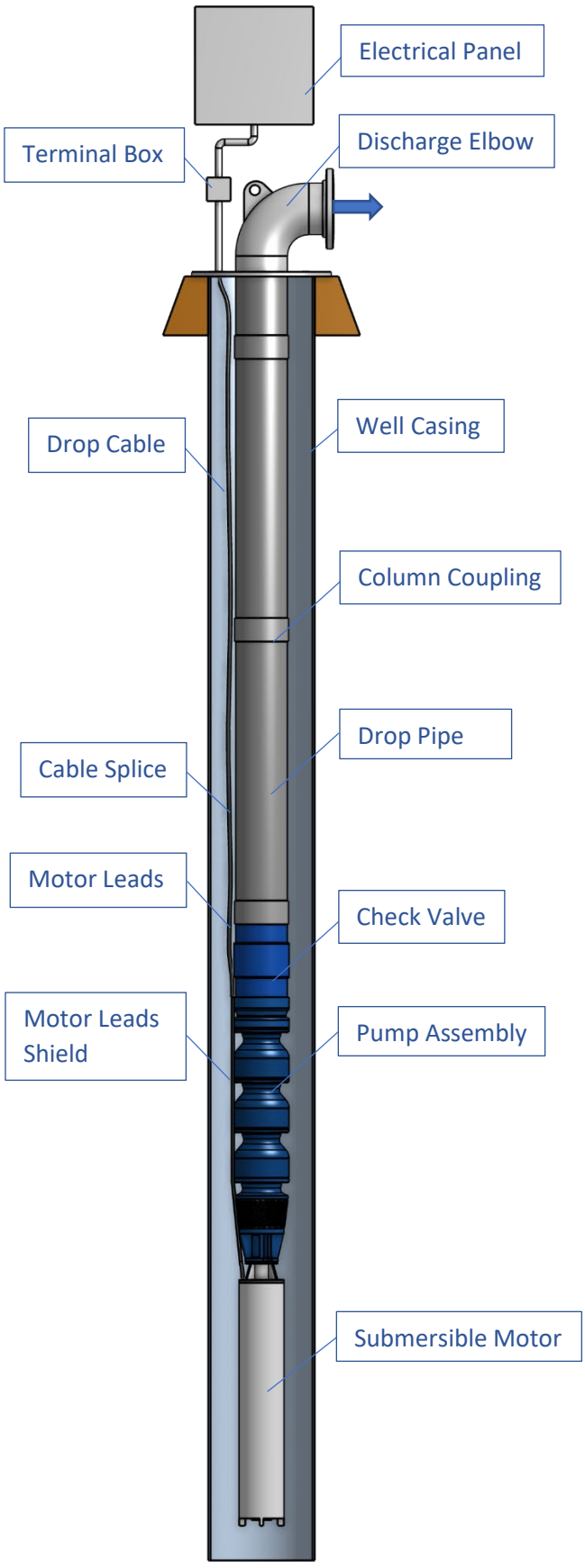
Hazards marked by this symbol may cause personal injury or result in major property damage.

Safety Considerations:

- **DO NOT** install submersible pumps in ponds, lakes, pools, or other bodies of water that people may enter. This is due to the risk of electrical shock from the submerged motor.
- **DO NOT REMOVE** any safety decals found on the equipment.
- **DO NOT** allow fluid to freeze inside the pump.
- **DO NOT** allow the pump to run dry or start without proper submergence.
- **DO NOT** allow the pump to run backwards. Proper motor rotation must be checked before starting the pump.
- **DO NOT** operate the pump outside of its recommended flow range. Consult the pump curves and/or your FloWise factory representative to determine proper pump design points.
- **DO NOT** operate the pump if noise or vibration is observed. Shutdown the pump immediately.
- **DO NOT** operate the pump without the coupling guard and any other safety devices properly installed.
- **DO NOT** apply heat during pump disassembly or impeller removal. Heat applied to components may cause entrapped liquid to vaporize, causing an explosion.

- Always make sure that proper lockout-tagout safety procedures have been performed and power is disconnected prior to starting maintenance on the pump.
- Use extreme caution if the pumped liquid is hazardous. Follow necessary precautions to avoid contact and prevent spills during installation, removal, and maintenance.
- Ensure adequate flow is available to the pump suction and that no valves are closed on the suction or discharge.

Figure 1 – General Pump Layout



General Layout and Description

The FloWise submersible turbine pump has the typical configuration shown in Figure 1. A submersible motor is connected to the suction side of the pump by means of a motor adapter. The motor adapter has a strainer to keep unwanted debris from entering the pump. The motor is connected to the bowlshaft, which runs through the bowl assembly and drives the impellers. The bowlshaft is lubricated by the fluid product passing through the pump. The impellers are either semi-open or enclosed. The impellers channel the flow from each bowl to the next, up the column pipe, and out through the discharge elbow. The column is either threaded or flanged. Typically, an in-line check valve is installed on the pump discharge to prevent flow reversal and subsequent impeller backspin.

Receiving

Perform a thorough inspection of the shipping crates for damage or signs of improper handling before unpacking. Then unpack and check all items for damage. Take extra care to ensure that all threads are undamaged, and that all items are present and match the bill of lading (BOL). Report any damage and/or missing items from the BOL immediately to your freight carrier. Also immediately report any damage and/or missing items (whether they were present on the BOL or not) to your local FloWise representative.

Storage

Short-Term (< 2 Months)

If the pump and components are to be stored in a dry, indoor environment for less than 2 months, standard factory shipping packaging will be adequate for protection. No less than once a month, the shaft shall be turned counterclockwise several times and left in a different position than it was before the rotation. The impellers shall not be allowed to rest on the top or bottom of the bowls (lateral shall not be at min or max).

