2022

# SUBMERSIBLE TURBINE PUMP

# 4”, 6” & 8” SIZES

INSTALLATION AND OPERATION

Bulletin B-2649804

2005 Dr Martin Luther King Jr Street
Indianapolis, IN 46202

# SUBMERSIBLE TURBINE PUMP INSTALLATION AND OPERATION INSTRUCTIONS

## 1.0 PRE-INSTALLATION CHECK LIST

### 1.1 Inspection of Shipment

#### 1.1.1 Motor

Standard Peerless Pump submersible pump motors are shipped assembled to their bowl units.

Check the following:

a. Appropriate motor installation and operation manual (provided by the motor manufacturer).

b. Motor must be free from evidence of external damage.

c. Motor nameplate voltage, horsepower, etc. must be compatible with the ratings on the pumping plant panel, the power meter and on the purchasing and shipping documents.

d. If the motor is equipped with a power cable, do not use it to support the weight of the motor.

e. Motor's electrical connector or cable leads must be compatible with the drop cable.

f. Check the motor's instruction tags or its installation manual to determine with what liquid it is filled. Add liquid if necessary.

g. Record the motor serial number, installation date and other pertinent information. Retain this information in the pump's permanent record file.

#### 1.1.2 Bowl Unit

Examine the bowl unit and its strainer for evidence of external damage. Be sure that the column adapter's threads are clean and undamaged. Check to be sure that the largest outside diameter of the motor/bowl unit assembly will fit inside the well. Record the bowl unit's serial number, model number, etc. and retain this information in the pump's permanent record file.

#### 1.1.3 Drop Pipe (Column Pipe)

Examine the pipe to be sure that it is sound, with clean, well formed threads. Be sure that enough pipe is on hand to reach the intended setting (depth).

#### 1.1.4 Power Cable

The exact type of cable to be used is a matter for the individual pump manufacturer or installer to decide. Several cable manufacturers have cable designed for use submerged in water. The insulation on the conductor should be Type RW, RUW, TW, or equivalent, specifically suitable for use submerged in water.

The cable may have three individual conductors twisted together, three conductors molded side by side in one flat cable, or three conductors with a round external jacket. Use of solid or stranded conductor cable is optional.

For information on cable selection, see paragraph 4.1.

#### 1.1.5 Connectors/Splicing Materials

Check to be sure that the connectors and/or splicing materials are suitable. When making a waterproof cable splice, we recommend using:

1.1.5.1 Scotch Cast Splicing Kit No. 82-A1; one for each lead. Each kit includes instructions for use. (Peerless part 2615720)

1.1.5.2 Taped Type Splice (Peerless part 2615721).

The following tapes are used:

a. "Bi-Seal" tape
Supplier: Mitchell-Rand Insulation Co.
51 Murray Street
New York, New York
or: "Scotchfil" electrical putty
Supplier: Minnesota Mining & Mfg. Co.

b. "Scotch: #33 electrical tape and "Scotchkote"

Supplier: Minnesota Mining & Mfg. Co.

"Bi-Seal" tape is a self-bonding polyehtelene tape which has excellent electrical properties and extremely low water vapor transmission. "Scotchfil" electrical insulation putty has good dielectric and excellent aging properties.

"Scotch" #33 tape, although a good insulating material, is used for mechanical protection due to its superior abrasion resistance. Among the many effective methods of making waterproof splices, those described in paragraph 2.6 are as effective as any.

#### 1.1.6 Electrical Panel

Examine the pumping plant panel (starter) to establish its compatibility with the motor, the electric meter and the requirements of the application. For use with submersible motors, the panel must have ambient quick trip overload relays instead of standard relays. The use of standard relays can void the motor warranty. For additional information on motor protection, see paragraph 4.3.

### 1.1.7 Airline

If an airline will be installed, check to ensure that the material (plastic, copper, black pipe) is appropriate, that the quantity on hand is sufficient, and that an exit opening is provided in the surface plate or through the pump foundation. See also paragraph 2.7.

## 1.2 Special Tools

Voltammeter for checking current

Sta-kon pliers or crimping tool for securing cable connectors to the cable

Banding tool for securing cable to the column

"Band-it" stainless steel band

"Band-it" buckles for use with bands

Rubber pads to protect cable under "Band-it" band

Cable: 3 parallel conductors #1 or #1/0 AWG approximately 20 feet

## 1.3 Well Site

### 1.3.1 Size of Well and Straightness

Before attempting to install the pump, the well should be carefully checked to determine that the casing is of the proper diameter, depth and straightness. If there is any doubt about the size of accuracy of the well, consult your pump dealer and, if necessary, have the well surveyed and plotted to determine that the pump can be installed properly and will operate normally. Since the pump drop pipe can be curved, within limits, without detriment to pump operation, the well should be surveyed to find out in what direction and how sharply it curves throughout its length.

Wells for which the exact depth and diameter are not known should be checked even if they are not crooked because the lower well casings are frequently smaller in diameter than the upper casings.

If a well is crooked, surveying it is especially important when the pump outside diameter is close to the well inside diameter.

Surveying involves lowering into the well to the proper depth a checking tool which is the maximum diameter and length of the pump together with a piece of drop pipe at least 50 feet long.

In a crooked well a submersible pump will work much better than a line shaft pump which might have excessive friction and wear. Be sure the pump is not installed in a bend.

### 1.3.2 Condition of Water

#### 1.3.2.1 Sand and Debris

Developing the well and freeing it from sand are part of the well driller's job and should be done with a test pump reserved for this purpose. However, if a test pump is not available and a new pump must be used, extreme care should be taken. Throttle the discharge at least until the water becomes clear of excessive sand. Even then, in spite of all precautions, the pump will probably be badly sand cut during the process. Peerless will not accept the responsibility for a new pump damaged in this manner.

#### 1.3.2.2 Gas

If air or other gas is present in the water, the pump will not perform as anticipated and, if gas is present in excessive quantities, pumping may stop altogether. The presence of gas may cause vibration and damage. If a gas is present, consult your dealer or the pump manufacturer for advice.

#### 1.3.2.3 Temperature

Submersible motors which meet NEMA standards are rated for full horsepower output in water at temperatures up to about 25° C (77° F). If the water temperature exceeds 25° C (77° F), check with the pump manufacturer to determine the maximum allowable motor load.

Some operating conditions do not ensure adequate flow past the motor. Examples are:

a. Top-feeding (cascading) wells can feed the water directly into the pump without its flowing past the motor if the well is not cased below the motor, or if the casing is perforated above the motor.

b. Flow may be inadequate if the motor is in a large body of water, if the casing is much larger than the motor, or if delivery is very low.

If either of these conditions exists, see paragraph 4.2.

### 1.3.3 Installation Depth

Seasonal and pumping drawdown should be

determined to prevent running dry with consequent damage to the pump and motor. If the seasonal or pumping drawdown levels are not available, the use of a low water level control or a low water level alarm or indicator is highly recommended. For best results the pump should be located below its lowest pumping level by at least the amount of its NPSH required (NPSHr) value. The NPSHr value can be determined from the pump performance curve. If possible, the pump should also be located above its water bearing stratum.

Do not locate the pump so that it is buried in sand or mud at the bottom of the well. The bottom of the motor should be at least five feet above the bottom of the well. If the motor or pump must be buried in mud at the bottom of the well, consult your pump dealer for recommendations.

### 1.3.4 Power Supply

Verification of the electrical supply should be made to ensure that its voltage, phase, and frequency match that of the motor. Motor voltage, phase, frequency, and full-load current information can be found on the nameplate attached to the motor. Most submersible motors are designed to operate with the normal NEMA input voltage range of nameplate voltage ± 10%, plus an additional 5% maximum drop in the supply cable. Voltages outside this range can cause reduced pump output, produce overload tripping, and cause failure to start.

In the specific case of a 200 or 208 volt supply, a 200 volt rated motor should be used. A 230 volt motor may be used with the following limitations and conditions:

a. The power supply must be a good, stable one which will maintain 200 volts or higher under running conditions.

b. Use the normal HP rated motor for the pump. Pump delivery and motor loading will be reduced slightly because the lower voltage will reduce motor speed.

c. Use motor cable two sizes larger than specified, such as #8 where #12 would normally be used.

d. If the control box for a single phase motor contains 230 volt relays, change them to 200-208 volt relays.

### 1.3.5 Pump Foundation

A substantial concrete foundation should be built around the well before the pump is installed. The top of the foundation should be a minimum of 3" above the top of the well casing and large enough so that a generous shoulder will extend beyond the base of the surface plate. The foundation should slope outward and downward and be sufficiently deep into the ground to provide the required thickness for strength as well as to secure a firm footing.

The thickness and the ground area for the foundation will depend upon the firmness of the supporting earth around the well under the worst possible conditions (considering rain or flood effects) and the weight of the complete pumping unit when full of water. If the temperature drops below freezing, the foundation must extend beyond the freezing level. The total load on the foundation equals the dead weight of all parts including the weight of the foundation itself plus the weight of water in the drop pipe. Tables 1, 2, 3, and 4 may be used for reference when figuring the size of the foundation.

A 2" pipe in one corner of the foundation (as shown in Figure 1) to accept a pipe extension will be convenient to anchor the chain tongs when tightening the drop pipe joints. A 1-1/2" or 2" pipe through the foundation to permit passage of the sounding weight of an electrical device to measure the distance to the surface of the water (also shown in Figure 1) is also recommended.

Properly constructed structural foundations or combination structural and concrete foundations can be acceptable. However, wooden timbers in contact with the soil or foundations resting on unstable soil are unsatisfactory.

## 2.0 INSTALLATION

### 2.1 Motor Leads Test

Test the motor leads and the motor connector (if used) as follows:

a. Check the winding resistance of the three-phase motor by touching the prongs of an ohmmeter to the cable leads of any two wires. The readings must be equal in all three legs; if otherwise, check with your dealer or motor manufacturer.

b. Check the resistance of each lead to the water or water container to measure the insulation resistance. The readings should be about 50,000,000 ohms (50 megohms) or more.

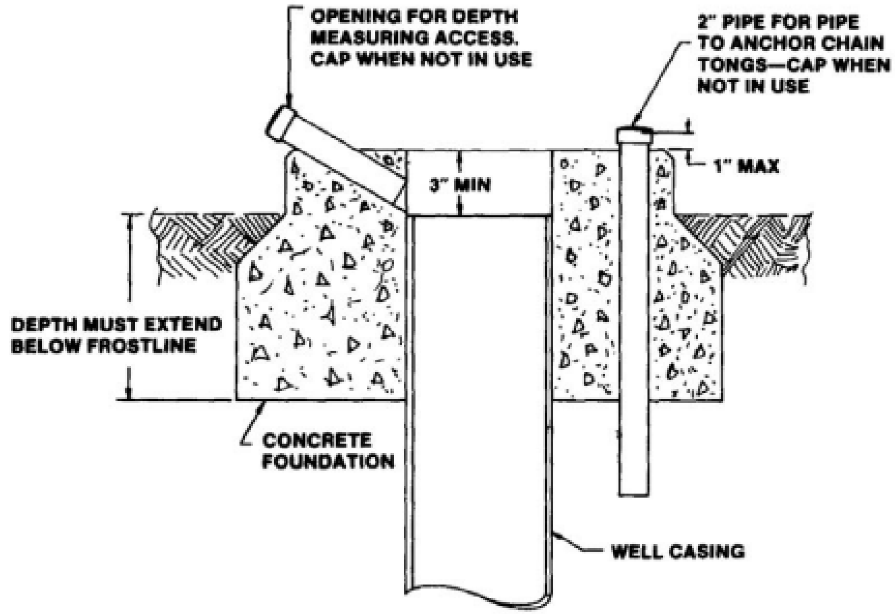



FIGURE 1

2.2 **Connect the Motor Leads to the Drop Cable**

Various motor connections to the drop cable are required depending upon the connection configuration furnished by the motor manufacturer. If the motor connection requires a splice, the procedure described in paragraph 2.6 can be used.

