Losses in Valves and Fittings

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Losses are caused by:

1. Change of the cross section of the flow path
2. Change in the direction of the flow.

Due to its complexity, analytical techniques cannot be used. Experimental methods are used instead to determine the losses.

Losses are proportional to the square of the velocity:

\[ H_L = k \left( \frac{v^2}{g} \right) \]

\( k \) is the factor of the loss coefficient.

Common valves & fittings:

1. Globe valve: Direction changes but allows close regulation.
2. Gate valve: Fluid flows in a straight line. Infrequent operation is fully open or fully closed.
3. 45° elbow.
4. 90° ".
5. Tee section (T) -
6. Return bend (180°)

\[
1 \text{ gpm} = 1 \left( \frac{\text{gallons}}{\text{min}} \right) \left( \frac{3.78541 \text{ L}}{1 \text{ gallon}} \right) \left( \frac{1 \text{ min}}{60.5} \right) = 6.309 \times 10^{-3} \text{ m}^3 \cdot \text{s}^{-1}
\]

<table>
<thead>
<tr>
<th>VALVE OR FITTING</th>
<th>K FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GLOBE VALVE:</strong></td>
<td></td>
</tr>
<tr>
<td>Wide Open</td>
<td>10.0</td>
</tr>
<tr>
<td>1/2 Open</td>
<td>12.5</td>
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<tr>
<td><strong>GATE VALVE:</strong></td>
<td></td>
</tr>
<tr>
<td>Wide Open</td>
<td>0.19</td>
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<tr>
<td>3/4 Open</td>
<td>0.90</td>
</tr>
<tr>
<td>1/2 Open</td>
<td>4.5</td>
</tr>
<tr>
<td>1/4 Open</td>
<td>24.0</td>
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<tr>
<td><strong>RETURN BEND</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.2</td>
</tr>
<tr>
<td><strong>STANDARD TEE</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.8</td>
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<tr>
<td><strong>STANDARD ELBOW?</strong></td>
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<tr>
<td></td>
<td>0.9</td>
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<tr>
<td><strong>45° ELBOW</strong></td>
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<td>0.42</td>
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<td><strong>90° ELBOW</strong></td>
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<td></td>
<td>0.75</td>
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<td><strong>BALL CHECK VALVE</strong></td>
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<td></td>
<td>4.0</td>
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</tbody>
</table>
Equivalent length method:

\[ f \left( \frac{L}{D} \right) \cdot \left( \frac{g}{2g} \right) = \frac{v^2}{2g} \]

\[ f \left( \frac{L_{eq}}{D} \right) = K \]

\[ L_{eq} = \frac{K \cdot D}{f} \]

Friction factor

Ex. 4-6

\[ D = 1 \text{ inch} = 0.0254 \text{ m} \]
\[ \rho = 900 \text{ Kg} \cdot \text{m}^{-3} \]
\[ \text{Flow} = Q = 30 \text{ gpm} = \left[ \frac{6.39 \times 10^{-5}}{1 \text{ gpm}} \right] \text{ m}^3 \cdot \text{s}^{-1} \]
\[ = 1.8927 \times 10^{-3} \text{ m}^3 \cdot \text{s}^{-1} \]

\[ A = \pi \left( \frac{0.0254}{2} \right)^2 = 5.06707 \times 10^{-4} \text{ m}^2 \]

\[ v = \frac{Q}{A} = 3.73529 \text{ m/s} \]
\[ K = 10 \]

\[ H_L = (10) \cdot \frac{v^2}{2g} = (10) \cdot \frac{3.73529^2}{(2)(9.81)} = 7.11 \text{ m} \]

\[ \Delta p = (H_L)(\rho g) = 62.7 \text{ kPa} \]

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**Ex 4.7**

**Gate Valve**

\[ \nu = 0.001 \text{ m}^2/\text{s} \] (Kinematic viscosity)

\[ \rho = 880 \text{ kg.m}^{-3} \] (Density)

\[ \phi = 0.02 \text{ m}^3/\text{s} \] (Volumetric flow rate)

\[ A = \pi \left( \frac{0.05}{2} \right)^2 = 1.963 \times 10^{-3} \text{ m}^2 \] (Area)

\[ \nu = \frac{\phi}{A} = 10.186 \text{ m/s} \] (Velocity)

\[ K = 0.19 \] (K-factor)

\[ H_L = (0.19)(10.2)^2 \]

\[ \frac{1}{(2)(9.81)} = 1.01 \text{ m} \] (Head loss)

\[ \Delta p = \rho g \cdot H_L = (880)(9.8)(1.01) = 8719 \text{ Pa} \]

\[ = 8.719 \text{ kPa} \]
Equivalent length method \[ \text{Ex. 4-8} \]

\[ L_{eq} = \frac{K D}{f} \]

\[ \nu = 100 \text{ es} = 100 \times 10^{-6} \text{ m}^2\text{s}^{-1} \]

\[ D = 1 \text{ inch} \]

\[ K = 10 \]

\[ \phi = 30 \text{ gpm} = (30) (6.39 \times 10^{-5}) = 1.893 \times 10^{-3} \]

\[ A = \pi \left( \frac{0.0254}{2} \right)^2 = 5.067 \times 10^{-4} \text{ m}^2 \]

\[ \nu = \frac{\phi}{A} = 3.736 \text{ m/s} \]

\[ N_R = \frac{(3.736)(0.0254)}{1 \times 10^{-4}} = 948.944 \]

\[ \Rightarrow \text{laminar flow} \]

\[ P = \frac{64}{N_R} = \frac{6.4}{948.944} = 0.06744 \]

\[ L_{eq} = \frac{CKD}{P} = \frac{(10)(0.0254)}{0.06744} = 3.766 \text{ m} \]