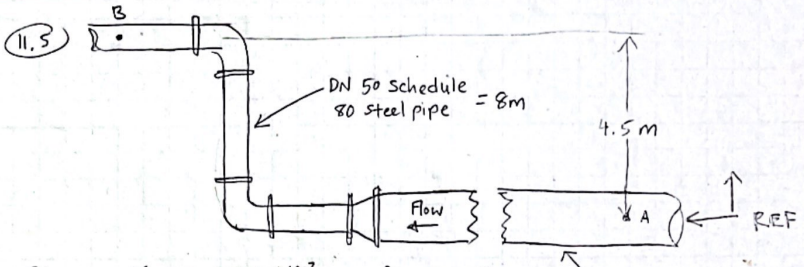
11.5




Given: $\gamma_{oil} = 8.80\ kN/m^3$ $P_B = 12.5\ MPa$

$Q = 0.015\ m^3/s$ $@\ 15°C\ \nu = 2.12\times10^{-5}\ m^2/s$

B = DN 50 flow area = $1.905\times10^{-3}\ m^2$

A = DN 150 flow area = $1.682\times10^{-2}\ m^2$

B = DN 50 inside dia = 49.3 mm $\left(\frac{1\,m}{1000\,mm}\right)$ = 0.0493 m

A = DN 150 inside dia = 146.3 mm $\left(\frac{1\,m}{1000\,mm}\right)$ = 0.1463 m

$$\frac{P_A}{\gamma_{oil}} + \frac{V_A^2}{2g} + \cancel{z_A}^{\,0} = \frac{P_B}{\gamma_{oil}} + \frac{V_B^2}{2g} + z_B + h_{L\,A-B}$$

$$\frac{P_A}{\gamma_{oil}} = \frac{P_B}{\gamma_{oil}} + \frac{V_B^2}{2g} + z_B + h_{L_{A-B}} + \frac{V_A^2}{2g}$$

$$P_A = \left(\frac{P_B}{\gamma_{oil}} + \frac{V_B^2}{2g} + z_B + h_{L_{A-B}} + \frac{V_A^2}{2g}\right)\gamma_{oil}$$

$$V_B = \frac{Q}{A_B} = \frac{0.015\,m^3/s}{1.905\times10^{-3}\,m^2} = 7.874\ m/s$$

$$V_A = \frac{Q}{A_A} = \frac{0.015\,m^3/s}{1.682\times10^{-2}\,m^2} = 0.892\ m/s$$

energy losses

Pipe A + Reduction + Pipe B + 2 elbows

$$h_l = f_A \cdot \frac{L_A}{D_A} \cdot \frac{V_A^2}{2g}$$

$$Re = \frac{V_A D_A}{\nu} = \frac{(0.892\ m/s)(0.1463\ m)}{2.12\times10^{-5}\ m^2/s} = 6155.64$$

$$\frac{D_A}{\varepsilon} = \frac{0.1463\,m}{4.6\times10^{-5}\,m} = 3180.43 \qquad f = 0.036$$

$$h_l = 0.036\left(\frac{180\,m}{0.1463\,m}\right)\left(\frac{(0.892\,m/s)^2}{2(9.81\,m/s^2)}\right) = 1.796\,m$$

$$h_2 = K\frac{V_B^2}{2g}$$

$$= 0.40\left(\frac{(7.874\ m/s)^2}{2(9.81\ m/s^2)}\right) = 1.264\ m$$

$$h_3 = f_B\frac{L_B}{D_B}\frac{V_B^2}{2g}$$

$$Re = \frac{V_B D_B}{\nu} = \frac{(7.874\ m/s)(0.0493\ m)}{(2.12\times10^{-5}\ m^2/s)} = 18310.76$$

$$\frac{D_B}{\varepsilon} = \frac{0.0493\ m}{4.6\times10^{-5}\ m} = 1071.74 \qquad f_B = 0.028$$

$$h_3 = 0.028\left(\frac{1.8\ m}{0.0493\ m}\right)\left(\frac{(7.874\ m/s)^2}{2(9.81\ m/s^2)}\right) = 14.36\ m$$

$$h_4 = K\frac{V_B^2}{2g}$$

$$= 30(0.019)\left(\frac{(7.874\ m/s)^2}{2(9.81\ m/s^2)}\right) = 1.801\ m \times 2 \text{ for } 2 \text{ elbow}$$

$$h_{LA-B} = h_1 + h_2 + h_3 + h_4$$

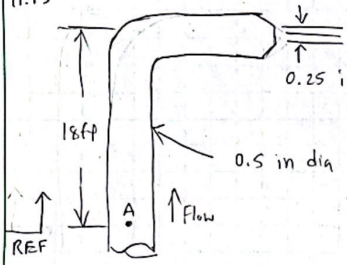
$$= 1.796m + 1.264m + 14.36\ m + (1.801m \times 2) = 21.022$$

