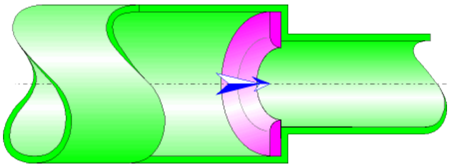
# Round-Edged Orifice (with Transition)
# Circular Cross-Section
# (Pipe Flow - Guide)



**Model description:**

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

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

**Model formulation:**

---

Ratio of orifice to major pipe diameters:

$$\beta = \frac{d_o}{d_1}$$

---

Major pipe cross-sectional area (m²):

$$A_1 = \pi \cdot \frac{d_1^2}{4}$$

---

Minor pipe cross-sectional area (m²):

$$A_2 = \pi \cdot \frac{d_2^2}{4}$$

---

Orifice cross-sectional area (m²):

$$A_o = \pi \cdot \frac{d_o^2}{4}$$

---

Major pipe velocity (m/s):

$$V_1 = \frac{Q}{A_1}$$

---

Minor pipe velocity (m/s):

$$V_2 = \frac{Q}{A_2}$$

Orifice velocity (m/s):

$$V_o = \frac{Q}{A_o}$$

Mass flow rate (kg/s):

$$G = Q \cdot \rho_m$$

Reynolds number in major pipe:

$$N_{Re1} = \frac{V_1 \cdot d_1}{\nu}$$

Reynolds number in minor pipe:

$$N_{Re2} = \frac{V_2 \cdot d_2}{\nu}$$

Reynolds number in orifice:

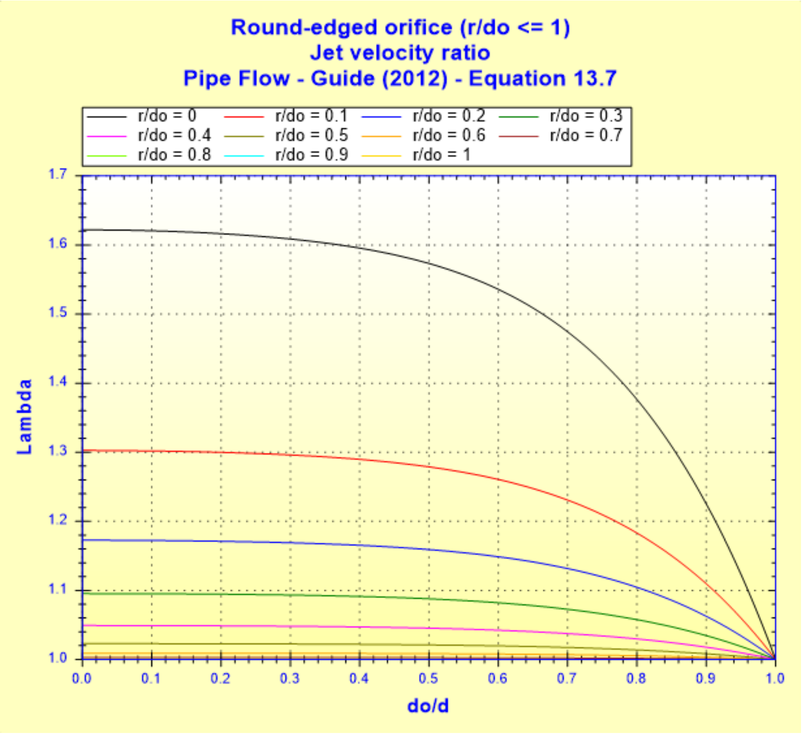
$$N_{Re_o} = \frac{V_o \cdot d_o}{\nu}$$

Jet velocity ratio:

■ $r/d_0 \le 1$

$$\lambda = 1 + 0.622 \cdot \left[1 - 0.3 \cdot \sqrt{\frac{r}{d_0}} - 0.7 \cdot \frac{r}{d_0}\right]^4 \cdot \left(1 - 0.215 \cdot \beta^2 - 0.785 \cdot \beta^5\right)$$

([1] equation 13.7)



■ $r/d_0 > 1$

$$\boxed{\lambda = 1}$$ ([1] § 13.3.1)

---

Velocity in vena contracta:

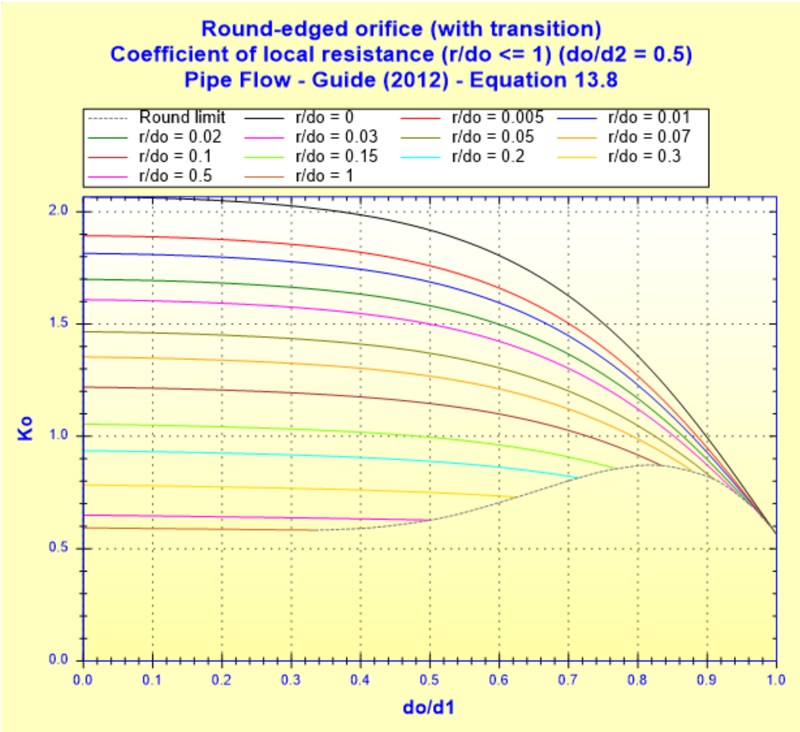
$$\boxed{V_c = V_0 \cdot \lambda}$$

---

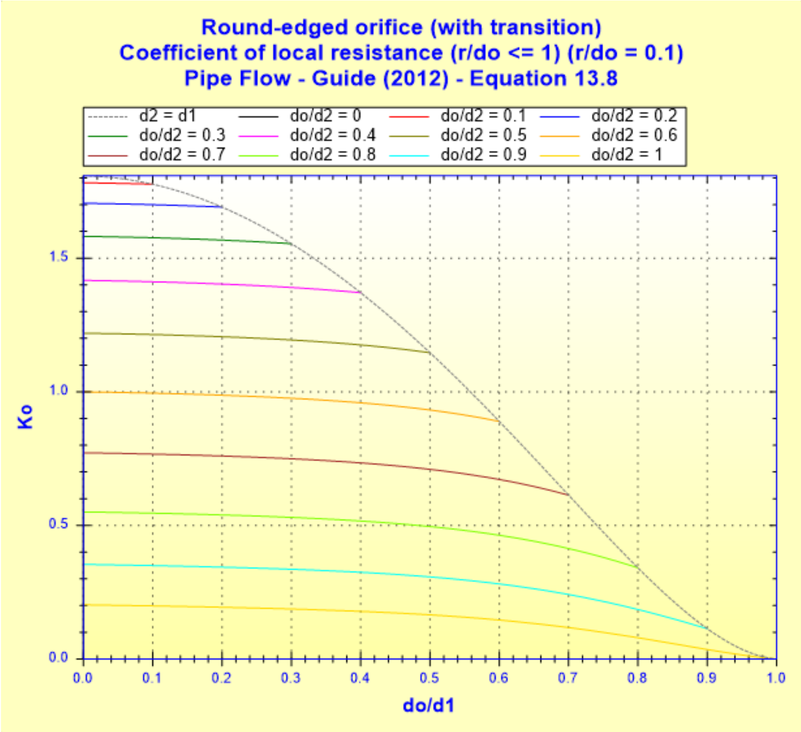
Coefficient of local resistance:

■ $r/d_0 \leq 1$

$$\boxed{K_o = 0.0696 \cdot \left(1 - 0.569 \cdot \frac{r}{d_0}\right) \cdot \left(1 - \sqrt{\frac{r}{d_0}} \cdot \beta\right) \cdot \left(1 - \beta^5\right) \cdot \lambda^2 + \left[\lambda - \left(\frac{d_0}{d_2}\right)^2\right]^2}$$ ([1] equation 13.8)