2.3 **Check Motor Rotation**

Check the direction of the motor rotation before the motor is installed in the well. Temporarily splice the ends of the drop cable which extend from the hub of the cable reel to #1 or #1/0 AWG cable. Connect this cable to the power supply. Momentarily energize the power supply (bump the switch). Observe the direction of rotation (through the suction screen). The direction of rotation must agree with the arrow fastened to the unit. Mark the drop cable leads extending from the cable reel hub for proper rotation when the cable is permanently connected. Disconnect and remove the temporary conductors.

2.4 **Place the Pump/Motor Assembly in the Well**

Place timbers or equivalent supports on the foundation around the well casing for use as resting blocks for the elevator clamps.

Fasten one pair of elevator clamps (see Figure 2) to the top end of the bowl assembly. Make certain that the clamps are fastened securely around a smaller diameter so that a larger diameter cannot pass through the clamps.

***Caution:*** Never clamp or hold the bowl unit with a Stillson type wrench or chain tongs.

***Caution:*** Fasten the elevator clamps in a manner which will not crush the motor cable or its metal guard.

***Caution:*** The entire down thrust of the pump is carried on a special thrust bearing. This bearing can be broken if the pump is dropped or jarred. PUMP FILURE WILL RESULT. The motor is enclosed in a metal tube. If this tube is damaged, motor failure can follow.

***Caution:*** Observe the instructions provided by the motor manufacturer. Failure to comply can shorten motor life and void the motor warranty.

***Note:*** If the motor/bowl unit assembly is longer than six feet, do not remove the shipping skids until the bowl unit has been hoisted to the vertical position. This is also good practice for shorter bowl units.

Attach a sling to the elevator clamps and pass its looped end over the hoist hook. While a helper steadies the lower end of the pump, hoist the unit into position over the well.

Slowly, carefully lower the unit into the well unit the weight of the unit is supported by the elevator clamps on the support timbers. Remove the sling if possible. (If a second sling is available, the first sling may be removed later.)

| TABLE 1. PERMISSIBLE LOAD ON SOIL | |
|---|---|
| Nature of Soil | Lbs. Per Sq. Ft. of Area |
| Packed Gravel | 16,000 |
| Compacted Sand | 8,000 |
| Dry-Thick Clay Bed | 8,000 |
| Moist Thick Clay Bed | 4,000 |
| Dry Sand | 4,000 |
| Soft, Wet Clay | 2,000 |
| Alluvial Top Soil | 1,000 |

| TABLE 4. WEIGHT OF SUBMERSIBLE MOTOR | | | | |
|---|---|---|---|---|
| Horse-power | Phase | Size | Thrust Rating | Weight, Pounds |
| 5 | 1 | 6" | 1500 | 107 |
| 7 ½ | 1 | 6" | 1500 | 123 |
| 10 | 1 | 6" | 3500 | 144 |
| 5 | 3 | 6" | 1500 | 95 |
| 7 ½ | 3 | 6" | 1500 | 107 |
| 10 | 3 | 6" | 3500 | 128 |
| 15 | 3 | 6" | 3500 | 144 |
| 20 | 3 | 6" | 3500 | 168 |
| 25 | 3 | 6" | 3500 | 186 |
| 30 | 3 | 6" | 3500 | 190 |
| 40 | 3 | 6" | 3500 | 304 |
| 50 | 3 | 6" | 3500 | 355 |
| 40 | 3 | 8" | 10000 | 345 |
| 50 | 3 | 8" | 10000 | 375 |
| 60 | 3 | 8" | 10000 | 405 |
| 75 | 3 | 8" | 10000 | 460 |
| 100 | 3 | 8" | 10000 | 550 |

| TABLE 3. WEIGHT OF PUMP AND INTERCONNECTOR-POUNDS | | |
|---|---|---|
| Type | 1st. Stage and Inter-Connector | Each Additional Stage |
| 6LB | 80 | 14 |
| 6MA | 86 | 14 |
| 6HXB | 83 | 14 |
| 7LB | 100 | 19 |
| 7HXB | 102 | 19 |
| 8LB | 115 | 32 |
| 8MA | 123 | 32 |
| 8HXB | 120 | 32 |
| 9LA | 144 | 56 |

| TABLE 2. WEIGHT OF PIPE AND WATER-POUNDS | | |
|---|---|---|
| Std. Pipe Size | Wt. Per Ft. of pipe | Wt. of Water Per Ft. of Pipe |
| 2 ½ | 5.79 | 2.1 |
| 3 | 7.58 | 3.0 |
| 4 | 10.79 | 5.0 |
| 5 | 14.62 | 8.0 |
| 6 | 18.97 | 12.0 |

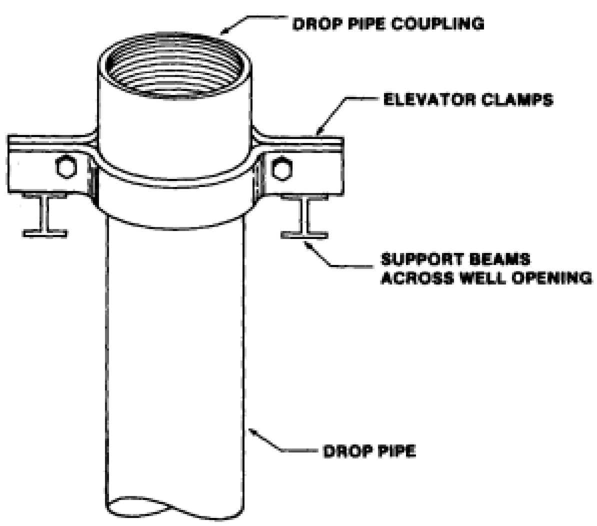



FIGURE 2

2.5 **Install the Drop Pipe**

Securely fasten elevator clamps to a joint of drop pipe immediately below its pie coupling. With a sling on the ears of the elevator clamps and the hook of the hoist, lift the pipe into a vertical position. A helper, with a "tail rope" on the pipe, should steady the pipe.

Slowly and carefully lower the drop pipe until its threads enter the bowl unit's column adapter.

Place chain tongs around the top end of the bowl unit to prevent its rotation.
The pipe threads must be square, well formed and clean. Liberally apply a good quality pipe sealant and joint compound. With chain tongs, thread the pipe into the column adapter. If cross threading has accidentally started, unthread the joint, file and clean the threads. Restart the threads, making sure that they engage fully and squarely. If cross threading damage is extensive, remove and replace the pipe joint.

Make all pipe joints TIGHT.

With the hoist, lift the motor/bowl unit/pipe joint assembly about one inch. Remove the chain tongs, the (lower) elevator clamps, and the first sling, if it was not previously removed. Slowly and carefully lower the assembly into the well until the elevator clamps are resting on the support timbers. Remove the sling, if possible.

Repeat this procedure (paragraph 2.5 – except that each pipe joint is threaded into the pipe joint below it instead of the bowl unit) until the desired setting (depth) is reached.

***Caution:*** Refer also to paragraphs 2.6 through 2.9 before proceeding with the installation.

2.6 **Installing the Cable**

2.6.1 **Splices**

2.6.1.1 If the cable furnished has three conductors in a single round jacket, snip the outer jacket in two or three places with Sta-kon or similar pliers and remove it by peeling the jacket back approximately one foot. Remove the cotton or any other tape from individual conductors in order to expose the insulation from each wire.

Utmost care must be exercised to remove all traces of tape from the insulation. Otherwise, through capillary action, water will enter the splice and short out the motor.

Strip the insulation of each conductor back far enough to allow the conductors to extend half way through the connector. Crimp the connectors to the conductors.

2.6.1.2 Apply "Be-Seal" tape. First, stretch the tape 2-3 times its normal length. Start taping with a view of making a smooth contour across the length of the splice. Use normal tension in taping. Continue taping until the thickest part of the splice is about 1-1/2" beyond the end of the wire insulation. When "Scotchfil" is used, make a smooth contour over the connection by filling the voids and padding the sharp edges of the cable connectors. Extend the filling at least 1" beyond the end of the wire insulation.

2.6.1.3 Apply four half lapped layers of "Scotch 33" tape going beyond the ends of the "Bi-Seal" tape.

2.6.1.4 Apply one coat of "Scotchkote" over the tape going beyond the end of the tape over the cable jacket.

2.6.1.5 Test the splice in accordance with the procedure described in paragraph 2.1.

2.6.2 **Feeding the Cable into the Well**

As the motor/bowl unit/drop pipe assembly is lowered into the well, extreme care must be exercised to avoid any nick or abrasion. Feed the cable into the well CAREFULLY. A substantial proportion of submersible pump failures result from cable damage during installation.

2.6.3 **Banding the Cable to the Drop Pipe**

At least once for every twenty feet of drop pipe band the cable to the drop pipe. Apply the bands in accordance with the procedure described in Figure 3. See also Figure 4 for a pictorial description of the banding at the upper end of the drop pipe and the route of the cable through the cable entrance fitting (cable entrance fitting is optional). The following recommendations will help to assure a satisfactory cable installation:

a. Slack in the cable, about one extra foot, should be provided at each band. Reason: Each band should support no more than the weight of twenty feet or cable.

b. Install a rubber block of appropriate height on either side of the cable so that the band does not damage the cable.

c. It is good practice to install a rubber "boot" under the band, as shown in Figure 4. This helps to keep the bands in place.

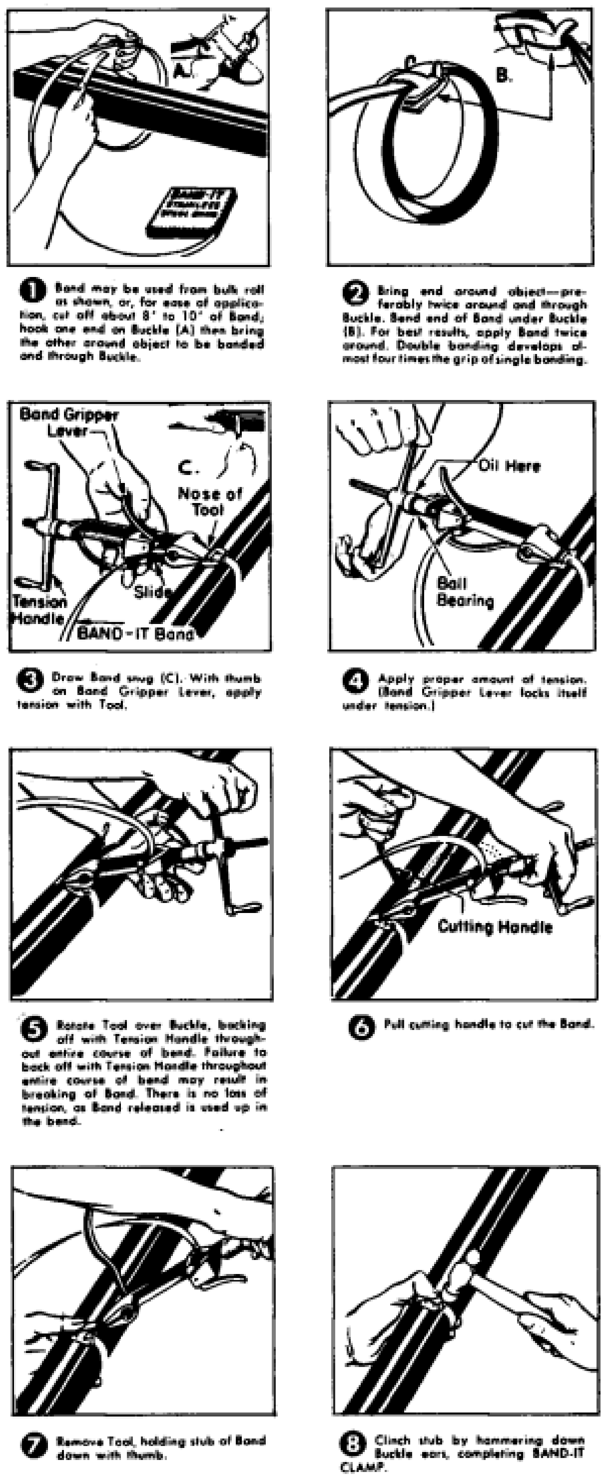



**FIGURE 3. BANDING PROCEDURE**

d. If airline is installed, band it to the drop pipe under the same bands used to band the cable to the drop pipe; see paragraph 2.7

## 2.7 Airline

Installation of airline is strongly recommended. It will be used to determine the standing and pumping water levels in the well to facilitate testing and monitoring changing well conditions. Band the airline to the drop pipe with the same bands used to secure the power cable.

