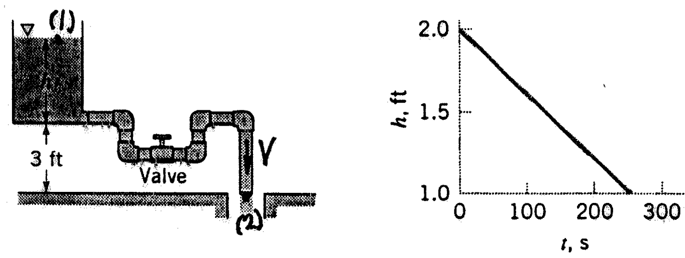
8.85

8.85 When water flows from the tank shown in Fig. P8.85, the water depth in the tank as a function of time is as indicated. Determine the cross-sectional area of the tank. The total length of the 0.60-in.-diameter pipe is 20 ft, and the friction factor is 0.03. The loss coefficients are: 0.50 for the entrance, 1.5 for each elbow, and 10 for the valve.



■ FIGURE P8.85

$$\frac{p_1}{\gamma} + z_1 + \frac{V_1^2}{2g} - h_L = \frac{p_2}{\gamma} + z_2 + \frac{V_2^2}{2g}$$

where

$p_1 = p_2 = 0$, $z_2 = 0$, $z_1 = 3\,ft + h$, $V_1 = 0$, $V_2 = V$ and

$h_L = \left(f\frac{\ell}{D} + \sum_i K_{L_i}\right)\frac{V^2}{2g}$ with $\sum_i K_{L_i} = 0.5 + 5(1.5) + 10 = 18$

Thus,

$$z_1 = h_L + \frac{V_2^2}{2g} = \left(f\frac{\ell}{D} + \sum_i K_{L_i} + 1\right)\frac{V^2}{2g}$$

Consider the flow when $h = 1.5\,ft$ so that $z_1 = 4.5\,ft$

Hence,

$$4.5\,ft = \left(0.03\,\frac{20\,ft}{\left(\frac{0.6}{12}ft\right)} + 18 + 1\right)\frac{V^2}{2\left(32.2\,\frac{ft}{s^2}\right)}$$

or

$V = 3.06\,\frac{ft}{s}$ so that $Q = AV = \frac{\pi}{4}\left(\frac{0.6}{12}ft\right)^2\left(3.06\,\frac{ft}{s}\right) = 0.00601\,\frac{ft^3}{s}$

But $Q = A_{tank}\left(-\frac{dh}{dt}\right)$

where from the graph

$$\frac{dh}{dt} \approx \frac{(-1\,ft)}{250\,s} = -0.004\,\frac{ft}{s}$$

Hence,

$$0.00601\,\frac{ft^3}{s} = A_{tank}\left(0.004\,\frac{ft}{s}\right)$$

or

$$A_{tank} = \underline{\underline{1.50\,ft^2}}$$