Long-Term (2-12 Months)

For storing the pump and components in a dry, indoor environment for 2 to 12 months, follow the instructions below:

- Construct a new solid wood skid that will elevate the pump and equipment no less than 3” off the ground and safely support the weight of all equipment.
- Cover the wood skid with industrial polyethylene shrink wrap.
- Set the pump on top of the shrink wrap and wood skid.
- Install a bolt, washer, and rubber bushing from the bottom of the wood skid, through the shrink wrap, through the casing and bearing housing feet holes, and secure with a hex nut. Continue installing bolts in this manner to adequately secure the equipment to the wood skid.
- When the equipment is all secured to the wood skid, place desiccant bags around the equipment (on top of the shrink wrap).
- Wrap the shrink wrap over the pump and apply heat to seal completely. Entrapped moisture will be absorbed by the desiccant.
- Every 3 months, the shaft shall be turned counterclockwise 10 revolutions and left in a different position than it was before the rotation. After rotation, reseal the shrink wrap.

Uncontrolled Storage

If storage is to be outside, subject to relative humidity >50%, subject to dust, or subject to other potentially damaging environments, it is considered uncontrolled.

For uncontrolled storage, take the steps listed above for long term storage and follow the additional instructions below:

- Seal all pipe threads with tape.
- Do not store in an area subject to flooding or pooling of water.
- Tarps or other weatherproof coverings used shall be flame resistant and tied down securely.
- Any stacking of components shall be such that all weight is supported by the crates, rack, etc. and no weight is transferred to the components.
- If outdoors, equipment should be stored under a roof or shed when possible.

Handling

In handling the pump and its components, great care must be taken to ensure that none of the precision machined parts are damaged.

CAUTION Damage to any parts may result in failure or malfunction of the pump. Never allow the pump or components to be dropped from the carrier vehicle to the ground.

Always ensure that lifting devices and equipment are rated and suitable for the equipment being handled. Also, always make sure all lifting devices are securely fastened.

If the pump is not immediately installed during delivery to the jobsite, create an installation area that is clean and convenient.

Store drop pipe on timbers in a convenient location. Ideally you can point the drop pipe couplings at the well or install site for convenience during installation. Leave the pump assembly in its crating and protect any power cables or motor leads from damage. Make sure all components are present and identify them as needed to prevent confusion with other on-site equipment.

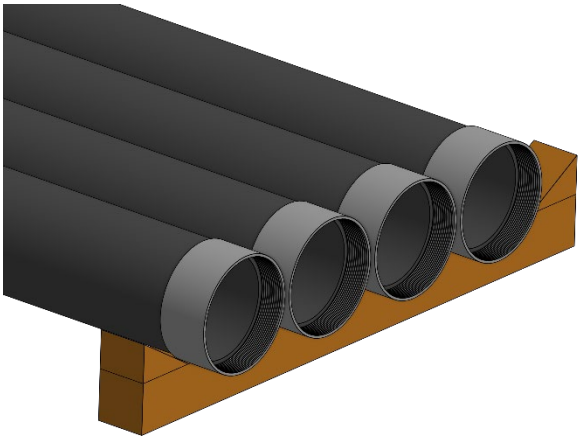


Figure 2 – Drop Pipe Storage

Well Design

Ensure that the well is large enough to accommodate the largest pump component diameter without rubbing or damaging the pump during installation. Take care to avoid rubbing or damaging the drop cable during installation. Pay special attention to the drop cable immediately under the discharge elbow, where it spans the gap between the column pipe and the hole in the discharge elbow surface plate. The top of the well may need to be widened to protect the drop cable at this point.

Sand, mud, and debris must be removed prior to the installation of the FloWise vertical turbine pump. This is typically done with a secondary pump and referred to as "test pumping". If test pumping is not performed, sand/mud/debris may damage the pump and void the warranty.

The well should be capable of producing more than the highest expected flow from the pump. Test pumping should not only clear the well of debris, but also confirm the expected production of the well and lowest drawdown level.

The pump will drawdown the immediate groundwater level around the well. For well installations, the suction of the pump must be submerged 10ft below the lowest drawdown level.

Ensure that the well is deep enough to accommodate the overall assembled length of the pump (including the motor). The pump should have 10ft of clearance from the bottom of the well. If debris enters the well, this space may allow it to settle to the bottom, rather than enter the pump.

WARNING Submersible motors must remain completely submerged in ***flowing*** water. If the well screen or inlet is positioned in a way that allows water to flow directly to the pump suction, without passing the motor, the motor may overheat and be damaged. A submerged motor can still overheat if the water does not adequately flow around it. To induce the flow past the motor, a flow inducing sleeve may be placed around the pump inlet and motor. This forces water passed the motor before entering the pump, resulting in better motor cooling characteristics. Flow inducer sleeves must be used in pit or tank applications.

Flow rate past the motor and flow inducer sleeve design should be found in the motor manual. For water temperature >80 degrees F, look for special considerations in the motor manual, or contact your local FloWise representative.

Sump Design

Proper sump design is critical to the performance of your pump. The sump inlet and shape, pump spacing, and pump operation characteristics can result in vortexing or turbulent flow patterns. Improper sump design may result in pump noise, vibration, or damage. Prior to creating the sump or installing your pump into an existing sump, we recommend you consult the Standards of the Hydraulic Institute as well as a professional with sump design experience. Also, you should follow these steps before installing your pump:

- Make sure you have an adequately designed flow inducer sleeve to protect the pump motor from overheating. Refer to the motor manual for adequate sleeve design.
- Ensure that the sump dimensions are adequate to receive the pump.
- Inspect the inlet for any blockages or debris. Clear anything that may cause damage or clog the pump.
- Screen the sump inlet when possible.
- Make sure the sump is clean and free of trash and debris.

Installation

Gather the tools, material, and equipment necessary for installation. Required equipment may vary with pump size and the installation. The following list is intended to serve as a guide.