Airline usually consists of ¼" black pipe or copper or plastic tubing. If copper or plastic tubing is used, rubber standoff blocks are recommended to prevent crushing.

The bottom end of the airline must remain open. Locate the bottom end about two feet above the top edge of the bowl unit's suction screen. All joints except the opening at the bottom must be air tight.

The overall length of the airline must be known to an accuracy of ± 2 or 3 inches. Normally the reference point for the top end of the airline is the center of the discharge fitting of the surface plate. Record the overall length of the airline in the pump's permanent record file.

A tee with a water level gauge and an air valve (all optional) can be assembled to the surface plate. If the airline is tubing, use a compression fitting where the airline passes through the base of the surface plate. Locate the center of the water level gauge at about the same height as the center of the discharge of the surface plate.

Adjust the movable gauge dial to reflect the length of the airline. Loosen the screws on the face of the gauge and turn it until the graduation corresponding to the vertical height is opposite the pointer when the gauge is in a n upright position. Check the dial after tightening the screws.

To obtain readings, pump air into the airline until the gauge needle ceases to rise. Note the gauge reading. This is the distance from the gauge center to the water level.

"Standing" or "static" water level readings are taken before starting the pump, or after a shutdown period long enough to allow the well water level to stabilize at its highest point. A "pumping level" reading is taken after the pump has been operating against normal head long enough for the water to stabilize at its lowest level. "Drawdown" is calculated by subtracting the standing water level from the pumping level.

An ordinary pressure gauge could be used instead of a water level gauge. In this case the pressure indicated by the gauge must be multiplied by 2.31 to get the water height in feet above the bottom end of airline. The water depth in the well is airline length minus water height.

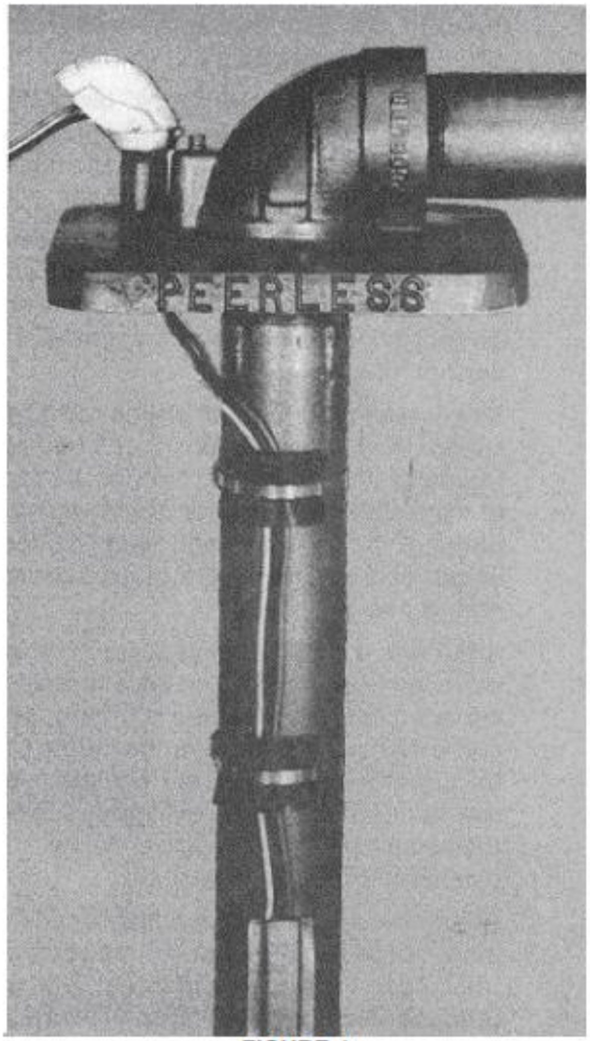



**FIGURE 4**

Keep a record of all readings and the dates taken for a complete history of well and pump performance.

### 2.6 Installing the Surface Plate

The top joint of drop pipe will have no pipe coupling at its top end. It is inadvisable to support the weight of the pump/drop pipe assembly from the elevator clamps on the top assembly from the elevator clamps on the top joint of drop pipe. Thread the top joint of drop pipe into the surface plate; make the joint relatively tight.

2.8.1 With the sling on the surface plate's lifting lugs, lift the surface plate/drop pipe assembly into position over the well. If a well seal will be used, slip it into place. Thread the drop pipe into its (lower) coupling tightly.

Lift the pump/drop pipe/surface plate assembly an inch or so. Remove the elevator clamps, unused sling, resting blocks and clean the foundation. If a well seal is used, position it on the foundation. Lower the surface plate to a

Convenient working height and complete tightening it onto the drop pipe. (A lever such as a 2' x 4" board or a 1-1/2" pipe inserted into the discharge will facilitate tightening.)

2.8.2 While the pump remains suspended, complete the airline assembly as described in paragraph 2.7.

2.8.3 While the pump remains suspended, unroll enough electrical cable to reach the pumping plant panel. Cut the cable. Test the cable as described in paragraph 2.1. Pass the cable through the (optional) cable entrance fitting. Band the cable to the drop pipe as shown in Figure 4.

2.8.4 Turn the pump as it hangs from the hoist until the discharge connection points in the desired direction. Slowly lower the pump and locate the column pipe approximately concentric with the well casing. If anchor bolts are used, they should be directly in line with the holes in the surface plate. Continue to lower the pump until the bolts just enter the holes. Locate the leveling wedges, one on each side of the surface plate where greatest support and rigidity are apparent. Lower the pump until the surface plate rests firmly upon the wedges while at the same time maintaining the concentric position of the column within the well casing. After carefully centering and aligning the surface plate and column, grout with high strength non-shrink grout.

### 2.9 Wiring the Control Panel

Before making the final wiring connections of the drop cable to the control box terminal, it is good practice to recheck the insulation resistance to ensure that the cable and splice are still good. Measurement for a new installation must be 1,000,000 ohms or more. Do not start the pump if the measurement is lower. If it is higher, finish the wiring and verify that all electrical connections are made in accordance with the wiring diagram and the motor rotation check in paragraph 2.3. Check to be sure that the control box and the high voltage surge arrestor (if used) have been grounded.

#### 2.9.1 Control Panel for Single Phase Three Wire Motors

A Franklin Electric control box must be used with a Franklin motor. Each control box has an overload protector, a capacitor or capacitors, and a starting relay, all of which are matched to the motor. Operation of a Franklin single phase three wire motor without a Franklin control box or with an incorrect control box or with an incorrect control box can result in immediate or early failure of the motor, control box or both.

Control boxes for 1-1/2 HP and larger motors have manual reset overload protectors or circuit breakers, each made to match and protect a motor with a specific horsepower rating.

Control boxes for motors with ratings above 1 HP, in addition to one or more electrolytic starting capacitors, also have one or more oil type running capacitors to provide a higher efficiency and power factor.

There are two types of starting relays generally used with single phase submersible motors which do not have centrifugal switches. One is called a current relay because it operates from the current through the main winding. The other is called a voltage or a potential relay since it operates from the voltage across the start winding. Each type will give satisfactory service. A different current relay is required for each motor current rating. One voltage relay is used for all 115 volt motors and one for all 230 volt motors.

For additional information relative to single phase control panels see paragraph 4.3.1.

### 2.9.2 Controls and Protection for Three Phase Motors

**Caution:** The normal thermal overload relays or heaters used for standard motors *will not* trip fast enough to protect a submersible motor and special *quick trip protectors must be used.*

**WARRANTY OF THREE PHASE SUBMERSIBLE MOTOR IS VOID IF PROPER QUICK TRIP PROTECTORS ARE NOT USED IN ALL THREE MOTOR INPUT LINES.**

If there is any question about the size/ratings of the overload heaters or relays, check with the motor manufacturer or the pump dealer.

In all cases, three properly selected overload protectors in series with the lines of a submersible motor will be needed to provide adequate motor protection. Two line protection is not acceptable.

Submersible motors are different from above-ground motors. If a submersible motor is stalled, the overload protector must trip within approximately 10 seconds to protect the motor windings. In single phase submersible motors, this protection is provided by the specially designed and selected protector in the control box, but in three phase submersible motors protection must be provided by the thermal overload relays in the magnetic motor starter.

The ambient temperature at the magnetic starter affects the trip current and time of the protector to a considerable degree unless the protectors are ambient compensated. To afford maximum motor protection and to avoid nuisance tripping, use *ambient compensated protectors*. If non-ambient compensated protectors are used, nuisance tripping may be experienced, especially in warm weather, because as the ambient temperature rises, the protectors' safety margin is diminished. If non-compensated relays or heaters are used and nuisance tripping occurs, do not substitute larger heaters. Instead, change to ambient compensated relays or heaters.
Compensated and non-compensated thermal relays or heaters are interchangeable in magnetic starters.

For additional information pertaining to controls and protection for three phase motors, see paragraph 4.3.2.

## 3.0 STARTING THE PUMP

### 3.1 General Review

Before starting the pump, it is good practice:

a. To review Section 2.0, the installation procedure, to ensure that all installation requirements have been met.

b. To clear the area surrounding the well of tools, equipment, discarded packaging, etc.

c. To review this complete Section 3.0 before starting the pump.

### 3.2 Energize the Pump

Turn the power switch to the "on" position. Stand by for several seconds to turn the switch "off" if anything should go wrong.

### 3.3 Check the Electrical Current

Using a snap-on voltammeter, measure the current in each line without throttling the flow. The readings obtained should be within 15% of nameplate rated full load amperage. Using the same instrument check the voltage in each line. The readings should be within

10% of nameplate rated voltage. Any readings outside acceptable limits indicates that the pump should be turned off; the pump should not be restarted until the problem is corrected. See paragraph 4.6.3 for additional information.

### 3.4 Check Motor Horsepower

Monitor motor horsepower at the power meter. (The power company can provide suitable instructions.) If power consumption exceeds (nameplate rating) x (1.15) turn the pump off and correct the difficulty before the pump is restarted. See also paragraph 4.6.3.

### 3.5 Throttle Valve Setting

Before the pump is started:

a. Attach a temporary horizontal length of pipe to the surface plate discharge.

b. Install a gate valve and another short length of pipe to the temporary pipe.

c. Adjust the gate valve one third of the way open.

When first starting the pump, determine the quantity of water the well can deliver to the pump and the quantity of water the pump can deliver to the system. The danger point is reached when the pup delivers water faster than it flows into the well. If this occurs the supply of water in the well will be depleted before a pumping cycle is completed causing the pup to run dry with consequent damage to the pump and motor.

When the pump is turned on, the system has no water pressure; the pump will deliver its maximum capacity until system pressure is developed. The sudden rush of water in the well may loosen sand, carry it into the water lubricated bearings of the motor and the pump, causing serious damage. Prevent this with the following procedure:

a. Before the pump is started:

(1) Open the discharge throttling valve to about 1/3 of full open.

(2) Determine the standing water level. Refer to paragraph 2.7.

b. Start the pump.

c. Determine the stabilized pumping level.

d. If the stabilized pumping level is above the lowest acceptable pumping level* the valve may be opened in small increments (repeating steps c and d) until either:

(1) The valve is completely open, or

***Caution:*** The pump should never be run in continuous upthrust. See paragraph 3.6.

(2) The lowest acceptable pumping level* is reached.

*e. The lowest acceptable pumping level is defined as that water level above the bowl unit's suction opening which equals the net positive suction head required (NPSHr) for that bowl unit. The NPSHr value can be determined from the manufacturer's performance curve or from the dealer.

**Caution:** If the final pumping level is within 20 feet of the lowest acceptable pumping level, monitor the pumping level frequently, so that the lowest acceptable pumping level will not be exceeding. or, install water level controls.

