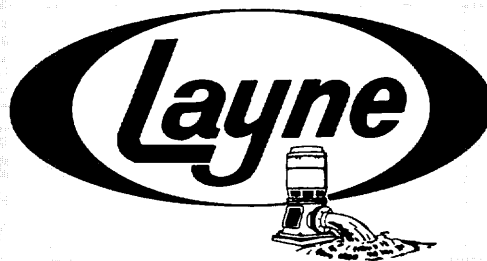


INSTALLATION, OPERATING, and MAINTENANCE INSTRUCTIONS

FOR

LAYNE SUBMERSIBLE PUMPS

READ AND UNDERSTAND THE PUMP AND THE ELECTRIC MOTOR
INSTRUCTIONS BEFORE ATTEMPTING TO INSTALL THE PUMP.



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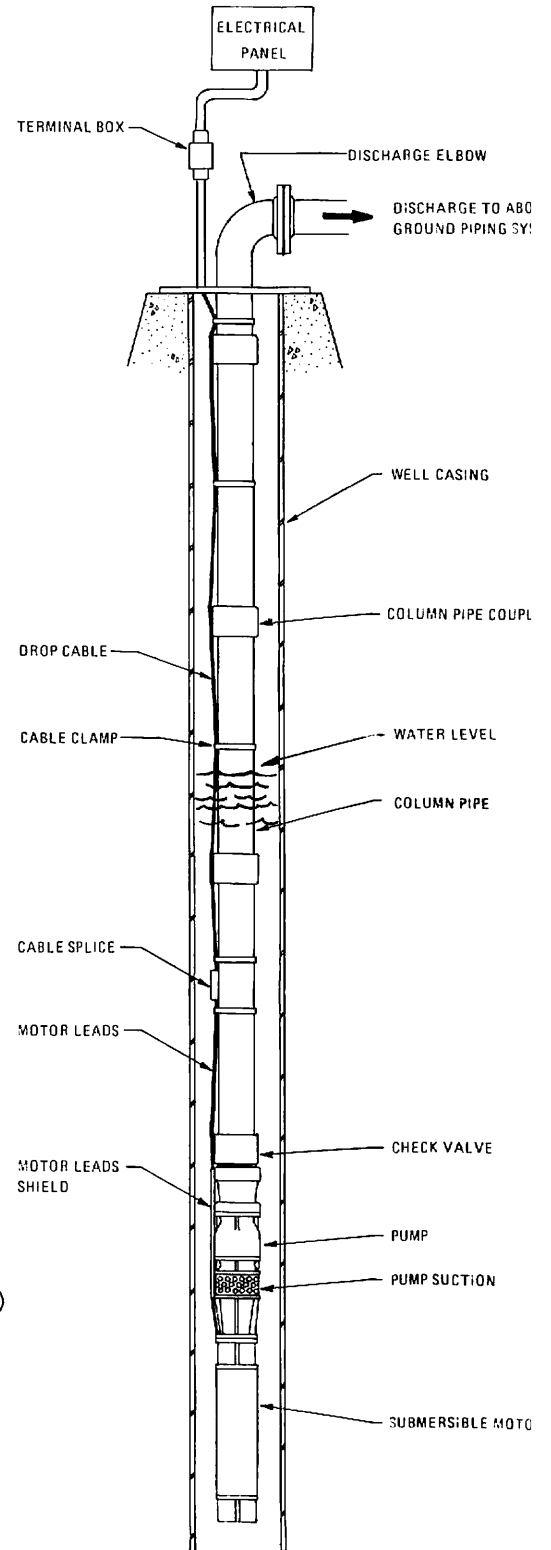


Fig. 1. Typical Submersible Pump Installation

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in conjunction with installation, operation, and maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to Layne & Bowler.

WARNING

High voltage, rotating parts, or falling parts can cause serious or fatal injury. The installation, operation, and maintenance of this equipment should be performed only by qualified personnel familiar with the contents of this manual, the contents of the pump motor manual, the National Electrical Code, local electrical codes, local plumbing codes, local water well codes, and sound practices for electrical and mechanical equipment. Among the many considerations are:

- Observe good safety practices at all times.
- Use proper procedures when handling, lifting, installing, operating, or maintaining the equipment.
- Avoid contact with electrically energized circuits.
- Before initiating maintenance procedures, be sure that all power has been removed from the pump and its accessories.
- Avoid removing, by-passing, or rendering inoperative any safeguards or protective devices.
- Be sure the unit is properly grounded per the instructions in the motor manual and per applicable electrical codes.
- Be sure the equipment is properly enclosed to prevent access by unauthorized personnel who could injure themselves or damage the equipment.
- When making electrical tests, use rubber gloves and rubber soled shoes for protection from possible electrical shock. Perform the tests in a dry location.

Submersible pumps should not be installed in ponds, lakes, or swimming pools due to possible electrical shock.

1. INTRODUCTION

Layne submersible pumps are carefully constructed of high quality materials and are designed to give long trouble-free life. This manual describes the basic procedure for installing, operating, and maintaining a Layne submersible pump. Failure to read, understand, and follow the instructions in this manual, the motor manual, and the instructions for accessory equipment can cause personal injury, poor performance of the equipment, shortened life of the equipment, and can void the warranty on the equipment.

A major portion of the work associated with submersible pump installation, operation, and maintenance is electrical. It is not the intent of the manual to provide detailed instructions for this electrical work. A brief summary of the electrical work that is required is given in Section 3. The service of a competent power electrician or electrical contractor will be required.

This manual will reference the pump motor manual in several places. Read the motor manual and the instructions for other equipment that is part of the installation and integrate these instructions with the basic instructions contained in this manual.

2. PREPARATIONS FOR INSTALLATION

A. EQUIPMENT INSPECTION

When the equipment is received, inspect it carefully for damage. Also check that the material received matches the description on the Bill of Lading. Report any damages or shortages to the carrier immediately. Within the first week after receipt of the equipment, check the motor nameplate to assure that the correct HP, voltage, phase, and frequency were provided.

B. WELL (OR SUMP) REQUIREMENTS

- The well must comply with applicable codes.
- The well should be developed with a test pump prior to installing the submersible pump. Test pumping the well serves several purposes. It removes the excess sand encountered during the initial pumping of the

2. PREPARATIONS FOR INSTALLATION (cont'd.)

well. Attempting to pump mud or sand with a submersible pump can bury the pump motor causing it to overheat and burnout. Test pumping also provides a means of determining the capacity and drawdown (lowering of the water level in the well during pumping). Pumping sand or other abrasives with a submersible pump will shorten the life of the pump and can void the warranty.

