8.77

8.77 The pressure at section (2) shown in Fig. P8.77 is not to fall below 60 psi when the flowrate from the tank varies from 0 to 1.0 cfs and the branch line is shut off. Determine the minimum height, h, of the water tank under the assumption that (a) minor losses are negligible, (b) minor losses are not negligible.

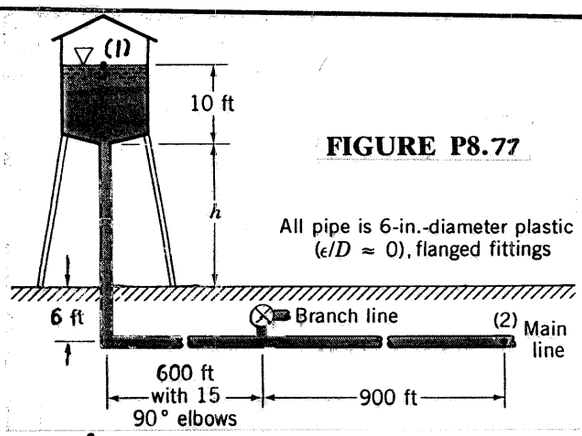

FIGURE P8.77

All pipe is 6-in.-diameter plastic ($\epsilon/D \approx 0$), flanged fittings

$\frac{p_1}{\gamma}+\frac{V_1^2}{2g}+z_1=\frac{p_2}{\gamma}+\frac{V_2^2}{2g}+z_2+\left(f\frac{l}{D}+\Sigma K_L\right)\frac{V^2}{2g}$, where $p_1=0$, $V_1=0$, $z_1=16\text{ ft}+h$, and $z_2=0$ Thus, with $V=V_2$

$16+h=\frac{p_2}{\gamma}+\frac{V^2}{2g}+\left(f\frac{l}{D}+\Sigma K_L\right)\frac{V^2}{2g}$. Note: h must be no less than that with $p_{2\,min}=60\text{ psi}$ and $Q_{max}=1\text{ cfs}$, or

$V_2=V=\frac{Q}{A_2}=\frac{1\frac{ft^3}{s}}{\frac{\pi}{4}\left(\frac{6}{12}\text{ ft}\right)^2}=5.09\frac{ft}{s}$

Hence,

$h=-16\text{ ft}+\frac{\left(60\frac{lb}{in^2}\right)\left(144\frac{in^2}{ft^2}\right)}{62.4\frac{lb}{ft^3}}+\left(1+f\left(\frac{h+6+600+900}{\frac{6}{12}}\right)+\Sigma K_L\right)\frac{\left(5.09\frac{ft}{s}\right)^2}{2\left(32.2\frac{ft}{s^2}\right)}$

or

$h=122.5+\left(1+f\left(\frac{1506+h}{0.5}\right)+\Sigma K_L\right)(0.402)\text{ ft}$, where $h\sim$ ft (1)

With $\frac{\varepsilon}{D}=0$ and $Re=\frac{VD}{\nu}=\frac{\left(5.09\frac{ft}{s}\right)\left(\frac{6}{12}\text{ ft}\right)}{1.21\times10^{-5}\frac{ft^2}{s}}=2.10\times10^5$ we obtain

$f=0.0155$ (see Fig. 8.20)

a) Neglect minor losses ($\Sigma K_L=0$):

From Eq. (1)

$h=122.5+\left(1+(0.0155)\left(\frac{1506+h}{0.5}\right)\right)(0.402)$

or $h=\underline{\underline{143\text{ ft}}}$

b) Include minor losses:

$\Sigma K_L=K_{L_{entrance}}+15\,K_{L_{elbow}}+K_{L_{tee}}=0.5+15(0.3)+0.2=5.2$

(see Table 8.2, assume flanged fittings)

Thus, from Eq. (1)

$h=122.5+\left(1+(0.0155)\left(\frac{1506+h}{0.5}\right)+5.2\right)(0.402)$

or

$h=\underline{\underline{146\text{ ft}}}$

Note: For this case minor losses are not very important.