

Cavitation is a recurring cause of premature pump failures that result from related seal, bearing, and impeller damage. In this issue we discuss the fundamentals of cavitation and the selection of pumps to avoid it.

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In our July newsletter on Inducers, we described the occurrence of cavitation in a centrifugal pump as follows:

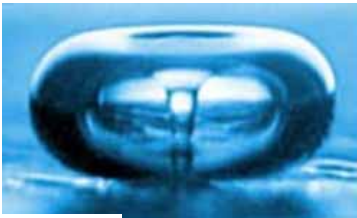


Fig 1

Vapor bubbles form in a pump inlet whenever the local absolute pressure of the liquid falls below its vapor pressure. These bubbles collapse rapidly and violently when the local absolute pressure increases due to kinetic forces being imparted by the impeller. Cavitation is the rapid formation and collapse of these vapor bubbles. Collapsing cavitation bubbles cause noise, vibration, and erosion of material from the impeller. Pump service life is shortened significantly when cavitation occurs. The severity of the effects of cavitation varies as a function of a machine's horsepower. Fig. 1 shows a photograph of a cavitation bubble implosion. Fig 2 shows an impeller that has been severely damaged by cavitation. Fig 3 is a diagrammatic view of the cavitation bubble implosion sequence.

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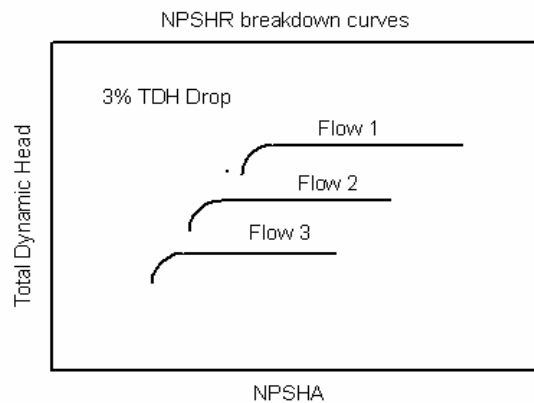


Fig 3: Cavitation bubble implosion onto a solid surface, arrows indicate fluid pressure.

For any given flow rate, every pump has an absolute suction head at which cavitation will occur. This suction head is referred to as the Net Positive Suction Head Required (NPSHR). Head is always expressed in feet or meters to make it independent of any specific fluid. The absolute suction head available at the pump inlet is termed the Net Positive Suction Head available (NPSHA). To avoid cavitation, the available NPSH must be greater than the required NPSH.

NPSHA is determined by subtracting the absolute vapor pressure of the fluid pumped from the total suction head available. Total suction head is the static head (suction gage pressure) corrected to the impeller centerline (or impeller inlet if vertical), plus the velocity head (found in most pipe friction tables), plus atmospheric pressure. All values should be expressed in feet of liquid.

NPSHR is determined by hydraulic testing and is available from the pump manufacturer. Pump manufacturers perform a series of 'breakdown' tests to determine the NPSHR. The pump is operated at a constant flow rate while the NPSHA is steadily decreased. A sudden drop in the total output head is evidence of cavitation. Industry standards establish that a 3% drop in total head as point where the NPSHR reading is taken.



It is important to note that ***an actual test curve showing NPSHR test results reflects a pump that is cavitating.***

To operate cavitation free, pumps need a margin of additional NPSH above the test values. The amount of margin depends on the suction energy of the pump. Suction energy reflects energy available for cavitation damage, and it is a function of the suction specific speed (S) of the pump.

$$S = \frac{rpm \times \sqrt{Q}}{NPSHR^{3/4}}$$

Chart 1 provides some basic guidelines on determining whether a pump falls under high or low suction energy.

Table 1 reflects the recommended margin that should be maintained between the NPSHA and the NPSHR.

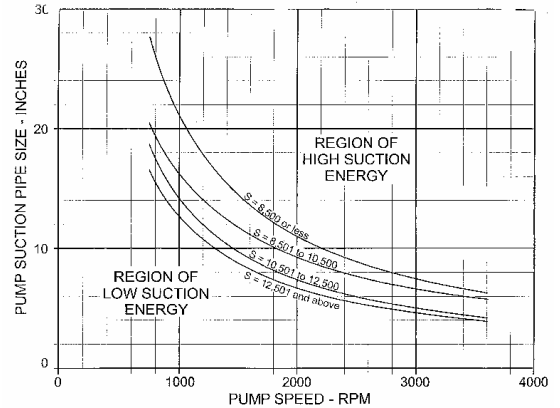


Chart 1

TABLE 1
NPSH MARGIN RATIO GUIDELINES (NPSHA/NPSHR)

Market	SUCTION ENERGY LEVEL		
	Low	High	Very High
Petroleum	1.1 ^a	1.3 ^c	
Chemical	1.1 ^a	1.3 ^c	
Electric Power	1.1 ^a	1.5 ^c	2.0 ^c
Nuclear Power	1.5 ^b	2.0 ^c	2.5 ^c
Water/Waste Water	1.1 ^a	1.3 ^c	2.0 ^c
General Industry	1.1 ^a	1.2 ^c	
Pulp and Paper	1.1 ^a	1.3 ^c	
Building Trades	1.1 ^a	1.3 ^c	
Cooling Towers	1.3 ^b	1.5 ^c	2.0 ^c
Slurry	1.1 ^a		
Pipeline	1.3 ^b	1.7 ^c	2.0 ^c
Water Flood	1.2 ^b	1.5 ^c	2.0 ^c

a. – or 2 feet whichever is greater

b. – or 3 feet whichever is greater

c. – or 5 feet whichever is greater

Note: Vertical turbine pumps often use a NPSH margin of 1.0 without damage, but with slightly reduced discharge head.

When selecting a pump, sufficient NPSH margin should be applied to cover the entire operating region for the application. Very high suction energy level pumps are those with speeds 1.5 to 2 times the levels shown in chart 1. These are approximate guidelines. The pump manufacturer should be consulted where high suction energy levels are suspected. Descriptions of each of the pump categories and the reasons for the selected margins can be found in Hydraulic Institute Standard HI 9.6.1 – 1998.

Fig 1. Courtesy of Solid State Fusion technologies

Fig 2 & 3. Lohrberg, H., Stoffel B., Intelligent Maintenance Management of Pumps , Pump Users International Forum, 2000

Chart 1 & Table 1 Hydraulic Institute Standard HI 9.6.1 – 1998 Pump NPSH Margin