

8.78

8.78 As shown in Video V8.15 and Fig. P8.78 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.

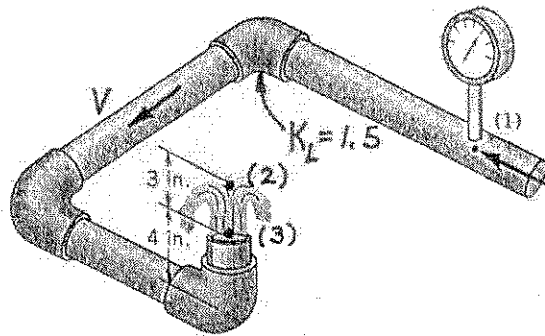


FIGURE P8.78

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

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

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

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

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

Thus,

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

and

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

$$f = 0.039$$

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

Hence, Eq. (1) becomes

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

or

$$\frac{p_1}{\gamma} = \frac{7}{12} \text{ft} + \left[0.039 \frac{21 \text{in.}}{0.75 \text{in.}} + 4.5 - 1 \right] \frac{\left(4.01 \frac{\text{ft}}{\text{s}} \right)^2}{2 \left(32.2 \frac{\text{ft}}{\text{s}^2} \right)} = (0.583 + 1.147) \text{ft} \\ = 1.73 \text{ft}$$

Thus,

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