8.80

8.80 According to fire regulations in a town, the pressure drop in a commercial steel horizontal pipe must not exceed 1.0 psi per 150 ft of pipe for flowrates up to 500 gal/min. If the water temperature is above 50° F, can a 6-in-diameter pipe be used?

Determine the pressure drop in a 6in. diameter pipe.

$\frac{p_1}{\gamma}+\frac{V_1^2}{2g}+z_1=\frac{p_2}{\gamma}+\frac{V_2^2}{2g}+z_2+f\frac{\ell}{D}\frac{V^2}{2g}$, where $V_1=V_2$ and $z_1=z_2$.

Thus

$\frac{p_1-p_2}{\gamma}=f\frac{\ell}{D}\frac{V^2}{2g}$, where $f=f(Re,\frac{\varepsilon}{D})$. (1)

From Table 8.1, $\varepsilon=0.00015ft$ so that $\frac{\varepsilon}{D}=\frac{1.5\times10^{-4}}{(6/12ft)}=3\times10^{-4}$

The largest p_1-p_2 will occur with the largest f, which occurs with the smallest Re, or largest V. Since the viscosity of water increases a the temperature decreases, we consider the coldest case – $T=50°F$.

From Table B.1, at 50°F, $\gamma=62.4\,lb/ft^3$ and $\nu=1.407\times10^{-5}\frac{ft^2}{s}$

Also,

$V=\frac{Q}{A}=\frac{(500\frac{gal}{min})(\frac{1\,min}{60s})(231\frac{in.^3}{gal})(\frac{1ft^3}{1728in.^3})}{\frac{\pi}{4}(\frac{6}{12}ft)^2}=5.67\frac{ft}{s}$

Thus,

$Re=\frac{VD}{\nu}=\frac{(5.67\frac{ft}{s})(6/12\,ft)}{1.407\times10^{-5}\frac{ft^2}{s}}=2.01\times10^5$

Hence, with $Re=2.01\times10^5$ and $\frac{\varepsilon}{D}=3\times10^{-4}$ we obtain from Fig. 8.20,

$f=0.018$

Therefore, from Eq. (1),

$\frac{p_1-p_2}{\gamma}=0.018\,\frac{(150ft)}{(6/12ft)}\,\frac{(5.67\frac{ft}{s})^2}{2(32.2\frac{ft}{s^2})}=2.70\,ft$

so that

$p_1-p_2=(2.70ft)(62.4\frac{lb}{ft^3})=168\frac{lb}{ft^2}(\frac{1ft^2}{144in.^2})=1.17\,psi>1.0psi$

A 6in. diameter pipe requires slightly more than the allowed 1.0psi per 150ft. Thus, no, a 6in. pipe cannot be used. The minimum diameter can be shown to be $D=0.513ft=6.37in.$