### 3.6 Running in Continuous Upthrust

To insure that the pump is not running in continuous upthrust, its flow must not exceed approximately 120% of the capacity for which the pump was selected. If the capacity is greater, throttle the flow until the limit is met. In seasons when the water level is high, the same flow limit exists.

A flow measuring device (flow meter, pitot tube, etc.) is recommended for installation in the discharge pipe. However, if no flow measuring device is available, the following procedure will provide satisfactory results:

a. Install a pressure gauge in the discharge head or discharge pipe between the discharge head and the throttle valve.

b. Determine the distance to water level with the pump running and the throttle valve partially closed.

c. Multiply the pressure gauge reading by 2.31, thus converting pressure to feet of water. Add this head to the distance to water which will then give the total head developed by the pump.

d. Adjust the throttle valve so that the result obtained in paragraph (c) corresponds to the head (in feet) for which the pump is selected.

## 4.0 Other Considerations

### 4.1 Cable Selection

Tables 5 and 6 list the copper cable sizes

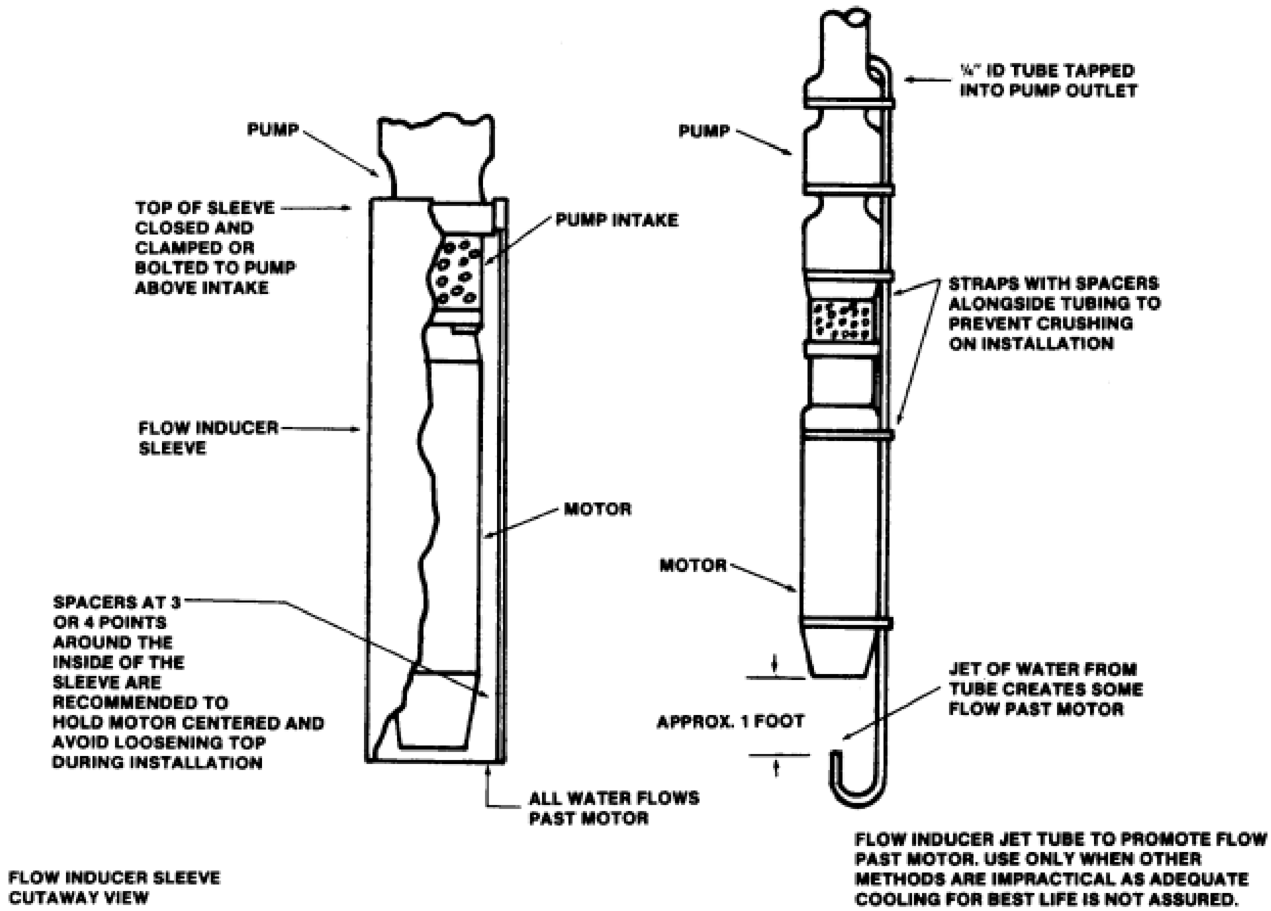



**FIGURE 5. COOLING FLOW INDUCERS**

recommended for various cable lengths. The tables comply with National Electrical Code Table 310-16, Column 2 for 75° C wire, with capacity divided by 1.25 per N.E.C. article 430-22 for motor branch circuits, based on motor amperages at rated horse powers.

Maximum cable lengths are calculated to maintain 95% of service entrance voltages with motors running at maximum nameplate amperes, and to maintain adequate starting torque. Calculations include consideration of basic cable resistance, reactance, power factor, and temperature rise. Cable larger than specified may always be used (if the well is large enough) and will reduce power usage.

The portion of the total cable length which is between the service entrance and a three phase motor starter should not exceed 25% of the maximum allowable length to insure reliable starter operation. Single phase control boxes may be connected at any point in the total cable length.

If aluminum conductors are used, they must be two sizes larger than the copper size specified, such as #0 aluminum in place of #4 copper.

**WARNING:**
**Use of cable smaller than recommended voids the warranty and can cause failure to start or operate properly.**

### 4.2 Cooling Flow Past the Motor

Check Figure 6 to determine if the expected delivery produces adequate flow past the motor. If necessary, use a flow inducer sleeve on the pump or provide flow.

A flow inducer's sleeve is a tube over the motor, closed off above the pump intake and

## TABLE 6. CABLE SELECTION FOR THREE PHASE MOTORS

| Motor Rating | | Maximum Cable Length (Feet) by Cable Size | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Volts** | **HP** | **14** | **12** | **10** | **8** | **6** | **4** | **2** | **0** | **00** | **000** | **0000** |
| 200V 60 Hz or 50 Hz | 1.5 | 320 | 510 | 800 | 1260 | | | | | | | |
| | 2 | 250 | 390 | 610 | 960 | 1500 | | | | | | |
| | 3 | 180 | 290 | 450 | 710 | 1110 | 1690 | | | | | |
| | 5 | | | 300 | 470 | 730 | 1110 | 1690 | | | | |
| | 7.5 | | | | 340 | 530 | 810 | 1230 | 1660 | | | |
| | 10 | | | | 250 | 390 | 600 | 920 | 1240 | 1540 | | |
| | 15 | | | | | 270 | 410 | 630 | 850 | 1060 | 1270 | |
| | 20 | | | | | | 320 | 480 | 650 | 810 | 970 | 1150 |
| | 25 | | | | | | | 390 | 530 | 660 | 790 | 930 |
| | 30 | | | | | | | | 430 | 540 | 640 | 750 |
| 230 V 60 Hz and 220 V 50 Hz | 1.5 | 430 | 680 | 1070 | 1680 | | | | | | | |
| | 2 | 320 | 510 | 790 | 1250 | 1940 | | | | | | |
| | 3 | 240 | 380 | 600 | 940 | 1470 | 2240 | | | | | |
| | 5 | | 250 | 390 | 620 | 960 | 1470 | 2230 | | | | |
| | 7.5 | | | 290 | 450 | 700 | 1070 | 1630 | 2200 | | | |
| | 10 | | | | 340 | 520 | 800 | 1220 | 1640 | 2050 | | |
| | 15 | | | | | 360 | 550 | 830 | 1130 | 1410 | 1680 | |
| | 20 | | | | | | 420 | 640 | 860 | 1070 | 1280 | 1510 |
| | 25 | | | | | | 340 | 520 | 700 | 870 | 1040 | 1230 |
| | 30 | | | | | | | 420 | 570 | 710 | 850 | 1000 |
| 460 V 60 Hz and 380 V thru 460 V 50 Hz (Divide lengths by 1.4 for 380 V 60 Hz) | 1.5 | 1720 | | | | | | | | | | |
| | 2 | 1280 | 2030 | | | | | | | | | |
| | 3 | 960 | 1530 | 2400 | | | | | | | | |
| | 5 | 630 | 1000 | 1570 | 2470 | | | | | | | |
| | 7.5 | 460 | 730 | 1150 | 1800 | 2810 | | | | | | |
| | 10 | | 550 | 850 | 1340 | 2090 | 3190 | | | | | |
| | 15 | | | 590 | 920 | 1430 | 2190 | 3340 | | | | |
| | 20 | | | | 700 | 1100 | 1670 | 2550 | 3440 | | | |
| | 25 | | | | 570 | 890 | 1360 | 2070 | 2800 | 3500 | | |
| | 30 | | | | | 730 | 1110 | 1690 | 2280 | 2850 | 3400 | |
| | 40 | | | | | | 850 | 1300 | 1750 | 2190 | 2610 | 3070 |
| | 50 | | | | | | 680 | 1040 | 1400 | 1750 | 2090 | 2450 |
| | 60 | | | | | | | 870 | 1180 | 1470 | 1760 | 2070 |
| | 75 | | | | | | | | 950 | 1190 | 1420 | 1670 |
| | 100 | | | | | | | | | 890 | 1060 | 1240 |
| 575 V 60 Hz | 1.5 | 2640 | | | | | | | | | | |
| | 2 | 1860 | | | | | | | | | | |
| | 3 | 1490 | 2370 | | | | | | | | | |
| | 5 | 980 | 1560 | 2440 | | | | | | | | |
| | 7.5 | 720 | 1150 | 1800 | 2820 | | | | | | | |
| | 10 | 540 | 850 | 1340 | 2090 | | | | | | | |
| | 15 | | 590 | 920 | 1440 | 2245 | | | | | | |
| | 20 | | | 700 | 1090 | 1700 | 2600 | | | | | |
| | 25 | | | | 890 | 1390 | 2130 | 3240 | | | | |
| | 30 | | | | 730 | 1130 | 1730 | 2640 | 3560 | | | |
| | 40 | | | | | 870 | 1330 | 2030 | 2730 | 3280 | | |
| | 50 | | | | | | 1060 | 1620 | 2190 | 2620 | 3128 | |
| | 60 | | | | | | 900 | 1360 | 1840 | 2210 | 2640 | 3100 |
| | 75 | | | | | | | 1100 | 1490 | 1790 | 2130 | 2510 |
| | 100 | | | | | | | | 1110 | 1330 | 1590 | 1860 |

### TABLE 5. CABLE SELECTION FOR SINGLE PHASE MOTORS
**(Two-Wire & Three-Wire)**

**Maximum Cable Length (Feet) by Cable Size**

| Volts | HP | 10 | 8 | 6 | 4 | 2 | 0 | 00 |
|---|---|---|---|---|---|---|---|---|
| 220 | 5 | 216 | 315 | 490 | 750 | 1142 | 1540 | |
| | 7 ½ | | 270 | 362 | 553 | 842 | 1136 | 1420 |
| | 10 | | | 250 | 425 | 650 | 875 | 1100 |

Example: Installation of a 5 HP 230 V single phase motor at 300 feet depth with 30 feet additional cable from well head to entrance totals 330 feet, and requires #6 or larger cable, since #8 is only suitable up to 315 feet.

NOTE: For two-wire installations with known low line voltage or sandy well conditions, use the next larger cable size (such as #4 in place of #6).