- The well capacity should equal or exceed the pump capacity. If the pump removes water at a higher rate than the well produces, the drawdown will be excessive and the pump will cavitate or "starve" resulting in damage to the pump and motor.
- The well must be deep enough so that the pump suction (see Fig. 1) is at least 10 feet below the expected drawdown level. The lower end of the pump should be at least 10 feet from the bottom of the well.
- **THE MOTOR MUST ALWAYS BE IMMERSSED IN FLOWING WATER.** The flow rate must be adequate to cool the motor. If the pump is set below the well screen openings or other conditions exist that cause the water to be supplied from above the pump, a flow inducer sleeve may be required. Flow inducer sleeves are generally required for all pit or tank applications. Detailed information concerning the required flow rate around the motor and the design of flow inducer sleeves is given in the motor manual.
- Water temperature in excess of 80 degrees F. may require special considerations concerning the pump motor. See the motor manual and if necessary contact the factory.
- The inside diameter of the well casing must be large enough to allow lowering the unit into the well without damaging the drop cable, the splice between the drop cable and the motor leads, or the motor leads. A slightly enlarged area may be required immediately underneath the discharge head to prevent pinching the cable against the well casing. The drop cable must be pulled away from the column pipe in this area to allow it to pass through the threaded opening in the surface plate of the discharge head. See Fig. 1.

C. ABOVE GROUND PIPING SYSTEMS

- The system must meet applicable codes.
- The system must be designed to match the flow and pressure produced by the pump. Systems that allow the pump to operate at low pressure/high flow conditions can cause cavitation or upthrust problems and damage the pump or the motor. Systems that allow the pump to run at high pressure/low flow conditions (i.e. operating at or very near shutoff) for extended periods of time can cause the motor to overheat and burn out. A pressure relief valve should be installed if the pump shutoff pressure exceeds the pressure rating of the system.
- The system must be designed so that the pump is not cycled ON and OFF excessively.
- The system must be protected from freezing.

D. TOOLS AND EQUIPMENT REQUIRED FOR INSTALLATION

- Hoisting equipment capable of controlled hoisting and lowering of the combined weight of the pump, motor, drop cable, column pipe, and discharge head.* The height of the equipment must be sufficient to accommodate the longest component to be installed.
- Pipe elevators (or equivalent) and lifting bail (or equivalent) for handling and installing sections of column pipe. The elevators and lifting bail must be capable of carrying the combined weight of the pump, motor, drop cable, and column pipe.*
- Chain tongs capable of tightening column pipe joints (in the vertical position) to a torque of at least 10 ft/lbs. per rated horsepower of the motor. See Note at beginning of Section 5.
- Cable, cable reel, reel stand, and any other equipment necessary to handle the drop cable without damaging it.
- Cable clamps for attaching the drop cable to the column pipe at approximately 10 foot intervals. Stainless steel bands with thick rubber chafing pads between the bands and the drop cable are recommended, especially for deep settings or other applications using heavy drop cable. Self locking plastic bands or two or more wraps of plastic tape may be sufficient for small pumps with lightweight drop cable.
- Drop cable splicing materials and tools.
- Ohmmeter or meggar, voltmeter, and ammeter.
- Normal mechanic's tools.
- Normal electrician's tools.
- Water level gauge.

The following will be required only if a performance test is to be conducted. See Section 7.C.

- Discharge pressure gauge.
- Flow meter.
- KW meter.

* Equipment for removal of the pump after it has been in operation must be capable of lifting the above weight plus the weight of the water in the column pipe.

3. ELECTRICAL CONSIDERATIONS

A major portion of the work associated with a submersible pump is electrical. It is not the intent of this manual to provide detailed instructions for the electrical work. The services of a competent power electrician or electrical contractor will be required.

All work must be done in accordance with applicable codes, the pump motor manual, instructions for other equipment that is part of the installation, and sound electrical practices. The electrical work performed will include but not be limited to the following:

- **PROVIDING A PROPER POWER SUPPLY.** The power supply must have an adequate capacity (KVA) and must be of the proper voltage, phase, and frequency to match the motor requirements. Three phase systems should have a full three phase supply utilizing three individual transformers or one three phase transformer. Open delta or wye systems using only two transformers must be de-rated. Such installations are also more likely to suffer from phase unbalance problems. Unbalanced voltage on three phase power sources will cause unbalanced motor currents. Motor current unbalances in excess of 5 percent can be expected to cause excessive heating in the motor, resulting in poor motor performance, nuisance overload tripping, and premature failure of the motor. If the power company cannot guarantee less than 5 percent unbalance, the use of the next larger size motor and the next larger size cable is recommended. Notify the factory of this requirement. The warranty can be voided by the use of an improper power supply.
- **SELECTING AND INSTALLING A PROPER MOTOR CONTROL SYSTEM.** The motor control system must be sized to accommodate the pump motor. The control system should protect the motor from damage from abnormal conditions such as low voltage, high voltage, overload, excessive current unbalance, phase loss, overheating, lightening, etc. Single phase 3-wire motors require a special submersible motor control box. A standard magnetic starter with special extra-quick overload relays can be used for three phase motors; however, a control such as the Franklin Subtrol which is designed specially for submersible pumps is recommended. Overload protection and fuse requirements are given in the pump motor manual. The warranty can be voided by the use of an improper control system.
- **SELECTING THE PROPER DROP CABLE.** Submersible pump drop cable is a special waterproof, heavily insulated cable made especially for this use. The cable size is based on the motor horsepower and voltage, and the distance from the motor to the control panel. Cable size selection charts are given in the motor manual. Failure to use the proper size and type cable can void the warranty.
- **MAKING THE SPLICE BETWEEN THE MOTOR LEADS AND THE DROP CABLE.** A water-tight splice must be made to connect the drop cable to the motor leads. See Section 4.D.
- **PROPERLY GROUNDING THE UNIT.** All units must be grounded per the specific requirements given in the applicable codes.

WARNING: Failure to ground the unit properly can result in serious or fatal shock.

- **MAKING AND EVALUATING ELECTRICAL TESTS.** Installation, troubleshooting, and maintenance of a submersible pump will require making and evaluating electrical tests such as resistance, continuity, voltage, current, current unbalance, etc. Some of these tests are described in Appendix A. The use of electrical testing as a troubleshooting tool can very often quickly identify the problem and prevent the unnecessary time and expense of pulling the pump.
- **SELECTING AND INSTALLING AUXILIARY EQUIPMENT.** A low water level switch is recommended. The installation will also most likely require auxiliary equipment such as flow switches, pressure switches, level switches, time switches, etc. The need for this equipment must be evaluated based on the requirements of each installation and the proper equipment must be selected and installed.