Materials

Thread Compound

Anti-galling Lubricant

Grease

Equipment

Crane

Drag Line

Lifting Bail for Threaded Drop Pipe

Elevator Clamps

Clevises

Timbers

I-Beams

Hand Tools

Pipe Wrenches

Feeler Gauges

Mechanics Toolset Including: Files, Wire Brush, Pliers, Wire Cutters, Pocket Knife

Clean Rags

Machinist Level

Instruments

Megger

Clamp-On Ammeter

Voltmeter

New Baseplate

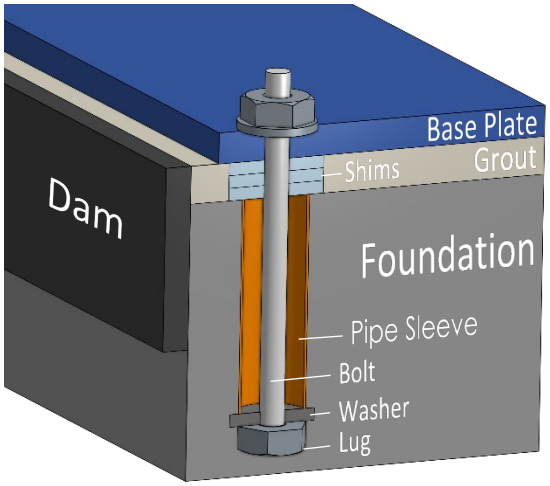
1. Prior to starting installation, make sure there will be adequate space for installation, operation, and maintenance of the pump and driver.

   Typical pump foundations consist of a steel plate mounted in grout or bolted to a structure. This plate is often referred to as a “foundation plate”, “sole plate”, “sub-base”, or “base plate”. In this manual, we will refer to the plate as “base plate”.

   The foundation must be able to withstand the weight of the pump plus the weight of the liquid flowing through it. It must also be able to absorb vibration and provide a rigid support for the entire pump assembly and driver.

   A typical base plate installation is shown in Figure 5 below. A pipe sleeve is embedded into the concrete foundation with a bolt passing through. The bolt secures the base plate to the grout, shims/leveling wedges, and foundation. The sleeve allows for some movement of the bolt and aids in alignment with the base plate holes. The pipe sleeve diameter is typically 2.5 times the bolt diameter.

Figure 3 – Base Plate and Foundation



2. Make sure the pipe sleeves are free from water and then carefully lower the base plate onto the foundation, making sure to line up all the foundation bolts with the bolt holes in the base plate. Install the nuts and washers on each bolt and hand tighten.

3. Level the base plate. Use leveling wedges, shims, nuts, or jackscrews to level the base plate. If using shims, make sure all anchor bolts have a shim installed nearby to prevent binding

the base plate. If the baseplate twists and binds, it will likely be impossible to level.

4. Ensure the plate is clean and free of dust and contaminants. Use a machinist level in two directions at 90 degrees to check level. Level tolerance is 0.005in per foot.

5. Once leveled, tighten all anchor bolts. After tightening, re-check the base plate for level. If tightening the anchor bolts has moved the base plate level out of tolerance, loosen the bolts, adjust the leveling devices until the base plate level is within tolerance, and re-tighten the anchor bolts. Repeat until the anchor bolts are tightened and the base plate level is within tolerance.

6. Build a dam around the foundation in preparation for grouting. Pour grout into the space between the base plate and foundation until the space is filled and level with the top of the dam. Make sure no air bubbles remain trapped in the grout and allow to cure. After curing, make sure no voids have formed and remove any leveling wedges, shims, nuts, or jackscrews.

Existing Baseplate

If using an existing baseplate, use the discharge flange of the pump to check level. First, install the pump on the existing baseplate using the appropriate directions in the Pump Installation section of this manual. Then use a machinist level in two directions at 90 degrees on the discharge flange to check level. If level is out of tolerance, add or remove shims between the discharge head and the baseplate.

Installation Preparation and Notes

CAUTION Never use the motor leads to lift or handle the motor. The motor leads should always be protected and handled with extreme caution.

Refer to the motor manual for any preinstallation service work.

If using a check valve on the pump, install now according to the manufacturer's recommendations.

If using threaded drop pipe, the motor torque may unscrew the threaded connections. Ensure that all threaded connections are tightened to a torque of at least 10ft-lbs per motor HP. Example: For a 25 HP motor, this would be 10 * 25 = 250ft-lbs. If this torque cannot be achieved by the tools available, the joints must be welded or secured in another manner.

Assembling the Motor and Pump

The pump and motor are typically shipped separately. If a pump has less than 5 stages, it is recommended that it be assembled to the motor horizontally on the ground. If the pump has 6 or more stages, it is recommended that the pump be assembled in the vertical position.

1. Check pump and motor shaft rotation. Both shafts should turn freely.
2. Clean the motor flange face, pump register, exposed motor shaft, exposed pump shaft, and inside of the pump/motor coupling (on the motor side only if pre-installed on the pump shaft). Remove all burrs.
3. Install the motor shaft key.
4. Remove any setscrews on the motor side of the pump/motor coupling.
5. Align the pump and motor. Slide the motor shaft into the pump/motor coupling until the shafts butt together. Be careful not to damage the shafts, coupling, or shaft key while installing.
6. Rotate the motor until the motor leads align with the notch in the pump flange. Install and tighten any shaft coupling setscrews.
7. Install and tighten the mounting bolts on the flange.
8. Remove the cable guard on the pump. Lay the motor leads underneath the guard and then reinstall the guard to the pump.

