Ensuring Peak Pump Performance:
Unlocking the Secrets of Net Positive Suction Head

In the world of water dynamics, Net Positive Suction Head (NPSH) is a crucial factor that can make or break the performance of a centrifugal pump. Understanding NPSH is essential for ensuring optimal pump efficiency, preventing cavitation, and extending the life of the equipment.

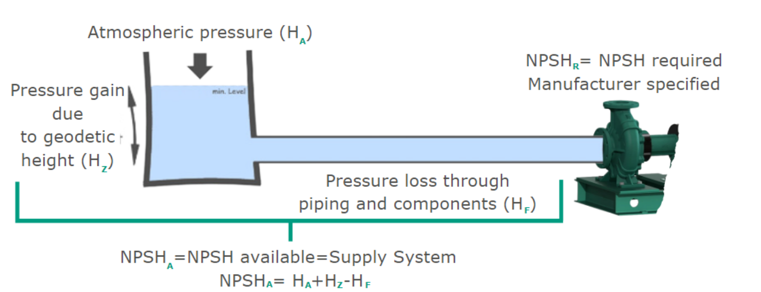
What is Net Positive Suction Head (NPSH)?

Net Positive Suction Head (NPSH) refers to the pressure (head) on the suction side of the pump. The Hydraulic Institute defines NSPH as the total head of fluid at the centerline of the impeller less the fluid's vapor pressure. Vapor pressure of a liquid is the pressure at which water changes from a liquid state to a vapor state. The NPSH is critical for ensuring the pump can handle the incoming fluid without experiencing vaporization (vapor cavities or bubbles) issues.

There are two forms of NPSH:

- **NPSH available ($NPSH_A$):** A system property, $NPSH_A$ is the pressure at the pump suction that the system can deliver to the pump. It is calculated from the suction-side of the system and considers the following factors:
    - Pressure on the surface of the water in the supply tank
    - The difference between the water level in the tank and the pump's centerline (eye of impeller)
    - Friction losses
    - Velocity head, and
    - Vapor pressure.
- **NSPH required ($NPSH_R$):** $NPSH_R$ is the minimum NPSH needed by the pump to operate correctly and avoid cavitation. It is a pump property specified by the pump manufacturer using standards and specifications from the Hydraulic Institute. Factors impacting $NSPH_R$ include:
    - Impeller geometry and
    - Rotational speed.

Image 1: Net Positive Suction Head Available ($NPSH_A$) and Required ($NPSH_R$)



The $NPSH_R$ curve can be displayed on the same pump performance chart (Image 2) or as a separate chart (Image 3), depending on the required y-axis values. The $NPSH_R$ increases with higher speeds due to increased frictional losses. Therefore, $NPSH_R$ is not a constant value, but is influenced by operating conditions.

Image 2: Net Positive Suction Head required ($NPSH_R$) Curve on Combined Pump Performance Chart

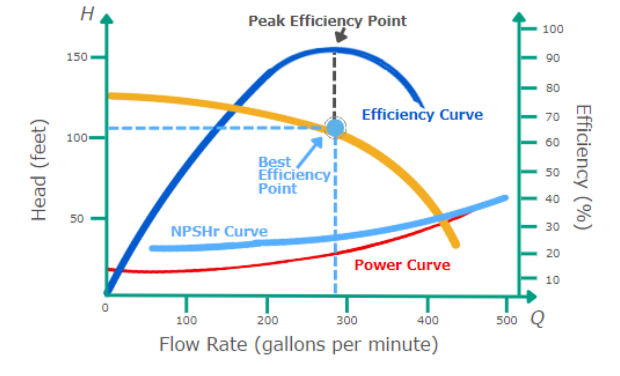
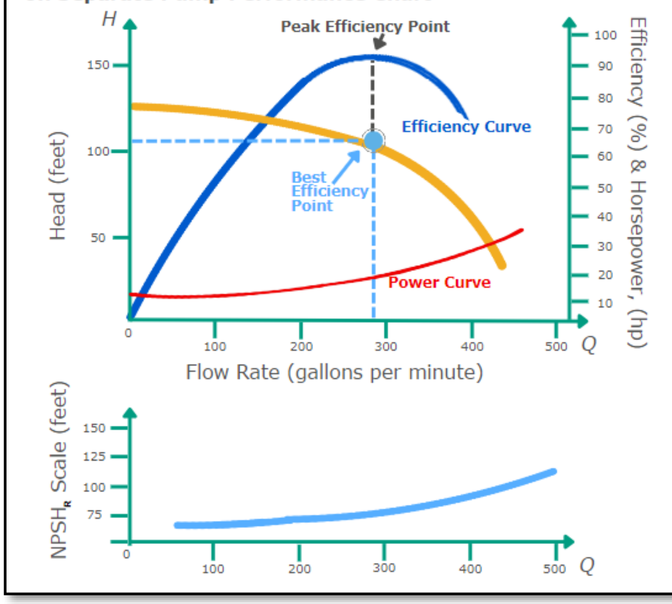


