FLUIDE DESIGN

MORE ON WHAT IS CAVITATION? (cont.)

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February 2003

Net Positive Suction Head Required (N.P.S.H.R.)

The N.P.S.H. required provides us with the level of head in terms of feet of water absolute required at the pump suction flange. When that level of head is insufficient the capacity and head of the pump will drop and cavitation will occur.

How do the pump manufacturers measure N.P.S.H. required?

The pump manufacturers measure the N.P.S.H. required in a test rig similar to that shown in Figure 6. The system is run in a closed loop where flow, total head and power consumed are measured. In order to provide a low N.P.S.H., a vacuum pump is used to lower the pressure in the suction tank that will provide a low head at the pump suction. The pressure in the suction tank is lowered until a drop of 3% (see figure 7) of the total head is measured. When that occurs the N.P.S.H. is calculated and recorded as the N.P.S.H. required for that operating point. The experiment is repeated for many operating points. Heating coils are also used to increase the water temperature thereby increasing the vapor pressure and further lowering the N.P.S.H. as needed.

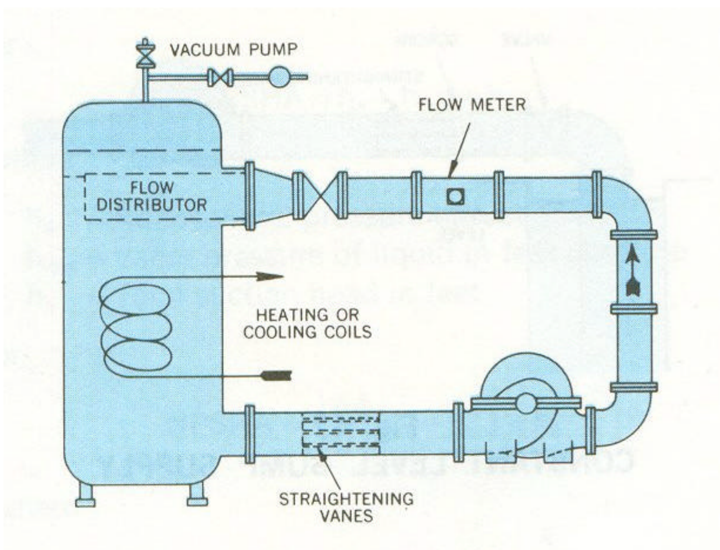

Figure 6 Test rig used to measure N.P.S.H. required (courtesy of the Hydraulic Institute www.pumps.org).

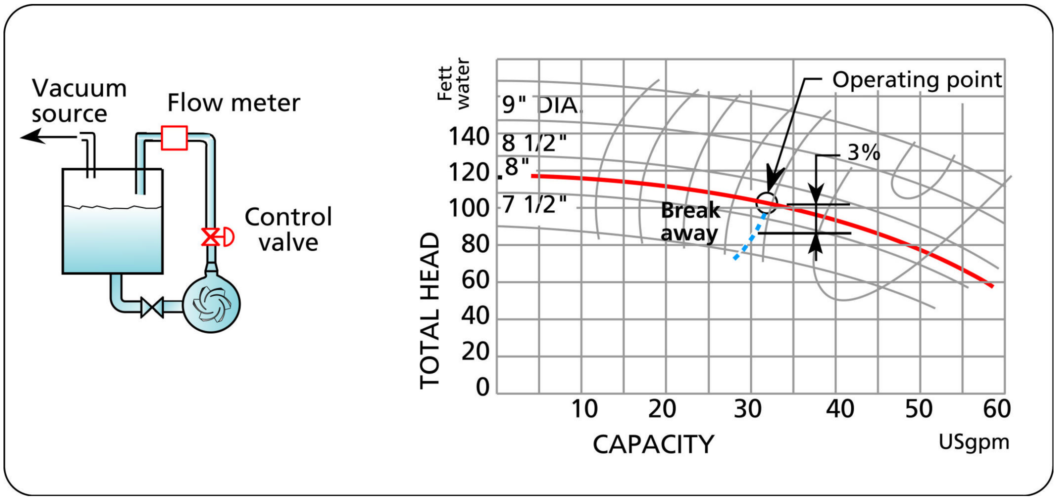

Figure 7 Measuring the drop in head to define the N.P.S.H. required at that operating point.

Guideline for the level of N.P.S.H. available

As stated, a total head drop of 3% is the criteria for setting the level of N.P.S.H. required. Since this results in a performance drop the user should ensure that there is a higher N.P.S.H. available. The recommendation that you will find in the literature is to have 5 ft of water absolute or a 15% margin above the N.P.S.H. required whichever is greatest.

How can the N.P.S.H. available be increased and cavitation avoided?

Table 1 gives the major components of N.P.S.H. available and how they affect the level of N.P.S.H. available.