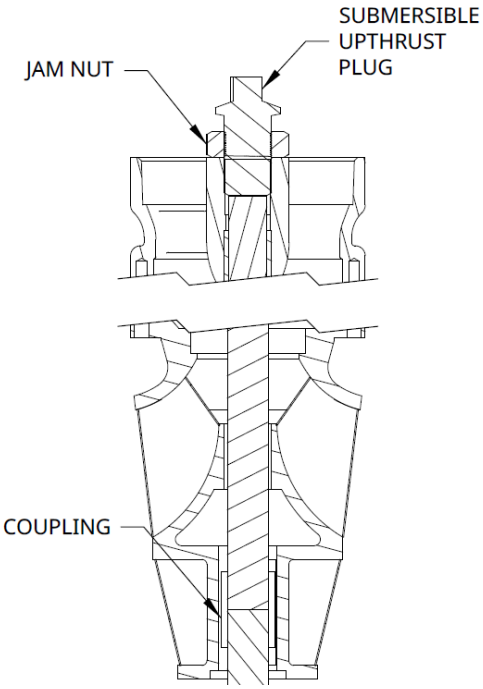
Upthrust Adjustment

4" - 12" Motors

The impeller upthrust has been preset at the factory to mount the pump end to the motor. The total amount of upward axial movement of the impeller must be 0.125 inches. If adjustments are required, loosen the jam nut at the discharge end plug and adjust the submersible upthrust plug until the up-thrust reaches the appropriate value. Tighten the jam nut to secure.

The impeller up-thrust must be checked and adjusted after motor installation.

Figure 4 – Upthrust Adjustment



Test the Motor

WARNING The unit must be grounded when testing. Failure to ground the unit properly can result in serious or fatal shock.

1. Ground Test – Insulation Resistance. Test should be performed with the motor submerged in water. See Appendix for testing instructions.
2. Motor Winding Resistance Test – Resistance Between Leads. See Appendix for testing instructions.

Record all test values for future reference.

WARNING The starting torque of the motor will cause the pump to jerk or "kick" when started. The unit must be sufficiently restrained to prevent serious or fatal injury and/or damage to the equipment.

3. Rotation Test. Secure the pump and motor to resist torque. If a tank of water is available, perform a 1 minute running test of the pump while submerged in the tank. If a tank is not available, briefly energize or "bump" the motor to check rotation. Do not exceed 2 seconds of run time when bumping.

Pump rotation should be counterclockwise when viewed from the discharge.

On three phase motors, if rotation is wrong, interchange any two of the motor leads at the control panel.

CAUTION It is extremely important the pump rotate the correct direction. The pump may generate excessive overload conditions with reversed rotation.

4. Drop Cable Test. Measure the resistance between the cable conductors and ground with the cable submerged in water. See Appendix for testing instructions.

Splice the Power Cable to the Motor Leads

Follow the instructions supplied with the drop cable or pump motor manual to create a waterproof splice between the power cable and motor leads. It is important to make a proper splice to prevent future service issues. The splice should be located above the pump bowl and should be as compact as possible. A compact splice has less chance of being damaged during pump installation.

Testing after Splicing Power Cable to the Motor Leads

Test the splice prior to lowering the pump into the well. To test the splice, follow these instructions:

1. Immerse the splice in a container of water for one hour. Afterwards, measure the resistance between each cable conductor and the water. See Appendix X.
2. Measure the total resistance of the complete drop cable and motor circuit. Use Table A.2 to ensure that the splice is good. Record the measured values.

Installing the Pump

1. Remove the suction screen if applicable and ensure that the pump and motor shaft spin freely. Re-install the suction screen.
2. Hoist the pump and motor assembly into the vertical position, leaving the shipping skids in place and secured. Remove the shipping skids, align the pump and motor assembly over the well. Slowly lower the assembly into the well. Clamp the bowl assembly near the top.
3. Attach elevators to the bottom column pipe, immediately below the column coupling. Slowly begin to hoist the column pipe into the vertical position. Use a soft board or pipe dolly to prevent damaging the threads on the end not attached to the elevators. Position the column pipe above the pump. Clean all threads with thread lubricant and thread the column pipe into the discharge case. Tighten the connection, using a set of chain tongs for backup.

CAUTION If using threaded drop pipe, the motor torque may unscrew the threaded connections. Ensure that all threaded connections are tightened to a torque of at least 10ft-lbs per motor HP. Example: For a 25 HP motor, this would be 10 * 25 = 250ft-lbs. If this torque cannot be achieved by the tools available, the joints must be welded or secured in another manner.

4. Install a cable clamp on each side of the cable splice. Do not damage the cable. If installing an air line, route the air line alongside the cable, but make sure it is not pinched by the clamps. If the splice may rub against the well during installation, it should be protected with thick rubber chaffing pads or a steel shield. Check that the grounding system is in place.

WARNING Failure to ground the unit properly can result in serious or fatal shock. Refer to electrical code requirements.

5. Slowly lower the assembly into the well and continue adding column pipe as the assembly is lowered. Ensure that each joint is tightened securely, as described above. Remove slack in the power cable and secure with a cable clamp every 20 feet. Additional clamps may be required for larger cables. Keep the cable aligned on one side of the pump and provide as much clearance as possible to that side while lowering. Hold the power cable up and away from the well casing as the pump is lowered into the well.

CAUTION Use extreme caution to ensure that the power cable, cable splice, and grounding system are not damaged while lowering the pump.

6. A check valve should be installed within 25 feet of the pump discharge case. If the pump is in a deep-set application, a check valve should be installed every 200 feet of column pipe. Do not install check valve above the pumping level.
7. Once the splice joint is submerged in water, take another resistance reading between the power cable conductors and ground. This is to ensure that the cable and splice were not damaged during installation.
8. After the last piece of column has been installed, install the well head. Install a cable clamp between the well head base and top column coupling. Route the power cable and grounding system through the large threaded hole in the head base. If using an air line, route it through one of the smaller threaded holes in the head base. The remaining small threaded hole is for connecting a well vent or other accessory. The holes are threaded standard

NPT. If using a gasket between the head base and mounting surface, install the gasket before lowering the head base into place on the foundation.

