

Losses in Pipe Flow

Major Losses

From Moody chart:

$$f_D = \phi(\text{Re}) \quad \text{for laminar flow}$$

$$f_D = \phi\left(\text{Re}, \frac{\varepsilon}{D}\right) \quad \text{for turbulent flow}$$

$$f_D = \phi\left(\frac{\varepsilon}{D}\right) \quad \text{for wholly turbulent flow}$$

Empirical fit of Moody chart: *Colebrook formula*

$$\frac{1}{\sqrt{f_D}} = -2.0 \log \left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{\text{Re} \sqrt{f_D}} \right) \quad \text{Eq (8.35a)}$$

Losses in Pipe Flow

Minor Losses: by valves, bends, tees, and other components

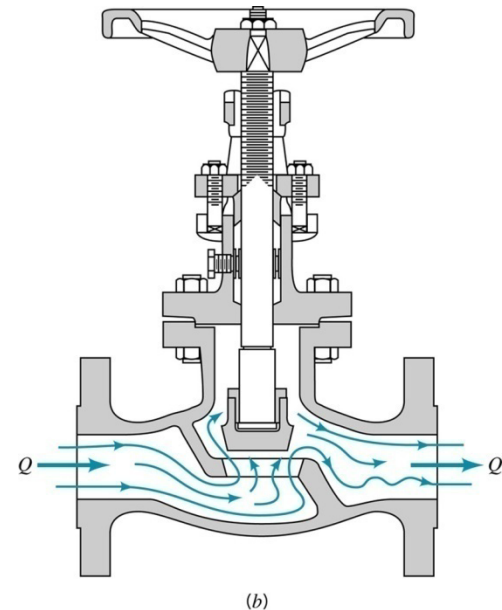
$$h_{L,\text{minor}} = K_L \frac{\bar{v}^2}{2g} \quad \text{Eq (8.36)}$$

Loss coefficient: how much kinetic energy is lost when fluid decelerates

$$K_L = \frac{h_{L,\text{minor}}}{\bar{v}^2 / 2g}$$

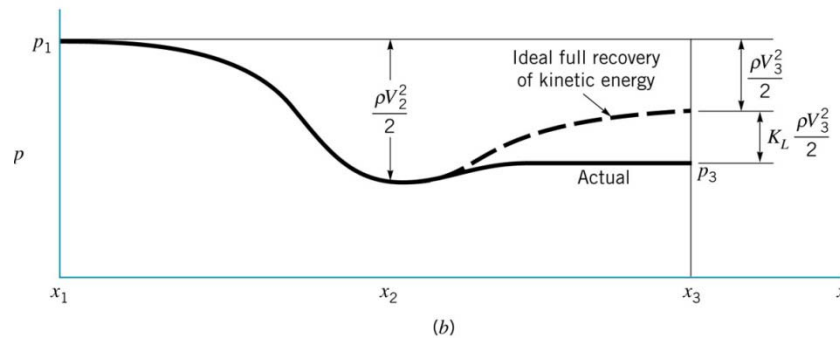
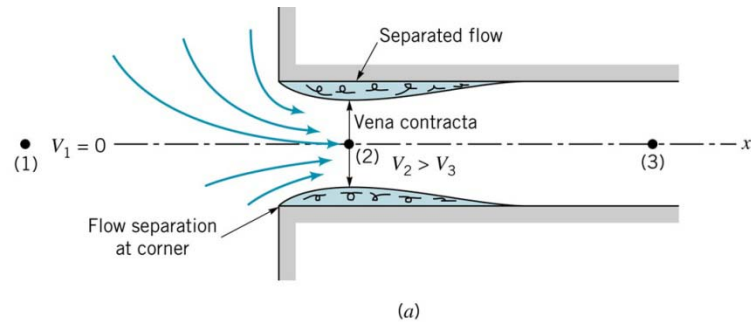
$$K_L = \phi(\text{Re}, \text{geometry})$$

