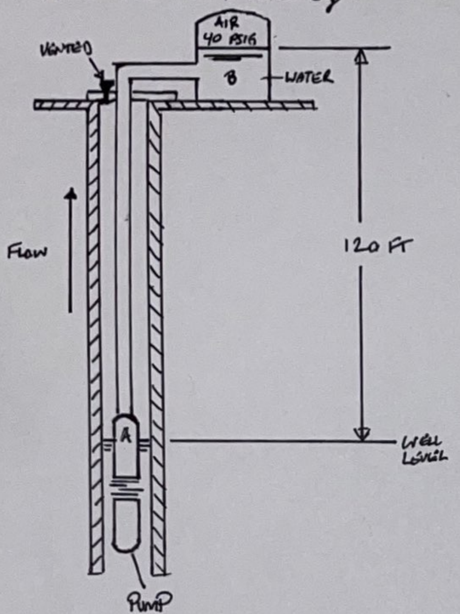
MET 330 HW-1.4

7.11) A SUBMERSIBLE DEEP-WELL PUMP DELIVERS 745 gph OF WATER THRNGH A 1-INCH SCHEDULE 40 PIPE WHEN OPERATING. AN ENERGY LOSS OF 10.5 lb-FT/lb OCCURS IN THE PIPING SYSTEM. (a) CALCULATE THE POWER DELIVERED BY THE PUMP TO THE WATER. (b) IF THE PUMP DRAWS 1 HP, FIND ITS EFFICIENCY.



GIVEN: 1-INCH SCH. 40 PIPE: $A = 0.006\ FT^2$ (APP. F, TABLE F.1)

$Q = 745\ \frac{GAL}{h}$ $\quad P_A = h_A \cdot \gamma \cdot Q \quad \gamma_w = 62.4\ \frac{lb}{FT^3}$

$h_L = 10.5\ \frac{lb\text{-}FT}{lb}$ $\quad P_B = 40\frac{lb}{in^2} \cdot \frac{144\ in^2}{1\ FT^2} = 5760\ \frac{lb}{FT^2}$

$$\frac{P_A}{\gamma} + Z_A + \frac{V_A^2}{2g} + h_A + h_R - h_L = \frac{P_B}{\gamma} + Z_B + \frac{V_B^2}{2g}$$

$P_I = 1\ Hp$

SOLUTION: 1. $Z_A + h_A + \cancel{h_R}^{\,0} - h_L = \frac{P_B}{\gamma} + Z_B + \frac{V_B^2}{2g}$

$\rightarrow \quad Z_A + h_A - h_L = \frac{P_B}{\gamma} + Z_B + \frac{V_B^2}{2g}$

$$h_A = \frac{P_B}{\gamma} + Z_B - Z_A + \frac{V_B^2}{2g} + h_L$$

2. FIND UNKNOWNS...

$V_B = \frac{Q}{A} \rightarrow 745\ \frac{\cancel{GAL}}{\cancel{h}} \cdot \frac{1h}{60\ min} \cdot \frac{1\ min}{60\ SEC} \cdot \frac{0.134\ FT^3}{1\ GAL} = \frac{0.02773056\ FT^3}{1\ SEC}$

$\rightarrow \quad \frac{0.02773056\ \frac{FT^3}{S}}{0.006\ FT^2} = 4.62176\ \frac{FT}{S} = V_B$

3. $h_A = \frac{P_B}{\gamma} + Z_B - Z_A + \frac{V_B^2}{2g} + h_L$

$= \frac{5760\frac{lb}{FT^2}}{62.4\frac{lb}{FT^3}} + 120\ FT + \frac{(4.62176\ \frac{FT}{S})^2}{2(32.2\ \frac{FT}{S^2})} + 10.5\ \frac{lb\text{-}FT}{lb}$

$= 92.3077\ FT + 120\ FT + 0.331687\ FT + 10.5\ FT$

$h_A = 223.14\ FT$

4. $P_A = h_A \cdot \gamma \cdot Q$

$= 223.14\ FT \cdot 62.4\ \frac{lb}{\cancel{FT^3}} \cdot 0.02773056\ \frac{\cancel{FT^3}}{S} = 386.119$