### TABLE 7. HEAD LOSS FROM FLOW PAST MOTOR

This table lists the approximate head loss in feet from flow between an average length motor and a smooth casing or sleeve.

| Motor (Nominal) | | 4" | 4" | 4" | 6" | 6" | 6" | 8" | 8" |
|---|---|---|---|---|---|---|---|---|---|
| Casing I.D. | | 4 ¼" | 5" | 6" | 6" | 7" | 8" | 8.1" | 10" |
| GPM | 25 | 0.2 | | | | | | | |
| | 50 | 0.6 | | | | | | | |
| | 100 | 1.6 | 0.2 | | 0.8 | | | | |
| | 150 | 4.8 | 0.5 | .1 | 1.4 | | | | |
| | 200 | | 0.9 | .2 | 2.2 | 0.3 | | 3 | |
| | 250 | | 1.3 | .3 | 3.0 | 0.4 | | 5 | |
| | 300 | | 1.8 | .4 | 4.2 | 0.6 | 0.2 | 8 | |
| | 400 | | | | 7.4 | 1.0 | 0.3 | 12 | |
| | 500 | | | | | 1.4 | 0.5 | 19 | 0.1 |
| | 600 | | | | | 2.0 | 0.7 | 27 | 0.2 |
| | 800 | | | | | | | | 0.4 |
| | 1000 | | | | | | | | 0.7 |

Curves are for 6" and 8" motors which require 1/2 ft/second minimum velocity.

Double the flow for motors which require 1 ft/second minimum velocity.

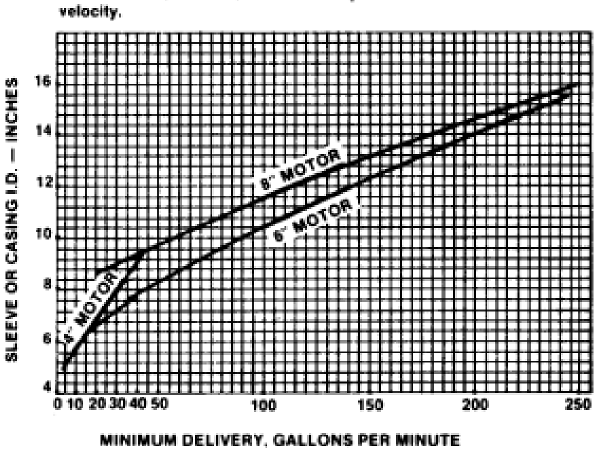



**FIGURE 6. REQUIRED FLOW FOR MOTOR COOLING**

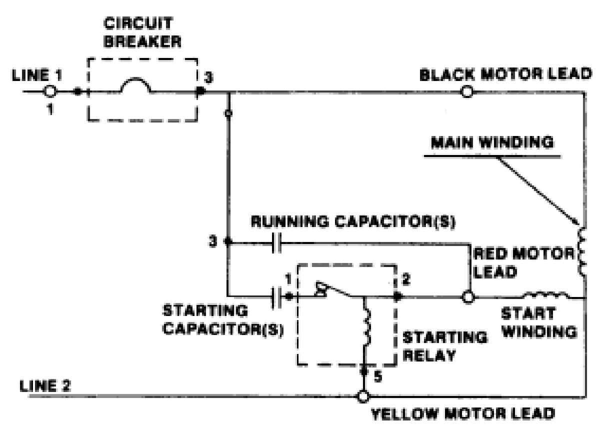



**FIGURE 7. CONTROL BOX COMPONENTS AND WIRING, 1 ½ HP AND LARGER MOTORS**

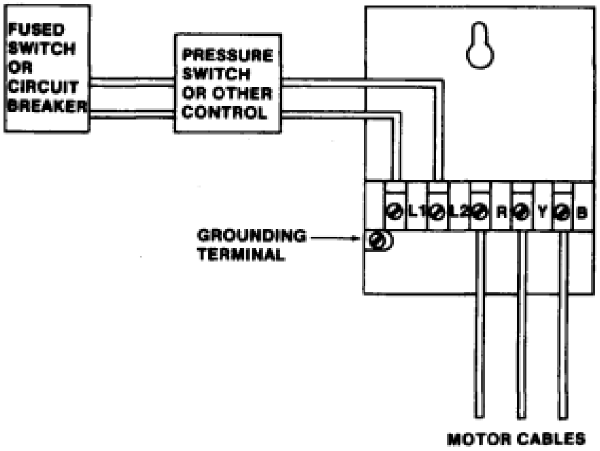



**FIGURE 8 CONTROL BOX CONNECTIONS**

extending to the bottom of the motor or lower. It must be securely fastened to the pump and its top closed to make water flow come in the bottom past the motor. The sleeve material may be heavy plastic or metal and it should resist corrosion. (See Figure 5.)

Figure 6 shows the delivery in gallons per minute required to provide minimum recommended water flow past the motors in different sizes of casings or flow sleeves. Table 7 gives approximate head losses from the flows past the motor.

If a well feeds water from above the pump, has a casing too small to allow a flow inducer sleeve on the pump, or does not have adequate level and flow to allow raising the pump above the inflow, it is difficult to cool the motor properly. When possible the casing depth should be increased so that flow must come from below the motor. If this is not practical, some flow past the motor can be attained by tapping a ¼" I.D. tube into the pump outlet, clamping it down past the pump and motor, and supporting it so that its inlet is aimed upward about a foot below the motor. The tubing should be protected against damage by the clamps or casing during installation and by spacers alongside the tubing. See Figure 5.

## 4.3 Controls and Overload Protection

### 4.3.1 Controls for Single Phase Motors

The diagram in Figure 7 and the explanation which follows show the components, their operation and the wiring schemes typically in control panels for 1-1/2 HP and larger single phase motors.

#### 4.3.1.1 Operation of Voltage Relays

Before the power is applied the starting relay contacts are closed. When the power is applied, both start and main motor windings are energized, and the motor starts. At this instant the voltage across the start winding is relatively low. This low value of voltage across the start winding is not enough to pick up (open the contacts of) the starting relay.

As the motor comes up to speed the voltage across the start winding (and the starting relay coil) increases. This higher voltage is enough to pick up the starting relay and open its contacts. This removes the start winding from the line and the motor continues to run on the main winding alone. Because of motor action when the motor is running, there is a voltage generated in the start winding. This voltage is applied to the coil of the starting relay. As long as the motor runs normally, this generated voltage is high enough to keep the starting relay "picked up" (contacts open) and keep the start winding circuit cut off from the line voltage.

The voltage type relay is affected slightly by position and for best operation the control box should be mounted vertically.

#### 4.3.1.2 Operation of Current Relays

Before power is applied the starting relay contacts are open. When power is applied the high main winding current through the relay coil immediately closes the contacts, energizing the start winding and starting the motor. As the motor comes up to running speed, the current through the relay coil gradually drops and allows the contacts to open the start winding circuit; the motor completes its acceleration and runs on the main winding.

#### 4.3.1.3 Mounting Control Box in Extreme Temperatures

The control box should never be mounted in direct sunlight or in high temperature locations. This can cause unnecessary tripping of the overload protector.

When the control box is mounted in extremely cold locations, there will be a reduction in the motor starting torque because of the action of the cold on the electrolytic starting capacitor. At minus 25° F, the starting torque is about 80% of normal immediately and 90% after a few seconds.

at minus 40° F, the starting torque is 33% of normal and at minus 80° F there is no measurable torque. Therefore, where the temperature may go below minus 25° F, we recommend that a small enclosure be built around the control box and that a 25 watt or larger light bulb be left burning inside the enclosure.

#### 4.3.1.4 Single Phase Control Boxes

Figure 8 shows schematically the wiring, connections and approximate relative positions of the components of the control boxes for single phase motors. Other types of control boxes for different components and internal arrangements, bat the wiring and motor connections are essentially the same. Each type of control box should be connected in strict accordance with the diagram furnished with the control box, usually attached inside its cover.

For both 115 and 230 volt installations, the two incoming line leads are connected to terminals L1 and L2. If the incoming leads include a (third wire) ground conductor, it must be connected to the grounding terminal in the control panel. If the circuit has no grounding conductor and metal conduit from the control box to the supply panel is not used, add a wire at least as large as the line conductors to connect the grounding terminal to a metal drop pipe, casing, water pipe, or driven ground rod. *Failure to ground the box frame can result in a serious electrical shock hazard if a circuit fault occurs.*

*IMPORTANT:* Boxes With Lighting Arresters When the control box has a lighting arrester, it *must* be grounded as described in paragraph 4.5 for proper lightning protection of the motor.

### 4.3.2 Controls for Three Phase Motors

#### 4.3.2.1 Motor Protection

All pumping plant panels are suitable for submersible motors by using ambient compensated fast trip overload relays. For assistance with the selection of appropriate relays, contact the pump dealer or the submersible motor manufacturer.

Note: Overload protection is required on all three motor input lines. FAILURE TO PROTECT ALL THREE MOTOR INPUT LINES WITH THE PROPER QUICK TRIP PROTECTORS WILL VOID THE MOTOR WARRANTY.

#### 4.3.2.2 Phase Fault Protectors

Many devices are available to warn or disconnect power if three phase line imbalance exceeds a preset limit. Some sense voltage imbalance, some current imbalance, and some even compensate to reduce current imbalance, thus offering widely varying degrees of protection. While these devices can be of value in detecting excessive imbalance and in preventing damage to a motor which has improper overload protection, they are not required when the recommended overload protection is used.

#### 4.3.2.3 Overload Protection with Heinemann Circuit Breakers

As an alternative to the use of extra-quick trip heaters in the thermal overload relays of motor starters for protection of three phase submersible motors, as specified in paragraph 4.3.2.1, Heinemann overload relays or circuit breakers may also be used. These differ from the thermal overload relays in that they are magnetic with a hydraulic time delay and the tripping characteristics are somewhat different. The ultimate trip current of the Heinemann relays or breakers is completely unaffected by the ambient temperature but their locked rotor trip time are faster than those of thermal protectors.

The locked rotor trip time of a Heinemann relay of breaker depends upon the time delay curve specified. To protect a stalled submersible motor time delay Curve No. 2 must be specified. Curve No. 1 normally supplied will not always trip quickly enough to protect the motor. These ratings and time delay curves apply whether the Heinemann equipment is the Type C overload relay (which opens the control circuit of the motor contactor or starter) or the General Purpose of F Frame circuit directly). If the latter are used, the circuit breaker, if mounted ahead of the motor starter or contactor, will serve as an overload protector for the motor as well as a safety switch to eliminate the need for a separate fused safety switch or combination starter.

Selection of the Heinemann equipment depends upon the type of mounting, terminals, connections, etc. For those who would like additional information or specific ordering instructions, contact Heinemann Electric Company, Trenton, New Jersey.

4.4 **Frequency of Starts**

From the standpoint of motor temperature and winding life, the starts per hour should not exceed the rate indicated in Table 8. More rapid cycling can cause overheating and possible failure, depending upon pump inertia and other factors.

The average number of starts per day over a period of months or years influences the life of the motor and, even more, the life of control components such as starters, relays, and capacitors. The pump size, tank size, and controls should be selected to keep the starts per day as low as practical for maximum life. Excessive cycling accelerates motor bearings and spline wear, pump wear, and control contact erosion.

4.5 **Lightning Protection**

Overhead power lines tend to draw lightning by a factor proportional to their height above the ground. Fortunately these lines are isolated from most residential equipment by transformers. However, lightning strokes on power lines can induce voltage surges in the secondary lines and damage submersible pump motors. These induced voltage surges can be protected against through the use of properly selected and applied lightning arresters.

A high surge will travel over the power lines looking for the best and closest connection to ground. If it finds it in the submersible motor, the surge will leave the power lines at the motor, jump across the motor winding insulation to the motor frame, and dissipate itself to ground. A very small hole will have been punctured through the motor winding insulation. If the motor is running at the time, the current of the normal voltage supply will follow through this hole in the motor winding insulation. It is this power follow current which causes the damage; it will be high, in the nature of a short circuit. Severe burning of the windings and insulation will result and the motor windings will be ruined. All motors are susceptible to this hazard. The replacement of a submersible pump motor which has been damaged by lightning is more expensive than the replacement of most other pump motors. For this reason it is most desirable to provide protection against these high voltage surges.

Protection consists of providing the best and shortest path to ground somewhere other than through the motor. Lightning arresters are available which will provide such a path.

