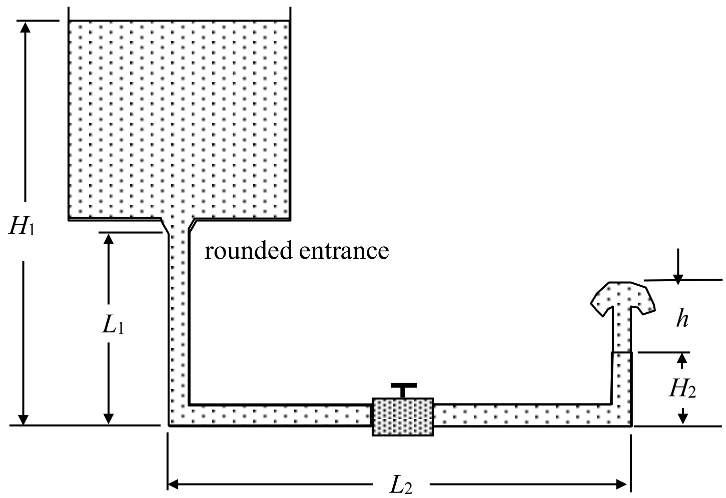
Water flows from a container as shown in the figure. Determine the loss coefficient needed in the valve if the water is to "bubble up" a distance h above the outlet pipe.



H_1= 45 in
L_1 = 18 in
L_2 = 32 in
H_2 = 2 in
h = 3 in

The pipe is ½ in diameter galvanized iron pipe with threaded fittings.

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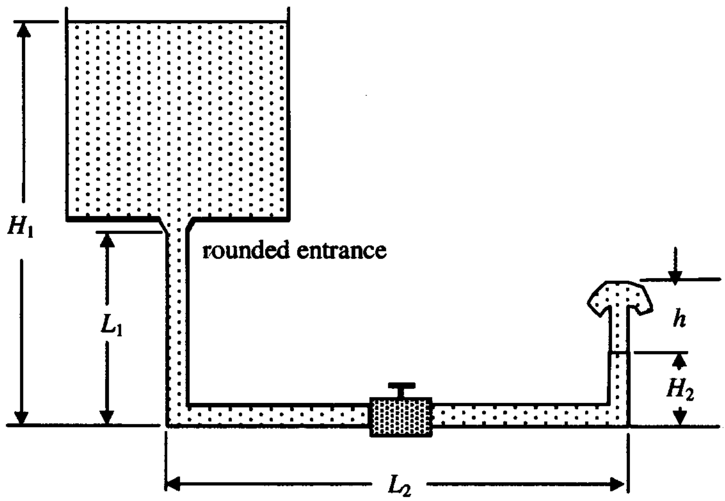

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$L_1 = 18$ in
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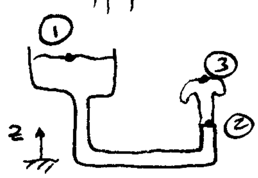
The pipe is ½ in diameter galvanized iron pipe with threaded fittings.

SOLUTION:

- Apply the Extended Bernoulli Eqn from (2) → (3):



$$\left(\frac{p}{\rho g} + \alpha\frac{\bar{V}^2}{2g} + z\right)_3 = \left(\frac{p}{\rho g} + \alpha\frac{\bar{V}^2}{2g} + z\right)_2 - H_{L_{2\to3}} + H_{S_{2\to3}}$$

where $p_2 = p_3 = p_{atm}$

$\bar{V}_2 = ?$ $\qquad \bar{V}_3 = 0$

$z_3 - z_2 = h$

$H_{L_{2\to3}} = 0$

$H_{S_{2\to3}} = 0$

- Assume flow is turbulent $\Rightarrow \alpha_2 \approx 1$

$$\rightarrow \bar{V}_2 = \sqrt{2gh}$$

- For $\left.\begin{array}{l} g = 32.2\ \text{ft/s}^2 \\ h = 3\text{in} = \tfrac{1}{4}\text{ft} \end{array}\right\} \Rightarrow \bar{V}_2 = 4.01\ \text{ft/s}$

- Apply the Extended Bernoulli Eqn from (1) → (3):

$$\left(\frac{p}{\rho g} + \alpha\frac{\bar{V}^2}{2g} + z\right)_3 = \left(\frac{p}{\rho g} + \alpha\frac{\bar{V}^2}{2g} + z\right)_1 - H_{L_{1\to3}} + H_{S_{1\to3}}$$

where $p_3 = p_1 = p_{atm}$

$\bar{V}_2 = \bar{V}_3 \approx 0$

$z_1 = H_1 \qquad z_3 = H_2 + h$

SOLUTION...

$$H_{L\,1\to3} = \sum_i K_i \frac{\bar{V}^2}{2g} = K_{entrance}\frac{\bar{V}_{entrance}^2}{2g} + K_{viscous}\frac{\bar{V}_{pipe}^2}{2g} + 2K_{90°bend}\frac{\bar{V}_{bend}^2}{2g} + K_{valve}\frac{\bar{V}_{valve}^2}{2g}$$

where $\bar{V}_{entrance} = \bar{V}_{pipe} = \bar{V}_{bend} = \bar{V}_{valve} = \bar{V}_2$

$K_{entrance} = 0.05$

$K_{90°bend} = 1.5$

NOTE: $K_{exit} = 0$ since water discharging into air.

$$K_{viscous} = f\left(\frac{L}{D}\right) = f\left(\frac{L_1 + L_2 + H_2}{D}\right)$$

where $f = 0.044$ (from Moody chart)

with $Re_D = \frac{\bar{V}_2 D}{\nu} = \frac{(4.01\,ft/s)(0.5\,in)\left(\frac{ft}{12\,in}\right)}{1.21\times10^{-5}\,ft^2/s}$

$\Rightarrow$ $Re_D = 13{,}800$ (turbulent flow! $\alpha \approx 1$ assumption valid)

and $\epsilon/D = \frac{0.0005\,ft}{(0.5\,in)\left(\frac{ft}{12\,in}\right)} = 0.012$ $\leftarrow$ galvanized iron pipe

- Substitute and simplify:

$$H_2 + h - H_1 = -\frac{\bar{V}_2^2}{2g}\left[K_{entrance} + 2K_{bend} + f\left(\frac{L_1 + L_2 + H_2}{D}\right) + K_{valve}\right]$$

- Solve for K_{valve}

$$\Rightarrow \boxed{K_{valve} = 5.9}$$