YEOMANS
CHICAGO
CORPORATION

Submersible Non-Clog Pumps
Minimum Submergence Considerations

Proper design and operation of submersible pump systems necessitates consideration of minimum submergence requirements. The water level in the wet-well must normally be maintained at a minimum level for two primary reasons:

1- Prevention of motor overheating
2- Prevention of "vortexing" and associated problems

From experience, many customers recognize the concern about motor overheating but fail to understand the concern about prevention of vortexing and the associated pump damage that can occur. In this paper we will address both issues and offer recommendations to help prevent both problems.

1- <u>**Prevention of motor overheating**</u>

Conventional submersible non-clog pump motors are air-filled non-jacketed type designed to be cooled by convection heat transfer to the surrounding media. Typically, these motors are conservatively rated for continuous operation in a fully submerged condition or for at least 15 minutes in a non-submerged condition. The minimum recommended submergence to prevent overheating will normally be noted in the pump manufacturer's product information.

<u>A common question:</u>
"But what if my pump occasionally runs non-submerged for longer than 15 minutes? Will it overheat and be damaged"?

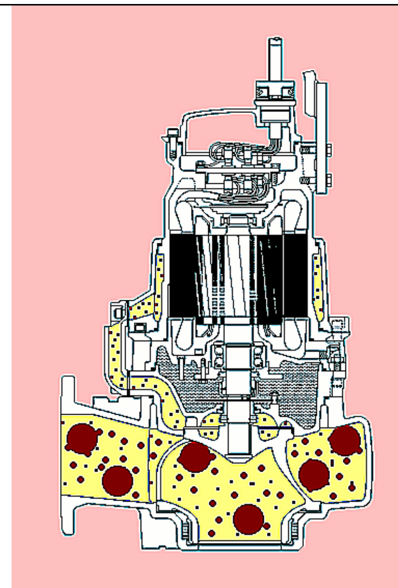
<u>Answer:</u>
No. Due to varying wet-well levels and inflow conditions, there may be occasions when the pump motor may be partially or fully non-submerged for periods longer than 15 minutes. To prevent any motor damage due to overheating, Yeomans pumps are equipped with three (3) normally-closed, automatic-reset thermostats connected in series and embedded in adjoining phases of the motor stator windings. Should the motor winding temperature rise excessively, the thermostats will open before the temperature can reach a level that can cause damage to the motor. When the thermostats open, power to the motor is interrupted. When the motor has cooled down, the thermostats automatically reset and the pump can resume normal operation. Caution: This should not be understood to mean that a submersible pump can be run for extended periods of time without adequate suction conditions, as that is detrimental to the pump seals.

For applications requiring the motors to operate in a non-submerged condition for sustained periods longer than 15 minutes, four (4) primary methods have been developed for motor cooling:

A- Oversizing of conventional submersible motors

For low horsepower applications, it is normally cost effective to utilize conventional non-jacketed submersible motors that are de-rated for continuous-in-air service. For example, a typical 7-1/2 HP, 4-pole non-jacketed submersible motor may, in some cases, be de-rated and nameplated at 5HP for continuous-in-air service. (The pump motor manufacturer should be consulted for any specific application.) For medium and larger horsepower size, this method is generally not cost effective.

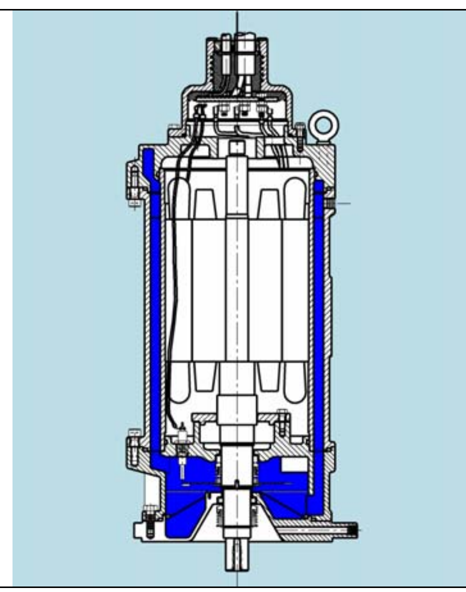
B- By-pass (pumpage-cooled) jacketed motor design

For medium and larger horsepower sizes, some manufacturers elect to offer by-pass (pumpage cooled) jacketed motor designs. These designs utilize an internal by-pass system to circulate the pumped liquid throughout the motor cooling jacket. For clean-water applications, this is an effective and reliable method for motor cooling. For dirty water or sanitary sewage applications, clogging of the cooling jacket passages can easily occur due to a build-up of solids, grease, corrosion and other matter. When this build-up and clogging occur, serious motor damage may result due to overheating and premature insulation failure. Periodic inspection and cleaning are required to prevent these problems.	