Most submersible pump service problems are electrical. It is therefore imperative that the electrical work be done properly using high quality materials if the pump is to provide the long trouble-free life for which it is designed.

4. PRE—INSTALLATION MOTOR AND DROP CABLE CHECKS AND PREPARATION

CAUTION: Do not use motor leads to lift or handle the motor. The motor leads are easily damaged. They should be protected and handled with care at all times.

The following tests can usually be done in the shop provided the motor leads and drop cable are protected and handled carefully during transportation to the installation site.

A. MOTOR SERVICING

Consult the motor manual and perform any pre-installation servicing that is required. Some motors may require filling with oil or water.

B. ATTACHMENT OF MOTOR TO PUMP

If the pump motor has not already been attached to the pump, attach it per the instructions given in Appendix B. For extra long units it may be more practical to assemble the pump to the motor in the vertical position at the installation site.

C. TESTING BEFORE SPLICING DROP CABLE TO MOTOR LEADS

Perform the following tests before making the splice between the motor leads and the drop cable. Instructions for performing resistance tests and evaluating the results are given in Appendix A.

MOTOR TESTS

1. Measure the resistance between each motor lead and ground with the motor submerged in water. See Appendix A, Section 1.
2. Measure the resistance of the motor windings. See Appendix A, Section 2. Record the values for future reference.
3. If possible, give the motor/pump unit a short (approx. 1 minute) running test in a tank of water. If a tank is not available, "bump" the motor (do not exceed 2 seconds) to check that it will run.

WARNING: Ground the unit when testing. Failure to ground the unit properly can result in serious or fatal shock. Also the high starting torque of the motor will cause it to "kick" when power is applied. The unit should be restrained sufficiently to prevent damage to the equipment or personal injury.

DROP CABLE TEST

Measure the resistance between the cable conductors and ground with the cable submerged in water. See Appendix A, Section 1.

D. SPLICING DROP CABLE TO MOTOR LEADS

A waterproof splice must be made to connect the drop cable to the motor leads. A properly made splice will last the life of the pump. An improperly made splice will become a service problem. Make the splice per instructions supplied with the drop cable or per instructions in the pump motor manual. The splice should be located above the pump bowl. See Figure 1. It should be as compact as possible. A compact splice is less likely to be damaged as the pump is being lowered into the well.

E. TESTING AFTER SPLICING DROP CABLE TO MOTOR LEADS

Perform the following tests after making the splice, but before lowering the pump into the well.

1. Check that the splice is waterproof by immersing it in a container of water for approximately one hour and then taking resistance readings between each cable conductor and the water. See Appendix A, Section 1.
2. Measure the total resistance of the complete drop cable and motor circuit to insure that a good splice was made. Record the values for future reference. See Appendix A, Section 2.

5. INSTALLING THE PUMP IN THE WELL (OR SUMP).

CAUTION: The pump motor will exert a torque that will tend to unscrew threaded column pipe connections. For this reason, threaded column joints must be tightened to a torque of at least 10 ft.-lbs per rated HP of the motor (example, 500 ft.-lbs for a 50 HP motor). If the pump installation rig cannot produce this amount of torque, it will be necessary to weld each joint or use some other method to keep the joints from unscrewing.

- a. If a check valve is to be used and it is not already installed, install the check valve on the pump. See Fig. 1. Clean the threads and apply thread sealant. Check that the arrow on the check valve is pointed in the direction of flow. Check that the valve disc or poppet is not stuck in the open or closed position. Tighten the valve securely. See Note above.
- b. The method of installing the pump, motor, and bottom piece of column will vary depending on the size and length of these components.
 - For smaller units, the bottom section of column can be screwed into the pump and the entire pump/motor/column assembly handled as one piece.
 - For larger units, it may be more practical to install the pump/motor assembly and the bottom piece of column pipe separately. A special elevator or clamp may be required to hold the pump/motor assembly in place while the first piece of column is being screwed into the pump discharge.
 - For very large units or extremely long units where the pump and motor have not been assembled, it may be desirable to lift the pump and motor separately and assemble the motor to the pump in the vertical position. See Appendix B for assembly instructions. This method requires a special elevator or clamp to hold the motor in place while the pump is being connected and a special elevator or clamp to hold the pump/motor assembly in place while the first piece of column is being installed. Eyebolts or some other means of lifting the motor will also be required.
- c. Rig the first piece of equipment for lifting, hoist it into the vertical position, and position it over the well. Do not allow the equipment to drag along the ground as it is lifted. Special care must be taken when lifting long pumps or pump/motor assemblies, since they may sag excessively in the middle when raised at one end and permanently deform the unit. The shipping skid should remain attached during uprighting of very long units.
- d. Check that all of the steps below have been completed.
 1. Assemble pump and motor. See Appendix B.
 2. Install the bottom piece of column in the pump discharge. Do not lower the unit into the well at this time.
 3. Complete Section 4.C. (testing before splicing cable).
 4. Complete Section 4.D. (cable splicing).
 5. Complete Section 4.E. (testing after splicing cable).
- e. Temporarily connect the drop cable to the electric panel and start the pump for not more than 2 seconds to check that it will run.

WARNING: Ground the unit when testing. Failure to ground the unit properly can result in serious or fatal shock. Also the high starting torque of the motor will cause it to "kick" when power is applied. The unit should be restrained sufficiently to prevent equipment damage or personal injury.

On 3 phase units check for proper rotation during this test. If the unit kicks clockwise (when viewed from above), the rotation is correct and the wires should be tagged so that they can be reconnected to the same terminals in the panel. If the unit kicks counter clockwise, interchange any two of the three wires before tagging them. **DISCONNECT THE CABLE FROM THE PANEL.**

- f. Install a cable clamp on each side of the cable splice. See Fig. 1. Be careful not to damage the cable. If an air line is to be installed, route it beside the cable, making sure that it is not pinched by the clamps. If there is any danger that the splice will rub against the well casing during installation, it should be protected by thick rubber chafing pads or by a steel shield. Check that the grounding system is in place.

5. INSTALLING THE PUMP IN THE WELL (OR SUMP) (cont'd.)

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

- g. Slowly lower the unit into the well (or sump) adding joints of column pipe as the unit is lowered. Tighten each joint securely. See note above. Remove slack from the drop cable and attach a cable clamp approximately every 10 feet. For units with large heavy drop cable, additional cable support can be obtained by installing a clamp immediately above each pipe coupling. Line up the cable on one side of the pump and maintain as much clearance as possible on that side when lowering the pump in the well. **BE EXTREMELY CAREFUL NOT TO SCRAPE OR DAMAGE THE DROP CABLE, DROP CABLE SPLICE, OR GROUNDING SYSTEM WHEN LOWERING THE PUMP.** Hold the drop cable up away from the well casing as the pump is being lowered. Never force the pump into the casing.
- h. After the last piece of column pipe has been installed, install the discharge elbow. Install a cable clamp between the last column pipe coupling and the discharge elbow surface plate. Route the drop cable and grounding system thru the large threaded hole in the surface plate. Route the air line (if used) thru one of the smaller threaded holes in the surface plate. The remaining small threaded hole is for connection of a well vent or other accessories. All of these holes are threaded with standard NPT pipe threads. If a gasket is required between the discharge elbow and its mounting surface, the gasket should be placed on the foundation prior to installing the discharge elbow.
- i. After the discharge elbow has been properly tightened, carefully rotate the entire unit in the well until the discharge flange is facing in the desired direction. Push the unit to one side of the well, providing the maximum clearance for the drop cable when rotating the unit.
- j. Slowly lower the discharge elbow onto its mounting surface. **BE CAREFUL NOT TO DAMAGE THE GROUNDING SYSTEM OR PINCH THE DROP CABLE BETWEEN THE SURFACE PLATE AND THE WELL CASING.** If a gasket or other sealing device is used, be sure that it is aligned properly and that it is not damaged. Install the discharge elbow mounting bolts.
- k. Before connecting the drop cable to the control panel:
 1. Take a resistance reading between the drop cable conductors and ground to assure that the insulation on the cable or splice was not damaged during installation. See Appendix A, Section 1.
 2. Measure the resistance of the drop cable and motor circuit. See Appendix A, Section 2. Compare these readings with those taken in Section 4.E.2 to assure that the splice is still intact.
- l. Make the electrical connection between the drop cable and the control panel. It may be desirable to use a terminal box at the discharge (See Fig. 1) to simplify the electrical work required when the pump is pulled. Be sure that the unit is grounded properly.

WARNING: Failure to ground the unit properly can result in serious or fatal shock.

Be sure to connect the leads as they were marked in para. 5.e above.

6. INITIAL START—UP

CAUTION: Initial start-up and testing may require starting and stopping the pump several times. **BE SURE TO ALLOW ADEQUATE COOLING OFF PERIOD BETWEEN STARTS.** Consult the motor manual. If no information is given, a good rule-of-thumb is to allow a minimum of 15 minutes between starts.

- a. For initial start-up allow the water to be pumped out onto the ground. A throttle valve in the discharge line is recommended. Position the throttle valve approximately one-fourth open for start-up of the pump. This will prevent surging the well or the pump during start-up.
- b. If the pump has been in the well for several days before the start-up, check the resistance between the cable conductor and ground to assure that water has not penetrated the splice or the cable insulation. See Appendix A, Section 1.
- c. Clamp the tongs of a clamp-on type ammeter around one power lead to the pump. Set the ammeter on the maximum scale. After the motor starts it can be reset to a lower scale as desired. Refer to the motor manual and determine the normal operating amps for the installed motor.
- d. Start the pump and observe and record the current readings on each conductor of the power lead. If the current exceeds the normal value determined in para. c above, stop the pump immediately. A high current reading indicates that something is wrong. Among the potential problems are:
 1. Incorrect pump rotation (3 phase only)
 2. Improper voltage
 3. Sand locked pump
 4. Improper cable size or leak in cable
 5. Mechanical damage

In any case, the problem must be corrected before the pump can be operated.

- e. On three phase units if water does not appear within one minute (deeper settings may require approx. one half minute per 100 ft. setting) the motor may be running backwards. Stop the pump and interchange any two of the three cable connections. If there is any doubt about the proper rotation, run the motor in one direction and then the other. The rotation that gives the highest pressure and flow is always the correct one.
- f. Check the voltage. The voltage when the pump is running should be within 5% of the pump motor nameplate voltage.
- g. Open the throttle valve. If a flow meter is available, open the throttle valve to rated flow of the pump. If sand appears in the water, throttle the pump at approx. 80% of full flow until the sand clears. If excessive noise develops, pressure fluctuates, or water appears foamy white, the pump is probably cavitating and the flow should be throttled until the noise diminishes, the pressure remains steady, and the water is clear.
- h. On three phase units check for current unbalance. Details of the current unbalance test are given in Section 3 of Appendix A. **THE MAXIMUM ALLOWABLE CURRENT UNBALANCE IS 5%.** If the current unbalance exceeds 5% after rolling the leads and connecting them for the lowest unbalance, the pump should be stopped and corrective action taken. Current unbalance in excess of 5% can be expected to cause excessive heating in the motor and premature failure. Operation with a current unbalance in excess of 5% will void the warranty.
- i. After the unit is operating properly, a performance test should be considered. See Section 7.C. If a performance test is conducted when the pump is new, subsequent tests can be used to determine the degree of wear or deterioration of the pump without removing it from the well.
- j. After the unit has been in operation for approximately a week, perform the routine tests listed in Section 7.B.

7. ROUTINE OPERATION AND MAINTENANCE

A Layne submersible pump properly installed in a clean well will run for a long period of time with a minimum of attention. However, conditions are not always ideal and can change for the worse in the course of time. Submersible pumps usually run unattended and automatic control devices are used to stop and start the unit and to protect it from abnormal conditions such as overloads, line faults, etc. It is important that these automatic devices be adjusted properly and maintained in good working condition. Failure of an automatic control can easily cause the failure of a pump that is in excellent condition. Unfortunately these protective devices may not protect the installation against all of the hazards that may be encountered.

In order to assure that potential problems are identified and corrected as soon as possible a program for regular inspection and testing of the unit should be established. The frequency of inspection and testing will vary depending on the complexity of the controls, the consequences of a failure, the cost of making the inspections and tests, the age and condition of the unit, the results of previous inspections and tests, and the operating philosophy of the owner.

A. ROUTINE INSPECTIONS

On a periodic basis the unit should be given a quick inspection. The inspection should include the following:

1. Check for any obviously abnormal conditions such as gross leakage or gross damage.
2. Check that the unit is not making an excessive noise.
3. Check the electric panel for alarms, blown fuses, etc.
4. Check the electrical system for signs of overheating or other abnormal conditions.

