5.101

5.101 Water flows through a valve (see Fig. P5.101) at the rate of 1000 lbm/s. The pressure just upstream of the valve is 90 psi and the pressure drop across the valve is 5 psi. The inside diameters of the valve inlet and exit pipes are 12 and 24 in. If the flow through the valve occurs in a horizontal plane, determine the loss in available energy across the valve.

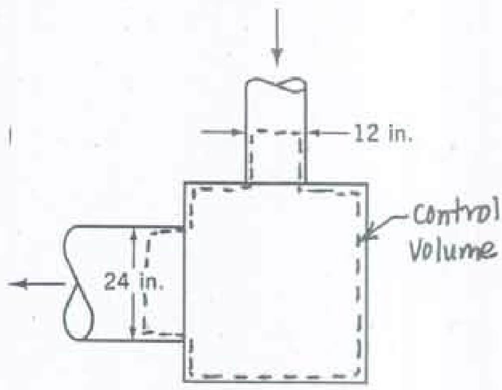

FIGURE P5.101

The control volume shown in the sketch above is used. We can use Eq. 5.79 to determine the loss in available energy associated with the incompressible, steady flow through this control volume. Thus

$$loss = \frac{p_1 - p_2}{\rho} + \frac{V_1^2 - V_2^2}{2}$$

From the conservation of mass principle

$$V_1 = \frac{\dot{m}}{\rho A_1} = \frac{\dot{m}}{\rho \frac{\pi D_1^2}{4}}$$

and

$$V_2 = \frac{\dot{m}}{\rho \frac{\pi D_2^2}{4}}$$

Thus

$$loss = \frac{p_1 - p_2}{\rho} + \frac{1}{2}\left(\frac{\dot{m}\,4}{\rho\pi}\right)^2\left(\frac{1}{D_1^4} - \frac{1}{D_2^4}\right)$$

$$loss = \frac{\left(50\,\frac{lb}{in.^2}\right)\left(144\,\frac{in.^2}{ft^2}\right)}{1.94\,\frac{slugs}{ft^3}} + \frac{1}{2}\left[\frac{\left(1000\,\frac{lbm}{s}\right)(4)}{\left(1.94\,\frac{slugs}{ft^3}\right)\left(32.2\,\frac{lbm}{slug}\right)\pi}\right]^2\left[\frac{\left(12\,\frac{in.}{ft}\right)^4}{(12\,in.)^4} - \frac{\left(12\,\frac{in.}{ft}\right)^4}{\left(24\,\frac{in.}{ft}\right)^4}\right]\left(\frac{1\,lb}{slug\cdot\frac{ft}{s^2}}\right)$$

$$loss = \underline{\underline{5660}}\,\frac{ft\cdot lb}{slug}$$