17 $\frac{h_{a1}}{h_{a2}} = \left(\frac{N_1}{N_2}\right)^2$

$\left(\frac{N_1}{\frac{N_1}{2}}\right)^2 = 4$

reduced by factor of 4

19 $\frac{Q_1}{Q_2} = \frac{D_1}{D_2}$

$\frac{D_1}{0.75 D_1} = \frac{1}{0.75}$

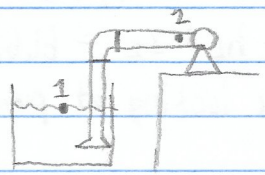
reduced by 25%

22

1½ inch discharge
3inch suction
6inch max impeller diameter

23 1½ inch discharge
3in Suction
10 inch max impeller diameter

55. $T = 80^\circ C$ $P_{atm} = 101.8\ kPa$ $z_1 - z_2 = -2\ m$



$Q = 300\ L/min$ $L_v = 2\ m$ $L_h = 1.5\ m$ Find $NPSH_a$.

$P_{sat} = 47.34\ kPa$ $\gamma = 9.53\ \frac{kN}{m^3}$ $D_v = 0.0779\ m$

$D_h = 0.0525\ m$ $A_v = 0.004768\ m^2$ $A_h = 0.002168\ m^2$ $Le/D_{elb} = 20$

$Le/D_{foot} = 75$ $h_L = h_{L\,foot} + h_{Lv} + h_{Lelb} + h_{Lh}$ $Q = 0.005\ \frac{m^3}{s}$

$V_v = Q/A_v = 1.05\ m/s$ $V_h = Q/A_h = 2.31\ m/s$ $h_{L\,foot} = \frac{Le}{D_{foot}} \cdot f_T \cdot \frac{V_v^2}{2g}$

$h_{L\,foot} = 75 \cdot 0.017 \cdot \frac{1.05^2}{2 \cdot 9.81} = 0.072\ m$ $h_v = f_v \cdot \frac{L_v}{D_v} \cdot \frac{V_v^2}{2g}$ $\nu = 3.6 \cdot 10^{-7}\ \frac{m^2}{s}$

$Re_v = \frac{V_v \cdot d_v}{\nu} = 227208$ $f_v = 0.25 / \left(\log\left(\frac{1}{3.7 \cdot D/\varepsilon} + \frac{5.74}{Re_v^{0.9}}\right)\right)^2$ $\varepsilon = 4.6 \cdot 10^{-5}\ m$

$f_v = 0.019$ $h_{Lv} = 0.028\ m$ $h_{Lelb} = \frac{Le}{D_{elb}} \cdot f_T \cdot \frac{V_v^2}{2g} = 0.021\ m$

$h_{Lh} = f_h \cdot \frac{L_h}{D_h} \cdot \frac{V_h^2}{2g}$ $Re_h = \frac{V_h \cdot d_h}{\nu} = 336875$ $f_h = 0.02$ $h_{Lh} = 0.156\ m$

$h_L = 0.072 + 0.028 + 0.021 + 0.156 = 0.277\ m$

$NPSH_a = (P_{atm} - P_{sat})/\gamma + z_1 - z_2 - h_L = \frac{101.8 - 47.34}{9.53} - 2 - 0.277$

$NPSH_a = 3.44\ m$

Q3. $T = 80°F$ $Q \geq 1500$ gpm $\gamma = 62.2 \frac{lb}{ft^3}$ $\nu = 9.15 \cdot 10^{-6} \frac{ft^2}{s}$

$Q = 3.35 \frac{ft^3}{s}$ $V \approx 9.84 \frac{ft}{s}$ $A \approx 0.34\ ft^2$

NPS 8" Schedule 40 Pipe $A = 0.3472\ ft^2$

$V = 9.63 \frac{ft}{s}$ $D = 0.6651$ ft $h_L = h_{LS} + h_{Ld}$

$L_S = 10$ ft $L_d = 115 + 55 = 170$ ft $Re = \frac{V \cdot D}{\nu} = 700000$ $\varepsilon = 1.5 \cdot 10^{-4}$ ft

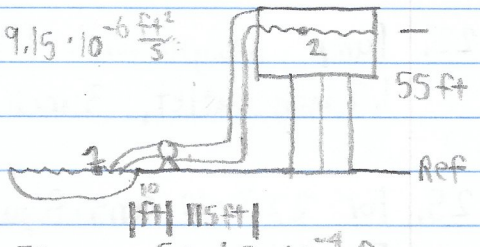
$f = 0.25 / \left(\log\left(\frac{1}{3.7 \cdot D/\varepsilon} + \frac{5.74}{Re^{0.9}}\right)\right)^2 = 0.015$ $h_{LS} = f \cdot \frac{L_S}{D} \cdot \frac{V^2}{2g} = 0.33$ ft

$h_{Ld} = f \cdot \frac{L_d}{D} \cdot \frac{V^2}{2g} + 2 \cdot \frac{L_e}{D} \cdot f_T \cdot \frac{V^2}{2g} = 5.53 + 0.81 = 6.34$ ft $f_T = 0.014$

$\frac{L_e}{D} = 20$ for long radius 90° elbow $h_L = 0.33 + 6.34 = 6.67$ ft

$h_a = h_L + z_2 = 61.67$ ft Preliminary pump choice: 8X8-10 1800 rpm

after looking at pump curve, final pump choice: 8X8-9.19 1800 rpm



13.65 $SG_{propane} = 0.48$, $T = 45°C$ $P_{atm} = 98.4\,kPa$ $h_{vapor} = 350m$

$\Delta z = 1.84m$ $h_L = 0.92m$ $NPSHA = 1.50m$

$NPSH_A = \left(\frac{P_{atm} + P_{tank}}{\gamma}\right) \pm \Delta z - h_L - h_{vapor}$

$\hookrightarrow P_{tank} = (\gamma(NPSH_A + \Delta z + h_L + h_{vapor})) - P_{atm}$

$\gamma = (0.48)(9.81\,kN/m^3) = 4.709\,kN/m^3$

$P_{tank} = ((4.709\,kN/m^3)(1.5m + 1.84m + 0.92m + 350m)) - 98.4\,kPa$

$\boxed{P_{tank} = 1569.81\,kN/m^2}$