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TECHNICAL INFORMATION
Bulletin

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SUBMERSIBLE MOTORS…RELIABLE PERFORMANCE DEPENDS ON RELIABLE INSTALLATION

Long and skinny and made to function in hostile environments, submersibles are far from ordinary motors. In fact, they are extraordinary – whether filled with water or oil, wet winding or other type construction. Subs are designed to do the job under conditions once regarded as impossible for any motor. Yet, as extraordinary as they are, the reliability of a sub's performance is directly related to its installation. Here is a review of some key points for assuring reliable installations.

Cooling: In all electric motors, only a portion of input energy from power lines is converted to mechanical output to drive the pump or other load. The rest unavoidably becomes heat which increases motor temperature, and must be carried away by motor surroundings to prevent over-heating. Air-cooled motors give off their heat to surrounding air which must circulate to avoid heat build-up in and around the motor. Submersible motors, designed with higher hp versus physical size than air-cooled motors because water absorbs heat faster than air, need similar circulation of the surrounding water to prevent overheating.

While most submersibles through one hp will operate without forced water flow, larger motors usually require at least a specified minimum flow rate for adequate cooling. Proper installation to ensure the necessary flow is essential, and the following factors are particularly important.

- The pump should always be mounted far enough above the bottom of the well to prevent the motor from being buried in sand or mud.
- When the nameplate or instructions specify a minimum flow velocity past the motor, the well size, pump setting, delivery and water inflow levels must be considered to ensure at least that flow. If the delivery in the well does not create enough velocity or the well inflow is above the pump intake, a flow sleeve that makes all pump intake water flow over the motor at adequate velocity should be used (See Figure 1).
- If water temperature is higher than rated for the motor, the loading may have to be reduced or the installation reviewed with the pump manufacturer. All submersibles meeting NEMA (National Electrical Manufacturers Association) standard are rated for 25°C (77°F) water, and many are rated for full output at 30°C (86°F) or 40°C (104°F). Check manufacturer recommendations as some motors may be used in even hotter wells with reduced loading.
- It is important to note that only thermal protection inside a submersible motor can protect it against failure from lack of cooling described in a, b and c. Aboveground thermal protectors and overload relays commonly used with large motors only protect against over current, not overheating caused by lack of proper cooling.

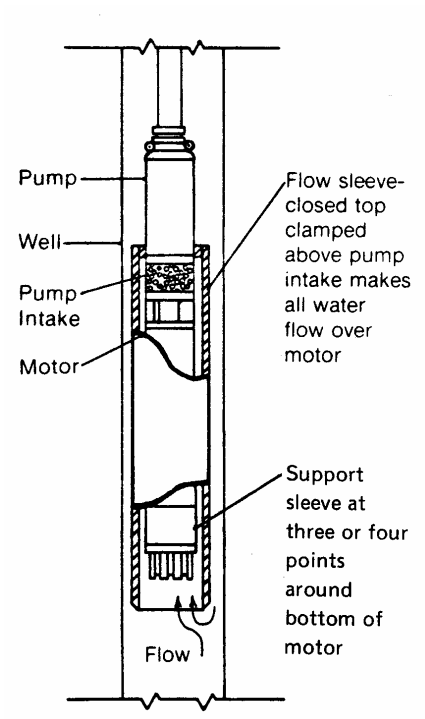

FIGURE 1. Flow Sleeve

Thermal protection: Submersible motors are typically furnished with thermal protection to prevent motor burnout or other damage from a locked pump, overloading or lack of cooling. Many small motors contain internal protectors which sense both current and temperature. These offer the best protection and require no matching with aboveground protective devices. Most lager motors contain no internal protection and depend on properly matched aboveground over current protection. In all cases, it is essential that motor manufacturer's protection recommendations be followed exactly to avoid the risk of motor burnout.

Grounding: Proper grounding of all aboveground metal plumbing (and the motor itself if operated outside a drilled well) is absolutely necessary to prevent electric shock hazard. All national, state and local electrical codes should be checked and followed. Some state and local codes require a ground wire directly attached to all submersible pump motors and will not approve new installations with-out it. All aboveground metal plumbing and electrical enclosures (and the motor if tested or used outside a drilled well) must be connected to the power supply grounding conductor with adequately sized wire. This will prevent an electrical fault from creating a shock hazard, and will trip the circuit fuse or breaker if a substantial ground fault occurs.

Operating the pump from a Ground Fault Interrupter (GFI) protected circuit provides added safety, and may be required in some areas.

Surge protection: Most electrical equipment is subject to damage from surges on power supply conductors. Submersible motors are particularly vulnerable if not properly protected. The potential for damage occurs when a surge creates a momentary high-voltage spike from one or more of the supply wires to ground. This can happen as a result of a nearby lightning stroke, switching of electrical equipment, or some circuit fault. If the voltage spike is higher than the system's insulation can withstand, it will arc to ground at the weakest point or points in the system. If this point is in the submersible motor, the motor may fail immediately or be weakened at that point and eventually fail. For this reason it is important that all submersible motors without their own internal lightning (surge) arrestors be furnished with arrestors above-ground to protect them from surge damage.