Any problems noted should be carefully investigated and corrected immediately.

B. ROUTINE TESTING

The following tests should be performed on a periodic basis and at any time the pump is started up after a prolonged shutdown. All test readings should be recorded so that they can be used for comparison. Gradual changes can indicate a gradual deterioration. Large changes can indicate rapid deterioration with a potential for sudden failure in the near future.

1. Check the resistance between the drop cable conductor and ground. See Appendix A, Section 1.
2. Measure the resistance of the drop cable and motor windings. See Appendix A, Section 2.
3. 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. See Appendix A, Section 3. Excessive current is an indication of a problem somewhere in the system which should be corrected immediately.
4. Measure the water level in the well. A drop in the water level may indicate overpumping of the well or clogging of the well screen which can result in damage to the well, pump, and the motor. Be sure that the pump is always under the water. Lowering the pump by installing additional column pipe should be considered if the pump suction is submerged 5 feet or less when pumping.

C. PERFORMANCE TESTING

Performance testing of the pump consists of measuring and recording the following:

1. Discharge pressure (feet) (feet = psi x 2.31 for water)
2. Pumping level (feet) (distance from the center of the discharge pressure gage to the water level when pumping)
3. Flow (gallons per minute)
4. Input power (kilowatts)
5. Line voltage on all phases (volts)
6. Current in all three phases (amps)

The above information should be taken at four operating points: shutoff, slightly less than rated flow, rated flow, and slightly greater than rated flow.

CAUTION: Do not operate the pump at shutoff for more than 30 seconds as this can cause the motor to overheat and burnout.

Record the above information and retain it for comparison with previous or subsequent performance tests.

7. ROUTINE OPERATION AND MAINTENANCE (cont'd.)

C. PERFORMANCE TESTING (cont'd.)

The following formulas will be helpful in evaluating the readings taken.

$$\begin{array}{l} \text{Pump Output HP} \\ \text{(Water Horsepower)} \end{array} = \frac{Q \times H \times \text{Sp Gr}}{3960}$$

Where: Q = flow in gallons/minutes

H = total head in feet

= discharge pressure (feet) + pumping level (feet)

Sp.Gr. = specific gravity of liquid being pumped (sp. gr. of water = 1)

$$\text{Power Input HP} = \text{KW input} \times 1.34$$

$$\begin{array}{l} \text{Wire-to-Water} \\ \text{Efficiency} \end{array} = \frac{\text{Pump Output HP}}{\text{Power Input HP}}$$

The pump output horsepower is a measure of pump performance. Over the lifetime of the pump the output horsepower will decrease due to wear. By comparing output horsepower readings taken over a period of time the rate and degree of wear of the pump can be determined. Note that both head (pressure) and flow are included in the pump output horsepower formula. Be careful not to try to draw conclusions about the pump's performance by considering pressure alone or flow alone. For example consider what happens if the pumping level in the well changes. The pump output horsepower will remain essentially the same and the flow will change. This change in flow could be misinterpreted as a change in pump performance.

The wire-to-water efficiency is a measure of how well the pump and motor unit are utilizing the power consumed.

8. TROUBLESHOOTING

If an operational failure occurs, conduct a routine inspection of the unit per Section 7.A. In many instances this simple inspection will reveal the cause of the failure. If the cause of the failure is not immediately obvious, the troubleshooting chart below will be helpful. The routine testing of Section 7.A. may also be helpful especially if data from previous tests is available.

Note that a large portion of the "Probable Causes" are electrical and also that a large portion of these electrical problems are due to above ground equipment. Before going to the time and expense of removing the pump from the well, be sure that all above ground problems have been corrected and that a thorough diagnosis has been made indicating that the problem is underground.

CONDITION	PROBABLE CAUSES
PUMP WILL NOT RUN	<ol style="list-style-type: none"> 1. No power to control box. 2. Motor control box or starter not in proper position. 3. Motor protection device tripped. See OVERLOAD PROTECTOR TRIPS below. 4. Blown fuse. See FUSES BLOW BUT OVERLOAD DOESN'T TRIP below. 5. Loose, corroded, broken, or incorrect electrical connections. 6. Faulty pressure switch or other control device. 7. Open circuit in cable, splice, or motor winding. See Appendix A. 8. Control box malfunction. See motor manual or control box manual.
PUMP RUNS BUT DELIVERS LITTLE OR NO WATER	<ol style="list-style-type: none"> 1. Air locked pump. (Start and stop pump several times, waiting fifteen minutes between cycles.) 2. Water level too low in well. 3. Pump inlet screen blocked with sand or debris. 4. Check valve stuck in closed or partially closed position or installed backwards. 5. Pump rotation backwards (3 phase only). 6. Broken pump shaft or shaft coupling. 7. Worn pump. 8. Discharge pipe clogged. 9. Column pipe clogged. 10. Gross leakage from column pipe. 11. Drop cable too small.
PUMP RUNS CONTINUOUSLY OR RUNS FOR LONG PERIODS OF TIME WITHOUT TURNING OFF	<ol style="list-style-type: none"> 1. Defective or improperly adjusted pressure switch or other control. 2. Clogged line to pressure switch. 3. Starter contacts welded shut. 4. Pump is not delivering enough pressure to open the pressure switch. See PUMP RUNS BUT DELIVERS LITTLE OR NO WATER. 5. Leak in pressurized portion of system.

8. TROUBLESHOOTING (cont'd.)

CONDITION	PROBABLE CAUSES
PUMP STARTS AND STOPS TOO OFTEN	<ol style="list-style-type: none"> 1. Pressure switch or other control device defective or out of adjustment. 2. Leak in pressurized portion of system. 3. Check valve between pump and pressurized system leaking. 4. Water logged pressure tank. (Defective air release or air intake mechanism.)
OVERLOAD PROTECTOR TRIPS	<ol style="list-style-type: none"> 1. Incorrect control box or control box component (such as capacitor or relay) being used. 2. Incorrect, loose, or corroded electrical connections. 3. Faulty protective devices. 4. Incorrect voltage. 5. Control box in sun or near a heat source. 6. Current overload due to: <ol style="list-style-type: none"> a. Tight motor or pump bearings. b. Pump clogged with sand. c. Pump motor rotor locked or dragging. d. Unbalanced voltage. e. Grounded cable, splice, or motor winding. See Appendix A. f. Defective motor. See Appendix A. g. Low voltage. h. Insufficient cooling of motor.
FUSES BLOW BUT OVERLOAD DOESN'T TRIP	<ol style="list-style-type: none"> 1. Fuse receptacles or connections loose, dirty, or corroded. 2. Ground wire connected to wrong control box terminal. 3. Fuses too small.

