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		PROPRIETARY INFORMATION - For Authorized Company Use Only	

SCOPE

This section consolidates most of the background information on net positive suction head (NPSH) needed to design pumping services. Estimating data on the NPSH requirements of centrifugal and positive displacement pumps are included in [Sections X-A Pumping Service Design Procedures](#) and [X-F Positive Displacement Pumps](#), respectively. ⁽¹⁾

REFERENCES

API 610 Centrifugal Pumps for Petroleum Heavy Duty Chemical, and Gas Industry Services.

Cameron Hydraulic Data, Ingersoll Rand.

Karassik, I. J., Krutzsch, W. C., Fraser, W. H., and Messina, J. P., *Pump Handbook*, Second Edition; McGraw Hill, 1986.

Stepanoff, A. J., *Centrifugal and Axial Flow Pumps, Theory, Design and Application*, Second Edition; John Wiley & Sons, 1957.

Welch, H. J., *Transamerica Delaval Engineering Handbook*, Fourth Edition; McGraw Hill, 1983.

DEFINITIONS

Cavitation - the formation and subsequent collapse of vapor-filled cavities in a liquid.

Head - the amount of energy per unit mass of a liquid. It is expressed in an equivalent column height of the fluid pumped; e.g., feet or meters.

Net Positive Suction Head Available (NPSH_A) - The total suction head, in feet (meters) of liquid absolute, determined at a datum elevation, minus the vapor pressure of the liquid in feet (meters) absolute.

Net Positive Suction Head Required (NPSH_R) - the reduction in total head as the liquid enters the pump. This includes losses due to friction and turbulence. The NPSH_A must always be greater than the NPSH_R to avoid cavitation.

BACKGROUND

In designing pumping systems, NPSH_A and NPSH_R are important considerations. The available NPSH (NPSH_A) is calculated by the designer and is the total suction head, in feet (meters) of liquid absolute, determined at a datum elevation, minus the vapor pressure of the liquid in feet (meters) absolute. The required NPSH (NPSH_R) is determined by manufacturer testing and is the total absolute head above vapor pressure required at the pump inlet flange, foundation top, or shaft centerline for satisfactory operation at the specified operating conditions. **The NPSH_A must always be greater than the NPSH_R.** This ensures that the fluid will not cavitate inside the pump.

CAVITATION

DEFINITION

Cavitation is a process which involves the formation and subsequent collapse of vapor-filled cavities in a liquid. In pumps, the cavities are formed when the total pressure of the liquid falls below the vapor pressure due to the dynamic action of the impeller in centrifugal pumps, the plunger in reciprocating pumps, or the rotor in rotary positive displacement pumps. As energy is added to the fluid by the impeller, plunger, or rotor the pressure increases, causing the vapor cavities to collapse or implode. The forces created by the bubbles collapsing can be large enough to cause severe damage if the collapse occurs near a solid surface.

Exposure to cavitation can have the following effects on pumps:

- High vibration and noise caused by the implosions, which sounds as if there is gravel in the pumps
- Reduced capacity due to the vapor present
- Cavitation erosion or pitting on the internal metal surfaces
- Losses in pump head and efficiency and erratic power consumption

Note:

(1) Pump data sheets specify pressure in psi, bar, and kPa. In this section, bar is the metric unit used for pressure.

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CAVITATION (Cont)

MECHANISM

In all pump types, the fluid incurs losses as it flows from the inlet flange to the impeller, rotor, or cylinder. The losses result in a decrease in the total pressure. If the total pressure is reduced to that of the fluid vapor pressure, vapor pockets will form. The pockets of vapor begin to affect the whole field of flow and result in a sharp drop in pump performance.

The bubbles are eventually swept into regions of high pressure where they collapse. This rapid condensation causes liquid surrounding the bubbles to hit the walls of the pump or adjacent liquid. The repeated action of bubbles forming and collapsing near solid surfaces leads to the effects listed above.

NPSH AVAILABLE

To avoid cavitation, the $NPSH_A$ of the system must be greater than the $NPSH_R$ of the pump. $NPSH_A$ is calculated using the following equation:

$$NPSH_A = h_p - h_{vpa} + h_{st} - h_{fs} - h_a$$

where: h_p - absolute pressure head in feet (meters) on the surface of the liquid supply level.

h_{vpa} - Vapor pressure of the liquid converted to feet (meters).

h_{st} - Static height in feet (meters) difference between liquid level and established pump datum. It is positive if the liquid level is above the pump datum and negative if the liquid level is below the pump datum. The liquid level used should be the minimum operable liquid level for the vessel. The pump datum level is arbitrarily set 2 ft (0.6 m) above the grade datum level. See [Section X-A, Suction Pressure and NPSH](#) for more information.

h_{fs} - All suction line losses converted from pressure to feet (meters) including piping entrance losses and friction losses through the pipe, valves, fittings, permanent strainers where specified, etc.

h_a - Acceleration head for reciprocating pumps only. It accounts for head losses due to pulsation in the flow. See [Section X-F NPSH Available-Acceleration Head](#) for information on how to calculate this value. ($h_a = 0$ for centrifugal and rotary pumps).

Pressure is converted to head in feet and meters using the following equations:

$$\text{Head (ft)} = \frac{\text{pressure (psi)} \times 2.31}{\text{Spec. Grav.}}$$

$$\text{Head (m)} = \frac{\text{pressure (bar)} \times 10.2}{\text{Spec. Grav.}}$$

Note: For reciprocating pumps, the $NPSH_A$ is specified both with and without the acceleration head h_a . See [Section X-F NPSH Available-Acceleration Head](#) for more information.

SAFETY FACTOR

When calculating $NPSH_A$, a safety factor is used to further ensure cavitation free performance of the pump. The safety factor is defined as follows:

$$\text{S. F. NPSH} = \frac{NPSH_{A \text{ Calculated}}}{NPSH_{A \text{ Specified}}}$$