CE 3372 WATER SYSTEMS DESIGN

PUMPS AND LIFT STATIONS – PART 3 (FALL 2020)

SUCTION REQUIREMENTS

- The most common cause of pumping failure is poor suction conditions
- Cavitation occurs when liquid pressure is reduced to the vapor pressure of the liquid
- For piping system with a pump, cavitation occurs when P_{abs} at the inflow falls below the vapor pressure of the water

SUCTION REQUIREMENTS

- Liquid must enter the pump eye under pressure; this pressure is called the **Net Positive Suction Head available ($NPSH_a$).**
- A centrifugal pump cannot lift water unless it is primed
  - the first stage impellers must be located below the static HGL in the suction pit at pump start-up

SUCTION REQUIREMENTS

- The manufacturer supplies a value for the minimum pressure the pump needs to operate.
- This pressure is the Net Positive Suction Head required ($NPSH_r$).
- For proper pump operation (w/o cavitation)

$$NPSH_a > NPSH_r$$

SUCTION REQUIREMENTS

- Available suction is computed from

$$NPSH_a = H_{abs} + H_s - H_f - H_{vp}$$

Absolute pressure at liquid surface in suction pit (H_{abs})

Static elevation of the liquid above the pump inlet eye (H_s)

Frictional head loss in inlet piping (H_f)

Absolute vapor pressure at liquid pumping temperature (H_{vp})

SUCTION REQUIREMENTS

A 3000 GPM vertical turbine is located 4000-feet above MSL. Water temperature is 90 degrees F. The suction bell is 24-inches diameter, reducing to 12-inches diameter at the first (lowest) impeller stage. Water level is NEVER less than 8 feet above the first impeller. What is the $NPSH_a$ under the worst conditions?

1. Determine anticipated air pressure in feet of water. $\frac{\Delta p}{\Delta z} = -0.5psi/1000ft$; Thus $H_{abs.} = 33.9 * (12.7/14.7) * (0.85) = 24.8$feet This result is the product of one atmp-sphere in feet of water, adjusted for the 4000 foot elevation, and adjusted again for a thunderstorm, which typically occurs at 85% of normal atmospheric pressure. This is a "worst case" air pressure estimate for the absolute head.

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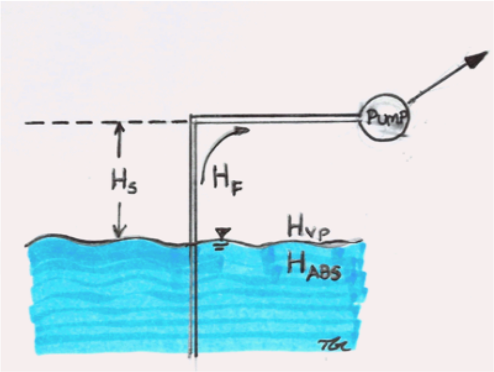
http://atomickitty.ddns.net/documents/mytoolbox-server/Hydraulics/NPSHCalculatorUS/NPSHCalculatorUS.html

Net Positive Suction Head - Available (US Customary)

Calculate NPSH Available



Habs = Absolute head at liquid surface in suction pit (feet of head) (elevation dependent)
Hstat = Static elevation of pump inlet eye above liquid (feet of head) (-head if water above pump eye!)
Hfric = Frictional head loss in inlet piping (feet of head)
Hvp = Absolute vapor pressure of liquid at pumping temperature (feet of head); temperature dependent

----- INPUT VALUES -----

Habs	24.8	Feet
Hstat		Feet
Hfric		Feet
Hvp		Feet
Submit Input Values		

----- COMPUTED RESULTS -----

SUCTION REQUIREMENTS

A 3000 GPM vertical turbine is located 4000-feet above MSL. Water temperature is 90 degrees F. The suction bell is 24-inches diameter, reducing to 12-inches diameter at the first (lowest) impeller stage. Water level is NEVER less than 8 feet above the first impeller. What is the $NPSH_a$ under the worst conditions?

2. $H_s = 8$ feet. This value is given, we are told the water level is always 8 feet or more above the impeller.

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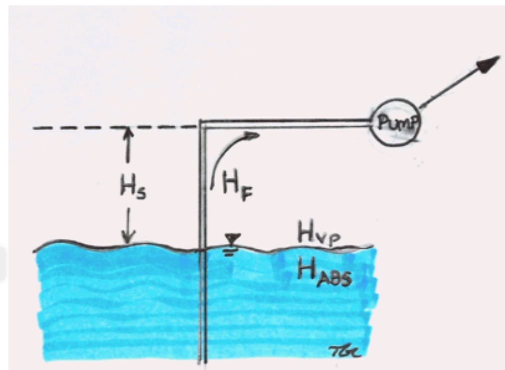
Net Positive Suction Head - Available (US Customary)

Calculate NPSH Available



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Hfric = Frictional head loss in inlet piping (feet of head)
Hvp = Absolute vapor pressure of liquid at pumping temperature (feet of head); temperature dependent

----- INPUT VALUES -----

Habs	24.8	Feet
Hstat	8	Feet
Hfric		Feet
Hvp		Feet
Submit Input Values		

----- COMPUTED RESULTS -----

SUCTION REQUIREMENTS

A 3000 GPM vertical turbine is located 4000-feet above MSL. Water temperature is 90 degrees F. The suction bell is 24-inches diameter, reducing to 12-inches diameter at the first (lowest) impeller stage. Water level is NEVER less than 8 feet above the first impeller. What is the $NPSH_a$ under the worst conditions?

3. $H_f = KV^2/2g = 0.112$feet. We obtain this from a head loss equation based on the nominal pumping rate of 3000 GPM, and the reduced inlet diameter of 1 foot. The inlet minor loss coefficient is 0.1 (we would get this value from a table). The inlet velocity is around 8.5 ft/sec from the discharge value given.

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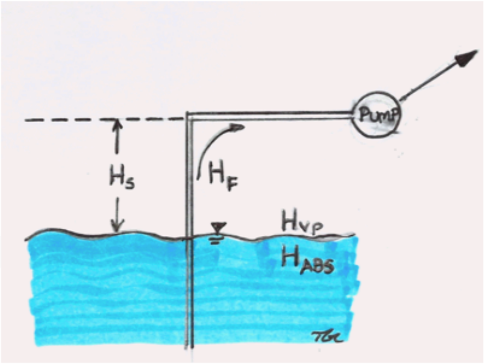
Net Positive Suction Head - Available (US Customary)

Calculate NPSH Available



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Hfric = Frictional head loss in inlet piping (feet of head)
Hvp = Absolute vapor pressure of liquid at pumping temperature (feet of head); temperature dependent

----- INPUT VALUES -----

Habs	24.8	Feet
Hstat	8	Feet
Hfric	0.112	Feet
Hvp		Feet
Submit Input Values		

----- COMPUTED RESULTS -----

SUCTION REQUIREMENTS

A 3000 GPM vertical turbine is located 4000-feet above MSL. Water temperature is 90 degrees F. The suction bell is 24-inches diameter, reducing to 12-inches diameter at the first (lowest) impeller stage. Water level is NEVER less than 8 feet above the first impeller. What is the $NPSH_a$ under the worst conditions?

4. $H_{vp} = 1.6$feet. We obtain this value from a table of water properties. We need the vapor pressure in feet of water at 90F.

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Water Properties (US Customary)
adapted from Table A5 in Elger, Crowe, Roberson 2013. Engineering Fluid Mechanics. Wiley

Machine name : theodore-macbookpro.ttu.edu
Run Date : Mon Aug 17 10:33:26 2020

------ INPUT VALUES ------		
Temperature =	80.0	(degrees F)

------ LOOKUP VALUES -----
Density = 1.93 (slugs/ft^3)
Specific Weight = 62.22 (lbf/ft^3)
Dynamic Viscosity = 1.8e-05 (lbf-s/ft^2)
Kinematic Viscosity = 9.3e-06 (ft^2/s)
Vapor Pressure = 0.506 (lbf/in^2) - absolute

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Water Properties (US Customary)
adapted from Table A5 in Elger, Crowe, Roberson 2013. Engineering Fluid Mechanics. Wiley

Machine name : theodore-macbookpro.ttu.edu
Run Date : Mon Aug 17 10:33:51 2020

------ INPUT VALUES ------		
Temperature =	100.0	(degrees F)

------ LOOKUP VALUES -----
Density = 1.93 (slugs/ft^3)
Specific Weight = 62.0 (lbf/ft^3)
Dynamic Viscosity = 1.42e-05 (lbf-s/ft^2)
Kinematic Viscosity = 7.39e-06 (ft^2/s)
Vapor Pressure = 0.949 (lbf/in^2) - absolute

$$H_{vp} = \frac{1}{2}(0.506 + 0.949)\,psi * \frac{33.9\,ft}{14.75\,psi} = 1.67\,ft$$

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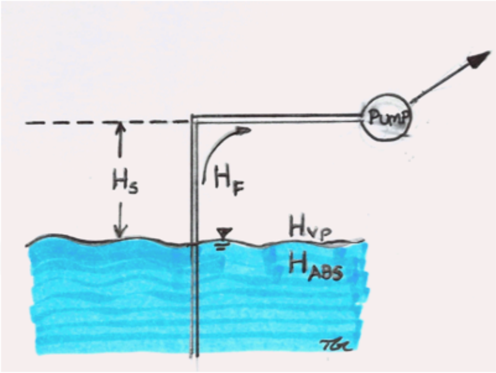
Net Positive Suction Head - Available (US Customary)

Calculate NPSH Available



Habs = Absolute head at liquid surface in suction pit (feet of head) (elevation dependent)
Hstat = Static elevation of pump inlet eye above liquid (feet of head) (-head if water above pump eye!)
Hfric = Frictional head loss in inlet piping (feet of head)
Hvp = Absolute vapor pressure of liquid at pumping temperature (feet of head); temperature dependent

----- INPUT VALUES -----

Habs	24.8	Feet
Hstat	8	Feet
	0.112	Feet
	1.6	Feet

RESULTS -----

SUCTION REQUIREMENTS

A 3000 GPM vertical turbine is located 4000-feet above MSL. Water temperature is 90 degrees F. The suction bell is 24-inches diameter, reducing to 12-inches diameter at the first (lowest) impeller stage. Water level is NEVER less than 8 feet above the first impeller. What is the $NPSH_a$ under the worst conditions?

Once the above values are determined the $NPSH_a$ is computed as $NPSH_a = 24.82 + 8 - 0.112 - 1.6 = 31.10$ feet. Using 10% as a margin of uncertainty, we would specify that the pump not require more that 28-feet of NPSH for operation. That is, if this pump has $NPHS_r > 28$ feet on its pump curve, we have a potential pumping problem and either a different pump should be used or the suction conditions must be changed (lower the pump deeper into the pit).

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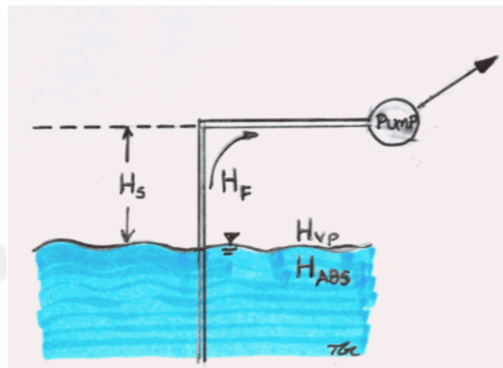
Net Positive Suction Head - Available (US Customary)

Calculate NPSH Available



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----- INPUT VALUES -----

Habs	24.8	Feet
Hstat	-8	Feet
Hfric	0.112	Feet
Hvp	1.6	Feet
Submit Input Values		

----- COMPUTED RESULTS -----

Net Positive Suction Head Available	31.088	Feet