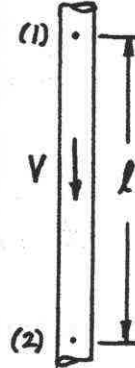


8.104

8.104 Water flows downward through a vertical smooth pipe. When the flowrate is  $0.5 \text{ ft}^3/\text{s}$  there is no change in pressure along the pipe. Determine the diameter of the pipe.



$$\frac{p_1}{\rho} + z_1 + \frac{V_1^2}{2g} = \frac{p_2}{\rho} + z_2 + \frac{V_2^2}{2g} + f \frac{l}{D} \frac{V^2}{2g}$$

where  $p_1 = p_2$ ,  $V_1 = V_2 = V$ , and  $z_1 - z_2 = l$

Thus,

$$l = f \frac{l}{D} \frac{V^2}{2g}, \text{ or } 1 = \frac{f}{D} \frac{V^2}{2g} \quad (1)$$

Also,

$$V = \frac{Q}{A} = \frac{Q}{\frac{\pi}{4} D^2} \text{ so that Eq. (1) becomes } 1 = \frac{f}{D} \frac{(\frac{4Q}{\pi D^2})^2}{2g}$$

or

$$D^5 = \frac{8}{\pi^2} f \frac{Q^2}{g} = \frac{8}{\pi^2} f \frac{(0.5)^2}{32.2} \text{ or } D = 0.363 f^{1/5} \quad (2)$$

Also,

$$Re = \frac{\rho V D}{\mu} = \frac{1.94 (\frac{4Q}{\pi D^2}) D}{2.34 \times 10^{-5}} = \frac{1.94 (\frac{4(0.5)}{\pi})}{2.34 \times 10^{-5} D} \text{ or } Re = \frac{5.28 \times 10^4}{D} \quad (3)$$

From Fig. 8.20 with  $\frac{\epsilon}{D} = 0$  we have  $f = f(Re, \frac{\epsilon}{D} = 0)$

Trial and error solution: 3 unknowns ( $D, Re, f$ ) and 3 equations  
(2), (3), and Fig. 8.20)

Assume  $f = 0.02$  so from Eq. (2),  $D = 0.166 \text{ ft}$  and from Eq. (3),  $Re = 3.18 \times 10^5$ . Thus, from Fig. 8.20,  $f = 0.014 \neq 0.02$

Assume  $f = 0.014$  so that  $D = 0.155 \text{ ft}$  and  $Re = 3.42 \times 10^4$

Thus, from Fig. 8.20,  $f = 0.014$  which checks with the assumed value.

Thus,  $D = \underline{0.155 \text{ ft}}$