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ON LINE WITH
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From the Desk of Mike Bell

This issue of On-Line provides an article on pump NPSH and some details on our new website.

As a young engineer I had a difficult time obtaining a satisfactory explanation of NPSH for a pump. Part of the difficulty in understanding NPSH is because the terms are expressed in absolute pressure rather than gauge pressure which we are more accustomed to dealing with. The article has been written with the hope that it will help young and not so young engineers in a basic understanding of pump net positive suction head (NPSH).

We have had a preliminary version of our website for sometime. However, we have been busy on projects and slow to complete the site. The website is finally complete and we invite everyone to visit it in the hope you will learn more about Mar Tech Engineering. Additionally, this edition of the newsletter is available for viewing and downloading from the website. At some point in the future we may issue new newsletters on the website rather than print hard copies. If you would like to receive notification of new online newsletters please reply to me with your e-mail address and any comments you might have.

Mar Tech has updated its' method of handling e-mail. Our computers have been networked for some time but all our e-mail has gone to one location in the office. This has been changed so each engineer and designer will have his or her own e-mail address. My new e-mail address is mike.bell@martecheng.com. Please contact us for any other desired e-mail addresses. The old e-mail address of martech@iamerica.net will be kept operational until the transition is complete.

Website

The new Mar Tech Engineering website can be found at www.martecheng.com. The website provides profiles of our experience and details some of our capabilities in different industries: chemical, pulp & paper, and wood products. Our most recent newsletter is available for viewing and downloading. The different industry profiles can also be downloaded for distribution if desired.

IN THIS ISSUE

Determining Pump Net Positive Suction Head

By Mike Bell P.E.

INTRODUCTION

Centrifugal pump Net Positive Suction Head (NPSH) is a subject that few engineers are taught in college. Or, if they were, it probably was not explained in a way that the engineer could apply it to the world in which he works. However, at least a general understanding of this subject is indispensable for the person involved in process plant pump selection.

When liquid flows through a pipe or piece of equipment, frictional resistance between the liquid and material surface develops which causes a pressure loss for the liquid. This same pressure loss occurs through the pump suction piping and pump casing entrance. If the pressure drop becomes so great that the liquid pressure drops below its vapor pressure, then the liquid will vaporize and cavitation will likely occur.

CAVITATION

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Conditions leading to cavitation occur when the liquid vaporizes in the pump inlet. As the vapor-liquid continues into the eye of the pump's impeller, vapor bubbles form until the pump energizes the liquid and its pressure increases above the vapor pressure. As the pressure increases, the vapor bubbles collapse releasing energy that erodes material from the pump, usually on the backside of the impellers. Initially, damage appears as small pits. However, as the problem worsens large holes eventually emerge in the affected area.

NPSH AVAILABLE

Every system supplying the suction of a pump (composed of pipe, valves, fittings, instruments, tank, etc.) has an available NPSH, and every pump has a required NPSH. To prevent a liquid from vaporizing, the NPSH available from the system ($NPSH_a$) must be equal to or greater than the NPSH required ($NPSH_r$) by the pump. Note that all terms are expressed in terms of absolute pressure in feet of liquid.

To determine $NPSH_a$ of a system under consideration, the following formula should be used:

$$NPSH_a = H_p + H_s - H_f - H_{vpa}$$

Where: $NPSH_a$ = NPSH available from the system.

H_p = absolute pressure in feet of liquid on the liquid's surface in the suction vessel. If a positive pressure is maintained on the vessel such as with a nitrogen blanket, then this value is increased. If a vacuum is pulled on the liquid level then the value is decreased.

H_s = static elevation of liquid with respect to the centerline of a horizontal pump, in feet of liquid. If the liquid level is above the centerline (suction head), then this value is a positive number. If the level is below the centerline (suction lift), it is a negative number.

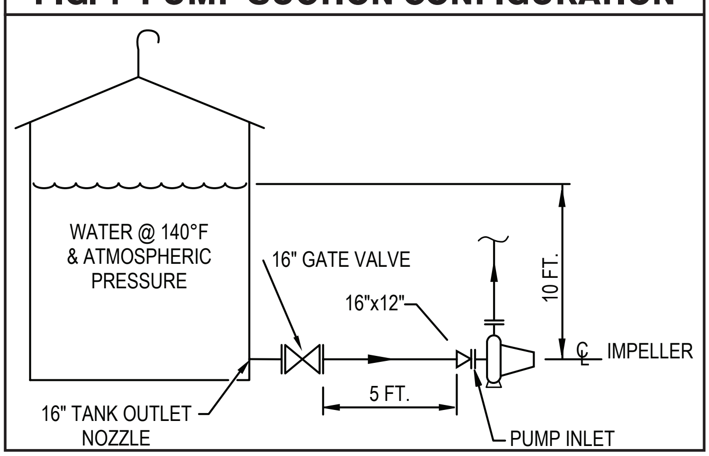
H_f = friction head in feet of liquid caused by losses through the suction pipe, valves, instruments, suction vessel discharge nozzle, etc. As the above formula shows, this value is always a negative number such that it subtracts from NPSHa.

H_{vpa} = liquid vapor pressure in feet of liquid at the pumping temperature. This value is obtained from the steam tables for water. Appropriate sources and Perry's should be consulted for the vapor pressure of other fluids.

