Good Practice in Suction Piping Design - Avoiding Hydraulic Noise

An Online Continuing Education Course for Engineers

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Credit: 3 Hours / 3 PDH / 3 CPD

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Good Practices in Suction Piping Design – Avoiding Hydraulic Noise

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Course Overview

This course is useful for engineers involved in designing systems using centrifugal pumps. The principles explained here are applicable to many industries including chemical processing, water, and wastewater treatment. The student is expected to already have a basic understanding of NPSH and how to calculate losses in suction piping. Definitions for these key terms and concepts will be reviewed at the beginning.

This course will explain two design objectives for avoiding cavitation damage, hydraulic noise, and the maintenance expenses associated with these problems-

1. Deliver fluid to the pump suction at a pressure that avoids cavitation damage.

2. Deliver fluid to the pump suction that has a uniform flow distribution.

The student will acquire specific knowledge from this course that can be used to design better suction piping by applying the guidelines presented. After reading this material and completing the quiz, the student should:

- have a better and more practical understanding of NPSH available and NPSH required.
- have the tools to make better judgments on a safe margin between NPSH available and NPSH required.
- be able to make wise suction piping design choices that produce uniform flow at the pump inlet.

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I. Review of Term and Definitions

Net Positive Suction Head (NPSH) – the total suction head in feet of liquid absolute determined at the suction nozzle and referred to datum, less the vapor pressure of the liquid in feet absolute. Note that NPSH is an ABSOLUTE pressure, not a relative or gauge pressure. In the absolute pressure scale, "0" is a perfect vacuum, and approximately 33 feet of water corresponds to a "0" gauge pressure.

Net Positive Suction Head Required (NPSHR) – the amount of total suction head in feet of liquid absolute, less the vapor pressure, required to prevent more than 3% loss in total head when operating at a certain flow rate. NPSH Required values are determined at various flow rates by the pump manufacturer. Plots of typical NPSHR tests and a general description of the most common test methods will be given later.

Net Positive Suction Head Available (NPSHA) – the total suction head in feet of liquid absolute, determined at the impeller datum, less the absolute vapor pressure of the liquid. The pump system designer must calculate the NPSH Available, which changes with flow rate and liquid level in the sump or suction tank. The general formula used by system designers is:

NPSHA = (Pt – Pv) / sg + Z – Hf
where Pt = absolute pressure on free surface of liquid (ft.)
Pv = vapor pressure of the liquid at pumping temperature (ft.)
sg = specific gravity of the liquid (water = 1.0)
Z = vertical distance between free surface and pump datum (ft., + or -)
Hf = friction loss in suction line and entrance losses

USING CONSISTENT UNITS IS IMPORTANT, as always. Note that there is no Velocity Head term [V^2/(2g)] in the equation above. This is because velocity head energy is lost accelerating the fluid from the sump or tank into the suction pipe. That energy is then recovered in the suction pipe. When using this equation at the design stage, the velocity head terms cancel out. When taking actual field test data with gauges, velocity head must always be added in. Gauges always measure static pressure.

Cavitation – the formation and subsequent collapse of vapor-filled cavities in a liquid. The cavities may be bubbles or vapor-filled pockets, or a combination of both. The local pressure must be at or below the vapor pressure of the liquid for cavitation to begin. And the cavities must encounter a region of pressure higher than the vapor pressure to collapse. Bubbles which collapse on a solid boundary (such as an impeller vane or shroud wall) will cause pitting, damage, and some vibration. Cavitation pitting is evident slightly down-stream from the inlet edge of the impeller vane because it's the bubble collapse that does the damage, not the bubble formation.

System Head - the sum of the static head between suction and discharge liquid levels, the pipe friction head, and the head lost through fittings and valves. In many systems, the static head varies because suction and discharge liquid levels vary. Friction head generally increases at a rate approximately equal to the square of the flow through the system. Friction head is affected by changes in pipe condition and valve opening.

II. NPSH Available vs. NPSH Required

A. Consider tw[illegible] gin between

NPS[illegible]). Margin is the amou[illegible]

- [illegible]
- [illegible]

An adeq[illegible]

1) Cavit[illegible] red (3% head drop[illegible] RE TIMES HIGHER [illegible] o performa[illegible] ented in the next s[illegible]

2) Frequen[illegible] ecause system hea[illegible] he rated flow will e[illegible] educe NPSH marg[illegible]

To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

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B. [illegible] manufacturer

There are two [illegible] test setups generally used by pump manufacturers. Probably the one most often used is the SUCTION SUPPRESSION test. Here a constant level open sump is used, and NPSH Available is slowly reduced by partially closing a suction valve. To obtain the most accurate results, the flow must enter the impeller eye uniformly, therefore there must be at least 5 – 10 diameters of straight pipe between the pump suction flange and the suppression valve. The second NPSHR test setup is the CLOSED LOOP test with vacuum control. This setup often gives more accurate results at low NPSH values. The suction tank is a closed vessel, and a