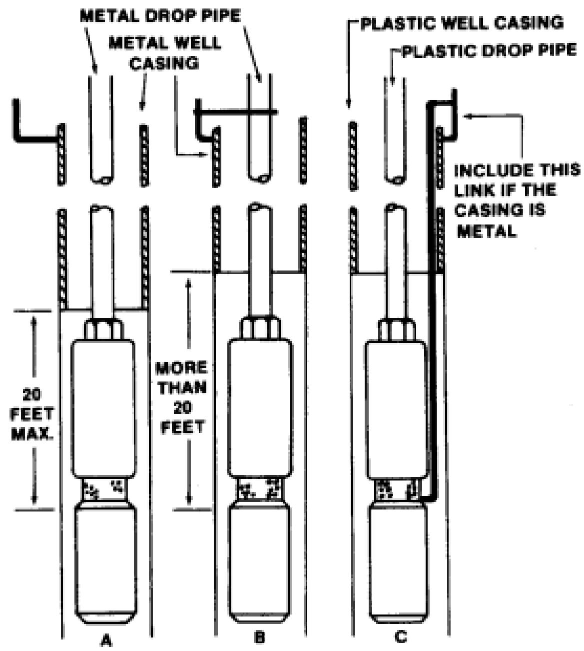



**FIGURE 9. ARRANGEMENTS FOR GROUNDING LIGHTENING ARRESTORS**

These arresters are capable of conducting the high voltage surge to ground (not a direct lightning stroke) and will immediately extinguish the power follow current without damage to themselves.

A lightning arrester installation is made by connecting the arresters to the power lines and to a suitable ground. *The suitability of the ground connection is all important. Ungrounded lightning arresters provide no protection.* A lightning arrester is merely a device which will connect a surge of electricity from the power lines to a ground connection. If this ground is better than the ground afforded by the submersible motor, most of the high voltage surge will go through the lightning arrester to ground and protection will have been provided to the motor. If the arrester ground is not as good as that of the motor, most of the high voltage surge will go to ground through the motor and damage the motor windings even though a lightning arrester is installed.

To provide motor surge protection, the high voltage surge should be discharged through an arrester to a *true ground* . *True ground is a water bearing stratum below the earth's surface.*

Listed above are three acceptable ways of grounding an above ground lightning arrester.

a. The best possible protection is provided by a metal well casing which extends to within 20 feet of the motor. In this fortunate situation, the arrester should be grounded to the well casing by means of #12 or larger wire. (Refer to Figure 9A).

b. If the well casing is plastic or terminates more than 20 feet above the motor and metal drop pipe is used, the best available protection is provided by grounding the arrester to the metal drop pipe. (Refer to Figure 9B).

c. If the well casing is plastic or terminates more than 20 feet above the motor and plastic drop pipe is used, then protection is only provided when the arrester is grounded to a #12 or larger bare copper wire run with the power cable to the motor and connected to a motor stud. This wire should also connect to the top of the well casing. (Refer to Figure 9C).

The degree of protection afforded will be in the order mentioned. Other factors affecting the degree of protection, but over which there is little control at the time of pump installation are:

a. Distance from bottom of well casing to motor (only if casing ends above motor).

b. Distance from transformer to well casing.

The shorter these distances are, the better the degree of protection.

The ground connection at the drop pipe and/or the well casing must be a good, substantial electrical connection. A bare wire wrapped around the drop pipe or a band type connector similar to a hose clamp is not adequate. Adequate ground connector fittings for use on metal pipes from 3/4" to 12" are available at electrical supply houses; I is strongly recommended that these be used. The connection between the lightning arrester and the drop pipe should be made with #12 or larger copper wire. Stranded wire is preferable as it is less susceptible to breaking; a broken ground wire will render the lightning arrester inoperative.

The sketches in Figure 10 show the method of attaching lightning arresters to the submersible motor power line.

### 4.6 Direction of Motor Rotation

#### 4.6.1 Single Phase Motors

If the wiring connections are made in accordance with the proper wiring diagram in

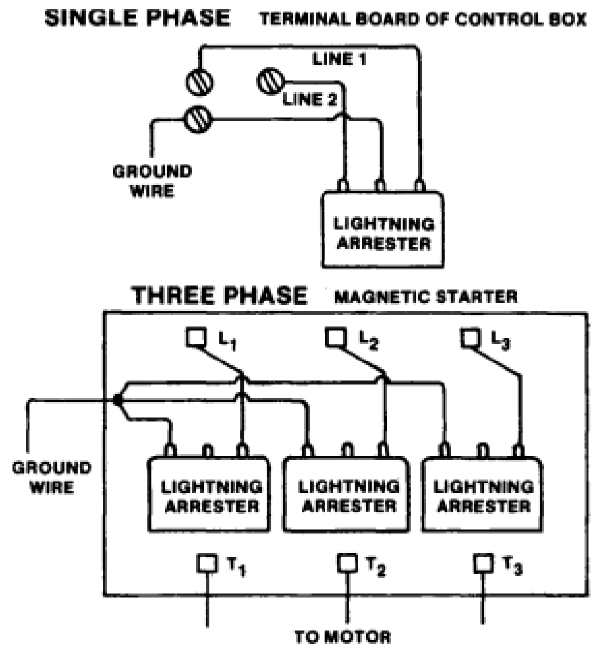



**FIGURE 10. ATTACHMENT OF LIGHTNING ARRESTORS TO SUBMERSIBLE MOTOR POWER LINE.**

the control box, single phase motors should rotate in the correct direction.

#### 4.6.2 Three Phase Motors

If the flow and pressure produced by the pump are significantly lower than expected, it is possible that the direction of motor rotation is wrong (in spite of the precautions described in paragraph 2.3).

If wrong motor rotation is suspected, interchange any two electrical cable leads in the pump plant panel and try the pump again. If flow and pressure are reduced, switch the electrical leads back to their original terminals and look elsewhere for the problem.

#### 4.6.3 Current Imbalance

Current imbalance causes the motor to have reduced starting torque, overload tripping, excessive vibration and poor performance which can result in early motor failure. It is very important that current imbalance be checked in all three phase systems. Current imbalance between the legs should not exceed 5% under normal operating conditions.

Check the power supply service to determine whether it is a two or a three transformer system. The information can be obtained by counting the transformers or by contacting your power company. If two transformers are

## TABLE 8. FREQUENCY OF STARTS

| Motor Rating | Maximum Frequency of Starts Per Hour | Average Number of Starts Per Day | |
|---|---|---|---|
| | | Single Phase | Three Phase |
| Lower than 1 HP | 150 | 300 | |
| 1 HP thru 5 HP | 100 | 100 | 300 |
| 7 ½ HP thru 30 HP | 60 | 50 | 100 |
| 40 HP and over | 20 | | 100 |

present, the system is an "open delta" or "wye." If there are three transformers, it is true three phase system. Make sure the transformer rating in kilovolt amps (KVA) is sufficient for the motor load. See table 9.

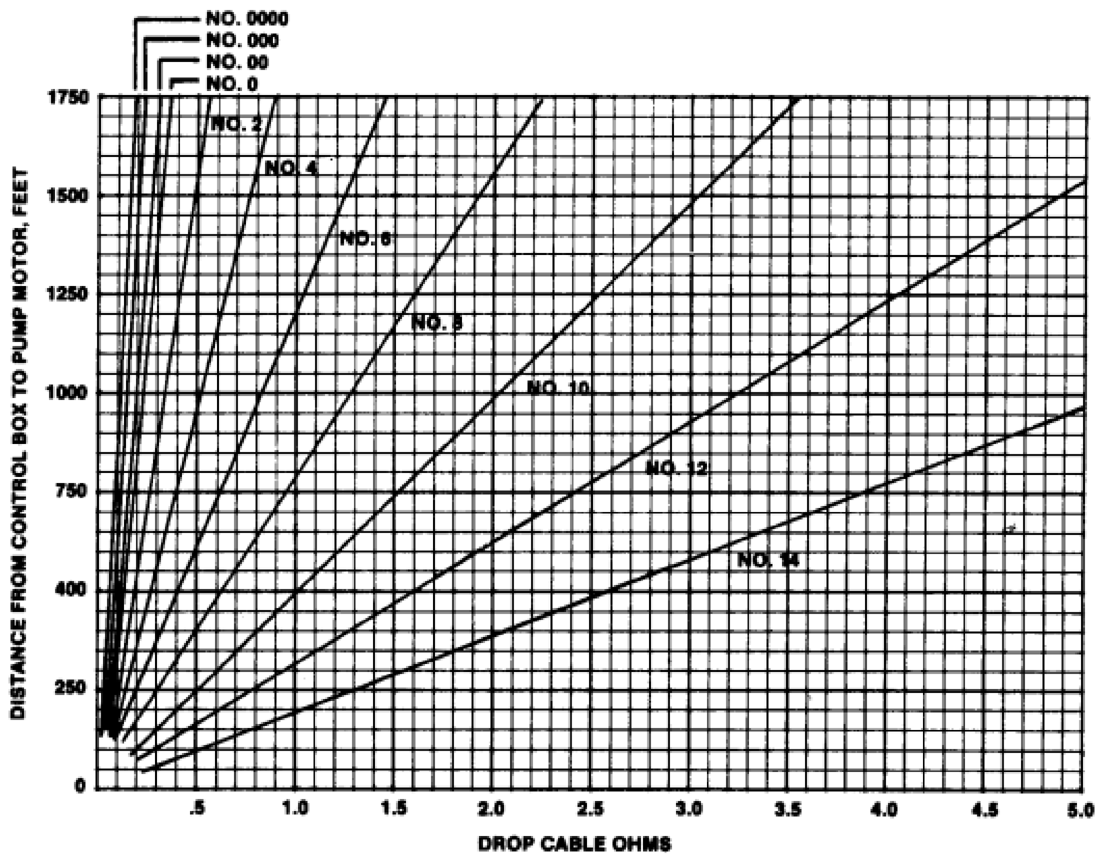
The percentage of current imbalance can be calculated as follows:

$$\textbf{\% Current Imbalance} = \frac{\textbf{Greatest amp difference from the average}}{\textbf{Average current}} \textbf{ X 100}$$

$$\textbf{Average current} = \frac{\textbf{Total of current values measured on each leg}}{\textbf{3}}$$

Determine the percentage of current imbalance by:

Step 1. Measure and record current readings in amps for each leg (hookup). Disconnect the power.




**VALUES SHOWN ARE FOR COPPER CONDUCTORS AT 25° C (77° F.)**
**VALUES ARE FOR TOTAL RESISTANCE OF DROP CABLE FROM THE CONTROL BOX TO THE MOTOR AND BACK.**
**FOR ALUMINUM DROP CABLE DIVIDE THE CHART VALUE BY 0.61.**

FIGURE 11. TOTAL RESISTANCE OF DROP CABLE

**TABLE 9. TRANSFORMER CAPACITY REQUIRED FOR THREE PHASE SUBMERSIBLE MOTORS**

| Three Phase Motor HP | Minimum Total KVA Required* | Minimum KVA Rating for Each Transformer | |
|---|---|---|---|
| | | 2 Transformers Open Delta or WYE | 3 Transformers Delta or WYE |
| 5 | 7½ | 5 | 3 |
| 7½ | 10 | 7½ | 5 |
| 10 | 15 | 10 | 5 |
| 15 | 20 | 15 | 7½ |
| 20 | 25 | 15 | 10 |
| 25 | 30 | 20 | 10 |
| 30 | 40 | 25 | 15 |
| 40 | 50 | 30 | 20 |
| 50 | 60 | 35 | 20 |
| 60 | 75 | 40 | 25 |
| 75 | 90 | 50 | 30 |
| 100 | 120 | 65 | 40 |

*Pump motor KVA requirements only, and does not include allowances for other loads.

Step 2. Shift the motor leads from left to right so the drop cable lead that was on terminal 1 is now on 2, lead on 2 is now on 3, and lead on 3 is now on 1 (Hookup 2). Changing the motor leads in this manner will not reverse the motor rotation. Start the pump. Measure and record the current reading on each leg. Disconnect the power.