A surge arrestor acts as a relief valve. It momentarily opens when a surge occurs, preventing voltage from reaching a level damaging to the motor or other equipment, then recluses to continue normal operation. Proper grounding of the arrestor to the motor per manufacturer's instructions is a must. Without it, the arrestor may give the motor no protection at all.

Well conditions: The submersible is more tolerant of various well conditions than most other type pumps. However, there are important guidelines and limitations that will increase life and reliability.

- Sand can cause rapid pump wear, possible failure to start and occasional motor failure. A well in a sandy area should be constructed to provide sand-free water. When practical, it should be developed using another pump before installing the permanent submersible. When a submersible is installed in a sandy well, it should be kept running the first time it is turned on until the delivery is clear and free from sand. This minimizes the probability of sand locking the pump.

- Chemical content of the water can cause motor corrosion or heavy mineral deposits which, in turn, cause overheating. Corrosive conditions require a submersible motor built or modified to withstand such conditions. A motor with internal thermal protection should be used to protect against overheating from mineral deposits, or the pump should be pulled periodically to clean off deposits.

Duty cycle: Duty cycles vary widely depending on pump size, tank size, control switching and other factors. Motor may have recommended limits set by the manufacturer for allowable starts per day or per hour. Submersibles generally allow relatively rapid cycling without overheating because of their low inertia and rapid acceleration. However, every pumping system should be designed to minimize cycling as much as is practical. If cycling is excessive, stop-start stress and wear in the motor, pump, coupling, pipe and controls may have more influence than total pumping time has on system life.

Torque effects: Whenever the pump starts, the reaction of starting torque on the motor and pump frame creates a twisting effect on the supporting pipe. This can cause problems unless the installation is adequate to resist the torque.

- Torque can unscrew threaded pipe if not adequately tightened, especially on large three-phase pumps.
- Torque can cause the pump and pipe to “wind up” and rub or strike the walls of the well during starting, particularly in relatively deep settings or those using plastic pipe.

With repeated cycling, this can cause wear on the motor or supply cable, and a torque arrestor or similar device to lock the pump in the well may be needed to prevent damage.

Check valves: While most pumps are installed with positive check valves in the drop pipe or pump itself, some have limited leak-back-type valves or no valves at all. The following conditions should be considered to make sure no problems are created.

- A single check valve, or the lowest valve if more than one is used, should be installed so it can never be more than 25 feet above the water level in the well (See Figure 2). If the valve is set too high, when the pump turns off the weight of water in the pipe below the valve will cause it to drain down to 34 feet or less above the well water level. Space in the pipe between the valve and the water below it will become a vacuum (See Figure 3). When the pump starts, the water in the pipe will rapidly close this vacuum and strike the check valve and stationary water column above it, creating a “water hammer” impact that can damage valves, pipe, pup and motor.
- With no check valves, water will drain back through the pump when it turns off, maintaining a thrust in the pump as it comes to a stop and possibly starts to backspin. This can cause wear in sliding-type thrust bearings. The suitability of the motor and pump for operation without a check valve should be confirmed before installation.
- Many pumps are designed to operate only above specified minimum heads. If operated at lower head or higher flow, a pump may create upthrust and damage itself or the motor not specifically designed to handle upthrust. When installed with no check valves or with leak-back-type valves, a pump starts at no head and may run at least several seconds below specified minimum head before creating enough head to prevent upthrust. Suitability of the pump for this operating condition should be confirmed before installation with drain back operation. If necessary, a flow-limiting device should be adequate head during starting.

Supply cable: Proper type, size and connection of the electrical supply cable is essential for efficient, reliable service.

- Cable must be specifically rated for underground or underwater use. Unsuitable cable may cause failure.
- Cable should be the size recommended by the pump or motor manufacturer or larger. Smaller cable may violate the National Electrical Code and be rejected by government inspectors.