Additional troubleshooting information is generally available in the motor manual, the control box manual, and manuals for other accessory equipment.

APPENDIX A – ELECTRICAL TESTS

1. MEASURING INSULATION RESISTANCE (GROUND TEST)

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 meggar or an ohm-meter. 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 given below.

- a. Turn off all power and disconnect the leads to be tested from the electrical panel.

WARNING: Failure to turn off the power will damage the meter and can cause serious or fatal shock.

Failure to disconnect the leads can result in false readings.

- b. Set the meter selector knob to RX100K or RX100,000. (Some meters may not have RX100K in which case RX10K or RX10,000 scale can be used.) Clip the meter leads together and adjust the meter to zero.

- c. Unclip the leads and attach them as shown in Fig. 2.

- d. Do not touch any bare wires or allow bare wires to come in contact with the ground or metal. False readings will result.

- e. If the meter needle is at either extreme end of the scale, a more accurate reading can be obtained by switching the selector switch to another scale. Re-zero the meter each time the selector switch is moved.

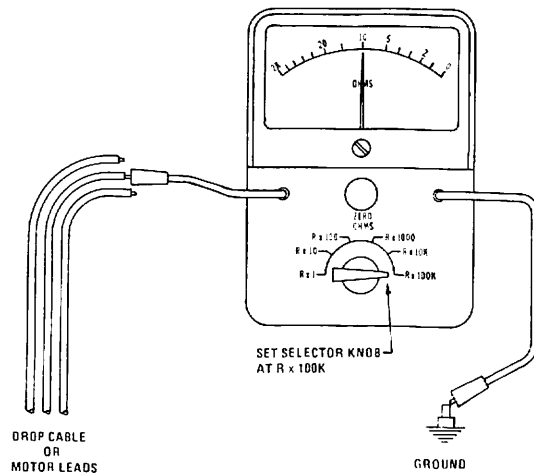


Fig. 2. Measuring Insulation Resistance

The readings obtained from drop cables and motor leads should be within the range specified in Table 1. Low readings indicate that the motor windings are grounded or that the cable or splice insulation is damaged. If low or marginal readings are obtained on a new installation the problem should be corrected before proceeding with the installation.

APPENDIX A – ELECTRICAL TESTS (cont'd.)

1. MEASURING INSULATION RESISTANCE (GROUND TEST) (cont'd.)

TABLE 1 – NORMAL INSULATION RESISTANCE VALUES BETWEEN ALL LEGS AND GROUND

Insulation resistance does not vary with rating. All motors of all HP, voltage, and phase rating have the same insulation resistance ranges.

CONDITION OF MOTORS AND LEADS	OHMS	MEGOHMS	METER READING	
			R x 100K or R x 100,000 scale	R x 10K or R x 10,000 scale
<p>BENCH TESTS</p> <ul style="list-style-type: none"> ● A new motor (without drop cable) ● A used motor which can be reinstalled in the well ● Cable splice after immersion for one hour in water 	<p>20,000,000 +</p> <p>10,000,000 +</p> <p>2,000,000 +</p>	<p>20 +</p> <p>10 +</p> <p>2 +</p>	<p>200 +</p> <p>100 +</p> <p>20 +</p>	<p>2000 + or 2K +</p> <p>1000 + or 1K +</p> <p>200 +</p>
<p>WELL TESTS Ohm readings are for drop cable plus motor.</p> <ul style="list-style-type: none"> ● A new motor or used motor motor in good condition. ● A motor in reasonably good condition. ● A motor which may have been damaged by lightning or with damaged leads. Do not pull the pump for this reason. ● A motor which definitely has been damaged or with damaged cable. The pump should be pulled and repairs made to the cable or the motor replaced. The motor will not fail for this reason alone, but will probably not operate for long. ● A motor which has failed or with completely destroyed cable insulation. The pump must be pulled and the cable repaired or the motor replaced. 	<p>2,000,000 +</p> <p>500,000–2,000,000</p> <p>20,000–500,000</p> <p>10,000–20,000</p> <p>less than 10,000</p>	<p>2 +</p> <p>0.5–2.0</p> <p>0.02–0.5</p> <p>0.01–0.02</p> <p>0–0.01</p>	<p>20 +</p> <p>5–20</p> <p>0.2–5</p> <p>0.1–0.2</p> <p>0–0.1</p>	<p>200 +</p> <p>50–200</p> <p>2–50</p> <p>1–2</p> <p>0–1</p>

+ Indicates that the reading should be the value shown or greater. Higher readings indicate better insulation.

APPENDIX A – ELECTRICAL TESTS (cont'd.)

2. MEASURING RESISTANCE BETWEEN LEADS (MOTOR WINDING RESISTANCE)

The general condition of motor windings can be determined by measuring the resistance of the motor windings (i.e. the resistance between the motor leads) and comparing the measured resistance with values given in the motor manual. The resistance is measured with an ohm-meter and the value is stated in ohms.

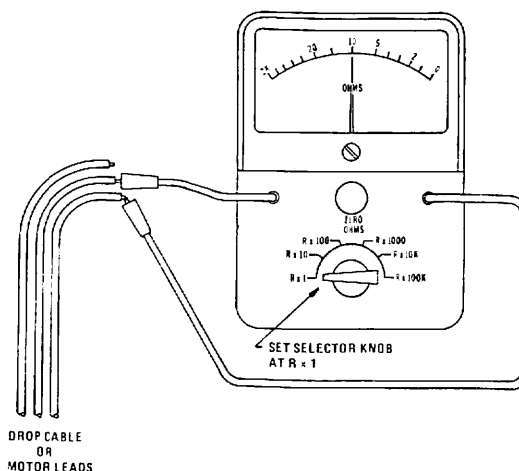
The basic procedure for measuring motor winding resistance is given below.

- a. Turn off the power and disconnect the leads to be tested from the panel.

WARNING: Failure to turn off the power will damage the meter and can cause serious or fatal electrical shock.

Failure to disconnect the leads can result in false readings.

- b. Set the meter selector knob to "Rx1". Clip the meter leads together and adjust the meter to zero.
- c. Unclip the leads and attach them as shown in Fig. 3.