See Table 8.2



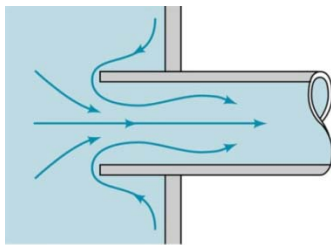
Losses in Pipe Flow

Minor Losses: by entrance flow

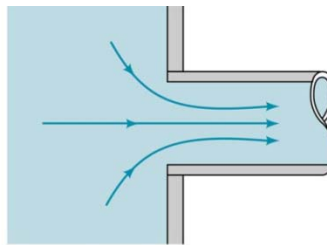


Losses in Pipe Flow

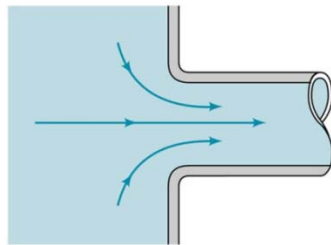
Minor Losses: by entrance flow



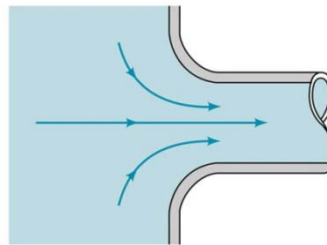
(a)



(b)

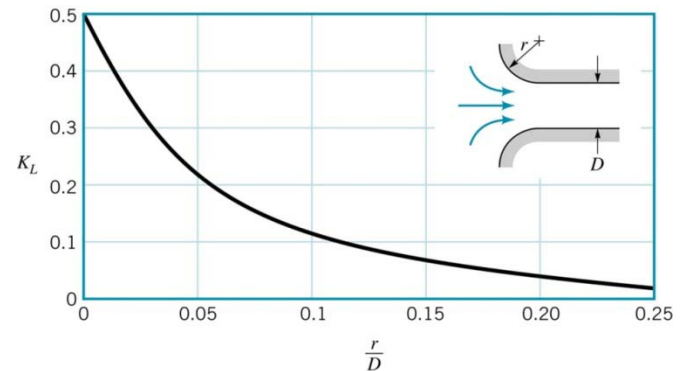


(c)



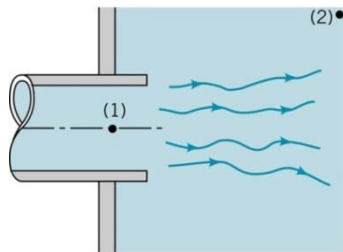
(d)

- (a) Reentrant: $K_L = 0.8$
- (b) Sharp-edged: $K_L = 0.5$
- (c) Slightly rounded: $K_L = 0.2$ (see figure below)
- (d) Well-rounded: $K_L = 0.04$ (see figure below)

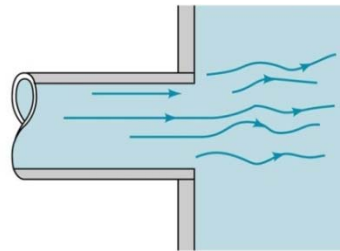


Losses in Pipe Flow

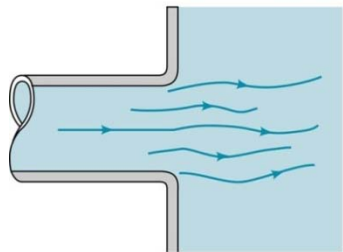
Minor Losses: by exit flow



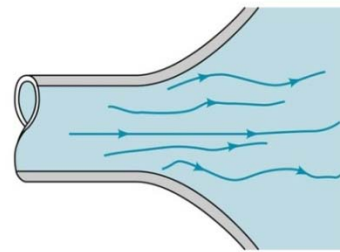
(a)



(b)



(c)



(d)

- (a) Reentrant: $K_L = 1.0$
- (b) Sharp-edged: $K_L = 1.0$
- (c) Slightly rounded: $K_L = 1.0$
- (d) Well-rounded: $K_L = 1.0$