$\rightarrow 386.119\ \frac{FT\cdot lb}{S} \cdot \frac{1\ HP}{550\ \frac{FT\cdot lb}{S}} = 0.702034\ Hp$

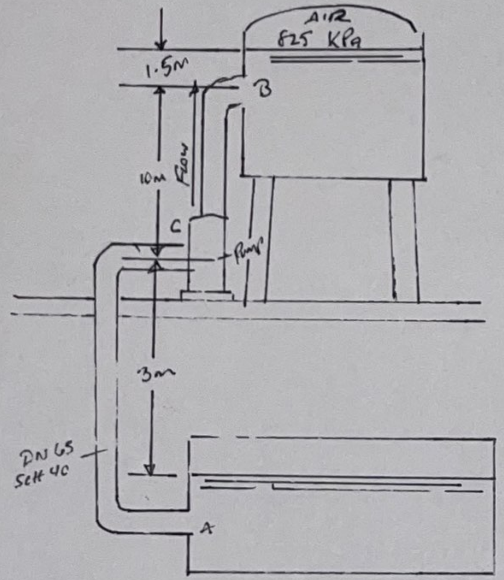
$\boxed{P_A = 0.7\ Hp}$

5. GIVEN $e_M = \frac{P_A}{P_I}$,

$e_M = \frac{0.7\ Hp}{1\ Hp} = 0.7$

$\boxed{e_M = 0.7 \text{ OR } 70\%}$

7.16) FIG. 7.21 SHOWS A PUMP DELIVERING 840 $\frac{L}{MIN}$ OF CRUDE OIL ($sg = 0.85$) FROM AN UNDERGROUND STORAGE DRUM TO THE FIRST STAGE OF A PROCESSING SYSTEM. (a) IF THE TOTAL ENERGY LOSS IN THE SYSTEM IS 4.2 $\frac{N \cdot M}{N}$ OF OIL FLOWING, CALCULATE THE POWER DELIVERED BY THE PUMP. (b) IF THE ENERGY LOSS IN THE SUCTION PIPE IS 1.4 $\frac{N \cdot M}{N}$ OF OIL FLOWING, FIND THE PRESSURE AT THE INLET OF THE PUMP.



GIVEN: $h_{L_S} = 1.4 \frac{N \cdot m}{N}$ $\quad h_{L_T} = 4.2 \frac{N \cdot m}{N}$ $\quad P_B = 825$ Kpa

$Q = 840 \frac{L}{MIN}$ $\quad P_A = h_A \gamma Q$

$Sg_{oil} = 0.85$ $\quad$ DN 65, SCH 40: $A = 3.09 \times 10^{-3} m^2$

$$\gamma_{oil} = 0.85\left(9.81 \frac{kN}{m^3}\right) = 8.3385 \frac{kN}{m^3}$$

SOLUTION: 1. $h_A = \frac{p_B - \cancelto{0}{p_A}}{\gamma} + \frac{\cancelto{0}{v_B^2} - \cancelto{0}{v_A^2}}{2g} + z_B - \cancelto{0}{z_A} + h_L$

$$\rightarrow h_A = \frac{p_B}{\gamma_{oil}} + z_B + h_L$$

$$P_B = 825 \text{ Kpa} \cdot \frac{1000 \frac{N}{m^2}}{1 \text{KPa}} = 825{,}000 \frac{N}{m^2}$$

$$z_B = 1.5m + 10m + 3m = 14.5m$$

$$\gamma_{oil} = 8.3385 \frac{kN}{m^3} \cdot \frac{1000N}{1kN} = 8338.5 \frac{N}{m^3}$$

$$h_{L_T} = 4.2 \frac{N \cdot m}{N}$$

$$h_A = \frac{825{,}000 \frac{N}{m^2}}{8338.5 \frac{N}{m^3}} + 14.5m + 4.2 \frac{N \cdot m}{N}$$

$$= 98.9387m + 14.5m + 4.2m = 117.639m$$

$$\rightarrow P = h_A \gamma_{oil} Q = (117.639m)\left(8338.5 \frac{N}{m^3}\right)\left(840 \frac{L}{min} \cdot \frac{0.001 m^3}{60 sec}\right)$$

