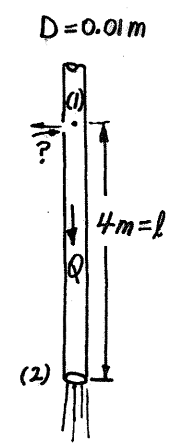
8.28

8.28 Water flows downward through a vertical 10-mm-diameter galvanized iron pipe with an average velocity of 5.0 m/s and exits as a free jet. There is a small hole in the pipe 4 m above the outlet. Will water leak out of the pipe through this hole, or will air enter into the pipe through the hole? Repeat the problem if the average velocity is 0.5 m/s.



$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + f\frac{\ell}{D}\frac{V^2}{2g}$, where $p_2 = 0$, $z_2 = 0$,

$z_1 = 4\,m$, $V_1 = V_2 = V$. Thus,

$\frac{p_1}{\gamma} = f\frac{\ell}{D}\frac{V^2}{2g} - z_1$, or $p_1 = f\frac{\ell}{D}\frac{1}{2}\rho V^2 - \gamma\ell$ With ε from Table 8.1, (1)

$\frac{\varepsilon}{D} = \frac{0.15\,mm}{10\,mm} = 0.015$ so that with $Re = \frac{VD}{\nu} = \frac{(5\frac{m}{s})(0.01m)}{1.12\times10^{-6}\frac{m^2}{s}} = 4.46\times10^4$

we obtain $f = 0.045$ (see Fig. 8.20).

Thus, from Eq. (1)

$p_1 = 0.045\left(\frac{4m}{0.01m}\right)\frac{1}{2}(999\frac{kg}{m^3})(5\frac{m}{s})^2 - 9800\frac{N}{m^3}(4m) = 1.86\times10^5\frac{N}{m^2}$

Since $p_1 > 0$, <u>water will leak out of the pipe when $V = 5\frac{m}{s}$</u>

If $V = 0.5\frac{m}{s}$, then $Re = 4.46\times10^3$ and $f = 0.052$

Thus, from Eq. (1)

$p_1 = 0.052\left(\frac{4m}{0.01m}\right)\frac{1}{2}(999\frac{kg}{m^3})(0.5\frac{m}{s})^2 - 9800\frac{N}{m^3}(4m) = -3.66\times10^4\frac{N}{m^2}$

Since $p_1 < 0$, <u>air will enter the pipe when $V = 0.5\frac{m}{s}$</u>

Note: The above conclusion is valid regardless of the length, ℓ.