The N.P.S.H. available depends on:	Effect on N.P.S.H. available.
1. The friction loss in the pump suction line.	The higher the friction loss, the lower the N.P.S.H. available.
2. The height of the suction tank fluid surface with respect to the pump suction.	The lower the height of the fluid surface, the lower the N.P.S.H. available.
3. The pressure in the suction tank.	This cannot be changed for atmospheric tanks. For tanks that are pressurized, the lower the pressure, the lower the N.P.S.H. available.
4. The atmospheric pressure.	This cannot be changed and depends on the elevation above sea level. The lower the atmospheric pressure, the lower the N.P.S.H. available.
5. Fluid temperature.	An increase in fluid temperature increases the vapor pressure of the fluid which decreases the N.P.S.H. available.

Table 1. How to affect the N.P.S.H. available.

How can you measure N.P.S.H. available?

It is easier to measure N.P.S.H. available than to calculate it, here's how it's done.

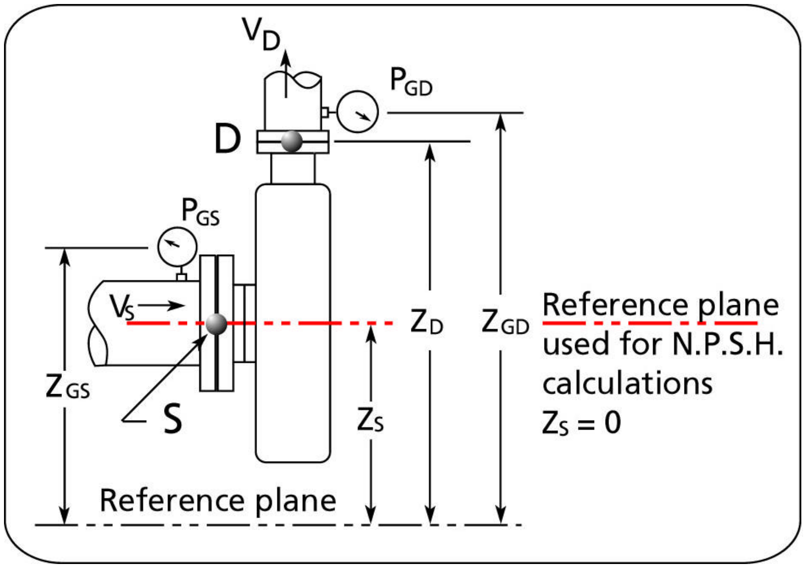

Figure 8 Location of the pressure gauges to measure N.P.S.H. available.

By definition, the NPSH available is the specific energy or head at the pump suction in terms of feet of fluid absolute, minus the vapor pressure of the fluid. According to equation [4], the head at point S is:

$$\bar{E}_S = H_S + \frac{v_s^{\,2}}{2g} \qquad [4]$$

The value of H_S is :

$$H_S = 2.31 \frac{p_{GS}\,(psig)}{SG} + z_{GS} - z_s \qquad [10]$$

Where the elevation difference $z_{GS} - z_S$ compensates for the height of the pressure gauge above the pump centerline.

By substituting the value of H_S from equation [10] into equation [4} we obtain:

$$\bar{E}_S = 2.31 \frac{p_{GS}\,(psig)}{SG} + z_{GS} - z_s + \frac{v_S^2}{2\,g} \qquad [11]$$

Since *N.P.S.H.* is in feet of fluid absolute, the value of the atmospheric pressure head must be added to $\bar{E}_S$ and the vapor pressure of the liquid (H_{va}) is subtracted to get the *N.P.S.H.* available.

$$NPSH_{avail}\ (ft\ fluid\ absol.) = \bar{E}_S + H_A - H_{va} \qquad [12]$$

By substituting equation [11] into [12] we obtain:

$$N.P.S.H.\ avail(ft\ fluid\ absol.) = 2.31\frac{p_{GS}(psig)}{SG} + z_{GS} - z_s + \frac{v_S^2}{2g} + H_A - H_{va} \qquad [13]$$

Or if the atmospheric and vapor pressures are available in terms of psi, then:

$$NPSH_{avail}\ (ft\ fluid\ absol.) = 2.31\frac{p_{GS}(psi)}{SG} + \frac{v_S^2}{2g} + z_{GS} - z_S + 2.31\frac{(p_A - p_{va})}{SG} \qquad [14]$$

What is the difference between the N.P.S.H.A. of equation [13] vs the N.P.S.H.A. of equation [8] which is restated here below:

$$N.P.S.H._{avail.}(ft\ fluid\ absol.) = -(\Delta H_{F1-S} + \Delta H_{EQ1-S}) + \frac{v_1^2}{2g} + (z_1 - z_s + H_1) + H_A - H_{va} \qquad [8]$$

Equation [8] corresponds to the NPSH available that is calculated according to the amount of specific energy or head available at the pump suction, which depends on the static head in the reservoir minus the friction head in the suction line. However equation [13] is the NPSH available based on a pressure measurement at the suction of the pump or point S. The head available at point S is generated by the static head less the friction head loss in the suction line; their contribution to pressure at point S is included in the pressure measurement.

Why is the velocity head at the pump suction required in equation [13], but not in equation [8]? In equation [8] the velocity energy was considered but cancels out during the development of the equation so that it does not appear in equation [8].