$$\boxed{P = 13733.1 \text{ W}} \quad \left(\frac{N \cdot m}{s}\right)$$

2. $\frac{\cancelto{0}{p_A}}{\gamma_{oil}} + \frac{\cancelto{0}{v_A^2}}{2g} + \cancelto{0}{z_A} = \frac{p_c}{\gamma_{oil}} + \frac{v_c^2}{2g} + z_c + h_{L_S}$

$$\rightarrow P_c = \left(-\frac{v_c^2}{2g} - z_c - h_{L_S}\right)\gamma_{oil}$$

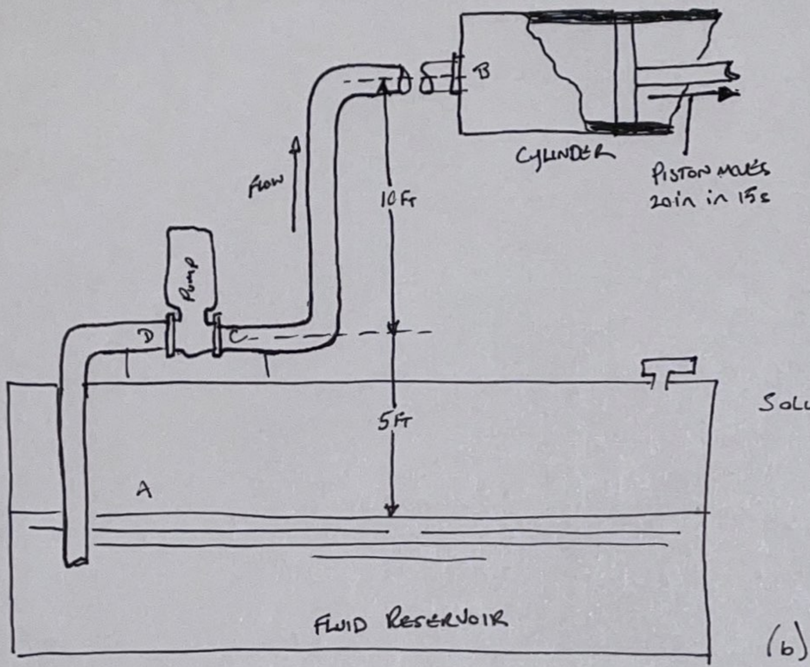
$$V_c = \frac{Q}{A} = \frac{\left(840 \frac{L}{min} \cdot \frac{0.001 m^3}{60 sec}\right)}{\left(3.09 \times 10^{-3} m^2\right)} \quad \left(\frac{m}{s}\right)$$

$$V_c = 4.53074 \frac{m}{s}$$

$$\rightarrow P_c = \left(-\frac{\left(4.53074 \frac{m}{s}\right)^2}{2\left(9.81 \frac{m}{s^2}\right)} - 3m - 1.4 \frac{N \cdot m}{N}\right)\left(8338.5 \frac{N}{m^3}\right)$$

$$\boxed{P_c = -45413.6 \text{ Pa or } -45.413 \text{ Kpa}}$$

7.22) THE FIGURE SHOWS THE ARRANGEMENT OF A CIRCUIT FOR A HYDRAULIC SYSTEM. THE PUMP DRAWS OIL W/ A SG OF 0.9 FROM A RESERVOIR AND DELIVERS IT TO THE HYDRAULIC CYLINDER. THE CYLINDER HAS AN INSIDE DIAMETER OF 5", AND IN 15 SEC THE PISTON MUST TRAVEL 20" WHILE EXERTING FORCE OF 11,000 lb. IT IS ESTIMATED THERE ARE ENERGY LOSSES OF 11.5 $\frac{lb\,ft}{lb}$ IN THE SUCTION PIPE. AND 35 $\frac{lb\,ft}{lb}$ IN THE DISCHARGE PIPE. BOTH PIPES ARE 3/8" SCH. 80 STEEL PIPES. FIND: (a) VOLUME FLOW RATE THROUGH PUMP. (b) PRESSURE AT THE CYLINDER. (c) PRESSURE AT OUTLET. (d) PRESSURE AT INLET. (e) POWER DELIVERED TO OIL.