9. After tightening the well head to the top column pipe, rotate the entire assembly until the discharge flange is oriented in the desired direction. Ensure that the cable side of the assembly has as much clearance as possible while rotating.
10. Slowly lower the assembly until the well head rests on the mounting surface. Take care not to damage or pinch the grounding system or power cable between the surface plate and the well casing. If a gasket was used between the head plate and mounting surface, ensure that it is aligned properly and undamaged. Install the mounting bolts.
11. Before connecting the power cable to the control panel:
    a. Measure the resistance between the power cable conductors and ground to ensure that the cable and splice were not damaged during installation.
    b. Measure the resistance of the power cable and motor circuit. See Appendix X. Compare these readings to those taken when preparing the pump for installation to ensure the splice is intact. Make the electrical connection between the power cable and the control panel. If desired, install a terminal box near the well head to simplify the electrical work required when removing the pump. Ensure that the unit is grounded properly.

WARNING Failure to ground the unit properly can result in serious or fatal shock. Refer to electrical code requirements.

Ensure that the leads are connected as they were marked previously in the procedure.

Starting the Pump

CAUTION Initial startup and testing may require starting and stopping of the pump several times. The motor must be allowed to adequately cool between starts. Consult the motor manual for time between starts or allow a minimum of 15 minutes between starts.

1. Install a throttle valve on the discharge set to one quarter open. Allow the water to flow directly out onto the ground during startup. If the valve is open more than one quarter, the pump and/or well may surge.

   If the pump has been installed for several days before startup, check the resistance between the cable conductor and ground to ensure that the splice and cable insulation are still good.

2. Using a clamp-on ammeter, clamp the tongs around one power lead of the pump. Set the ammeter on the maximum scale. After the motor starts, it can be reset to a lower scale as desired.

   Consult the motor manual for normal operating amps of the installed motor.

   Start the pump. Observe and record the current readings on each conductor of the power lead. If the current exceeds the normal value shown in the motor manual, stop the pump immediately. A high current indicates something is wrong and may be due to the following:

   - Incorrect pump rotation (3 phase only)
   - Improper voltage
   - Sand locked pump
   - Improper cable size or leak in cable
   - Mechanical damage

   A high current reading must be corrected before operating the pump.

   On three phase short set units, water should reach the surface within one minute. On deep set units, allow for half a minute per 100 feet of

setting. If water does not reach the surface in these time frames, the pump may be running backwards. Stop the pump and interchange any two of the three cable connections. If correct rotation cannot be determined, note the flow and pressure when running the pump each direction. The correct rotation will produce more flow and pressure.

3. Check the voltage and make sure it is within 5% of the pump motor nameplate voltage when the pump is running.
4. Open the throttle valve slowly. If sand appears, open the valve to 80% of full flow until the sand clears. Excessive noise, pressure fluctuations, and foamy water indicate that the pump is cavitating. Throttle the valve to produce backpressure until these issues cease.
5. On three phase units, check for current imbalance. See Appendix X. The maximum allowable current unbalance is 5%. If the current unbalance exceeds 5% after rolling th e leads and connecting them for the lowest unbalance, the pump should be stopped and corrective action taken. Current unbalance greater than 5% may cause excessive heating in the motor and premature failure. Operating the unit with a current imbalance greater than 5% will void the warranty.
6. After the unit is operating properly, a performance test should be conducted. Recording the values of a performance test on a new pump will provide a baseline for subsequent tests and allow for determining the degree of wear on the pump without removal of the unit.
7. After the system has been in operation for one week, perform the routine tests.

Performance Testing

To conduct a performance test of the pump, measure and record the following:

- Discharge pressure (feet)
- Pumping level (feet)
- Flow (gallons per minute)
- Line voltage on all phases (volts)
- Current in all three phases (amps)

Record the information above at the following operating points:

- Shutoff
- Slightly less than rated flow
- Rated Flow
- Slightly more than rated flow

CAUTION Do not run the pump at shutoff for more than 30 seconds or the motor may be damaged.

Use the following formulas to aid in evaluating the measurements taken.

$$Pump\ Output\ Horsepower = \frac{Q\ x\ W\ x\ SG}{3960}$$

Where:

Q = flow (GPM)

H = total head (feet)

SG = specific gravity (unitless)

$$Power\ Input\ HP\ =\ KW\ input\ x\ 1.34$$

$$Wire - to - Water\ \ Efficiency = \frac{Pump\ Output\ HP}{Pump\ Input\ HP}$$

Routine Testing

Perform the following tests on a routine basis or after the pump has been shutdown for a prolonged period.

- Check the resistance between the drop cable conductor and ground.
- Measure the resistance of the drop cable and motor windings.
- Measure the voltage and the current. Compare the readings with previous readings. If either the voltage or the current has changed substantially, check the current unbalance. Excessive current indicates a problem in the system that should be corrected immediately.
- Measure the water level in the well. A drop in the water level may indicate over pumping of the well or clogging of

the well screen which can result in damage to the well, pump, and/or motor. It may be necessary to lower the pump if the suction is submerged 5 feet or less when pumping.

Appendix

Electrical Tests

Ground Test – Insulation Resistance

The condition of the insulation around a conductor can be determined by measuring the electrical resistance between the conductor and ground. This measurement can be made with a megger or an ohmmeter. The value is stated in ohms or megohms (ohms x 1,000,000). High ohm values indicate good insulation. The basic procedure for measuring insulation resistance is outlined below:

1. Turn off all power and disconnect the leads to be tested from the electrical panel. **Follow lockout/tagout procedures.**

Failure to completely disconnect power will damage the meter and can cause serious or fatal shock.

