NET POSITIVE SUCTION HEAD

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INTRODUCTION

Net Positive Suction Head ($NPSH$) is the measure of positive fluid pressure on the suction side of a pump. Unless the available NPSH ($NPSH_a$) exceeds—with appropriate safety factors—the required NPSH ($NPSH_r$), the pump will likely not operate properly, including increased vibration, not pumping, and/or cavitation. This worksheet calculates the NPSH conditions for a centrifugal pump.

EQUATIONS

Net Positive Suction Head Available: [1]

$$NPSH_a = H_{atm} + H_{st} - H_{fr} - H_{vp} - H_{vol} - U$$

$NPSH_a$ = [Atmospheric Head] + [Static Head] – [Friction Head Losses] – [Vapor Pressure Head] – [Partial Pressure Head of Dissolved Gases] – [Uncertainty]

Note: The inlet Velocity Head is included by the pump manufacturer in the $NPSH_r$ and thus is not included here. Friction Head Losses are suction-side losses only.

DEFINITIONS

$psia \equiv psi$ $\quad pcf \equiv \frac{lbf}{ft^3}$ $\quad mm\_Hg \equiv \frac{in\_Hg}{25.4}$

DATA — PROJECT

Pump: Mfr / Model / Impeller

Design pumping range: $Q_{min} := 800\ gpm$ $\quad Q_{max} := 1000\ gpm$

Maximum $NPSH_r$ over range of Q: $NPSH_r := 25.0\ ft$ (per pump manufacturer)

Elevation (above MSL): $Elev := 350\ ft$

Maximum water temperature (°F):* $T_F := 65$ $\quad T_C := \frac{5}{9} \cdot (T_F - 32) = 18.3$

Note: Do not use units here. Unlike MC 15, MC Prime cannot strip temperature units as required below.

Minimum Static Head on pump suction: $H_{st} := 10.00\ ft$ (negative if lift to pump)

Friction Head Losses in suction piping: $H_{fr} := 7.50\ ft$ (pipe losses + minor losses)

Partial Pressure Head of Dissolved Gases: $H_{vol} := 0.00 \cdot ft$

Note: Typically use zero for water and about $2\ ft$ for wastewater.

Uncertainty: $U := 3.00\ ft$

Note: U is an additional factor of safety to account for uncertainty in the data, the hydraulic calculations, etc.

DATA — OTHER

NPSH Safety Factors for comparing $NPSH_a$ & $NPSH_r$: [2]

Difference: $SF_1 := 5\ ft$

Ratio: $SF_2 := 1.35$

Weight density of water: $\gamma_w := 62.4\ pcf$

U.S. Standard Atmosphere (1976): [3]

$Altitude$ (m)	P_{static} (Pa)
0	101325
11000	22632.1

CALCULATIONS

Atmospheric Pressure & Head:

Atmospheric Pressure: $P_{atm} := \text{linterp}\left(Altitude, P_{static}, Elev\right)$

$P_{atm} = 14.59\ psi$

Atmosperic Head: $H_{atm} := \dfrac{P_{atm}}{\gamma_w} = 33.66\ ft$

Vapor Pressure & Head

Vapor Pressure (Antoine Equation) $P_{vp} := 10^{\left(8.07131 - \frac{1730.63}{233.426 + T_C}\right)}\ mm\_Hg$ [4]

$P_{vp} = 0.30\ psi$

Vapor Pressure Head: $H_{vp} := \dfrac{P_{vp}}{\gamma_w} = 0.70\ ft$

Net Positive Suction Head Available: $NPSH_a := H_{atm} + H_{st} - H_{fr} - H_{vp} - H_{vol} - U$

$NPSH_a = 32.46\ ft$

$NPSH_a - NPSH_r = 7.46\ ft$

$\dfrac{NPSH_a}{NPSH_r} = 1.30$

CHECK RESULTS

$$Result := \left\| \begin{array}{l} \text{if } NPSH_a - NPSH_r \geq SF_1 \\ \quad \left\| \begin{array}{l} \text{if } \dfrac{NPSH_a}{NPSH_r} \geq SF_2 \\ \quad \left\| Pump \leftarrow \text{“OK”} \right. \\ \text{else} \\ \quad \left\| Pump \leftarrow \text{“NO GOOD”} \right. \end{array} \right. \\ \text{else} \\ \quad \left\| Pump \leftarrow \text{“NO GOOD”} \right. \end{array} \right.$$

The $NPSH_a$ for this pump is:

$Result = \text{“NO GOOD”}$

REFERENCES

[1] Sanks, Robert L., Editor-in-Chief, *Pumping Station Design, Second Edition*, Butterworth–Heinemann, Boston, 1998, p. 258, Eq. 10-23.
[2] Ibid, p. 259.
[3] http://en.wikipedia.org/wiki/U.S._Standard_Atmosphere, November 20, 2013.
[4] http://en.wikipedia.org/wiki/Antoine_equation, November 20, 2013