8.49

8.49 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.

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

Thus,

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

Now, for a horizontal pipe

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

$$Re = \frac{VD}{\nu} = \frac{7.27\,\frac{ft}{s}\left(\frac{0.75}{12}\,ft\right)}{1.21\times10^{-5}\,\frac{ft^2}{s}} = 3.76\times10^4$$

and

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

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

Thus,

$$\frac{\Delta p}{\ell} = \frac{0.037\,(1.94\,slugs/ft^3)\,(7.27\,ft/s)^2}{\left(\frac{0.75}{12}\,ft\right)(2)} = 30.4\,\frac{lb}{ft^3}\left(\frac{1\,ft^2}{144\,in.^2}\right)$$

$$= \underline{\underline{0.211\,psi/ft}}$$