GIVEN: $SG_{oil} = 0.9$

$D_{cyl} = 5"$

$Z_B = 15\,ft$

$F = 11{,}000\,lb$

$h_{LS} = 11.5\,\frac{lb\,ft}{lb}$

$h_{LD} = 35\,\frac{lb\,ft}{lb}$

3/8" SCH. 80 STEEL

$D_{ip} = \cancel{0.0411\,ft}\ 0.03525\,ft$

$A_p = \cancel{0.00133\,ft^2}\ 0.000976\,ft^2$

OR

$\cancel{0.1912\,in^2}$

$A_{cyl} = \frac{\pi}{4}(5\,in)^2 = 19.635\,in^2$

$\gamma_{oil} = 0.9\left(62.4\,\frac{lb}{ft^3}\right) = 56.16\,\frac{lb}{ft^3}$

SOLUTION: (a) $Q = V_B \cdot A$

$\rightarrow Q = (19.635\,in^2)\left(\frac{20\,in}{15\,s}\right) = 26.18\,\frac{in^3}{s}$

$Q = 26.18\,\frac{in^3}{s} \cdot \frac{1\,ft^3}{1728\,in^3}$

$\boxed{Q = 0.01515\,\frac{ft^3}{s}}$

(b) $P_{cyl} = \frac{F}{A_{cyl}} = \frac{11{,}000\,lb}{19.635\,in^2} = 560.225\,\frac{lb}{in^2}$

$\boxed{P_{cyl(B)} = 560.225\,\frac{lb}{in^2} \text{ or psi}}$

$560.225\,\frac{lb}{in^2} \cdot \frac{144\,in^2}{1\,ft^2} = 80{,}672\,\frac{lb}{ft^2}$

(c) $\frac{P_C}{\gamma_{oil}} + \frac{V_C^2}{2g} + Z_C = \frac{P_B}{\gamma_{oil}} + \frac{V_B^2}{2g} + Z_B + h_{LD}$

$V_B = \frac{20\,in}{15\,s} \cdot \frac{1\,ft}{12\,in} = 0.111\,\frac{ft}{s}$

$V_C = \frac{Q}{A} = \frac{0.01515\,ft^3}{0.000976\,ft^2} = 15.5225\,\frac{ft}{s}$

$\rightarrow P_C = \left(\frac{P_B}{\gamma_{oil}} + \frac{V_B^2 - V_C^2}{2g} + Z_B - Z_C + h_{LD}\right)(\gamma_{oil})$

$= \left(\frac{80{,}672\,\frac{lb}{ft^2}}{56.16\,\frac{lb}{ft^3}} + \frac{0.111^2\,\frac{ft}{s} - 15.5225^2\,\frac{ft}{s}}{2(32.2\,\frac{ft}{s^2})} + 15\,ft - 5\,ft + 35\,\frac{lb\,ft}{lb}\right)\left(56.16\,\frac{lb}{ft^3}\right)$

$\boxed{P_C = 82{,}989.25\,\frac{lb}{ft^2} \text{ or } 576.314\,psi}$

(d) $\frac{\cancel{P_A}^{0}}{\gamma_{oil}} + \frac{\cancel{V_A^2}^{0}}{2g} + \cancel{Z_A}^{0} = \frac{P_D}{\gamma_{oil}} + \frac{V_D^2}{2g} + Z_D + h_{LS}$

$\rightarrow P_D = \left(-\frac{V_D^2}{2g} - Z_D - h_{LS}\right)(\gamma_{oil})$

$= \left(-\frac{15.5225^2\,\frac{ft}{s}}{2(32.2\,\frac{ft}{s^2})} - 5\,ft - 11.5\,\frac{lb\,ft}{lb}\right)\left(56.16\,\frac{lb}{ft^3}\right)$

$= (-3.74143 - 5 - 11.5)(56.16)$

$\boxed{P_D = -1136.76\,\frac{lb}{ft^2} \text{ OR } -7.89416\,psi}$

(e) $h_A = \frac{P_B - \cancel{P_A}^{0}}{\gamma_{oil}} + \frac{V_B^2 - \cancel{V_A^2}^{0}}{2g} + Z_B - \cancel{Z_A}^{0} + h_{LS} + h_{LD}$

$h_A = \frac{P_B}{\gamma_{oil}} + \frac{V_B^2}{2g} + Z_B + h_{LS} + h_{LD}$

$= \frac{80{,}672\,\frac{lb}{ft^2}}{56.16\,\frac{lb}{ft^3}} + \frac{0.111^2\,\frac{ft}{s}}{2(32.2\,\frac{ft}{s^2})} + 15\,ft + 11.5\,ft + 35\,ft$

