

12.3 Given: 850 L/min of water at 10°C  
 DN 100 Schedule 40 pipe  
 DN 50 Schedule 40 pipe

$h_L = f \left( \frac{L}{D} \right) \frac{V^2}{2g}$   
 $DN 50 = 5 \text{ in} = 0.127 \text{ m}$   
 Inside Diameter = 0.0525 m

$h_L = f \left( \frac{30}{0.0525} \right) \frac{V^2}{2g}$   
 $h_L = 571.6 \frac{V^2}{2g}$

90° Elbow  $A = 2.18 \times 10^{-3} \text{ m}^2$   
 $L_e = 30$   
 Fully open  $f = 1.50$   
 $R = \frac{D}{\epsilon} = \frac{0.0525}{4.5 \times 10^{-5}} = 1.17 \times 10^3$   
 Roughness  $\epsilon = 4.5 \times 10^{-5}$

Total Head Loss  
 $h_L = f_1 \left( \frac{L_1}{D_1} \right) \frac{V_1^2}{2g} + f_2 \left( \frac{L_2}{D_2} \right) \frac{V_2^2}{2g} + 3 f_b \left( \frac{L}{D} \right) \frac{V^2}{2g}$   
 $f = 0.022$   
 $f_1 \left( \frac{60}{0.0525} \right) \frac{V^2}{2g} + 0.019 \times (50) \frac{V^2}{2g} + 3 \times 0.014 \times 20 \frac{V^2}{2g}$   
 $571(0.022) = (1146(0.022) + 9.56) \frac{V^2}{2g}$   
 $V = 1.55 V_b$

Reynolds Number  
 $N_R = \frac{V_b D_b}{\nu} = \frac{2.55(0.0525)}{1.30 \times 10^{-6}} = 1.02 \times 10^5$   
 $f = 0.0215$   
 $N_R = \frac{3.87 \times 0.0525}{1.30 \times 10^{-6}} = 1.60 \times 10^5$   
 $f = 0.0215$

Total Flow Rate  
 $850 \text{ L/min} = 0.0141 \text{ m}^3/\text{s}$   
 $Q = A_1 V_1 + A_2 V_2$   
 $0.0141 = 2.18 \times 10^{-3} (1.55) + 2.18 \times 10^{-3} (V_b)$   
 $0.0141 = 3.38 \times 10^{-3} + 2.18 \times 10^{-3} V_b$   
 $V_b = 0.55 \text{ m/sec}$   
 $V = 2.55 \times 1.55$   
 $V = 3.97 \text{ m/sec}$

$V_b = \frac{0.0141}{2.18 \times 10^{-3} + 2.18 \times 10^{-3}}$   
 $= 2.55 \text{ m/sec}$   
 $V = 1.55 \times 2.55$   
 $= 3.97 \text{ m/sec}$

$Q = AV$   
 $Q = 2.18 \times 10^{-3} (3.97)$   
 $Q = 0.008628 \text{ m}^3/\text{s}$

$Q = 0.008628 \text{ m}^3/\text{s} = 517 \text{ L/min}$   
 $Q = AV$   
 $Q = 2.18 \times 10^{-3} (2.55)$   
 $Q = 0.00556 \text{ m}^3/\text{s} = 331 \text{ L/min}$

$h_L = (h_L)_R$   
 $= 571.6 \frac{V^2}{2g}$   
 $571(0.022) = (1146(0.022) + 9.56) \frac{V^2}{2g}$   
 $\Delta p = 9.81 \times 9.68 = 94.5 \text{ kPa}$

11.24 A 4in Schedule 40 pipe has an outside diameter of 4.5 in. and a wall thickness of 0.237 in and bore of 4.026 in.