Failure to disconnect the leads may result in false readings.

2. Set the meter selector knob to R X 100K or R X 100,000. Some meters may not have R X 100K. In this case, use E X 10K or E X 10,000 scale.
3. Clip the meter leads together and adjust the meter to zero.
4. Unclip the leads. Attach one of the meter leads to one of the power cable leads or motor leads. Connect the meter ground lead to ground.
5. Do not touch any bare wires or allow bare wires to contact the ground or metal. False readings will result.
6. If the meter needle is at either extreme end of the scale, switch the selector to another scale. Re-zero the meter each time the selector switch is moved.
7. Examine the readings and compare to Table A.2. Low readings indicate that the motor windings are grounded or that the cable or splice insulation is damaged. Low or marginal readings on a new installation must be corrected before proceeding.

Motor Winding Resistance Test – Resistance Between Leads

The general condition of motor windings can be determined by measuring the resistance between the motor leads and comparing with the nominal values given in the motor manual. The resistance is measured with an ohmmeter and the value is stated in ohms. The basic procedure for measuring motor winding resistance is outlined below:

1. Turn off all power and disconnect the leads to be tested from the electrical panel. **Follow lockout/tagout procedures.**

Failure to completely disconnect power will damage the meter and can cause serious or fatal shock.

Failure to disconnect the leads may result in false readings.

2. Set the meter selector knob to “R X 1”.
3. Clip the meter leads together and adjust the meter to zero.
4. Unclip the meter leads and attach them to the motor leads.

Resistance measured between the motor leads prior to splicing the drop cable to the motor leads should be within the motor winding resistance limits specified in the motor manual.

Resistance measured between the motor leads after splicing the drop cable to the motor leads will indicate the resistance of the power cable plus the motor windings. The motor winding resistance is obtained by the formula below. The calculated value should be within the limits specified in the motor manual.

Motor Winding Resistance	=	Reading taken at Power Cable	-	Cable Resistance from Table A.3

A higher winding resistance than shown in the motor manual indicates a possible burned (open) winding, an open cable, a loose connection, or the wrong motor

(different HP or voltage than readings being referenced).

A considerably lower winding resistance than shown in the motor manual indicates a possible shorted (burned together) winding or the wrong motor.

Unequal resistance between the windings on a three phase motor indicates a burned winding or a faulty connection.

Current Unbalance Test

For three phase units, after correct rotation has been established, check the current in each of the three motor leads and calculate the current unbalance as explained below. If the current unbalance is 2% or less, leave the leads as connected. If the current unbalance is over 2%, current readings should be checked on each leg using one of three possible hook-ups indicated in the Table A.1 below. Roll the motor leads across the starter in the same direction to prevent motor rotation reversal. This procedure is commonly known as "rolling the leads". The hookup that results in the lowest percent current unbalance should be used for the final connection of the power leads.

Current unbalance is determined by measuring the amperage of each of the three legs and then calculating the percent current unbalance using the formula below. This calculation must be performed using each of the three hookups shown in Figure X.

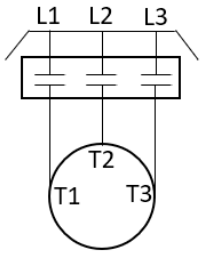
$$\text{Percent Current Unbalance} = \frac{\text{Maximum Current difference in any leg from average current}}{\text{Average Current}} \times 100$$

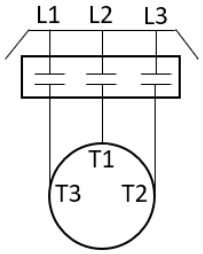
Calculation sheet and diagram on the following page.

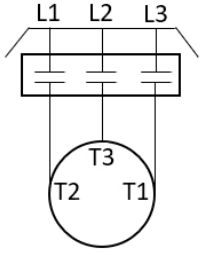
The current unbalance between legs should not exceed 5% at service factor load or 10% at rated input load. If rolling the leads does not lower the unbalance to within tolerance, corrective action must be taken.

If the leg furthest from average is always on the same motor lead, the primary source of unbalance is on the motor side of the starter. Possible causes are damaged cable, bad splices, poor connection, or faulty motor windings.