$= 1436.7\,ft + .000191\,ft + 15\,ft + 11.5\,ft + 35\,ft$

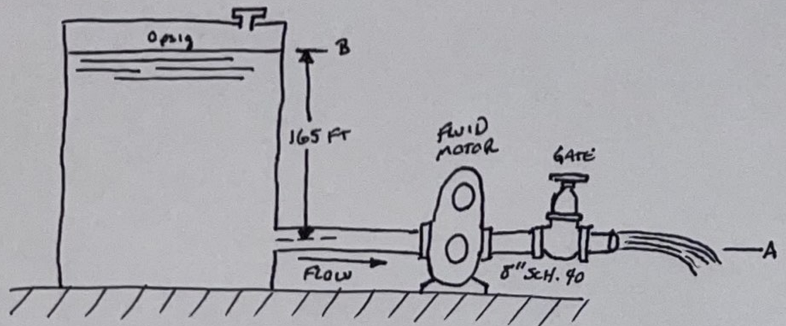
$h_A = 1498.2\,ft$

$P = h_A\,\gamma_{oil}\,Q = (1498.2\,ft)\left(56.16\,\frac{lb}{ft^3}\right)\left(0.01515\,\frac{ft^3}{s}\right)$

$P = 1274.7\,\frac{ft\,lb}{s} \cdot \frac{1\,HP}{550\,\frac{ft\,lb}{s}}$

$\boxed{P = 2.31764\,HP}$

7.30) WATER AT 60°F FLOWS FROM A LARGE RESERVOIR THROUGH A FLUID MOTOR AT THE RATE OF 1000 gpm IN THE SYSTEM SHOWN IN THE FIGURE. IF THE MOTOR REMOVES 37 HP FROM THE FLUID, CALCULATE THE ENERGY LOSSES IN THE SYSTEM.



GIVEN: $Q = 1000 \frac{GAL}{MIN}$

$Z_A = 0$

$Z_B = 165\ FT$

$P_A =$

$P_B = 0\ psig$

$V_1 = 0 \frac{FT}{S}$

$V_2 = ?$

8" SCH. 40 PIPE

$A = 0.3472\ FT^2$

$g = 32.2 \frac{FT}{S^2}$

$P_R = h_R \gamma_w Q$ (CH. 7)

$\gamma_w = 62.4 \frac{lb}{FT^3}$

SOLUTION:

$$\frac{\cancel{P_A}}{\gamma} + \cancel{Z_A} + \frac{V_A^2}{2g} = \frac{\cancel{P_B}}{\gamma} + Z_B + \frac{\cancel{V_B^2}}{2g} + \cancel{h_A} - h_R - h_L$$

(0 psig, 0 FT, 0 psig, $0 \frac{FT}{S}$, $0 \frac{lbFT}{lb}$)

$$\rightarrow h_L = Z_B - h_R - \frac{V_A^2}{2g} \quad \bigstar$$

$$P_R = h_R \gamma_w Q \rightarrow h_R = \frac{P_R}{\gamma_w Q} = \frac{20{,}350 \frac{lbFT}{SEC}}{(62.4 \frac{lb}{FT^3})(2.22816 \frac{FT^3}{SEC})}$$

$$h_R = 146.364 \frac{lbFT}{lb}$$

$$V_A = \frac{Q}{A_A}$$

$$Q = 1000 \frac{GAL}{MIN} \cdot \frac{1\ FT^3}{7.48\ GAL} \cdot \frac{1\ MIN}{60\ SEC} = 2.22816 \frac{FT^3}{SEC}$$

