Run Times
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Understanding the suction requirements of vertical centrifugal pumps can save on both capital budgets and maintenance expenses. This month's issue explores the hydraulic considerations for starting and operating vertical sump and tank-mounted pumps.

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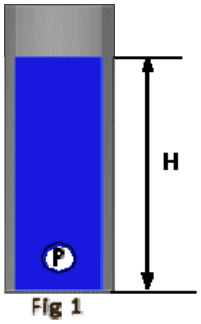


Fig 1

Any discussion about vertical pump priming needs to begin with suction head[1]. Suction head[2] is the term used to define the fluid energy available at the impeller eye. In the absence of any velocity, suction head is equal to the height of a static column of fluid that could be supported by the pressure (P) measured the impeller eye. The static head (H) as depicted in figure 1 is the ratio of pressure to the density (specific weight) of the fluid being pumped. If the fluid is in motion, there is kinetic energy associated with fluid velocity. This is referred to as the velocity head. The sum of velocity head and suction head at the impeller eye is the Total Suction Head.

Fluid enters a centrifugal pump because suction head forces the fluid into the impeller passages. Centrifugal pumps cannot pull (or suck) fluid. Fluids are for practical purposes inelastic. Whenever any force is applied to a fluid to induce motion there is no tendency for the fluid particles to return to their original position when released[3]. There is no pull on the upstream fluid from the action of the impeller. To offer a practical analogy, one cannot remove all of the fluid from a full gallon bucket by grasping hold of a fist full of fluid and lifting.

A very important term that defines the amount of suction head available to a centrifugal pump is Net Positive Suction Head Available (NPSHA). NPSHA is expressed in absolute pressure terms with atmospheric pressure head added to the suction head to arrive at the NPSHA. Atmospheric pressure varies with time and location but for estimation purposes we

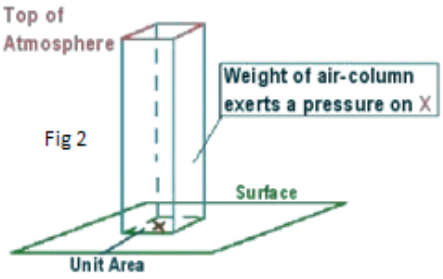
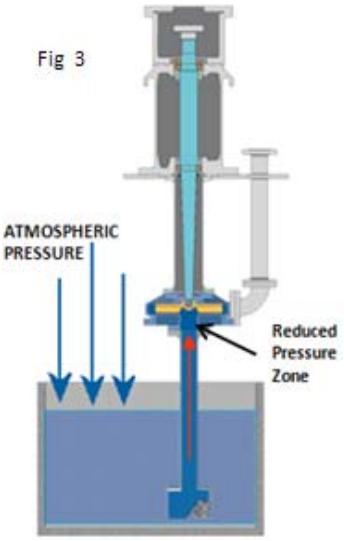


Fig 2

[1] Not to be confused with Total Dynamic Head (TDH) which defines the energy supplied to the liquid by a pump.
[2] Head is independent of the type of fluid being pumped and is usually expressed in feet or meters.
[3] Elasticity should not be confused with viscosity which is a fluid's resistance to shear. A fluid's resistance to shear retards fluid flow, but there is no elasticity.

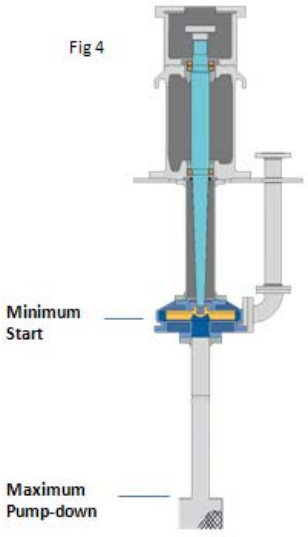
can use 14.7 psia[4], 34 feet, or 10.4 m (Fig 2). It is very important to understand that a vacuum gage measures a reduction in atmospheric pressure. Absolute vacuum is a total absence of atmosphere or zero PSIA. Any pressure above absolute vacuum is pressure that is available to push fluid into the impeller eye.



Fluid always moves from high pressure areas towards low pressure areas. When a centrifugal pump operates, the rotating impeller accelerates fluid outward. This fluid acceleration lowers the pressure at the impeller eye and, because the suction line pressure is higher than the pressure in the eye, fluid flows from the suction line into the impeller eye (Fig 3).

Every fluid has a vapor pressure defined as the absolute pressure that a fluid will boil at for any given temperature. For water at 100°c (212°f), the vapor pressure is 14.7 psia or about 101 kPa. At lower temperatures the vapor pressure is reduced. The margin with which a pump can operate without cavitation[5] is the difference between the lowest pressure at the impeller eye and the vapor pressure of the fluid. This is the NPSHA. Through testing, pump manufactures establish a characteristic of the Net Positive Suction Head Required (NPSHR) for their pumps to operate without suffering severe performance loss. It is imperative for pumps to be operated with an NPSHA greater than the manufacturer's published NPSHR values. Failure to do so will result in reduced operational life and loss of performance.

When a vertical centrifugal pump is started two conditions must exist in order to pump. First, the fluid level must be high enough to immerse the impeller eye (Fig 4). Secondly, there must be sufficient NPSHA for the pump to operate without cavitation[6].



If the impeller is not covered the pressure at the eye never becomes low enough for atmospheric pressure to push fluid into the impeller. Air or gas around the impeller easily recirculates from the discharge of the impeller back to the suction preventing any substantive pressure drop at the impeller eye. This is why standard centrifugal pumps are not self-priming[7].

[4] Pounds per square inch absolute

[5] Cavitation is the vaporization of a fluid and its subsequent violent implosion. For r... our October 2004 newsletter.

[6] When dealing with boiling fluids with a vertical pump assume the NPSHA is approximately the submergence of the impeller. Vapor pressure equals atmospheric pressure so submergence is the only suction head available. There may be some additional losses associated with a suction pipe or other geometry, but this is a good rule for most pump installations.

[7] For the principles of operation and limitations of self-priming pumps see our June 2008 issue.

Once a vertical pump starts to pump it can lower the fluid level in a sump until A) the pump pulls air or vapor into the suction inlet, B) performance is lost because of insufficient NPSHA, C) discharge pressure can no longer overcome system pressure, or D) air or gas is pulled into the eye from back side of the impeller[8].

Understanding these principles can generate significant capital savings. If operation permits flexibility of operating levels the purchase of a short setting pump with a tail pipe can be a significant savings over a full length unit. Operationally, it is merely a question of ability to dictate the start-level of the pump and having sufficient NPSHA for pumping the sump or tank level down using a tailpipe.

[8] This can happen with open column style pumps such as cantilever pumps when they are equipped with open style impellers or impeller s with thrust balance holes.