SINGLE PHASE, 2 WIRE—MEASURE BETWEEN TWO WIRES
SINGLE PHASE, 3 WIRE—MEASURE BETWEEN BLACK AND YELLOW
AND THEN MEASURE BETWEEN RED AND YELLOW.
THREE PHASE—MEASURE BETWEEN EACH PAIR, AB, AC, BC

Fig. 3 Measuring Winding Resistance

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 drop cable leads after splicing the drop cable to the motor leads will indicate the resistance of the drop 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.

$$\text{Motor Winding Resistance} = \text{Reading taken at Drop Cable} - \text{Cable resistance from Table 2}$$

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.

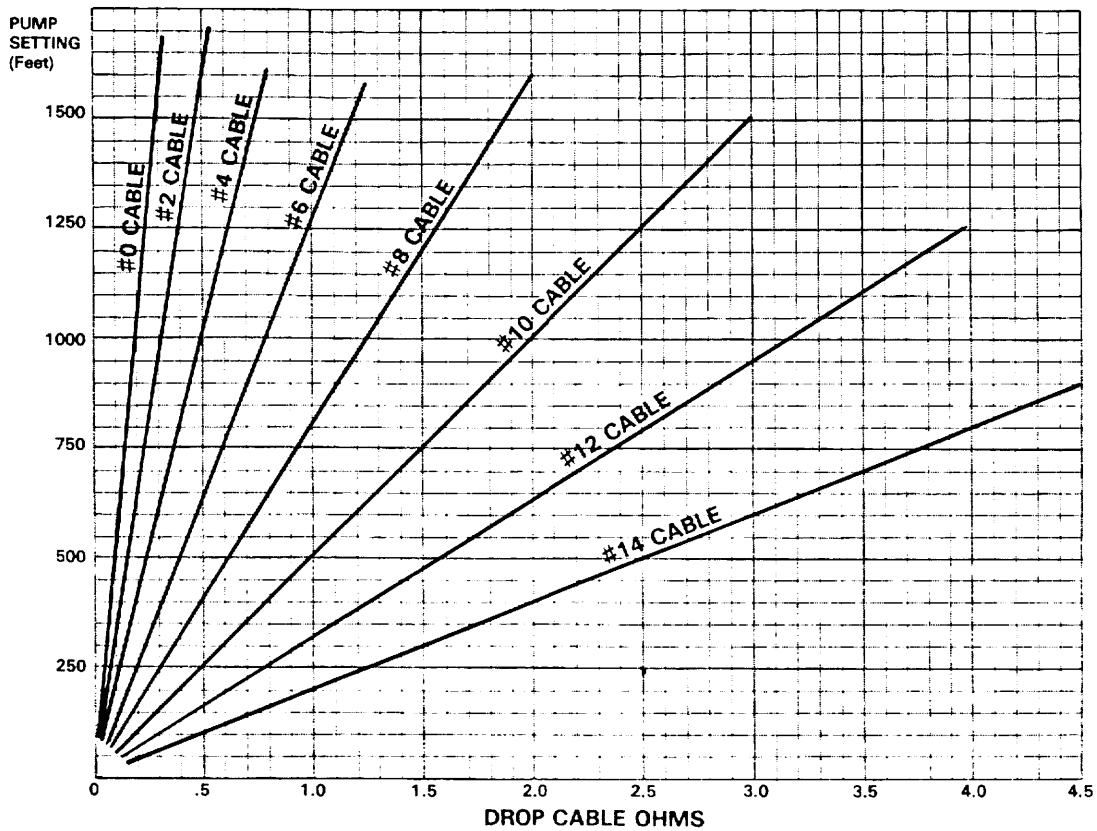
Unequal resistance between the windings on a three phase motor indicates a burned winding or a faulty connection.

APPENDIX A – ELECTRICAL TESTS (cont'd.)

2. MEASURING RESISTANCE BETWEEN LEADS (MOTOR WINDING RESISTANCE) (cont'd.)

TABLE 2– DROP CABLE RESISTANCE

The values below are for copper conductors. If aluminum conductor drop cable is used, the resistance will be higher for each foot of cable of the same size. To determine the actual resistance of aluminum drop cable, divide the ohm readings from this chart by 0.61. This chart shows total resistance of cable from control box to motor and back.



3. CURRENT UNBALANCE TEST

For three phase units, THE CURRENT UNBALANCE BETWEEN LEGS OF THE POWER SUPPLY SHOULD NOT EXCEED 5%. Current unbalance is determined by measuring the amperage in 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. THE HOOKUP THAT RESULTS IN THE LOWEST PERCENT CURRENT UNBALANCE SHOULD BE USED FOR THE FINAL CONNECTION OF THE POWER LEADS. This procedure is commonly known as "rolling the leads". To prevent changing the motor rotation, be careful to follow the hookups shown below very carefully. A worksheet and sample calculation are given.

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

	Sample Calculation	1st Hook Up	2nd Hook Up	3rd Hook Up
● Measure current in each leg.	T ₁ L ₁ 51 amps T ₂ L ₂ 46 amps T ₃ L ₃ 53 amps	T ₁ L ₁ _____ T ₂ L ₂ _____ T ₃ L ₃ _____	T ₃ L ₁ _____ T ₁ L ₂ _____ T ₂ L ₃ _____	T ₂ L ₁ _____ T ₃ L ₂ _____ T ₁ L ₃ _____
● Add leg currents to determine total current.	<u>150</u> amps	_____	_____	_____
● Calculate average leg current.	÷ 3 <u>50</u> amps	÷ 3 <u>_____</u>	÷ 3 <u>_____</u>	÷ 3 <u>_____</u>
● Determine max. difference of any one leg from the average	51-50 = 1 50-46 = 4 ← max 53-50 = 3	____ - ____ = ____ ____ - ____ = ____ ____ - ____ = ____	____ - ____ = ____ ____ - ____ = ____ ____ - ____ = ____	____ - ____ = ____ ____ - ____ = ____ ____ - ____ = ____
● Calculate percent unbalance using formula above	$\frac{4}{50} \times 100 = 8\%$	____ x 100 = ____ %	____ x 100 = ____ %	____ x 100 = ____ %

THE MAXIMUM ALLOWABLE UNBALANCE IS 5%.

Since loads on a transformer bank may vary during the day, readings should be taken at least twice; once during the day at what would be considered the normal load period and once in the evening during the usual peak load period. The leads should then be connected for the lowest percent current unbalance during the period that the pump will operate the most.

By observing where the highest current reading is for each leg of each of the hookups, the cause of the unbalance can be determined. If the high current leg is always on the same power leg L, this indicates that most of the unbalance is from the power source. If the high current is always on the same motor lead T, this indicates that the motor or a poor connection is causing most of the unbalance.

