Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a sharp-edged orifice installed in a straight pipe.

The head loss by friction in the inlet and outlet piping is not taken into account in this component.

Model formulation:

Hydraulic diameter (m):

\[ D_h = D_0 \]

Pipe cross-section area (m²):

\[ F_1 = \pi \cdot \frac{D_1^2}{4} \]

Orifice cross-section area (m²):

\[ F_0 = \pi \cdot \frac{D_0^2}{4} \]

Mean velocity in pipe (m/s):

\[ w_1 = \frac{Q}{F_1} \]

Mean velocity in orifice (m/s):

\[ w_0 = \frac{Q}{F_0} \]

Mass flow rate (kg/s):

\[ G = Q \cdot \rho \]
Reynolds number in pipe:

\[ Re_1 = \frac{w_1 \cdot D_1}{v} \]

Reynolds number in orifice:

\[ Re_0 = \frac{w_0 \cdot D_0}{v} \]

Pressure loss coefficient (based on the mean pipe velocity):

- \( Re_0 \geq 10^5 \)

\[ \zeta_1 = \left( 1 - \frac{F_0}{F_1} \right) + 0.707 \cdot \left( 1 - \frac{F_0}{F_1} \right)^{0.375} \cdot \left( \frac{F_1}{F_0} \right)^2 \]  

([1] diagram 4.14)

- \( Re_0 \leq 10^5 \)

Quadratic pressure loss coefficient:

\[ \zeta_{1quad} = \left( 1 - \frac{F_0}{F_1} \right) + 0.707 \cdot \left( 1 - \frac{F_0}{F_1} \right)^{0.375} \cdot \left( \frac{F_1}{F_0} \right)^2 \]  

([1] diagram 4.14)

Velocity factor:

\[ \zeta_\phi = f \left( Re_0, \frac{F_0}{F_1} \right) \]  

([1] diagram 4.19)
Contraction factor:

\[ \bar{\zeta}_{0 \text{Re}} = f(\text{Re}_0) \]  

([1] diagram 4.19)

Pressure loss coefficient (based on the mean pipe velocity):

- \( 30 < \text{Re}_0 < 10^5 \)

\[ \zeta_1 = \zeta_{\cdot} \left( \frac{F_1}{F_0} \right)^2 + \bar{\zeta}_{0 \text{Re}} \cdot \zeta_{\text{quad}} \]  

([1] diagram 4.19)

- \( 10 < \text{Re}_0 \leq 30 \)
\[ \zeta_1 = \frac{33}{\text{Re}_0} \left( \frac{F_1}{F_0} \right)^2 + \zeta_0 \text{Re} \cdot \zeta_{1,quad} \]  

([1] diagram 4.19)

- \text{Re}_0 \leq 10

\[ \zeta_1 = \frac{33}{\text{Re}_0} \left( \frac{F_1}{F_0} \right)^2 \]  

([1] diagram 4.19)

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**Total pressure loss (Pa):**

\[ \Delta P = \zeta_1 \cdot \frac{P \cdot w_1^2}{2} \]

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**Total head loss of fluid (m):**

\[ \Delta H = \zeta_1 \cdot \frac{w_1^2}{2 \cdot g} \]

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**Hydraulic power loss (W):**

\[ Wh = \Delta P \cdot Q \]

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**Symbols, Definitions, SI Units:**

- \( D_h \): Hydraulic diameter (m)
- \( D_1 \): Pipe internal diameter (m)
- \( F_1 \): Pipe cross-sectional area (m²)
- \( D_0 \): Orifice diameter (m)
- \( F_0 \): Orifice cross-sectional area (m²)
- \( Q \): Volume flow rate (m³/s)
- \( G \): Mass flow rate (kg/s)
- \( w_1 \): Mean velocity in pipe (m/s)
Mean velocity in orifice (m/s)
Orifice thickness (m)
Reynolds number in pipe ()
Reynolds number in orifice ()
Quadratic pressure loss coefficient determined as \( \text{Re} = 10^5 (\) 
Velocity factor ()
Contraction factor ()
Pressure loss coefficient (based on the mean pipe velocity) ()
Total pressure loss (Pa)
Total head loss of fluid (m)
Hydraulic power loss (W)
Fluid density (kg/m³)
Fluid kinematic viscosity (m²/s)
Gravitational acceleration (m/s²)

Validity range:
- any flow regime: laminar and turbulent
- stabilized flow upstream of the orifice
- thickness to orifice diameter ratio (\(l/D_0\)) lower than or equal to 0.015

Example of application:
References: