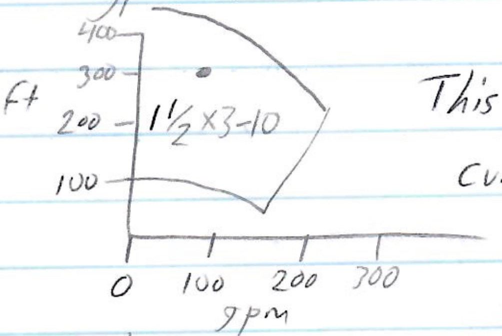
Team 5

HW 3.3

13.22) $1\frac{1}{2} \times 3 - 6$

This means the pump has a $1\frac{1}{2}$" discharge, 3" suction, and 6" housing.

13.23) For fig. 13.22, specify a size for delivering 100 gpm with 300ft head.



This point lies neatly in the curve of the $1\frac{1}{2} \times 3 - 10$ pump

13.25) For the 2×3-10 centrifugal pump describe the performance from an 8" impeller at 200ft. Give capacity, power required, and NPSH.

From the curve:

$Q \cong 230$ gpm
$HP \cong 22.5$
$NPSH \cong 10$ ft
Efficiency $\cong 54\%$

13.34a) Select pump for 500gpm / 80ft water

Rotary, 3500 rpm centrifugal, or reciprocating

13.34b) Select pump for 500gpm / 800ft water

Rotary or reciprocating

13.17) For a centrifugal pump if speed is cut in half how does head change?

$$\frac{h_{a_1}}{h_{a_2}} = (0.5)^2 = 0.25.$$

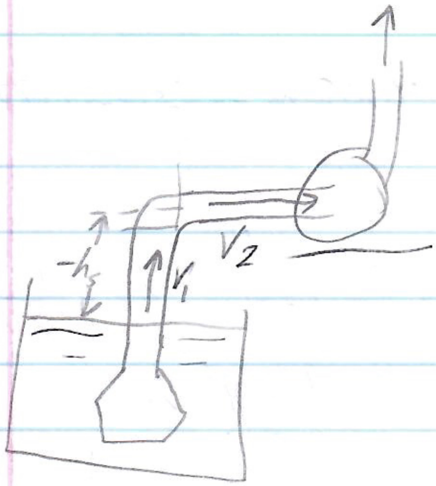
Head reduced to 1/4 of original

13.19) For a centrifugal pump if the impeller diameter is reduced by 25% how does the capacity change?

$$\frac{Q_1}{Q_2} = \left(\frac{0.75}{1.0}\right) = 0.75$$

Capacity reduced by 25%

13.55 Determine $NPSH_A$ for the following system:



Water @ 80°C
$P_{atm} = 101.8 kPa$
$z = 2.0 m$
Vertical leg is DN80 SCH40 Steel
Horizontal is DN50 SCH40 Steel
1.5m long
Long radius elbow
Hinged disk foot valve & strainer
$Q = 300 \ L/min$

$NPSH_A = h_{sp} - h_s - h_f - h_{vp}$

$h_{sp} = \dfrac{101.8 \ kPa}{9.53 \ kN/m^3} = \underline{10.68 \ m}$

$h_s = 2.0 \ m$

$h_{vp} = 4.97 m$ @ 80°C

$V_2 = \dfrac{Q}{A} = \dfrac{300 \ L/min}{2.168 \times 10^{3} m} \times \dfrac{1 \ m^3/s}{60000 \ L/min} = 2.306 \ m/s$

$V_1 = \dfrac{Q}{A} = \dfrac{300 \ L/min}{4.768 \times 10^{3} m} \times \dfrac{1 \ m^3/s}{60000 \ L/min} = 1.049 \ m/s$

$N_{R_2} = \dfrac{V_2 D_2}{\nu} = \dfrac{(2.31 \ m/s)(0.0525 m)}{3.60 \times 10^{-7} \ m^2/s} = 3.4 \times 10^5$

$N_{R_1} = \dfrac{(1.049)(0.0779)}{3.60 \times 10^{-7}} = 2.3 \times 10^5$

$\dfrac{D_2}{\varepsilon} = \dfrac{0.0525}{4.6 \times 10^{-5}} = 1141 \qquad \dfrac{D_1}{\varepsilon} = 1693$

$f_2 = 0.021$ $\qquad f_1 = 0.0195$

$f_{1T} = 0.018$ $\qquad \frac{V_1^2}{2g} = 0.056\,m \qquad \frac{V_2^2}{2g} = 0.271\,m$

$$h_f = f_1\left(\frac{L}{D_1}\right)\frac{V_1^2}{2g} + f_2\left(\frac{L}{D_2}\right)\frac{V_2^2}{2g} + 75 f_{1T}\frac{V_1^2}{2g} + 20 f_{1T}\frac{V_1^2}{2g}$$

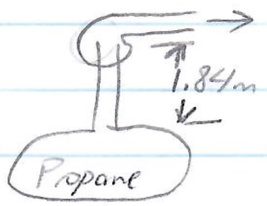
$$h_f = (0.0195)\left(\frac{2}{0.0779}\right)(0.056) + (0.021)\left(\frac{1.5}{0.0525}\right)(0.271) + (95)(0.018)(0.056)$$

$$h_f = 0.286\,m$$

$NSPH_A = 10.68 - 2.0 - 4.97 - 0.286$

$\boxed{NSPH_A = 3.42\,m}$

13.65) A pump draws propane at 45°C (sg = 0.48) from a tank 1.84m below inlet. $h_f = 0.92$ and $P_{atm} = 98.4$ kPA absolute. Determine pressure above propane for $NSPH_A > 1.50\,m$



$NPSH_A = 1.50\,m$

$h_s = 1.84\,m$

$h_{vp} = 350\,m$

$h_f = 0.92\,m$

$h_{sp} = NPSH_A + h_s + h_f + h_{vp}$

$h_{sp} = 350 + 1.84 + 0.92 + 1.50 = 354.3\,m$

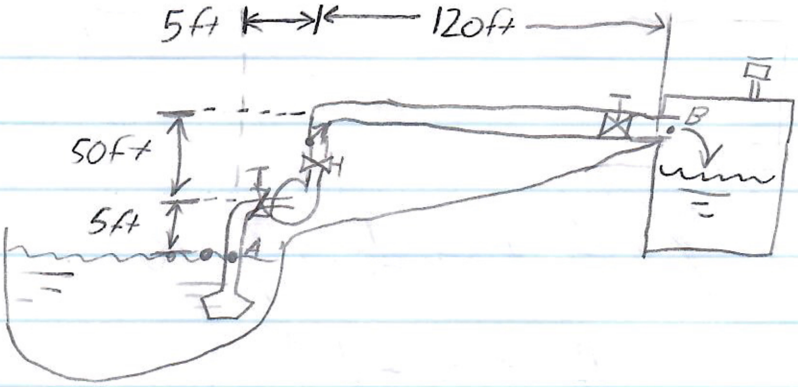
$P_{sp} = \gamma h = (0.48)(9.81\,kN/m^3)(354.3\,m) = 1668.3\,kPa$ abs

$P_{tank} = P_{gage} = P_{sp} - P_{atm} = 1668.3 - 98.4 = 1569.9\,kPa$ gage

$\boxed{P_{tank} = 1569.9\,kPa}$

Design Problem #3

Design a system to pump water @90°F from a river to a tank 55 ft above the surface of the river. The min flow rate is 1500 gpm. The tank is set back 125 ft from the river.



$$A = \frac{Q}{V} = \frac{1500\,gpm}{9.843\,ft/s} \cdot \frac{1\,ft^3/s}{448.8\,gpm} = 0.339\,ft^2$$

Select 8" NPS SCH40 Steel Pipe

$$v = \frac{Q}{A} = \frac{3.34\,ft^3/s}{0.3472\,ft^2} = 9.62\,ft/s$$

$$\frac{v^2}{2g} = 1.44\,ft \qquad \frac{D}{\varepsilon} = \frac{0.6651\,ft}{4.6\times10^{-5}\,ft} = 14460$$

$$N_R = \frac{vD}{\nu} = \frac{(9.62)(0.6651)}{8.29\times10^{-6}} = 7.7\times10^5$$

$$f = 0.0135 \qquad f_T = 0.014$$

$$h_A + \cancel{\frac{P_A}{\gamma}} + \cancel{z_A} + \cancel{\frac{V_A^2}{2g}} = \cancel{\frac{P_B}{\gamma}} + z_B + \frac{V_B^2}{2g} + h_L$$

$$h_a = z_B + \frac{V_B^2}{2g} + h_L$$

3 gate valve, hinged disc foot valve, swing check valve

$$h_L = f\left(\frac{L}{D}\right)\frac{v^2}{2g} + (3)(8)f_T\frac{v^2}{2g} + (75)f_T\frac{v^2}{2g} + (100)f_T\frac{v^2}{2g}$$

$$h_L = (0.0135)\left(\frac{180}{0.6651}\right)(1.44) + (24+75+100)(0.014)(1.44)$$

$h_L = 5.66$ ft

$h_a = 55$ ft $+ 1.44$ ft $+ 5.66$ ft

$h_a = 62.1$ ft $\quad Q = 1500$ gpm

From Sulzer catalog, select <u>8×8-10 pump</u>

at <u>1800 rpm</u>

Use 9.19 in impeller. Provides 1675 gpm at 64 ft head.

$$NPSH_R = 36\text{ ft}(0.5)^{3/4} = 21.4\text{ ft}$$

$$NPSH_A = h_{sp} - h_s - h_f - h_{vp}$$

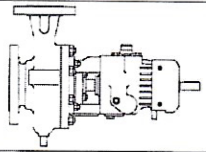
$$= \frac{14.7\text{ psi}}{62.1\text{ lb/ft}^3} \cdot \frac{144\text{ lb/ft}^2}{1\text{ psi}} - 5\text{ ft} - h_{f_s} - 1.618$$

$$h_{f_s} = (0.0135)\left(\frac{10}{0.6651}\right)(1.44) + (8+75)(0.014)(1.44)$$

$h_{f_s} = 1.97$ ft

<u>$NPSH_A = 25.5$ ft</u>

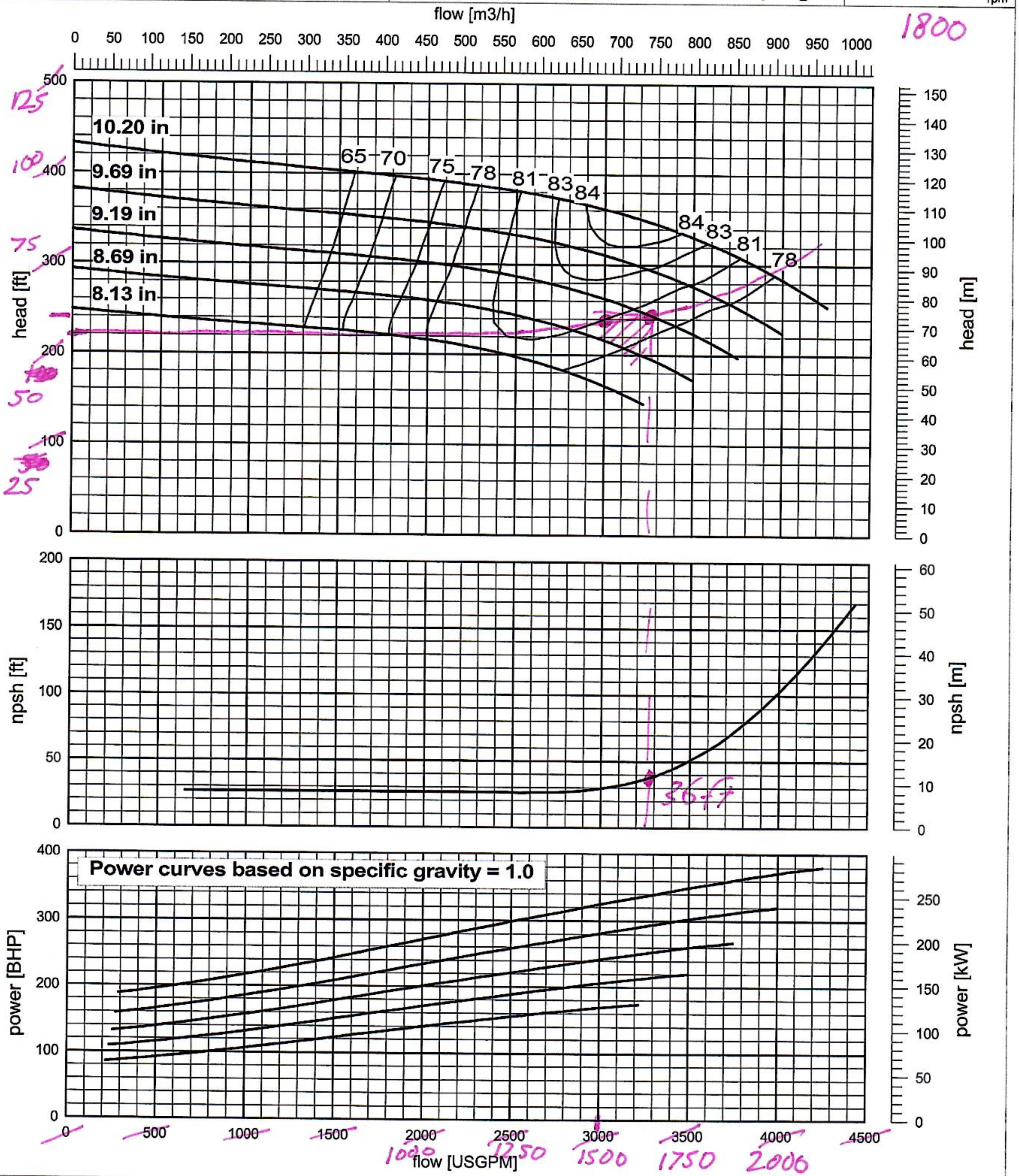
$NPSH_A > (1.10)(NPSH_R)$



8 x 8 x 10 -2 OHH

SULZER
Series 2.00 / 60Hz E034

Curve No	OHH 66-2-1-01			Speed
Efficiency Basis	API Std. clearances	NS	2470 (48)	~~3570~~ rpm
Max Solid	.47 in (12 mm)	Rotation	CCW viewed from coupling	1800



Rated Conditions

Project	Item	
H =	Q =	P =
Calculated Efficiency =		NPSH$_{3\%}$ =
		Issued: MSC / 12.21.2001

In this section I learned how to properly select pumps. This starts with calculating the specific speed to determine the type of pump. From there, with flow rate and pump head I learned how to use a pump catalog to select an appropriate size. Once a pump is selected the desired flow/head will likely not fall neatly on a provided impeller size. In this case a balancing valve, affinity law, or settling for a nearby flow rate can be used. The system curve is drawn on the pump curve starting at elevation and ending at the desired flow and head. Finally, I learned how to check NPSH to avoid cavitation.