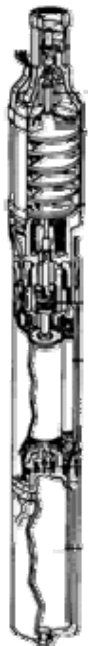


Submersible pumps are increasingly relied upon as a cost effective alternative to large vertical pumps. Submersible pumps are easy to install, easy to operate, and simple in construction. Unfortunately, they are also easy to misapply and abuse. This issue covers common submersible pump designs and some common, but easily avoidable, problems.

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Electric submersible centrifugal pumps (ESPs) are comprised of an electric motor close-coupled to a centrifugal pump operating in a partially or completely submerged environment. Submersible pumps are manufactured in both single and multistage configurations and are available in a broad range of sizes.

Submersible pumps are best suited for applications where the liquid depth exceeds 3-5m (~10-15ft). In shallower applications, simple, reliable designs such as cantilever pumps and self-priming pumps may be used. These alternative designs become less viable as sump depth increases. Self-priming pumps become ineffective because of lift and NPSH limitations and vertical pumps become less cost effective from both capital and maintenance cost standpoints. Submersible pumps are lighter in weight and require less foundation and lifting support infrastructure than large vertical pumps. Additionally, a large vertical pump has more wear parts and repairs are more labor intensive than for a comparably sized submersible pump.

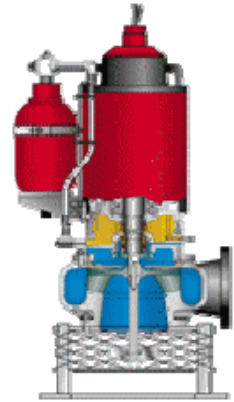


Submersible pumps are available in either wet or dry rotor designs. Wet wound motor designs typically are either water or oil filled and incorporate a simple sealing device to exclude sand and other solids. Water filled motors are wound with polymer encapsulated windings to prevent electrical failure. Water filled motors are simple motors that are easy to repair. The primary drawback is that the winding encapsulation system is more temperature limited than traditional insulation systems and any breach of the winding encapsulation will result in motor failure. Alternatively, oil filled motors have a traditional winding insulation system and rely on the dielectric (non-conductive) properties of the oil to prevent electrical failure. The windings can operate at higher temperatures but will fail upon contamination of the dielectric fluid by any conductive fluid (such as water). Wet rotor designs are very common in deep well and subsea applications and other applications where the motors are subject to very high external pressures. Their hydrostatic containment facilitates the balancing of high pressures without the need for more complex pressure containment or sealing systems.

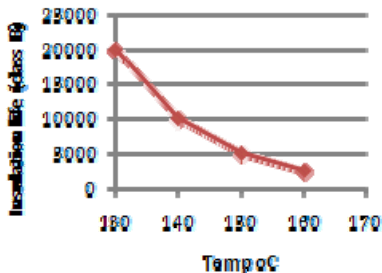
Dry rotor designs incorporate a dual mechanical seal arrangement with a dielectric oil filled chamber interposed between the mechanical seals. The motor rotor/stator operates with an air gap and is supported by rolling element bearings. The air gap allows the dry rotor design to operate at lower temperatures and higher efficiencies than similarly sized wet rotor motors because of the absence of fluid friction in the rotor/stator interface. The rolling element bearings provide a more stable operating

environment for mechanical seals than the journal bearings that are found in wet wound designs.

In either the oil filled or dry rotor design, electrical failure will occur if a conductive pumped fluid contaminates the motor housing chamber. Contamination may result through a breach of either the dynamic mechanical shaft seals or the static seals. Mechanical shaft seals fail for all of the same reasons that they fail in any other centrifugal pump: cavitation, air entrainment, improper assembly, and solids contamination being the most common causes. Static seals such as o-rings and gaskets may also fail due to scored surfaces or improper mounting. Next to the mechanical seals, the cable entry is probably the most common source of leakage. Cuts or nicks in the cable sheathing due to improper handling or failure due to chemical incompatibility of the cable sheathing materials are frequent causes of premature submersible failure.



Motor overheating is another avoidable cause of failure. Most submersibles are designed to receive cooling from the surrounding liquid. All submersible motors are rated for a maximum continuous winding temperature based upon the type of insulation system purchased. Heat buildup in an electric motor deteriorates the winding insulation over time. Overheating will exponentially accelerate the insulation deterioration process. A general rule is that a 10°C. rise in motor temperature will cut the insulation life in half. Any heat damage is cumulative, and will eventually result in winding and motor failure. Any submersible system must have a provision for adequate motor cooling or it will fail prematurely. Many submersible pumps channel the pump discharge around the motor housing for cooling. Where a pump uses the discharge stream to cool the motor, the pumping of sludge or other solids can plug cooling passages and create motor hot spots. Use of submersibles with pump discharge cooling should be avoided in applications where there is a risk of solids build-up.



Pump designs that rely on motor submergence for cooling limit the amount of time that the motor may operate in air without cooling (usually about 10min). Continuous in air motors are available if the sump design or process requirements are such that the motor is likely to be uncovered for longer periods. Continuous in air motors usually are over-sized for the power rating creating a power density so low that the motor is incapable of overheating in continuous operation. The trade-off is that because they are larger, continuous in air motors are significantly more costly than standard models of the same power rating.

Any of the failure modes discussed above can be prevented through due diligence in selection, operation, and maintenance. Given proper care submersible pumps are a lower cost alternative to large vertical pump designs both from the standpoint of capital expense and life cycle cost. Large vertical pumps are more forgiving of improper operation and maintenance than submersible pumps, and do not require any special skills such as motor rewinding to repair. However, there is a larger initial capital expense and higher labor and material costs for each repair.