Table A.1 Current Unbalance Calculation – Rolling the Leads





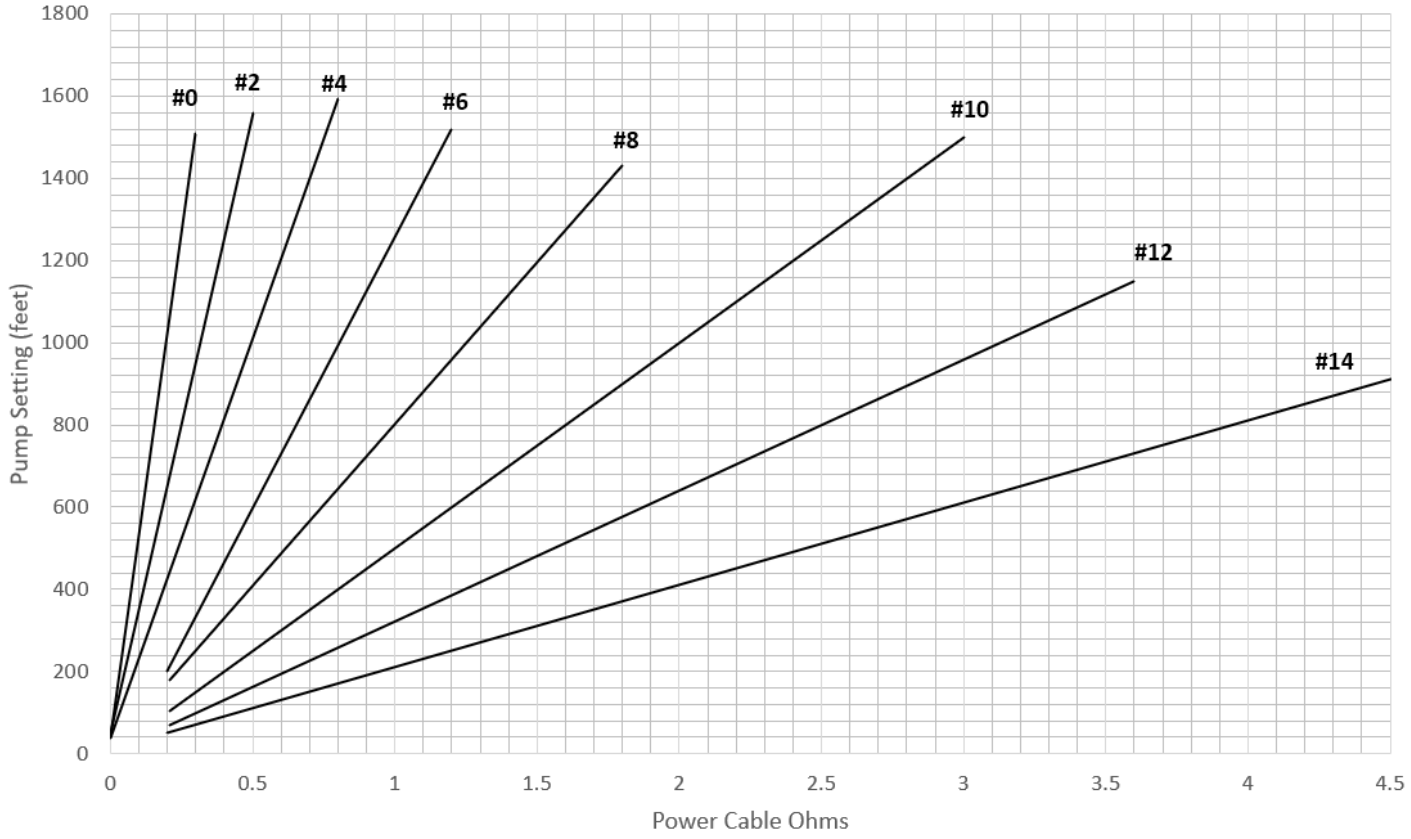


	Sample Calculation			
Measure current in each leg. Add leg currents to determine total current. Calculate average leg current.	T1 L1 83 amps T2 L2 74 amps T3 L3 +83 amps 240 amps ÷ 3 80 amps	T1 L1 _____ T2 L2 _____ T3 L3 _____ ÷ 3	T3 L1 _____ T1 L2 _____ T2 L3 _____ ÷ 3	T2 L1 _____ T3 L2 _____ T1 L3 _____ ÷ 3
Determine highest difference of any one leg from the average.	83 – 80 = 3 80 – 74 = 4 ← Highest 83 – 80 = 3	____ - ____ = _____ ____ - ____ = _____ ____ - ____ = _____	____ - ____ = _____ ____ - ____ = _____ ____ - ____ = _____	____ - ____ = _____ ____ - ____ = _____ ____ - ____ = _____
Calculate percent unbalance using formula above.	$\frac{4}{80}\ x\ 100 = 5\%$	____ x 100 = ____%	____ x 100 = ____%	____ x 100 = ____%

Table A.2 – Normal Insulation Resistance Values Between All Legs and Ground

Condition of Motors and Leads	Ohms	Megohms	Meter Reading	
			R x 100K Or R x 100,000 Scale	R x 110K Or R x 10,000 Scale
Bench Tests				
New motor (without drop cable)	20,000,000+	20+	200+	2000+ or 2K+
Used motor	10,000,000+	10+	100+	1000+ or 1K+
Cable splice (after immersion in water for 1 hour)	2,000,000+	2+	20+	200+
Well Tests (Ohm readings are for drop cable plus motor)				
New motor or used motor in good condition	2,000,000+	2+	20+	200+
Motor in reasonably good condition	500,000-2,000,000	0.5-2.0	5-20	50-200
Motor possibly damaged by lightning or with damaged leads. Do not pull the pump for this reason.	20,000-500,000	0.02-0.5	0.2-5	2-50
Damaged motor or damaged cable. Pump should be pulled and repaired/replaced. The motor will not fail for this reason alone, but will probably not operate for long.	10,000-20,000	0.01-0.02	0.1-0.2	1-2
Motor that has failed or with destroyed cable insulation. Pump must be pulled and the cable repaired or the motor replaced.	Less than 10,000	0-0.01	0-0.1	0-1

