8.33

8.33 Determine the thickness of the viscous sublayer in a smooth 8-in.-diameter pipe if the Reynolds number is 25,000.

$\delta_s = \frac{5\nu}{u^*}$, where $u^* = \left(\frac{\tau_w}{\rho}\right)^{1/2}$ and $\tau_w = \frac{D\Delta p}{4\ell}$. Since $\Delta p = f\frac{\ell}{D}\frac{1}{2}\rho V^2$ we obtain $\tau_w = \frac{\rho f V^2}{8}$ and $u^* = \sqrt{\frac{f}{8}}\,V$

Thus,

$$\delta_s = \frac{5\nu}{\sqrt{\frac{f}{8}}\,V} = \frac{5\nu D}{\sqrt{\frac{f}{8}}\,VD}, \text{ or } \delta_s = \frac{5D}{Re\sqrt{\frac{f}{8}}} \qquad (1)$$

From Fig. 8.20, for a smooth pipe with $Re = 2.5\times10^4$, $f = 0.024$

Thus, from Eq. (1)

$$\delta_s = \frac{5\sqrt{8}\left(\frac{8}{12}\text{ ft}\right)}{2.5\times10^4\sqrt{0.024}} = \underline{\underline{0.00243\text{ ft}}}$$