**6.108** The water pump in Fig. P6.108 maintains a pressure of 6.5 psig at point 1. There is a filter, a half-open disk valve, and two regular screwed elbows. There are 80 ft of 4-inch diameter commercial steel pipe. (a) If the flow rate is 0.4 $ft^3/s$, what is the loss coefficient of the filter? (b) If the disk valve is wide open and $K_{filter} = 7$, what is the resulting flow rate?

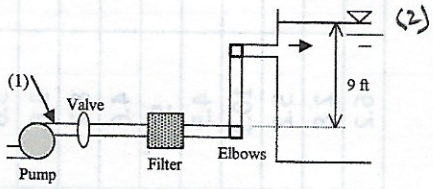


Fig. P6.108

$\rho = 1.94$ slug/ft$^3$ $\quad \mu = 2.09E\text{-}5$

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + \frac{V_1^2}{2g}\left[f\frac{L}{D} + \Sigma K_m\right]$$

$$\Sigma K_m = K_{valve} + K_{filter} + 2K_{elbow} + K_{exit}$$

(a) $V_1 = Q/A = .4/(\pi/4)(4/12)^2 = 4.58$ ft/s

$$\frac{6.5 \times 144}{62.4} + \frac{(4.58)^2}{2\times 32.2} + 0 = 0 + 0 + 9 + \frac{(4.58)^2}{2\times 32.2}\left[f\frac{240}{4/12} + 2.8 + K_{filter} + 2\times .64 + 1\right]$$

$15$ $\qquad$ $2.8 + K_{filter} + 2\times.64 + 1$

$f = f(Re, \varepsilon/D)$

$Re = VD\rho/\mu = 141{,}700$

$\varepsilon/D = .00015/(4/12) = .00045$

$f = .0193$

$$15 + .326 = 9 + .326\left(\underbrace{.0193\times 240}_{4.62} + 2.8 + K_{filter} + 1.28 + 1\right)$$

$K_{filter} = 9.7$

(b) $$15 + \frac{V^2}{2\times 32.2} = 9 + \frac{V^2}{2\times 32.2}\left[f\times 240 + 0 + 7 + 1.28 + 1\right]$$

$f = f\left(\frac{VD\rho}{\mu}, .00045\right)$

$f = .0189$

iterations using Moody diagram: $Re_D = 169{,}000$

$V = 5.49$

$Q = .48$ ft$^3$/s