Step 3. Again shift drop cable leads from left to right so the lead on terminal 1 now goes to 2, 2 to 3, and 3 to 1 (Hookup 3). Start the pump. Measure and record the current readings on each leg. Disconnect the power.

Step 4. Add together the values for each hookup.

Step 5. Divide the total by 3 to obtain the average.

Step 6. Compare each single leg reading with the average to obtain the greatest amperage difference from the average.

Step 7. Divide this difference by the average to obtain the percentage of imbalance. Use the wiring hookup which provides the lowest percentage of imbalance. See Table 10 for a specific example of correcting for three phase power imbalance.

## 5.0 TROUBLE SHOOTING

Many of the problems which develop with submersible pumps are electrical; most problems can be serviced without pulling the pumps from their wells. The following charts cover most of the submersible pump service work. As with any trouble shooting procedure, start with the simplest solution first; always make all the above ground checks before considering pulling the pump from the well.

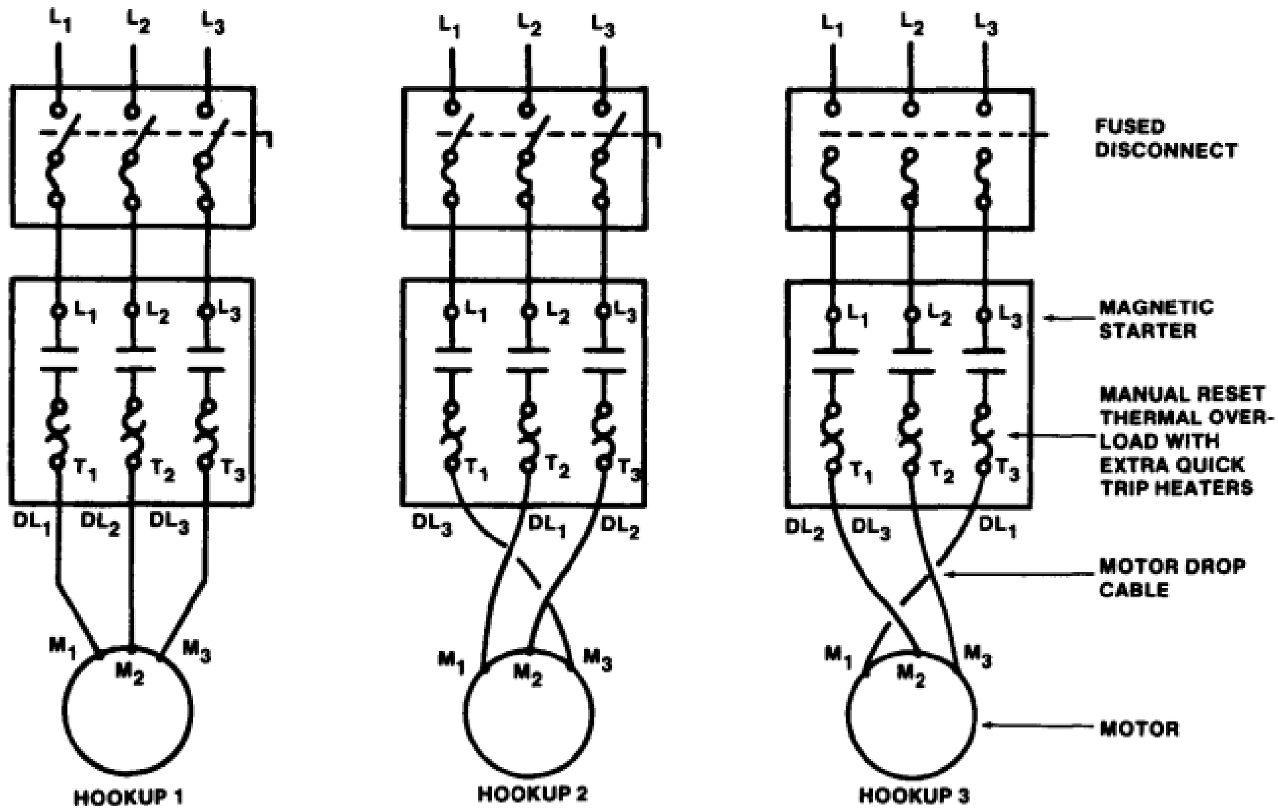
**WARNING**
**WHEN WORKING WITH ELECTRICAL CIRCUITS, USE CAUTION TO AVOID ELECTRICAL SHOCK.**

It is recommended that rubber gloves and boots be worn and that care be taken to have metal control boxes and motors grounded to power supply grounds or steel drop pipes or casings extended into the wells.

Basically, only two instruments are needed – a combination voltmeter/ammeter and an ohmmeter. These are relatively inexpensive and can be obtained from most water systems suppliers.

**WARNING:**
**A SUBMERSIBLE MOTOR IS INTENDED FOR OPERATION IN A WELL. WHEN NOT OPERATED IN A WELL, FAILURE TO CONNECT THE MOTOR FRAME TO THE POWER SUPPLY WITH A NEUTRAL GROUND MAY RESULT IN SERIOUS ELECTRICAL SHOCK.**

## TABLE 10. CORRECTING FOR THREE PHASE POWER IMBALANCE




Example: Check for current imbalance for a 230 volt, 3 phase, 60 Hz submersible pump motor, 18.6 full load amps.

Solution: Steps 1 to 3 measure and record amperages on each motor drop lead for Hookups 1, 2, & 3.

| | **Step 1 (Hookup 1)** | **Step 2 (Hookup 2)** | **Step 3 (Hookup 3)** |
|---|---|---|---|
| **($T_1$)** | **$DL_1$ = 19 amps** | **$DL_3$ = 17 amps** | **$DL_2$ = 17 amps** |
| **($T_2$)** | **$DL_2$ = 14** | **$DL_1$ = 15** | **$DL_3$ = 14** |
| **($T_3$)** | **$DL_3$ = 15** | **$DL_2$ = 16** | **$DL_1$ = 17** |
| **Step 4** | **Total = 48 amps** | **Total = 48 amps** | **Total = 48 amps** |

**Step 5** **Average Current** $= \dfrac{\text{Total current}}{\text{3 Readings}} = \dfrac{48}{3}$ **= 16 Amps**

**Step 6** **Greatest difference from the average amperage**

**(Hookup 1) = 19 – 16 = 3**
**(Hookup 2) = 16 – 15 = 1**
**(Hookup 3) = 16 – 14 = 2**

**Step 7** **% Imbalance**

**(Hookup 1)** $= \dfrac{3}{48} \times 100 = 6.25$

**(Hookup 2)** $= \dfrac{1}{48} \times 100 = 2.08$

**(Hookup 3)** $= \dfrac{2}{48} \times 100 = 4.17$

Hookup 2 should be used since it shows the least amount of current imbalance. Therefore, the motor will operate at maximum efficiency and reliability.

By comparing the current values recorded on each leg, note that the highest value was always on the same leg, $L_1$. This indicates the imbalance is in the power source. If the high current values were on a different leg each time the leads were changed, the imbalance would be caused by the motor or a poor connection. If the current imbalance is greater than 5%, contact your power company for help.

## TABLE 11. TYPICAL ELECTRICAL DATA FOR 6" 60 HERTZ SUBMERSIBLE MOTORS

| Rated HP | Volts | Ph. | Service Factor | Rated HP Input | | Maximum Input (S.F. Load) | | Maximum Thrust Load Pounds | Circuit Breaker Or Std. Fuse | Duel Element Fuse | Locked Rotor Amps |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Amps | Watts | Amps | Watts | | | | |
| 5 | 230 | 1 | 1.15 | 26.0 | 5070 | 29.5 | 5820 | 1500 | 35 | 35 | 95 |
| 7.5 | 230 | 1 | 1.15 | 34.5 | 7300 | 40.0 | 8500 | 1500 | 45 | 45 | 145 |
| 10 | 230 | 1 | 1.15 | 45.0 | 9800 | 52.0 | 11500 | 3500 | 60 | 60 | 223 |
| 5 | 200 | 3 | 1.15 | 17.0 | 4800 | 19.1 | 5600 | 1500 | 50 | 25 | 103 |
| | 230 | 3 | 1.15 | 14.8 | 4800 | 16.6 | 5600 | 1500 | 45 | 20 | 90 |
| | 460 | 3 | 1.15 | 7.2 | 4800 | 8.3 | 5600 | 1500 | 25 | 10 | 45 |
| | 575 | 3 | 1.15 | 5.9 | 4800 | 6.6 | 5600 | 1500 | 20 | 8 | 36 |
| 7.5 | 200 | 3 | 1.15 | 24.2 | 7000 | 27.5 | 8200 | 1500 | 70 | 30 | 156 |
| | 230 | 3 | 1.15 | 21.0 | 7000 | 23.9 | 8200 | 1500 | 70 | 30 | 136 |
| | 460 | 3 | 1.15 | 10.5 | 7000 | 11.9 | 8200 | 1500 | 30 | 15 | 68 |
| | 575 | 3 | 1.15 | 8.4 | 7000 | 9.5 | 8200 | 1500 | 25 | 12 | 54 |
| 10 | 200 | 3 | 1.15 | 32.1 | 9600 | 36.8 | 11100 | 3500 | 100 | 40 | 235 |
| | 230 | 3 | 1.15 | 27.9 | 9600 | 32.0 | 11100 | 3500 | 80 | 35 | 204 |
| | 460 | 3 | 1.15 | 13.9 | 9600 | 16.0 | 11100 | 3500 | 40 | 20 | 102 |
| | 575 | 3 | 1.15 | 11.1 | 9600 | 12.8 | 11100 | 3500 | 35 | 15 | 82 |
| 15 | 200 | 3 | 1.15 | 47.2 | 13900 | 53.6 | 16100 | 3500 | 150 | 60 | 306 |
| | 230 | 3 | 1.15 | 41.0 | 13900 | 46.6 | 16100 | 3500 | 125 | 60 | 266 |
| | 460 | 3 | 1.15 | 20.5 | 13900 | 23.3 | 16100 | 3500 | 60 | 30 | 133 |
| | 575 | 3 | 1.15 | 16.0 | 13900 | 18.6 | 16100 | 3500 | 50 | 25 | 106 |
| 20 | 200 | 3 | 1.15 | 60.3 | 1830 | 70.2 | 21600 | 3500 | 200 | 80 | 430 |
| | 230 | 3 | 1.15 | 52.4 | 1830 | 61.0 | 21600 | 3500 | 175 | 70 | 374 |
| | 460 | 3 | 1.15 | 26.2 | 1830 | 30.5 | 21600 | 3500 | 80 | 35 | 187 |
| | 575 | 3 | 1.15 | 21.0 | 1830 | 24.4 | 21600 | 3500 | 70 | 30 | 150 |
| 25 | 200 | 3 | 1.15 | 74.8 | 22600 | 86.3 | 26100 | 3500 | 225 | 100 | 598 |
| | 230 | 3 | 1.15 | 65.0 | 22600 | 75.0 | 26100 | 3500 | 200 | 90 | 520 |
| | 460 | 3 | 1.15 | 32.5 | 22600 | 37.5 | 26100 | 3500 | 100 | 45 | 260 |
| | 575 | 3 | 1.15 | 26.0 | 22600 | 30.0 | 26100 | 3500 | 80 | 35 | 208 |
| 30 | 200 | 3 | 1.15 | 92.0 | 27000 | 105.8 | 31500 | 3500 | 300 | 125 | 662 |
| | 230 | 3 | 1.15 | 80.0 | 27000 | 92.0 | 31500 | 3500 | 250 | 110 | 576 |
| | 460 | 3 | 1.15 | 40.0 | 27000 | 46.0 | 31500 | 3500 | 125 | 50 | 288 |
| | 575 | 3 | 1.15 | 32.0 | 27000 | 36.8 | 31500 | 3500 | 100 | 40 | 230 |
| 40 | 460 | 3 | 1.15 | 51.5 | 36000 | 60.0 | 42000 | 3500 | 150 | 70 | 400 |
| | 575 | 3 | 1.15 | 41.0 | 36000 | 48.0 | 42000 | 3500 | 125 | 60 | 320 |
| 50 | 460 | 3 | 1.15 | 64.0 | 44000 | 75.0 | 52000 | 3500 | 200 | 90 | 520 |
| | 575 | 3 | 1.15 | 53.5 | 44000 | 60.0 | 52000 | 3500 | 150 | 70 | 416 |