C- External water cooled jacketed motor design

When a reliable external source of clean, cool water is available, this type of system has proven to be an effective means of motor cooling. In most cases however, a suitable external water supply is not available or the cost of the clean water is prohibitive. Thus, this type of system has very limited applicability for most customers.

D- Closed loop cooled (self-contained cooling system) motor design

The closed-loop cooled jacketed motor design offers practical solutions to problems found with other designs. Initial cost is comparable to that of by-pass cooled or external cooled jacketed motor. The self-contained cooling system eliminates the need for an external water supply. The clear, environmentally safe cooling fluid eliminates clogging, associated maintenance and premature failure commonly associated with “pumpage-cooled” motors and makes this system the most cost effective when considering overall operating costs.	

2- **Prevention of surface "vortexing" and associated problems**

Inadequate submergence can result in pre-rotation of the water in the wet-well, resulting in the formation of strong free-surface air core vortices and the entrance of air into the pump suction inlet. This phenomenon is commonly called "vortexing".

"Vortexing" can cause unstable pump operation, vibration, pulsation and severe mechanical damage.

The U.S. based Hydraulic Institute has produced the following guidelines for recommended minimum submergence of the pump suction inlet to reduce the probability that strong free-surface air core vortices will occur:

S = Minimum submergence to prevent vortexing, in inches
D = Pump suction inlet diameter (available from the pump manufacturer), in inches
Q = Pump design flow rate, in USGPM
$S = D + [(0.574 \times Q) / D^{1.5})]$

Source: *American National Standard for Pump Intake Design*, Hydraulic Institute, ANSI/HI 9.8-1998, Section 9.8.7

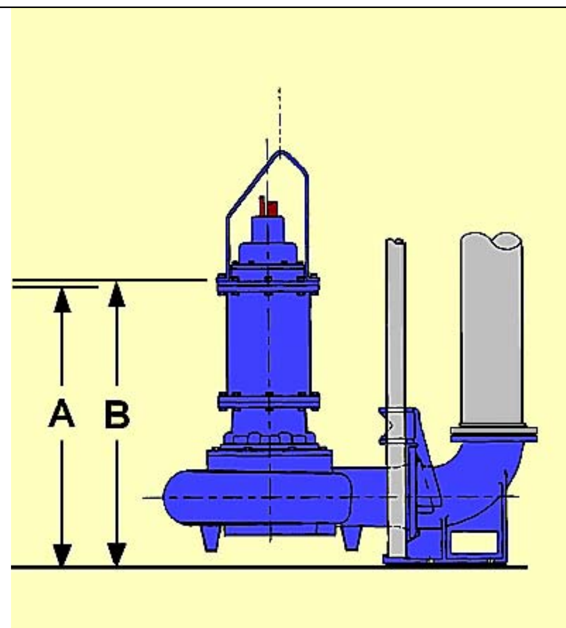
In most cases, the recommended submergence for prevention of free-surface air vortices is more than adequate to prevent motor overheating. The following illustration provides a typical example:

Typical 4" Submersible Non-Clog Pump with Guiderail Installation

Rated Capacity: 400 USGPM
Suction Inlet Diameter: 4"

A = 32.70" = Recommended submergence per ANSI/HI standards for prevention of "vortexing"

B = 33.25" = Distance from sump floor to top of motor stator housing



A common question:
"What if I operate my pump at a very low level for sump cleanout purposes?

Answer:
It is normally acceptable to pump the wet-well completely down for purposes of cleaning, inspection or maintenance. This is a common practice and should not result in any damage to the unit. Sustained operation at extremely low levels should be avoided to prevent premature pump seal damage from "vortexing".

Conclusions

Pump system designers and end-users should consider both motor overheating and prevention of "vortexing" (inadequate suction conditions) when designing systems and specifying non-clog submersible pumps, regardless of the preferred pump manufacturer(s). Proper consideration of both items will help the customer determine suitable sump pit dimensions and level control elevations.

For wet-pit installations, it is recommended that the low water level elevation be specified to meet or exceed the minimum submergence to prevent vortexing. In many cases it will be found that the minimum recommended submergence to prevent vortexing will be equal to, or greater than, the minimum submergence required to prevent overheating. This is particularly true if it has been confirmed that the submersible motor has been rated in strict conformance with NEMA standards as is recommended by the Submersible Wastewater Pump Association (SWPA). Thus, once proper anti-vortexing submergence is established, the concern about motor overheating will frequently be eliminated.

For applications that require continuous non-submerged operation, such as dry-pit submersible installations, it is recommended that the design engineer specify the motor type best suited for the intended service. For sewage or similar water-based mixtures containing solids, grease or fat, the closed-loop-cooled motor design is the preferred choice whenever the horsepower size required exceeds the practical limit for de-rating of conventional submersible motors.

Since all applications have specific requirements, the pump manufacturer should be consulted for verification of the proper application of their products and for recommendations of specific equipment for the intended service.

Prepared by D.W. Page / 11-1-00