$Q = 121 \times 10^3 \frac{bbL}{day} \Big| \frac{m^3}{6.29\ bbL} \Big| \frac{day}{24 \times 3600\ s} = 0.22265\ m^3/s$

$\rho = 1144\ kg/m^3$, $\mu = 0.0008\ Pa.s$, $L = 7.14\ m$

$OD_p = 20''$, $wt = 0.375''$, $ID_p = 19.25''$

$U_p = \frac{4Q}{\pi ID_p^2} = 1.1858\ m/s$, $Re_p = 829111$

$f = 0.01364$, $\Delta P_{pf} = f \frac{L}{ID} \cdot \rho \cdot \frac{U_p^2}{2} =$ **0.02324 psi**

Valves, Fittings:

x4, 90° std (r/d=1) Elbow, class 150:

- $wt = 0.594''$ (Sch 40), $ID = 18.812''$

$V_{90} = 1.24163\ m/s$, $Re_{90} = 848394$

$f_T = 0.01188$

using Crane, $K = 20 \cdot f_T = 0.2376$

$\Sigma K = 0.9504$

$\Delta P_{90} = \Sigma K \cdot \rho \cdot \frac{U^2}{2} =$ **0.12159 psi**

Outlet Nozzle, flush Type:

using Crane, $K = 0.04$, $\Delta P_{ON} =$ **0.005117 psi**

Butterfly valves, class 150, size 18":

$wt = 0.562''$, $ID = 16.876''$, $V_{BF} = 1.5428\ m/s$, $f_T = 0.0121$

using Crane $K = 25 \cdot f_T = 0.3025$

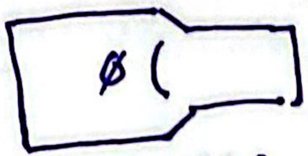
$\Sigma K = 0.605$

$\Delta P_{BF} =$ **0.1195 psi**

Pipe Reducers: Class 150

20"×18":

$\beta = \frac{16.876}{18.812} = 0.89709$

18.812"  16.876"

$\theta = 45°$

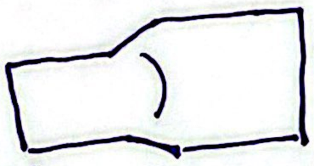
using Crane: $K_2 = \frac{0.8 \cdot \sin\left(\frac{\theta}{2}\right)(1-\beta^2)}{\beta^4}$ (based on larger dia)

$K_2 = 0.09228$

$\Delta P_R = K_2 \cdot \rho \cdot \frac{U_2^2}{2}$, $U_2 = 1.24163$ m/s

$\Delta P_R = \boxed{0.01181 \text{ psi}}$

18"×20"

 18.812"

16.876" $\theta = 45°$

$\beta = \frac{16.876}{18.812} = 0.89709$

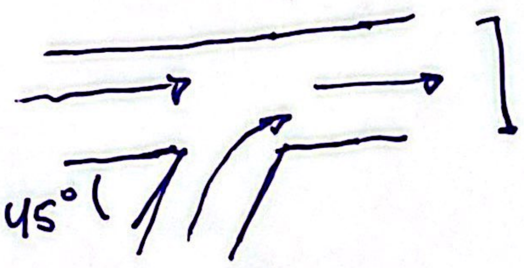
using Crane: $K_2 = \frac{2.6 \cdot \sin\left(\frac{\theta}{2}\right)(1-\beta^2)^2}{\beta^4}$

$K_2 = 0.05855$

$\Delta P_R = K_2 \cdot \rho \cdot \frac{U_2^2}{2}$, $U_2 = 1.24163$ m/s

$\Delta P_R = \boxed{0.007491 \text{ psi}}$

WYE:



45°

36" NPS Sch std 550×10^3 $\frac{bbl}{day}$

20" NPS Sch std $Q = 121\times10^3$ $\frac{bbl}{day}$

$ID_B = 20" - 2\times0.375" = 19.25"$

$ID_C = 36" - 2\times0.375" = 35.25"$

$\frac{ID_B}{ID_C} = 0.5461 = \beta$

$\frac{Q_B}{Q_C} = \frac{121\times10^3}{550\times10^3} = 0.22 = R$

$\beta^2 = 0.5461^2 = 0.2982$

For Converging Flow: $K_B = 1 + \left(R \times \frac{1}{\beta^2}\right)^2 - 2(1-R)^2 - 1.41\left(\frac{R^2}{\beta^2}\right)$

$K_B = 0.09864$

$\Delta P_{Branch} = K_B \cdot \rho \frac{U_B^2}{2}$, U_B based on ID = 19.25" & $Q = 121\times10^3$ $\frac{bbl}{day}$

$\rightarrow V_B = \frac{4Q_B}{\pi ID_B^2} = 1.1858\ m/s$

$\rightarrow \Delta P_B = \boxed{0.01151\ psi}$

$K_{Run} = 1 - (1-R)^2 - 1.41\left(\frac{R^2}{\beta^2}\right)$

$= 0.1628$

$\Delta P_{Run} = K_{run} \times \rho \times \frac{V_R^2}{2}$, V_R = based on 35.25" & 550×10^3 bbl/day

$V_R = \frac{4Q_c}{\pi ID_c^2} = 1.607\ m/s$

$\rightarrow \Delta P_{Run} = \boxed{0.03491\ psi}$