$$V_A = \frac{2.22816 \frac{FT^3}{SEC}}{0.3472\ FT^2} = 6.41752 \frac{FT}{SEC}$$

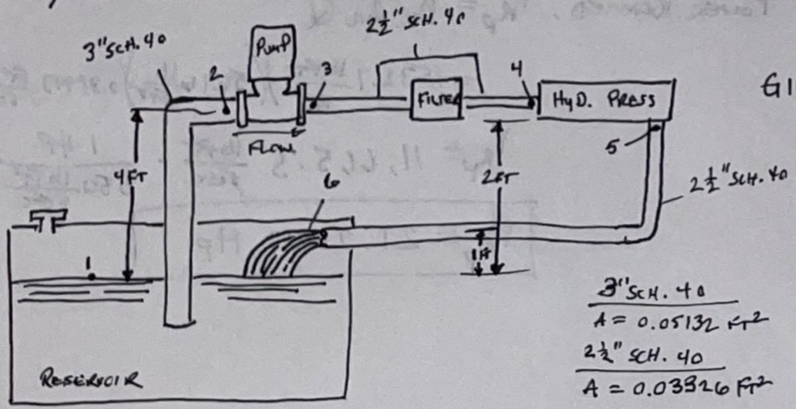
$$P_R = 37\ HP \cdot \frac{550 \frac{lbFT}{SEC}}{1\ HP} = 20{,}350 \frac{lbFT}{SEC}$$

$$\bigstar\ h_L = Z_B - h_R - \frac{V_A^2}{2g}$$

$$= 165\ FT - 146.364 \frac{lbFT}{lb} - \frac{(6.41752 \frac{FT}{SEC})^2}{2(32.2 \frac{FT}{SEC^2})}$$

$$\boxed{h_L = 17.9965 \frac{lbFT}{lb}}$$

7.35) COMPUTE THE POWER REMOVED FROM THE FLUID BY THE PRESS.



3" SCH. 40
$A = 0.05132\ ft^2$

$2\frac{1}{2}$" SCH. 40
$A = 0.03326\ ft^2$

GIVEN: $sg_{oil} = 0.9\left(62.4 \frac{lb}{ft^3}\right) = 56.16 \frac{lb}{ft^3} = \gamma_{oil}$

$Q = 175 \frac{gal}{min} \cdot \frac{1\,ft^3}{7.48\,gal} \cdot \frac{1\,min}{60\,sec} = 0.38993 \frac{ft^3}{sec}$

$P_A = 28.4\,hp \cdot \frac{550 \frac{lb\,ft}{sec}}{1\,hp} = 15{,}620 \frac{lb\,ft}{sec}$

$\varepsilon = 0.8 \qquad = P \cdot \varepsilon = 15{,}620(0.8) = 12{,}496 \frac{lb\,ft}{s}$

$h_{L_{1-2}} = 2.8 \frac{lb\,ft}{lb}$

$h_{L_{3-4}} = 28.5 \frac{lb\,ft}{lb}$

$h_{L_{5-6}} = 3.5 \frac{lb\,ft}{lb}$

SOLUTION:

$$\frac{\cancel{P_1}^{0}}{\gamma_{oil}} + z_1 + \frac{\cancel{V_1^2}^{0}}{2g} + \cancel{h_A}^{0} - \cancel{h_R}^{0} - h_L = \frac{P_2}{\gamma_{oil}} + z_2 + \frac{V_2^2}{2g} \longrightarrow z_1 - h_L = \frac{P_2}{\gamma_{oil}} + z_2 + \frac{V_2^2}{2g}$$

$$\longrightarrow P_2 = \left(z_1 - z_2 - \frac{V_2^2}{2g} - h_{L_{1-2}}\right)(\gamma_{oil}) \;\star$$

FIND $V_2 \longrightarrow V_2 = Q/A_2 = \dfrac{0.38993 \frac{ft^3}{sec}}{0.05132\ ft^2} = 7.59801 \frac{ft}{s}$

$$\star\; P_2 = \left(0 - 4\,ft - \frac{\left(7.59801 \frac{ft}{s}\right)^2}{2\left(32.2 \frac{ft}{s^2}\right)} - 2.8 \frac{lb\,ft}{lb}\right)\left(56.16 \frac{lb}{ft^3}\right) = \cancel{17.0488 \frac{lb}{ft^2}} - 432.231 \frac{lb}{ft^2}$$

$$\frac{P_3}{\gamma_{oil}} + \cancel{z_3}^{\text{same}} + \frac{V_3^2}{2g} = \frac{P_2}{\gamma_{oil}} + \cancel{z_2}^{\text{same}} + \frac{V_2^2}{2g} + h_A - \cancel{h_R}^{0} - \cancel{h_L}^{0} \longrightarrow P_3 = \left(\frac{P_2}{\gamma_{oil}} + \frac{V_2^2}{2g} - \frac{V_3^2}{2g} + h_A\right)(\gamma_{oil}) \;*$$