Image 3: Net Positive Suction Head required ($NPSH_R$) Curve on Separate Pump Performance Chart



The role of NPSH in pump performance

Net positive suction head has two major areas of impact in pump performance: cavitation and pump efficiency and longevity.

In a centrifugal pump, the water pressure is at a minimum at the eye of the impeller (Image 4). If the suction pressure is too low and falls below water's vapor pressure, inadequate NPSH will cause the water to flash to a vapor phase at the low pressure of the eye of the impeller. As shown in Image 5, when the pressure at the eye of the impeller falls below the water's vapor pressure, vapor bubbles form and move through the impeller vanes, subsequently collapsing when they reach an area of higher pressure at about one-third to one-half the distance along the underside of the impeller vane. The return to water's liquid form is a phenomenon called cavitation. The implosion of the vapor bubble is violent enough to remove metal, or engineered composite, causing erosion and damage to the impeller and casing.

Image 4: Pressure (Head) Gradient Through a Centrifugal Pump

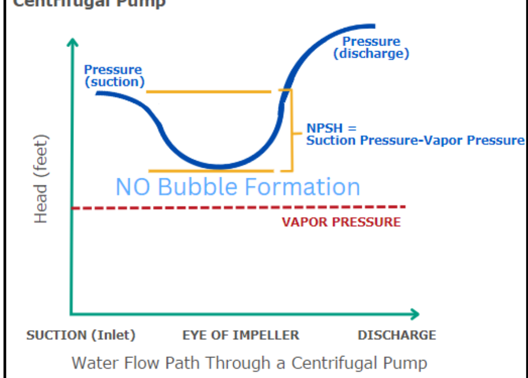
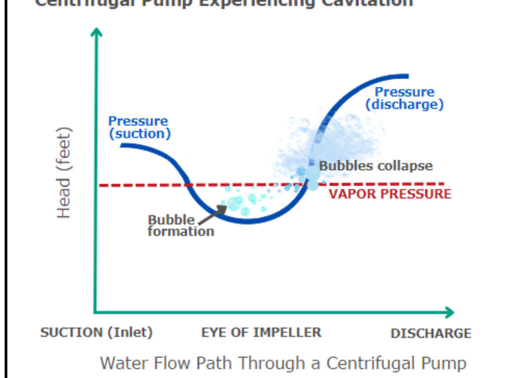


Image 5: Pressure (Head) Gradient Through a Centrifugal Pump Experiencing Cavitation



Inadequate NPSH can lead to insufficient pump operation, increased wear and tear, and reduced lifespan. Proper NPSH helps prevent cavitation by ensuring sufficient pressure at the pump suction.

To avoid performance reduction and cavitation, the $NPSH_A$ at the pump's suction side must be greater than the $NPSH_R$ in the pump. Never select a pump where the $NPSH_R$ exceeds the $NPSH_A$ of the application.

