Run Times
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**In addition to operation outside of a pump's stable operating range[1] or operating with insufficient NPSHA[2], vertical pump reliability is also often compromised by adverse inlet conditions. Insufficient submergence or high entrance velocities can also significantly reduce pump performance and bearing life.**

*Dale B. Andrews*
**Dale B. Andrews – Editor**

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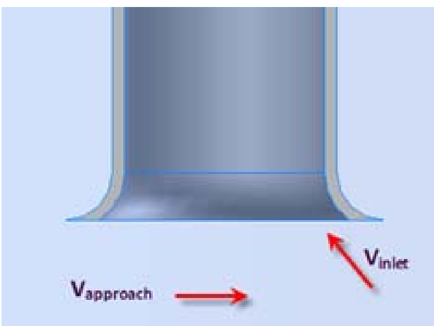


Centrifugal pumps generally have inlet velocities of 1.2 to 2.1 m/sec (4 to 7 ft/sec) with 1.7 m/sec (5.6 ft/sec) considered optimal for flows greater than 60 $m^3$/hr (264 gpm). Lower flows have a greater allowable range as there is less energy associated with lower flow rates. As a general rule, suction energy will increase with increased specific speed as the impeller inlet diameter approaches the impeller outlet diameter. Higher inlet velocities may be necessary in some special cases, such as where the user needs to keep solids from settling out. However, in most all cases inlet velocities should be kept under 4 m/sec (13 ft/sec).

Approach velocity to the pump should be as low as practicable. Recognizing that sump design is a compromise between cost and utility, the Hydraulic Institute has raised its recommended approach velocity from 0.3 m/sec to 0.5 m/sec (1 to 1.6 ft/sec). Approach velocity angles are often at $90^o$ or more with respect to the pump inlet velocity. The greater the differential in either speed or direction between the approach flow and the inlet flow, the more likely it is that turbulence at the inlet nozzle will occur. Inlet turbulence can cause cavitation or otherwise disrupt the hydraulic balance of the impeller and result in unwanted bearing loads or impeller damage. Pumps installed in a row with the supply coming from one end should have lower approach velocities (~0.3 m/sec (1 ft/sec) to minimize eddy currents around the pump bodies). Additionally, sumps should be sized such that the last pump in series does not violate the approach velocity guidelines.

Adequate submergence and clearance from adjacent structures is important to avoid the formation of vortices. Vortices may take the form of a liquid core vortex originating

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[1] See our February 2006 newsletter for allowable operating ranges
[2] See our June 2009 newsletter on suction energy and NPSH margin.

from an adjacent surface such as the sump floor or wall, or it may be a free surface vortex that originates at the fluid surface. Depending on its severity, a surface vortex may have a liquid core or an air core. Both liquid and air vortices can be highly damaging to a pump. Like tornadoes, their path is unpredictable. A vortex may extend down into a tailpipe inlet and continue all the way up into the impeller eye. Vortices can vary randomly in speed, and direction, creating disruption of flow into the impeller passages. Disruption of flow into the impeller vane passages will cause vibration and high cyclic radial and axial loads on a pump. If the vortex has an air core, it will not only result in adverse bearing loads, it will also rob pumps of capacity and efficiency. Most centrifugal pumps can tolerate 2-3% of entrained air, and still operate, albeit with some performance penalty. Between 5% and 10% entrained gas traditional centrifugal pumps will lose prime.

The submergence at which a pump will form a surface vortex is called the critical submergence. The minimum submergence of a pump must be at a depth greater than the critical submergence. Chart 1 shows recommended values for suction bell diameter, and submergence for various flow rates to avoid damaging surface vortices. The distance from the floor of the sump to the suction inlet should be between 0.3 and 0.5 times the inlet diameter. Other clearance dimensions for numerous sump configurations are provided in the Hydraulic Institute Standards (see references).

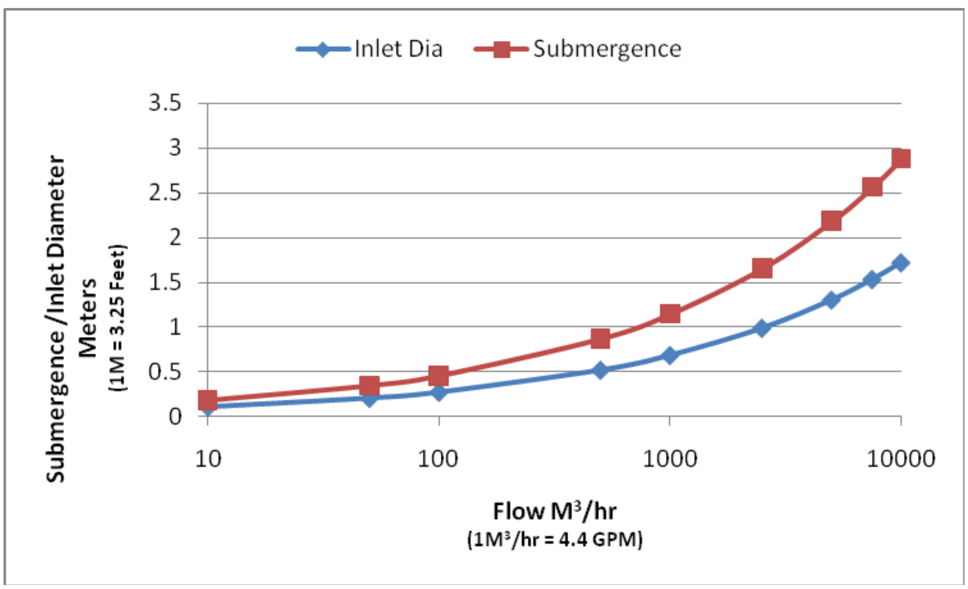


Chart 1

Clearance from adjacent structures and submergence depth can be reduced through the use of devices such as splitters and crosses (vortex breakers) to disrupt vortex formation. Such devices can reduce the required submergence depth by 10% to 25% than the values shown.

Modifications within an existing installation are going to be limited by the physical constraints of the sump. However, improvements may still be made through the installation of suction bells and vortex breakers, and by changing the minimum operating submergence. Any installation regularly experiencing vibration and pre-mature bearing failure in a vertical pump should be evaluated for 1) operation outside of the pump stable operating range, 2) insufficient NPSHA; 3) high approach/inlet velocities; and 4) inadequate submergence.

*References:*

*Centrifugal Pumps*, Johann Gülich, (ISBN 978-3-540-73694-3), Springer-Verlag Heidelberg (2008).
*Centrifugal/Vertical Pump Intake design*, (ANSI/HI 9.8), (ISBN 1-880952-26-2), Hydraulic Institute