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Minor Losses

we learned that for real pipe flows, the pressure drop ΔP_L across a pipe system occurs due to the friction between the pipe system and the viscous fluid.

$$\Delta P_L = \Delta P_{major} + \Delta P_{minor}$$

$$h_{major} = \frac{f.L}{D} * \frac{V^2}{2g}$$

$$h_{minor} = K_L * \frac{V^2}{2g}$$

And the main equation to solve this kind of problems will be:

$$\frac{p_1}{\rho g} + \frac{{u_1}^2}{2g} + Z_1 = \frac{p_2}{\rho g} + \frac{{u_2}^2}{2g} + Z_2 + h_{f.major} + h_{f.minor}$$

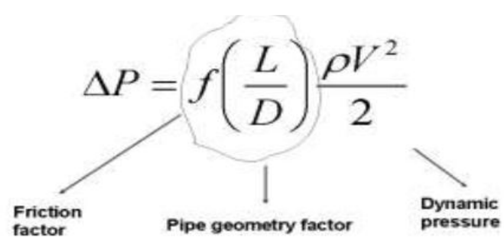
Loss coefficient *(K*$_L$)

The flow patterns are generally very complex in a pipe component, such as flow through a valve. Therefore, the analysis of pressure drop across a pipe component is very complicated because the pressure drop is not only a function of the flow itself but also the complex geometrics of the component.

Similarity between major and minor losses equations

If we closely examine major and minor equations, which are used to calculate major and minor loss, respectively, we can see that the two equations are fundamentally similar.

For *major loss* in straight pipes:



For *minor loss* in pipe components:

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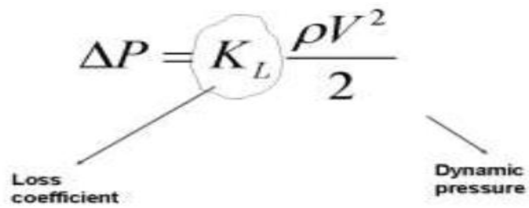
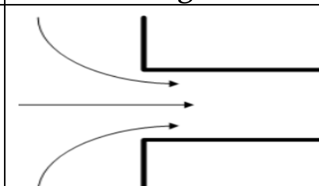
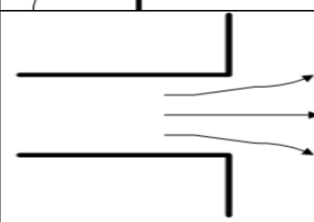
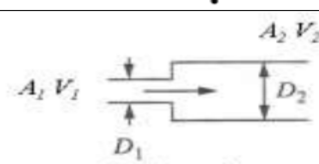
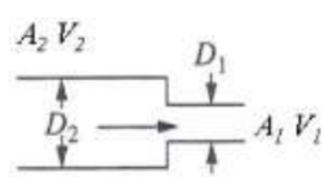


A key difference between the two equations is that the friction factor *f* and pipe geometry factor *(L/D)* in the calculation of *major loss* have been accumulated into a single factor, loss coefficient K_L in the calculation of *minor loss*.

K_L of a pipe component strongly depends on the geometry of the component and normally can only be determined experimentally.

K_L Values:

Region	K_L		Figure
Entrance	0.5		
Exit	1		
Sudden enlargements	$= \left[1 - \frac{A_1}{A_2}\right]^2 = \left[1 - \frac{d_1}{d_2}\right]^2$		
Sudden contractions	$\frac{d_1}{d_2}$	K_L	
	0	0.5	
	0.1	0.49	
	0.2	0.48	
	0.4	0.44	
	0.6	0.32	
	0.7	0.23	
	0.8	0.15	

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	0.9	0.06	
90° Elbow	0.9		
45° Elbow	0.4		
Gate valve fully opened	0.19		
Globe valve fully opened	10		
Tee along pipe run	0.4		
Tee along branch	1.8		
Angle valve fully open	2		
Gate valve fully open	0.15		

Steps for solving Type I problems

1. Write the energy governing equation for the pipe system;
2. Determine pressure drop due to the changes in elevation and kinetic energy.
3. Calculate relative pipe roughness (ε/D)

and Reynolds number,

$$\boldsymbol{Re = \frac{\rho u d}{\mu}}$$

4. Determine the friction factor *f* using the Moody chart (Figure 6-16) or Equations E6-26, therefore *major loss;*
5. Determine the loss coefficient K_L of pipe components, therefore *minor loss;*
6. Calculate the total pressure drop or head loss.