$NPSH_A > NPSH_R$

Common issues caused by inadequate NPSH:

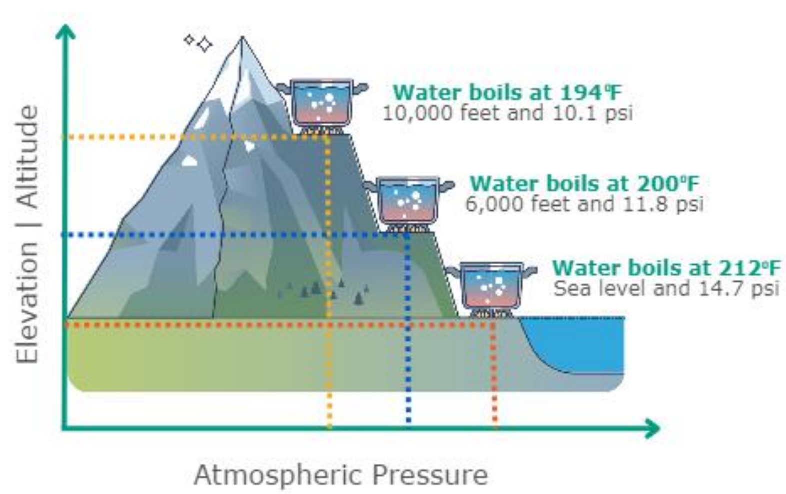
- **Reduced pump capacity**
- **Increased vibration and noise**, affecting system stability
- **Accelerated wear** from repeated cavitation can erode pump components and lead to premature pump failure

Factors influencing NPSH

Several factors can influence NPSH, including:

- **Altitude:** Altitude changes can affect $NPSH_A$. At higher altitudes, air becomes thinner, making it harder for heat to dissipate from the pump, while atmospheric pressure decreases. As atmospheric pressure drops, less energy is needed for water to boil, resulting in a lower boiling point and lower vapor pressure. Conversely, at higher pressures, more energy is required for liquid to boil, raising the boiling point. At sea level, water boils at 212 ^{0}F, and is lowered almost 1^{0}F for every 500-feet increase in altitude. This means vapor pressure and $NPSH_A$ is reduced as atmospheric pressure is decreased at higher altitudes such as Denver, CO (5,280 feet above sea level and 12.4 psi) compared to lower altitudes like New Orleans (at sea level and 14.7 psi). One should be mindful of vapor pressure at an altitude beginning at 1,000 meters above sea level.

Image 6: Boiling point at various altitudes and atmospheric pressure



- **System design and friction losses:**
  - Static head: An increase in static head (the height of the water above the pump's centerline) results in higher $NPSH_A$. Conversely, if the water source is below the pump's centerline, the pump must work harder to draw the water up. Too much "suction lift" decreases $NPSH_A$ and can lead to cavitation.
  - Piping diameter: Increasing the piping diameter into the pump increases $NPSH_A$, while decreasing it reduces $NPSH_A$ due to friction losses prior to the pump suction.
  - Suction-side piping configuration: Multiple valves, fittings, and elbows increase friction losses, decreasing $NPSH_A$.
- **Pump speed:**
  - Increased flow rate: As pump speed increases, flow rates rise, leading to greater pressure drops in the suction piping due to friction losses, which can reduce $NPSH_A$.
  - Higher $NPSH_R$: The $NPSH_R$ also increases as pump speed rises, potentially exceeding $NPSH_A$. This is because the pump requires more energy (head) to maintain the same flow rate while compensating for increased friction losses.
  - Friction impact: Higher flow rates and pump speeds amplify frictional losses, further lowering NPSHa.
- **Too far right of Best Efficiency Point (BEP):** As the pump operates beyond BEP, $NPSH_R$ increases. Higher flow rates require more pressure, increasing $NPSH_R$.

Table 1: Factors influencing NPSH	
Factor	**Impact**
Increase altitude, decrease atmospheric pressure	Decrease $NPSH_A$
Increase static head	Increase $NPSH_A$
Increase suction lift	Decrease $NPSH_A$
Increase pipe diameter	Increase $NPSH_A$
Increase number of valves, fittings, and elbows on suction side (increase friction loss)	Decrease $NPSH_A$
Increase flow rate	Decrease $NPSH_A$ and increase $NPSH_R$

Understanding and managing NPSH is essential for ensuring efficient and reliable pump operation. The $NPSH_A$ and $NPSH_R$ can be likened to a pump's income and expenses. Just as we must live within our means, ensuring our expenses don't exceed our income, a pump must not demand more NPSH than is available. By recognizing the factors that influence NPSH, you can prevent cavitation, improve pump performance, and prolong the lifespan of your equipment.

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