If the current unbalance still exceeds 5% after rolling the leads and connecting them for the lowest unbalance, the pump should be stopped and corrective action taken; The power company should be contacted for assistance.

APPENDIX B – ASSEMBLY OF PUMP AND MOTOR

The size and length of the pump/motor assembly will determine whether the pump and motor can be assembled in the shop or must be assembled in the vertical position at the well site. Very large units or long units with many stages must be assembled at the well site.

CAUTION: Do not use the motor leads to lift or handle the motor. The motor leads are easily damaged. They should be protected and handled with care at all times.

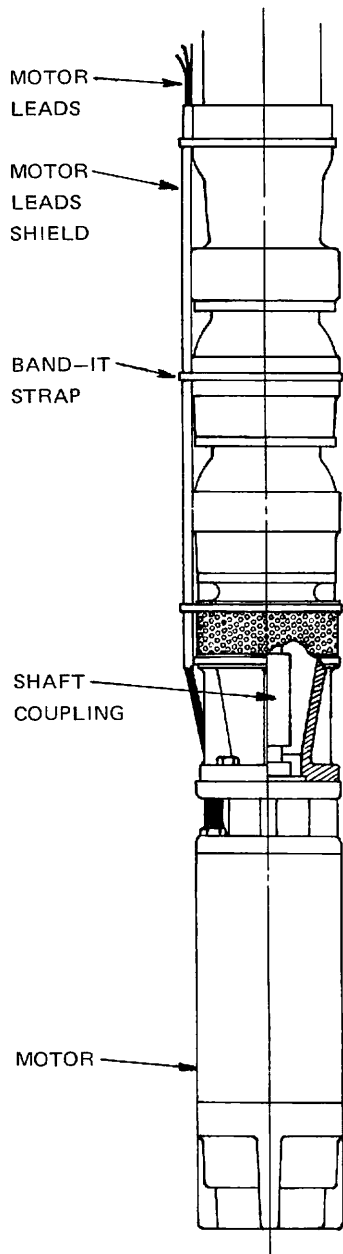


Fig. 4 Typical Pump/Motor Assembly

1. Consult the motor manual and perform any pre-installation servicing of the motor that is required. Some motors will require filling with oil or water.
2. If the motor is to be assembled to the pump while in the shop, go to Step 3 below. If the motor is to be assembled at the well site, perform the MOTOR TESTS of Section 4.C. while the motor is still in the shop. Be careful to protect the motor leads during transportation of the motor to the well site.
3. Check that the pump shaft and motor shaft turn freely.
4. Clean the exposed portion of the pump shaft and motor shaft. Clean the flange faces and registers on the pump and motor mating flanges. Remove all burrs from these areas.

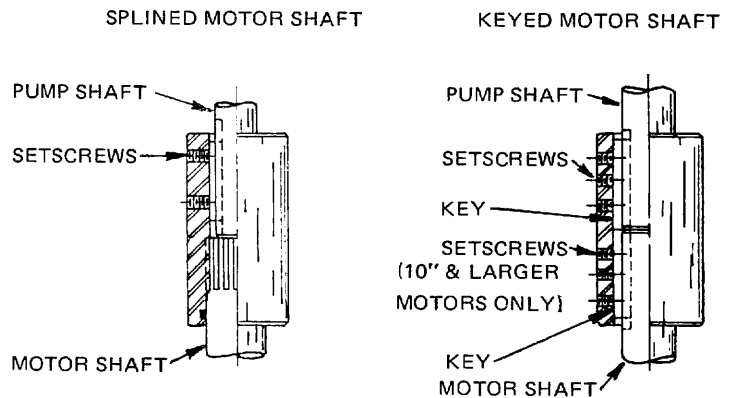


Fig. 5 Shaft Coupling Detail

5. Install the key in the motor shaft. See Fig. 5. Splined motor shafts do not use a key.
6. If the shaft coupling has setscrews in motor shaft half of the coupling, loosen or remove these setscrews.
7. Align the motor with the pump and slide the motor shaft into the shaft coupling on the pump. Be careful not to damage the shaft, the coupling, or the key. Orient the motor so that the motor leads are aligned with the notch provided in the pump mounting flange. Install and tighten the mounting bolts (or capscrews).

APPENDIX B—ASSEMBLY OF PUMP AND MOTOR (cont'd.)

8. If the shaft coupling has setscrews in the motor shaft half of the coupling, pull the coupling toward the motor until the shafts butt and then install and tighten the setscrews on the motor end of the coupling.
9. Install a shield over the motor leads to prevent damaging the leads when lowering the pump into the well. A channel shaped metal shield held in place with 1/2" wide stainless steel "Band-It" straps is recommended. The shield should be installed as shown in Fig. 4 with the lower end positioned immediately above the suction inlet, the upper end at the top of the discharge case (or check valve) and straps located as shown.
10. Test the completed pump/motor assembly per the MOTOR TESTS in Section 4.C. Ignore this step if the pump was assembled at the well site.

WARRANTY

Products manufactured by Seller and sold under this agreement are warranted free from defects in materials and workmanship for one year from the date of shipment to the Buyer. Goods manufactured by other than Seller and sold under this agreement are warranted only to the extent that the manufacturer warranted them to Seller. Seller's obligation is limited to repair or replacement f.o.b. seller's plant, when examination of such products shall disclose them, to Seller's satisfaction, to have been defective and Buyer shall have notified Seller promptly of the discovery of any such defect. At the Seller's option such products shall be returned to Seller transportation charges prepaid. This warranty does not apply to any products which have been opened, disassembled, repaired or altered by anyone other than Seller or subjected to misuse or abuse. In addition to the foregoing, all products furnished hereunder are warranted with respect to (a) title, and (b) in the case of standard commercial products, non-infringement; in each case to the extent provided by the Uniform Commercial Code. Unless otherwise specifically agreed in writing by Seller, the obligation of Seller is limited, in the case of a material breach of the warranties set forth in (a) and (b) above, to the return of Buyer's purchase price or, at Seller's option in the case of infringement, to the prompt replacement of the products with non-infringing conforming products. Except as above specifically provided, Seller's liability to Buyer shall not exceed the cost of correcting defects in the goods sold and Seller shall not in any event be liable to Buyer or third parties for any delays or special, indirect or consequential damages. The foregoing warranties are in lieu of all other warranties, express or implied, including, without limitation, warranties of merchantability, fitness for any particular purpose and noninfringement.