Example

The following example illustrates the use of each term (See Figure 1):

FIG. 1 PUMP SUCTION CONFIGURATION



A pump takes suction from a tank operating at atmospheric pressure. Four thousand gpm of water is pumped at 140° F, and the liquid level in the tank is 10 feet above the centerline of the pump. The pump total dynamic head has been calculated to be 150 feet of liquid. The installation is located near sea level altitude. Determine the $NPSH_a$ for the system.

Absolute pressure for this system (H_p) is atmospheric pressure. Atmospheric pressure at sea level is 14.7 psia (Note that the atmospheric pressure changes at various altitudes). To convert this to feet of liquid, multiply psia by 2.31 and divide by the liquid's specific gravity. In this case,

H_p = 14.7 psia x (2.31/0.98) = 34.65 feet of liquid.

Static Elevation H_s

Water static elevation (H_s) is 10 feet of liquid. Since the liquid level is above the pump horizontal centerline (static head), this term is positive in the $NPSH_a$ formula. In normal practice the reader will want to use the lowest liquid level anticipated. This will provide a lower and more conservative value of the $NPSH_a$. Typically a minimum operating level of 3 feet is assumed for most applications.

Friction Loss H_f

Friction losses (H_f) will be encountered through the various piping components. Loss values for the different fittings may be found in any of several sources. The following numbers are representative, given in terms of equivalent lengths of pipe:

16" nozzle entrance = 23.0 feet (equivalent length)
16" gate valve = 9.5 feet (equivalent length)
16" x 12" reducer = 9.5 feet (equivalent length)
16" diameter pipe, 5 feet long = 5.0 feet
Total Equivalent Length of Pipe = 47.0 feet

H_f = Total Equivalent Length of Pipe x (Friction Loss/100 feet)

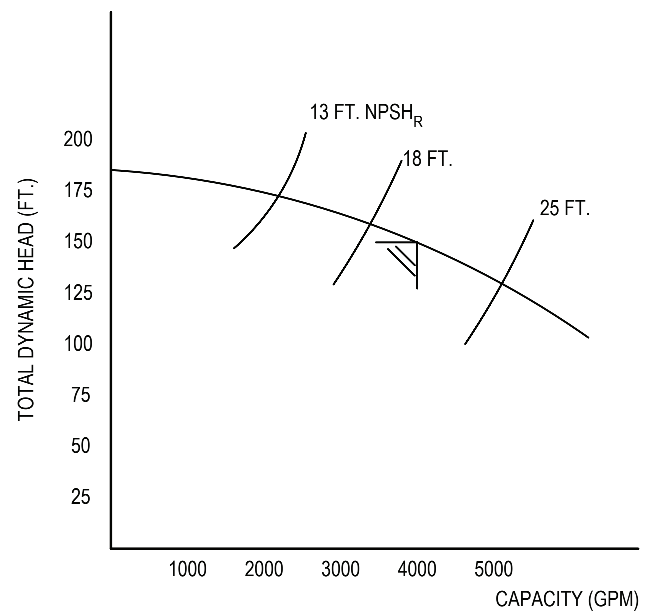
H_f = 47.0 feet x (1.20 feet/100 feet) = 0.56 feet

Vapor Pressure H_{vpa}

Water vapor pressure (H_{vpa} at 140° F) is 2.889 psia

H_{vpa} = 2.889 psia x (2.31/0.98) = 6.81 feet of liquid

FIG. 2 PUMP PERFORMANCE CURVE



$NPSH_a$ Summary

$NPSH_a = H_p + H_s - H_f - H_{vpa}$ =
(34.65 + 3.0 - .56 – 6.81) = 30.28 feet

PUMP SELECTION

Now that the system $NPSH_a$ has been found, a suitable pump may be selected which will operate under the described conditions. Pump data or curves are available from pump manufacturers, which give the $NPSH_r$ at various flow rates and total dynamic heads (See Figure 2). From this pump performance curve at 4,000 gpm and 150 feet TDH, the $NPSH_r$ is approximately 20 feet, which is less than the $NPSH_a$. This provides a satisfactory pump NPSH selection. As long as the pump $NPSH_r$ is less than the $NPSH_a$ calculated by the above procedure, the pump should have sufficient net positive suction head.

However, having performed the general procedure to determine NPSH, a couple of precautions are in order. If more than one operating condition is anticipated so that the pump will function at more than one point on its performance curve, the reader must repeat the above calculation to see if the system's $NPSH_a$ is greater than the pump's $NPSH_r$ for all conditions. If a pump has a suction specific speed over 11,000 then the pump must operate close to the best efficiency point for the

Continued on Page 4

Determining Pump Net Positive Suction Head, Continued

particular impeller selected. Otherwise, even if $NPSH_a$ is sufficiently higher than $NPSH_r$, cavitation may result from hydraulic recirculation.

CONCLUSION

Applications that are especially prone to NPSH problems are those that have low $NPSH_a$ values. A difficult installation often occurs when the liquid operating temperature is relatively close to the boiling point such as hot condensate or boiler feed water service. High temperatures cause high vapor pressures and sufficient suction-side pressure may not be available to generate an adequate $NPSH_a$. Also, those services that require suction lift generate lower $NPSH_a$ values and may require attention to the proper pump selection.

The guidelines presented in this article provide a safe beginning to solve most pump NPSH problems that may be encountered.

Opportunity doesn't just knock here... It also puffs, pings, and rattles!

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