

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.

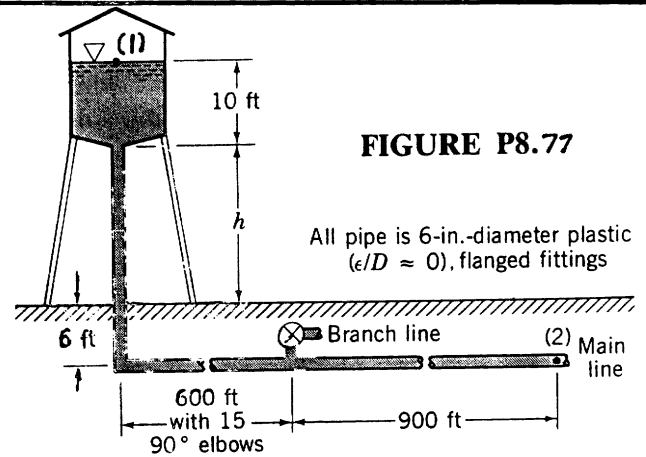


FIGURE P8.77

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

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

$$16 + h = \frac{p_2}{\rho} + \frac{V^2}{2g} + \left(f \frac{L}{D} + \sum K_L\right) \frac{V^2}{2g}. \text{ Note: } h \text{ must be no less than that with}$$

$$p_{2 \text{ min}} = 60 \text{ psi and } Q_{\text{max}} = 1 \text{ cfs, or}$$

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

Hence,

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

or

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

$$\text{With } \frac{\epsilon}{D} = 0 \text{ and } Re = \frac{VD}{\nu} = \frac{(5.09 \frac{\text{ft}}{\text{s}})(\frac{6}{12} \text{ ft})}{1.21 \times 10^{-5} \frac{\text{ft}^2}{\text{s}}} = 2.10 \times 10^5 \text{ we obtain}$$

$$f = 0.0155 \text{ (see Fig. 8.20)}$$

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

From Eq. (1)

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

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

b) Include minor losses:

$$\sum K_L = K_{L \text{ entrance}} + 15 K_{L \text{ elbow}} + K_{L \text{ tee}} = 0.5 + 15(0.3) + 0.2 = 5.2$$

(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.