$$P_A = \left(\frac{P_B}{\gamma_{oil}} + \frac{V_B^2}{2g} + z_B + h_{LA-B} + \frac{V_A^2}{2g}\right)\gamma_{oil}$$

$$P_A = 8.80\ KN/m^3\left(\frac{12.5\times10^6\ N/m^2}{8.80\ KN/m^3} + \frac{(7.874\ m/s)^2}{2(9.81\ m/s^2)} + 4.5m + 21.022 \text{ or} + \frac{(0.892\ m/s)^2}{2(9.81\ m/s^2)}\right)$$

$$P_A = 12.5\times10^6\ N/m^2 \quad \text{or} \quad 12.5\ MPa$$

11.13




Given: $D = 0.50\,in\left(\frac{1\,ft}{12}\right) = 0.0415\,ft$

$L = 20\,ft$

$K = 0.15$

(a) $P_A = 20\,psig \times 144 = 2880\,lb/ft^2$

(b) $P_A = 80\,psig$

$100^\circ F$ : $\nu = 7.37 \cdot 10^{-6}\,\frac{ft^2}{s}$

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

$Q_A = Q_B$

$$V_A \cdot \frac{\pi r^2}{4} = V_B \cdot \frac{D^2 V_B}{D^2}$$

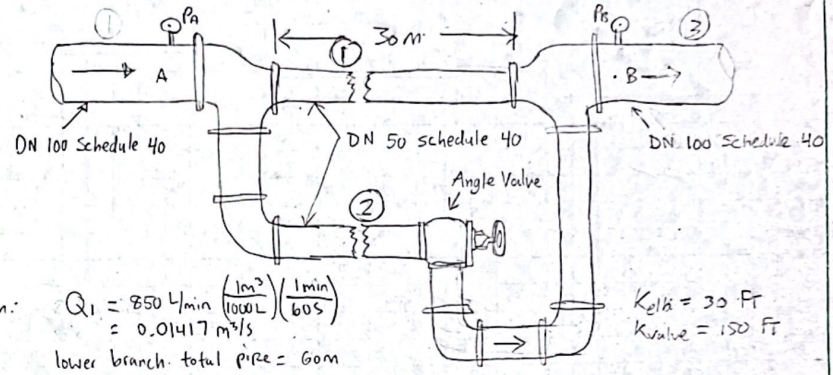
$h_L = h_1 + h_2$

$= f\frac{L}{D}\frac{V_A^2}{2g} + K\frac{V_B^2}{2g}$

$$V_B = \sqrt{\frac{2g\left(\frac{P_A}{\gamma_W} - z_B\right)}{1 - \frac{r^4}{D^4} + K + f\frac{Lr^4}{D^5}}}$$

(1) Assume $V_B$
(2) Compute for $Re$
(3) Compute for $f$
(4) Solve for New $V_B$
(5) Compare $V_B$ to New $V_B$

12.3




Given: $Q_1 = 850\ L/min \left(\frac{1m^3}{1000L}\right)\left(\frac{1min}{60S}\right)$
$= 0.01417\ m^3/s$
lower branch total pipe = 60m

$K_{elb} = 30$ Ft
$K_{valve} = 150$ Ft

(a) calculate for flow rate of each branches Q
(b) pressure difference $p_A - p_B = \Delta P$

$D_1 = 102.3\ mm = 0.1023\ m$

$D_2 = D_3 = 52.5\ mm = 0.0525\ m$

$10^{\circ}C\ \nu = 1.3 \times 10^{-6}\ m^2/s$

$$Q_1 = Q_2 + Q_3 \quad \text{I}$$

$$\frac{\Delta P}{\gamma} = f_1 \frac{L_1}{D_1}\frac{V_1^2}{2g} + 2K_{tee}\frac{8Q_1^2}{g\pi^2 D_1^4} + f_2\frac{L_2}{D_2}\frac{8Q_2^2}{g\pi^2 D_2^4} \quad \text{II}$$

$$\frac{\Delta P}{\gamma} = f_1 \frac{L_1}{D_1}\frac{V_1^2}{2g} + 2K_{tee}\frac{8Q_1^2}{g\pi^2 D_1^4} + \left(3K_{elb} + K_{valve} + f_3\frac{L_3}{D_3}\right)\frac{8Q_3^2}{g\pi^2 D_3^4}$$

1) Assume $\Delta P$
2) Solve for $Q_2$
   - Assume $f_2$
     compute $D_2/\varepsilon$ $ft_2$
     Solve for $Q_2$
     Compute $Re_2$
     Compute for New $f_2$
     Compare old $f_2$ and New $f_2$
3) $Q_1 = Q_2 + Q_3$
   $Q_3 = Q_1 - Q_2$
4) use the $Q_2$ found to solve for New $\Delta P$.