

8.38

8.38 Water flows at a rate of 10 gallons per minute in a new horizontal 0.75-in.-diameter galvanized iron pipe. Determine the pressure gradient, $\Delta p/\ell$, along the pipe.

$$Q = 10 \frac{\text{gal}}{\text{min}} \left(\frac{1 \text{ min}}{60 \text{ s}} \right) \left(\frac{231 \text{ in.}^3}{1 \text{ gal}} \right) \left(\frac{1 \text{ gal}}{1728 \text{ in.}^3} \right) = 0.0223 \frac{\text{ft}^3}{\text{s}}$$

Thus,

$$V = \frac{Q}{A} = \frac{0.0223 \frac{\text{ft}^3}{\text{s}}}{\frac{\pi}{4} \left(\frac{0.75}{12} \text{ ft} \right)^2} = 7.27 \frac{\text{ft}}{\text{s}}$$

Now, for a horizontal pipe

$$\Delta p = f \frac{\ell}{D} \frac{1}{2} \rho V^2 \text{ where since}$$

$$Re = \frac{VD}{\nu} = \frac{7.27 \frac{\text{ft}}{\text{s}} \left(\frac{0.75}{12} \text{ ft} \right)}{1.21 \times 10^{-5} \frac{\text{ft}^2}{\text{s}}} = 3.76 \times 10^4$$

and

$$\frac{\epsilon}{D} = \frac{0.0005 \text{ ft}}{\left(\frac{0.75}{12} \text{ ft} \right)} = 0.008$$

it follows from Fig. 8.20 that $f = 0.037$

Thus,

$$\begin{aligned} \frac{\Delta p}{\ell} &= \frac{0.037 (1.94 \text{ slugs/ft}^3) (7.27 \text{ ft/s})^2}{\left(\frac{0.75}{12} \text{ ft} \right) (2)} = 30.4 \frac{\text{lb}}{\text{ft}^3} \left(\frac{1 \text{ ft}^2}{144 \text{ in.}^2} \right) \\ &= \underline{\underline{0.211 \text{ psi/ft}}} \end{aligned}$$