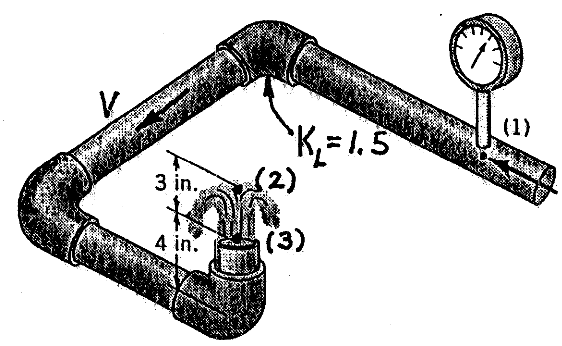
8.76

8.76 As shown in Video V8.6 and Fig. P8.76, water "bubbles up" 3 in. above the exit of the vertical pipe attached to three horizontal pipe segments. The total length of the 0.75-in.-diameter galvanized iron pipe between point (1) and the exit is 21 in. Determine the pressure needed at point (1) to produce this flow.



■ FIGURE P8.76

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 - h_L = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2$$

where $z_1 = 0$, $p_2 = 0$, $V_2 = 0$ Thus,

(1) $$\frac{p_1}{\gamma} = z_2 + h_L - \frac{V_1^2}{2g} \quad \text{where } V_1 = V_3 = V$$

With no head loss from (3) to (2) and $p_2 = p_3 = V_2 = 0$ we obtain

$$\frac{V_3^2}{2g} + z_3 = z_2, \text{ or } V_3 = \sqrt{2g(z_2 - z_3)} = \sqrt{2\left(32.2\,\frac{ft}{s^2}\right)\left(\frac{3}{12}\,ft\right)} = 4.01\,\frac{ft}{s}$$

Thus,

$$Re = \frac{VD}{\nu} = \frac{V_3 D}{\nu} = \frac{4.01\,\frac{ft}{s}\left(\frac{0.75}{12}\,ft\right)}{1.21 \times 10^{-5}\,\frac{ft^2}{s}} = 2.07 \times 10^4$$

and

$$\frac{\varepsilon}{D} = \frac{0.0005\,ft}{\left(\frac{0.75}{12}\right)ft} = 0.008$$ (see Table 8.1), so that (see Fig. 8.20)

$f = 0.039$

Also, $h_L = f\frac{\ell}{D}\frac{V^2}{2g} + \sum K_L \frac{V^2}{2g}$ where $\sum K_L = 3(1.5) = 4.5$

Hence, Eq. (1) becomes

$$\frac{p_1}{\gamma} = z_2 + \left[f\frac{\ell}{D} + \sum K_L\right]\frac{V^2}{2g} - \frac{V_1^2}{2g} \quad \text{where } V_1 = V$$

or

$$\frac{p_1}{\gamma} = \frac{7}{12}\,ft + \left[0.039\,\frac{21\,in.}{0.75\,in.} + 4.5 - 1\right]\frac{\left(4.01\,\frac{ft}{s}\right)^2}{2\left(32.2\,\frac{ft}{s^2}\right)} = (0.583 + 1.147)\,ft$$

$$= 1.73\,ft$$

Thus,

$$p_1 = \left(62.4\,\frac{lb}{ft^3}\right)(1.73\,ft) = 108\,\frac{lb}{ft^2} = \underline{\underline{0.750\,psi}}$$