NEED TO FIND V_3, $h_A \longrightarrow h_A = \dfrac{P_A}{\gamma_{oil} Q} \longrightarrow \dfrac{12{,}496 \frac{lb\,ft}{sec}}{\left(56.16 \frac{lb}{ft^3}\right)\left(0.38993 \frac{ft^3}{sec}\right)} = 570.634 \frac{lb\,ft}{lb}$

$\longrightarrow V_3 = Q/A_3 = \dfrac{0.38993 \frac{ft^3}{sec}}{0.03326\ ft^2} = 11.7237 \frac{ft}{s}$

$$*\; P_3 = \left(\frac{-432.231 \frac{lb}{ft^2}}{\cancel{62.4 \frac{lb}{ft^3}}\ 56.16 \frac{lb}{ft^3}} + \frac{\left(7.59801 \frac{ft}{s}\right)^2}{2\left(32.2 \frac{ft}{s^2}\right)} - \frac{\left(11.7237 \frac{ft}{s}\right)^2}{2\left(32.2 \frac{ft}{s^2}\right)} + 570.634 \frac{lb\,ft}{lb}\right)\left(56.16 \frac{lb}{ft^3}\right) = 31545.1 \frac{lb}{ft^2}$$

$$\frac{P_4}{\gamma_{oil}} + \cancel{z_4}^{\text{same}} + \frac{\cancel{V_4^2}^{N/A}}{2g} + h_{L_{3-4}} = \frac{P_3}{\gamma_{oil}} + \cancel{z_3}^{\text{same}} + \frac{\cancel{V_3^2}^{N/A}}{2g} \longrightarrow P_4 = \left(\frac{P_3}{\gamma_{oil}} - h_{L_{3-4}}\right)(\gamma_{oil})$$

$ft \cdot \frac{lb}{ft^3} = \frac{lb}{ft^2}$

$$= \left(\frac{31545.1 \frac{lb}{ft^2}}{56.16 \frac{lb}{ft^3}} - 28.5 \frac{lb\,ft}{lb}\right)\left(56.16 \frac{lb}{ft^3}\right)$$

$$P_4 = 29944.5 \frac{lb}{ft^2}$$

$$\frac{P_4}{\gamma_{oil}} + z_4 + \frac{\cancel{V_4^2}^{0}}{2g} + \cancel{h_A}^{0} - h_R - \cancel{h_L}^{0} = \frac{P_5}{\gamma_{oil}} + z_5 + \frac{\cancel{V_5^2}^{0}}{2g} \longrightarrow \text{ENERGY REMOVED, } -h_R = \frac{P_5 - P_4}{\gamma_{oil}} + z_5 - z_4$$

$$\longrightarrow -h_R = \frac{P_5 - P_4}{\gamma_{oil}} + z_5 - z_4 \;\star\; \text{NEED } P_5.$$

$$\frac{P_5}{\gamma} + z_5 + \frac{\cancel{V_5^2}^{\text{same}}}{2g} + \cancel{h_A}^{0} - \cancel{h_R}^{0} - h_{L_{5-6}} = \frac{\cancel{P_6}^{0\,psig}}{\gamma} + z_6 + \frac{\cancel{V_6^2}^{\text{same}}}{2g} \longrightarrow P_5 = \left(h_{L_{5-6}} + z_6 - z_5\right)(\gamma_{oil})$$

$$= \left(3.5 \frac{lb\,ft}{lb} + 1\,ft - 2\,ft\right)\left(56.16 \frac{lb}{ft^3}\right)$$

$$= 140.4 \frac{lb}{ft^2}$$

$$\star\; -h_R = \frac{140.4 \frac{lb}{ft^2} - 29944.5 \frac{lb}{ft^2}}{56.16 \frac{lb}{ft^3}} + 2\,ft - 4\,ft = -532.7 \frac{lb\,ft}{lb} = +532.7 \frac{lb\,ft}{lb}$$