## TABLE 12. TYPICAL ELECTRICAL DATA FOR 8" 60 HERTZ SUBMERSIBLE MOTORS

| Rated HP | Volts | Service Factor | Rated HP Input | | Maximum Input (S.F. Load) | | Maximum Thrust Load Pounds | Circuit. Breaker Or Std. Fuse | Dual Element Fuse | Locked Rotor Amps |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Amps | KW | Amps | KW | | | | |
| 40 | 460 | 1.15 | 53 | 37 | 60 | 42 | 10,000 | 175 | 70 | 342 |
| 50 | 460 | 1.15 | 66 | 44 | 75 | 51 | 10,000 | 200 | 90 | 433 |
| 60 | 460 | 1.15 | 77 | 53 | 89 | 61 | 10,000 | 225 | 100 | 560 |
| 75 | 460 | 1.15 | 97 | 66 | 110 | 76 | 10,000 | 300 | 125 | 750 |
| 100 | 460 | 1.15 | 128 | 87 | 148 | 102 | 10,000 | 400 | 175 | 1000 |

## TABLE 13. TYPICAL MOTOR WINDING RESISTANCE

**Single Phase Motors**

| HP | Motor | Volts | Resistance – OHMS<br>Main Winding<br>Black-Yellow | <br>Start Winding<br>Red-Yellow |
|---|---|---|---|---|
| 5 | 6" | 230 | .55-.68 | 1.30-1.6 |
| 7 ½ | 6" | 230 | .40-.50 | .98-1.2 |
| 10 | 6" | 230 | .27-.33 | .80-.98 |

**Three Phase Motors**

| HP | Motor Size | Resistance – OHMS<br>200V | <br>230V | <br>460V | <br>575V |
|---|---|---|---|---|---|
| 5 | 6" | .70-.88 | .87-1.1 | 3.1 –4.1 | 5.7- 7.0 |
| 7 ½ | 6" | .48-.59 | .56- .71 | 2.1 –2.9 | 4.0- 4.8 |
| 10 | 6" | .28-.46 | .35- .55 | 1.5 –2.1 | 2.5- 3.2 |
| 15 | 6" | .19-.24 | .27- .37 | 1.1 –1.4 | 1.7- 2.2 |
| 20 | 6" | .15-.22 | .19- .27 | .77-1.1 | 1.2- 1.6 |
| 25 | 6" | .10-.19 | .13- .21 | .53- .81 | .91-1.3 |
| 30 | 6" | .08-.14 | .11- .15 | .40- .59 | .70-9.5 |
| 40 | 6" | | | .38- .54 | .64- .80 |
| 50 | 6" | | | .28- .40 | .47- .65 |
| 40 | 8" | | | .264-.282 | |
| 50 | 8" | | | .184-.216 | |
| 60 | 8" | | | .150-.166 | |
| 75 | 8" | | | .114-.126 | |
| 100 | 8" | | | .078-.090 | |

## TABLE 14. INSULATION RESISTANCE VALUES FOR MOTOR AND CABLE

| Condition of Motor and Leads | OHM Value | MEGOHM Value |
|---|---|---|
| New motor. | 2,000,000 (or more) | 2.0 |
| Used motor which can be reinstalled in the well. | 1,000,000 (or more) | 1.0 |
| Motor in the well in reasonably good condition. | 500,000 – 1,000,000 | 0.5 –1.0 |
| Motor which may have been damaged by lightning or with damaged leads. Do not pull the pump for this reason. | 20,000 – 500,000 | 0.02 –0.5 |
| Motor or cable with damaged insulation. The pump should be pulled and repair made to the cable or the motor replaced. The motor will not fail for this reason alone, but it will probably not operate for long. | 10,000 – 20,000 | 0.01 –0.02 |
| Motor or cable insulation has failed. The pump must be pulled and the cable repaired or the motor replaced. The motor will not run in this condition. | Less than 10,000 | 0 – 0.01 |

## 5.1 Preliminary Test

### 5.1.1 Supply Voltage

**HOW TO MEASURE**

By means of a volt meter which has been set to the proper scale, measure the voltage at the control box or starter. On single phase units measure between line and neutral.
On three phase units measure between the legs (phases).

**WHAT IT MEANS**

When the motor is under load, the voltage should be within ± 10% of the nameplate voltage. Larger variations may cause winding damage. Large variations in the voltage indicate a poor electrical supply and the pump should not be operated until these variations have been corrected. If the voltage constantly remains high or low the motor should be changed to the correct supply voltage.

### 5.1.2 Current Measurement

**HOW TO MEASURE**

By use of an ammeter set to the proper scale, measure the current on each power lead at the control box or starter. See the Electric Data, Tables 11 and 12, for motor amperage draw information. Current should be measured when the pump is operating at constant discharge pressure with the motor fully loaded.

**WHAT IT MEANS**

If the amperage drawn exceeds the listed service factor amps (SFA) or if the current imbalance is greater than 5% between each leg on three phase units, check the following:

1. Burned contacts in motor starter.
2. Loose terminal in starter or control box or possible cable defect. Check winding and insulation resistance.
3. Supply voltage too high or low.
4. Motor windings are shorted.
5. Pump is damaged causing a motor overload.

### 5.1.3 Winding Resistance

**HOW TO MEASURE**

Turn off power and disconnect the drop cable leads in the control box or starter. Using an ohmmeter, set the scale selectors to R x 1 for values under 10 ohms and R x 10 values for over 10 ohms. Zero adjust the meter and measure the resistance between loads. Record the values. Motor resistance values can be found in Table 13, Cable resistance values in Table 14.

**WHAT IT MEANS**

If all the ohm values are normal, and the cable colors are correct, the motor windings are not damaged. If any one ohm value is less than normal the motor may be shorted. If any one ohm value is greater than normal, there is a poor cable connection or the windings or cable may be open.
If some of the ohm values are greater than normal and some less, the drop cable leads are mixed. To verify lead colors, see resistance values in Electrical Data, Table 13.

### 5.1.4 Insulation Resistance

**HOW TO MEASURE**

Turn off power and disconnect the drop cable leads in the control box or starter. Using an ohm or megohmmeter, set the scale selector to R x 100K and zero adjust the meter. Measure the resistance between the lead and ground. (A steel well casing or discharge pipe is an acceptable ground.)

**WHAT IT MEANS**

For ohm values, refer to Table 14. Regardless of horsepower, phase, voltage or Hertz, all insulation has the same resistance values.

## 5.2 TROUBLE SHOOTING CHART

### 5.2.1 Pump Does Not Run

**Correction**

1. **No electricity at pump panel.**
   Check for voltage at pump panel.

   If no voltage at pump panel, check house or feeder panel for tripped circuits.

2. **Fuses are blown or circuit breakers are tripped.**
   Remove fuses and check for continuity with ohmmeter.

   Replace blown fuses or reset circuit breaker. If new fuses blow or circuit breaker trips, the electrical installation, motor and cable must be checked.

3. **Motor starter overloads are burned or have tripped.**
   Check for voltage on line and load.

   Replace burned heaters or reset. Inspect starter for other damage. If heater trips again, check the supply voltage and starter holding coil.

4. **Starter does not energize.**
   Energize control circuit and check for voltage at the holding coil.

   If no voltage, check control circuit. If voltage, check holding coil for short. Replace bad coil.

5. **Defective controls.**
   Check all safety and pressure switches for operation. Inspect contacts in control devices.

   Replace worn or defective parts.

6. **Motor and/or cable are defective.**
   Turn off voltage, disconnect drop leads from control box to the motor. Measure the lead to ground values with ohmmeter (R x1). Measure the lead to ground values with ohmmeter (R x 100K). Record measured values.

   If open winding or ground is found, remove pump and recheck values at the surface. Repair or replace motor or cable.

7. **Defective capacitor.**
   Turn off voltage, discharge capacitor. Check with ohmmeter (R x 100K).

   Replace if defective.

### 5.2.2 Motor Runs but Pump Does Not Deliver Water

**Correction**

1. **Water level in well is too low or well is collapsed.**
   Check well drawdown.

   Submergence required varies with the particular pump model installed. Contact your dealer.

2. **Pump check valve is blocked.**
   Install pressure gauge, start pump, gradually close the discharge valve and read pressure at shut-off.

   Remove pump and inspect discharge section. Remove blockage, repair valve and valve seat, if necessary. Check for other damage. Rinse out pump and reinstall.

3. **Inlet strainer is clogged.**
   Same as number 2 above.

   Remove and inspect pump. Clean strainer, check the check valve for blockage. Rinse out pump and reinstall.

4. **Coupling or shaft sheared between motor and pump.**
   Check for very low motor amperage.

   Pull pump and repair.

5. **Pump is defective.**
Same as number 2 above.

### 5.2.3 Pump Runs but at Reduced Capacity

1. **Wrong rotation.**
Check for proper electrical connection in control box.

2. **Drawdown is larger than anticipated.**
Check drawdown during pump operation.

3. **Discharge piping or valve leaking.**
Examine system for leaks.

4. **Pump strainer or check valve are clogged.**
Remove pump and inspect.

5. **Pump worn.**
Install pressure gauge, start pump, gradually close the discharge valve and read pressure at shut-off.

6. **Pump may be airlocked.**

### 5.2.4 Pump Cycles Too Much

1. **Pressure switch is defective.**
Check pressure setting on switch and operation. Check voltage across closed contacts.

2. **Level control is not properly set or is defective.**
Check setting and operation.

3. **Insufficient air charging or leaking tank or piping.**
Pump air into tank or diaphragm chamber.

4. **Plugged snifter valve or bleed orifice.**
Examine valve and orifice for dirt or corrosion.

5. **Tank is too small.**
Check tank size.

### 5.2.5 Fuses Blow or Circuit Breakers Trip

1. **High or low voltage.**
Check voltage at pump panel.

Convert PSI to feet (PSI x 2.31 ft/PSI = _____ft), add elevation from top of well to water level to the pressure reading. Refer to the specific pump curve for shutoff head for that pump model. If head is close to curve, pump is probably OK. If not, remove pump and inspect.

**Correction**

Correct wiring and change leads as required.

Lower pump if possible. If not, throttle discharge valve and install water level control.

Repair leaks.

Clean, repair, rinse pump and reinstall.

Convert PSI to feet (PSI x 2.31 ft/PSI = _____ft), add elevation from top of well to water level to the pressure reading. Refer to the specific pump curve for shutoff head for that pump model. If head is close to curve, pump is probably OK. If not, remove pump and inspect.

Stop and start several times, waiting about one minute between cycles.

**Correction**

adjust switch or replace if defective.

Readjust setting (refer to manufacturer's data). ce if defective.

Check diaphragm for leak. Check tank and piping for leaks with soap and water solution. Check air to water volume.

Clean and/or replace if defective.

Tank volume should be approximately 10 gallons for each gpm of pump capacity.

**Correction**

If not within ± 10%, check wire size and length of run to pump panel.

1. **Three phase current imbalance.**
   Check current draw on each lead.

   Must be within ± 5%; if not contact power company.

3. **Wrong control box wiring or components.**
   Check that control parts match parts list. Check wiring matches wiring diagram. Check for loose or broken wires or terminals.

   Correct as required.

4. **Bad capacitor.**
   Discharge capacitor. Check using an ohmmeter (R x 100K).

   When meter is connected, the ohmmeter needle should jump forward and slowly drift back. If no needle movement, replace the capacitor.

5. **Starting relay defective (single phase motors only).**
   Check resistance of relay coil with an ohmmeter (R x 1000). Check contacts for wear.

   Replace defective relay.

6. **Pump is sand locked or otherwise jammed.**
   Check current draw. See Tables 9 and 10.

   Pull pump and clean or repair.