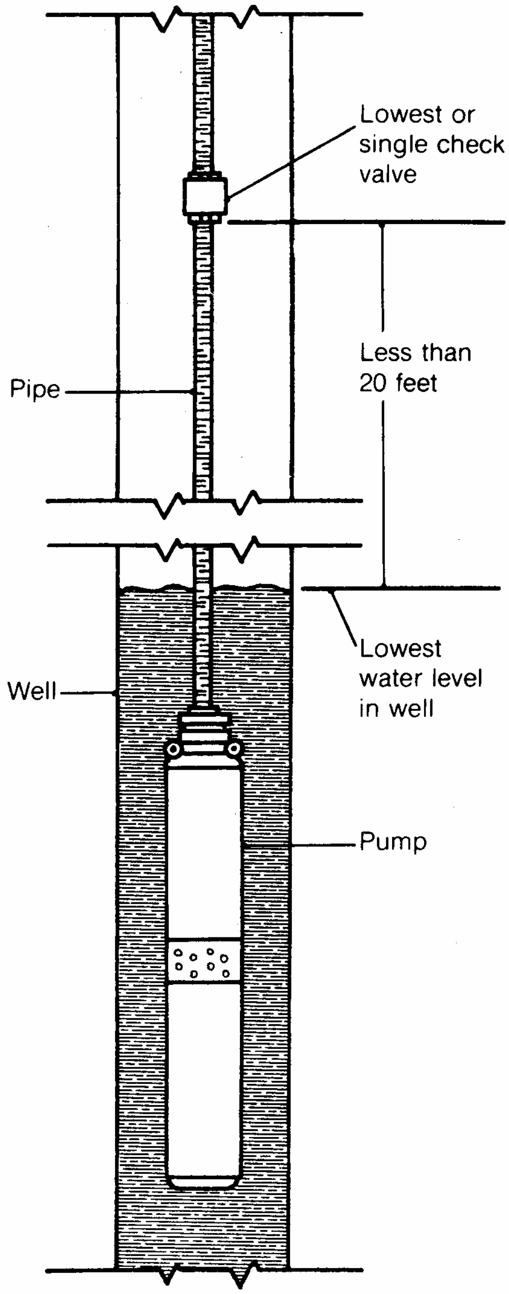

FIGURE 2. Correct Check Valve Location

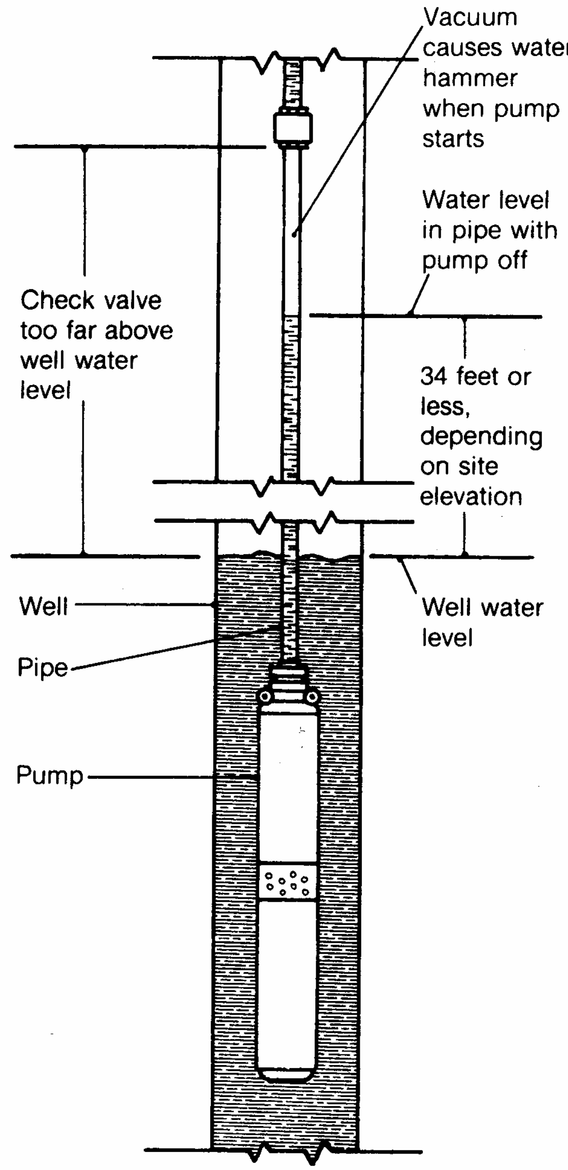

FIGURE 3. Incorrect Check Valve Location Causes Water Hammer

When installing long lengths of cable, larger than NEC size is required to maintain adequate voltage at the motor. Use of undersized cable in this situation will cause lower water delivery and efficiency, and may cause motor overloading and starting problems.

- Cable connections to motor must be clean, dry and properly tightened. Old cable and connectors should be replaced if they show signs of deterioration or damage.
- Cable must fit through the pump cable guard without cutting or pinching. Sharp edges must be removed or covered with padding to prevent cutting the cable.
- Splices in cable must be electrically sound and watertight. Only rosin core soldered joints or properly crimped commercial terminals should be used; crimped copper tubing and plain twisted connections are not adequate. Each joint must be insulated watertight with suitable tape, shrink tube, or resin potting at least as thick as cable insulation.

A leaky or high-resistance joint will eventually fail, requiring the pulling of the pump.

- Cable should be tightly fastened to the pipe at least every 20 feet. Clamps or straps should be used for heavy cable, and tape or straps for light cable. Loose cable may be damaged during installation or may wear through from rubbing against the wall during operation.

Power supply: Like other motors, submersibles require correct input voltage and frequency for reliable operation. The nominal voltage and hertz of the supply should match and motor nameplate, and voltage should check within 10 percent of nominal under running conditions. Three-phase supplies need balanced voltage to maintain current in each line within 10 percent of their average current during all normal operation. Check with the power company to correct low, high or unbalanced voltages which may cause low output, protection tripping, reduced efficiency, and other problems.

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