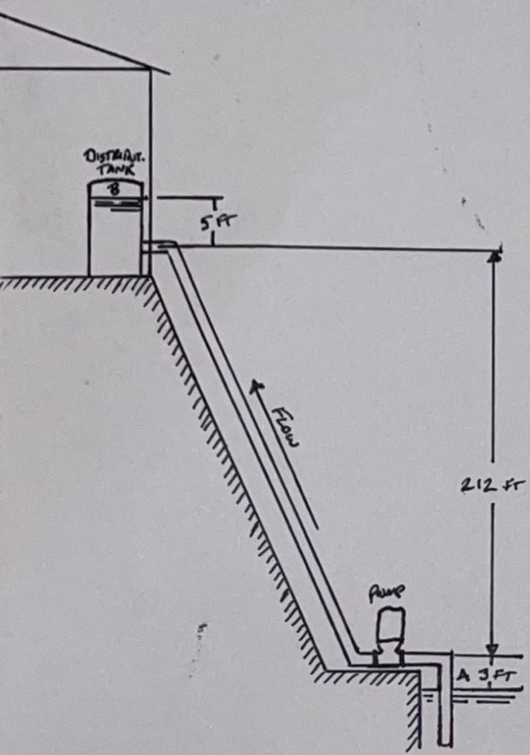
7.35 CONT.) $h_R = 532.7 \frac{lb\,ft}{lb} \longrightarrow$ POWER REMOVED, $P_{R_p} = h_R \gamma_{oil} Q$

$$= \left(532.7 \frac{lb\,ft}{\cancel{lb}}\right)\left(56.16 \frac{\cancel{lb}}{\cancel{ft^3}}\right)\left(0.38993 \frac{\cancel{ft^3}}{sec}\right)$$

$$P_{R_p} = 11{,}665.3 \frac{lb\,\cancel{ft}}{\cancel{sec}} \cdot \frac{1\ Hp}{550 \frac{lb\,\cancel{ft}}{\cancel{sec}}}$$

$$\boxed{P_{R_p} = 21.2097\ Hp}$$

7.42) THE DISTRIBUTION TANK IN THE CABIN MAINTAINS A PRESSURE OF 30 psig ABOVE THE WATER. THERE IS AN ENERGY LOSS OF 15.5 $\frac{lb\text{-}ft}{lb}$ IN THE PIPING. WHEN THE PUMP IS DELIVERING 40 GAL/MIN OF WATER, COMPUTE THE HP DELIVERED BY THE PUMP TO THE WATER.



GIVEN: $P_B = 30\,\frac{lb}{in^2}\cdot\frac{144\,in^2}{1\,ft^2} = 4320$ $\quad \gamma_w = 62.4\,\frac{lb}{ft^3}$ $\quad Z_A = 0$ ft, $Z_B = 220$ FT

$h_L = 15.5\,\frac{lb\,ft}{lb}$

$Q = 40\,\frac{GAL}{MIN}\cdot\frac{1\,FT^3}{7.48\,GAL}\cdot\frac{1\,MIN}{60\,SEC} = 0.089127\,\frac{ft^3}{SEC}$

$P = \frac{P_A}{\eta_A} = \frac{\gamma Q h_A}{\eta_A}$

SOLUTION: $h_A + \cancel{\frac{P_A}{\gamma_w}}^{0} + \cancel{\frac{V_A^2}{2g}}^{0} + \cancel{Z_A}^{0} = \frac{P_B}{\gamma_w} + \cancel{\frac{V_B^2}{2g}}^{0} + Z_B + h_L$

$\rightarrow h_A = \frac{P_B}{\gamma_w} + Z_B + h_L$

$= \frac{4320\,\frac{lb}{ft^2}}{62.4\,\frac{lb}{ft^3}} + 220\text{ ft} + 15.5\,\frac{lb\,ft}{lb}$

$h_A = 304.731$ FT

(POWER) $P_A = \gamma_w Q\, h_A$

$= (62.4\,\frac{lb}{ft^3})(0.089127\,\frac{ft^3}{sec})(304.731\text{ ft})$

(POWER) $P_A = 1694.77\,\frac{lb\,ft}{sec}\cdot\frac{1\,HP}{550\,\frac{lb\,ft}{sec}} = 3.0814$ HP

$\boxed{\text{POWER DELIVERED BY PUMP} = 3.0814\text{ HP}}$