Table A.3 – Power Cable Resistance

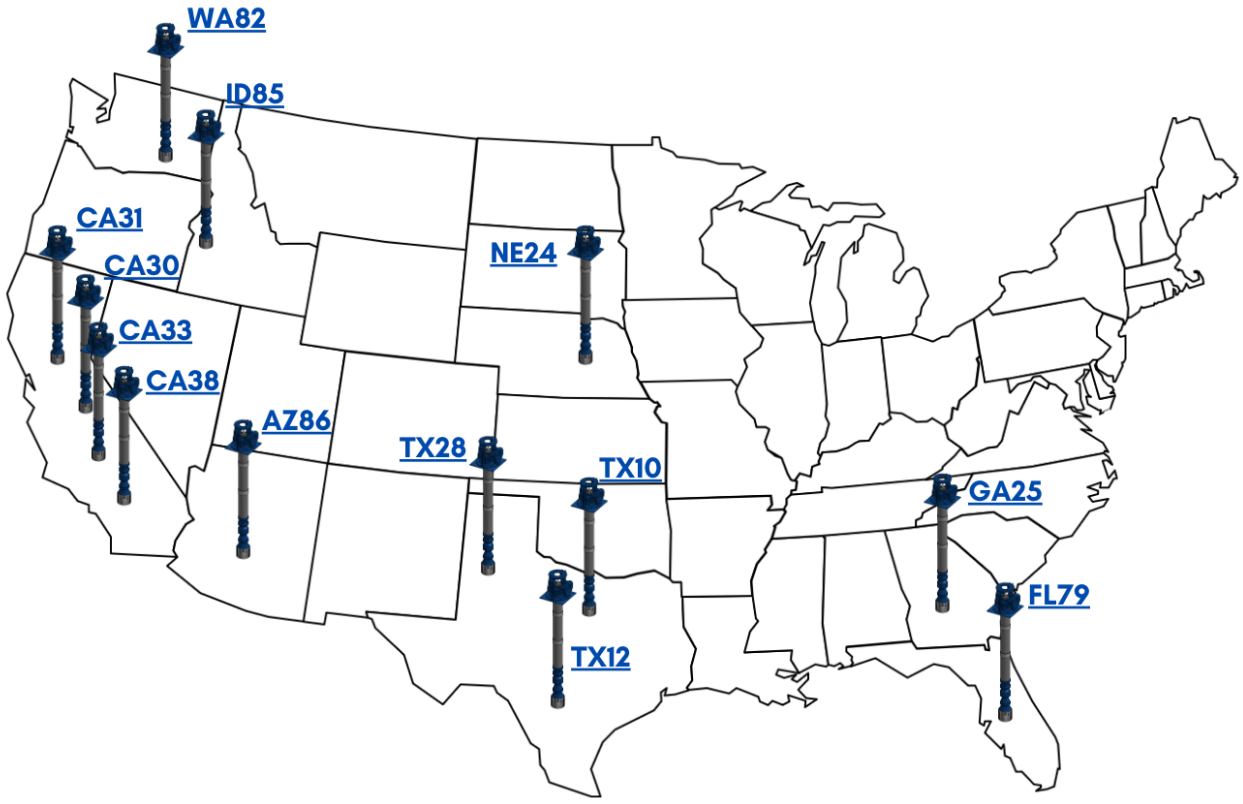


Troubleshooting		
ISSUE	**POSSIBLE CAUSE**	**SOLUTION**
1. *Pump will not start*	A. Inadequate or incomplete electrical circuit	A. Check electrical circuit and make necessary corrections.
	B. Improper electrical connections	B. Check electrical connections and make necessary corrections.
	C. Impeller interference with bowls due to improper lateral adjustment	C. Repeat impeller adjustment.
	D. Motor defect	D. Consult motor supplier or factory.
2. *Pump is not producing design flow*	A. Pump rotation is backwards	A. Confirm rotation is backwards (rotation should be CCW when viewed from above) then swap any two motor leads (for a three phase motor).
	B. Actual system head is greater than design	B. Check system design calculations. Consult factory for additional stages / impeller diameter changes that may be available.
	C. Well level is below the lowest impeller	C. Increase pump length or raise the well level to ensure proper submergence.
	D. Inadequate Net Positive Suction Head Available (NPSHa)	D. Confirm NPSHa > NPSH required by the pump for design point. If there is inadequate NPSHa, consult factory.
	E. Blockage at pump inlet, strainer, impeller, or other pump component	E. Modify inlet design to keep fibrous material and solids away from the pump inlet.
	F. Broken or disconnected pump shaft	F. Remove pump and repair all damaged or disconnected components
	G. Discharge valve partially closed	G. Adjust discharge valve as necessary for design condition.
	H. Pump speed is too low	H. If motor is across-the-line, check that the motor is receiving full voltage. If motor is using a variable frequency drive, adjust speed as necessary to achieve design speed.
	I. Damaged or worn bowl assembly components	I. Remove pump and repair/replace all damaged components. Consult factory for required parts.
	J. Improper impeller diameter	J. Consult factory for required parts. Remove pump and replace impeller(s).
	K. Entrained air	K. Check for vortexing in the well and install vortex breakers as required. Check that minimum submergence is met.

3. *Pump is not producing design head / pressure*	Follow possible causes and solutions found in Issue 2	
4. *Pump is not producing any flow*	Follow possible causes and solutions found in Issue 2: A-J	
5. *Pump only operates for a short period*	A. Undersized motor	A. Increase motor to larger HP. Consult factory.
	B. Blockage of pump suction	B. Remove pump and clear strainer / well as required.
	C. Excess well level drawdown	C. Check well level and adjust pump length as required.
	D. Air lock	D. Check for vortexing in the well and install vortex breakers as required. Check that minimum submergence is met. Install air release valves on discharge as required.
6. *Excessive pump noise*	A. Cavitation	A. See Issue 2:D
	B. Resonant vibration	D. Relieve any piping strain from the discharge and consult factory
	C. Impeller interference with bowls	E. Remove pump and inspect impellers for damage. Replace as necessary and readjust.
7. *Pump Will Not Run*	A. No power	A. Refer to Electrical Tests
	B. Motor protection device has tripped.	B. Refer to Electrical Tests
	C. Blown Fuse	C. Refer to Electrical Tests
	D. Open circuit in cable, cable splice, or motor winding.	D. Refer to Electrical Tests
	E. Control box malfunction.	E. Refer to Electrical Tests
8. *Overload Protector has Tripped*	A. Incorrect Control box.	A. Replace with correct control box.
	B. Incorrect, loose, or corroded electrical connections.	B. Replace defective items. Refer to Electrical Tests.
	C. Incorrect Voltage	C. Correct line voltage.
	D. Current overload	D. Check the following: - Tight motor or pump bearing. - Pump clog - Unbalanced voltage - Grounded cable, cable splice, or motor winding. Refer to Electrical Tests - Low voltage - Insufficient motor cooling

NOTES:

NOTES:



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