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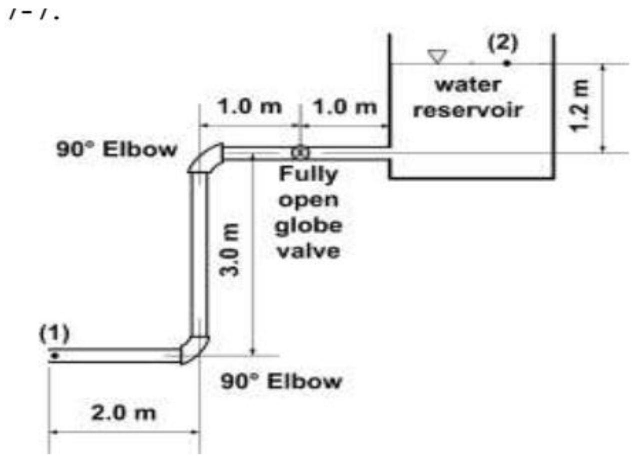
Example 1: Water at room temperature (density ρ =**1000** kg/m3, viscosity μ =**1.12×10-3** Ns/m2) is delivered from the basement to a reservoir at upstairs through the **20.0-mmdiameter** copper (roughness ε =**0.015** mm) tubing system at a rate of ***Q*** = **60** L/min as shown below. The type and diameters of all tubing in the pipe system are same. The tubing system has two 900 elbows. The globe valve is fully open and the water reservoir is maintained at a constant water level during operation. Determine the pressure at point (1).



Solution: we can write the energy governing equation for point (1) and (2).

$$\frac{p_1}{\rho g} + \frac{{u_1}^2}{2g} + Z_1 = \frac{p_2}{\rho g} + \frac{{u_2}^2}{2g} + Z_2 + h_{f,major} + h_{f,minor}$$

Base on figure, the equation will reduce to:

$$\frac{p_1}{\rho g} + \frac{{u_1}^2}{2g} = Z_2 + h_{f,major} + h_{f,minor}$$

Where, $Z_1 = 0$, $\frac{p_2}{\rho g} = 0$, $u_2 = 0$.

Major losses can be calculated by:

$$h_f = \frac{f.L}{D} * \frac{V^2}{2g}$$

We can calculate water velocity at point (1) and inside the tubing:

$$u_1 = \frac{4 * 0.001}{\pi * 0.02^2} = 3.185\ m/sec$$

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$$\boldsymbol{Re = \frac{\rho u d}{\mu}}$$

$$Re = \frac{1000 * 3.185 * 0.02}{1.12 * 10^{-3}} = 56856$$

The flow is turbulent.

$$\frac{\epsilon}{D} = \frac{0.015}{20} = 0.00075$$

From Moody chart the friction factor can be estimated to be $f = 0.023$. and the major losses can be calculated by:

$$h_{f,major} = 0.023 * \frac{7}{0.02} * \frac{3.185^2}{2 * 9.81} = \ 4.16\ m$$

While, minor losses can be estimated by:

$$h_{minor} = K_L * \frac{V^2}{2g}$$

And K_L as below:

$$K_L = \sum K_L\ , exit + \ K_L, fully\ open\ globe\ valve + 2 * \ K_L, elbow\ 90^{\circ}$$

$$K_L = 1 + 10 + 2 * 0.9 = 12.8$$

$$h_{minor} = 12.8 * \frac{3.185^2}{2 * 9.81} = \ 6.62\ m$$

Now:

$$p_1 = 1000 * 9.81 \left[4.2 - \frac{3.185^2}{2 * 9.81} + 4.16 + 6.62\right] = 1474.3\ pa$$