(with $d_0/d_2 = 0.5$)

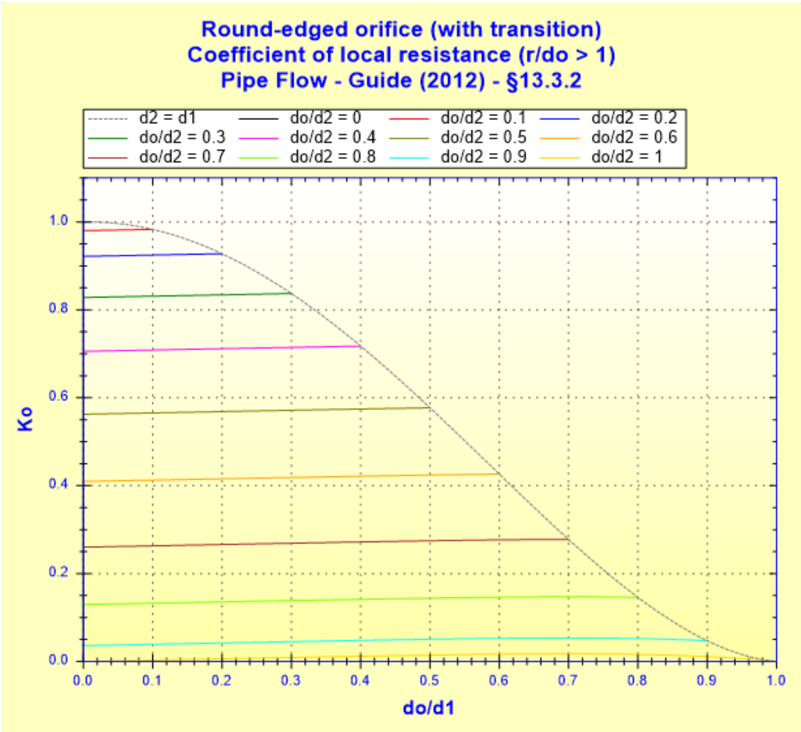



(with r/$d_0$ = 0.1)

■ r/$d_0$ > 1

$$K_o = 0.03 \cdot (1-\beta) \cdot (1-\beta^5) + \left[1 - \left(\frac{d_0}{d_2}\right)^2\right]^2$$

([1] § 13.3.2)

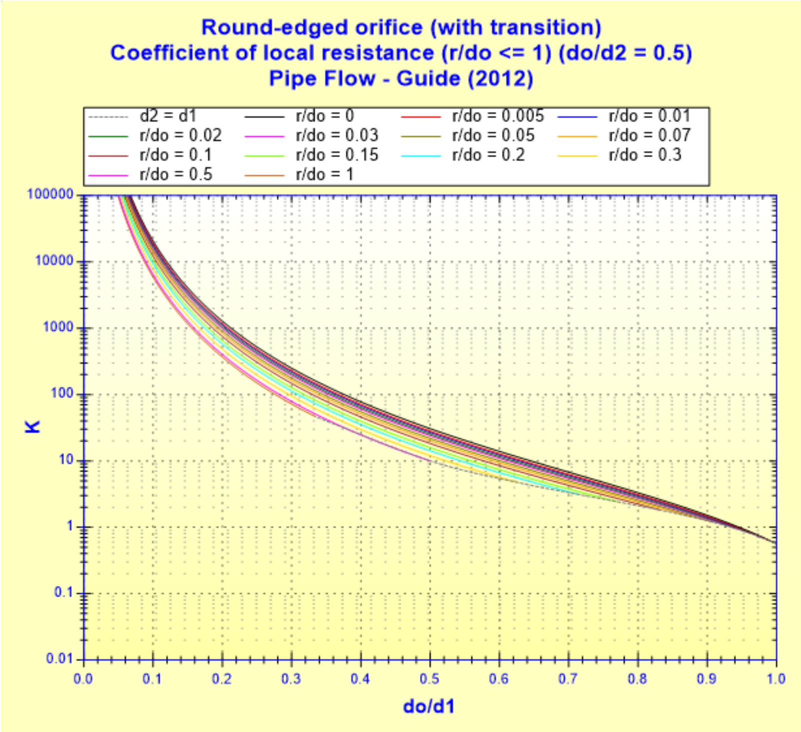



---

Total pressure loss coefficient (based on the major pipe velocity):

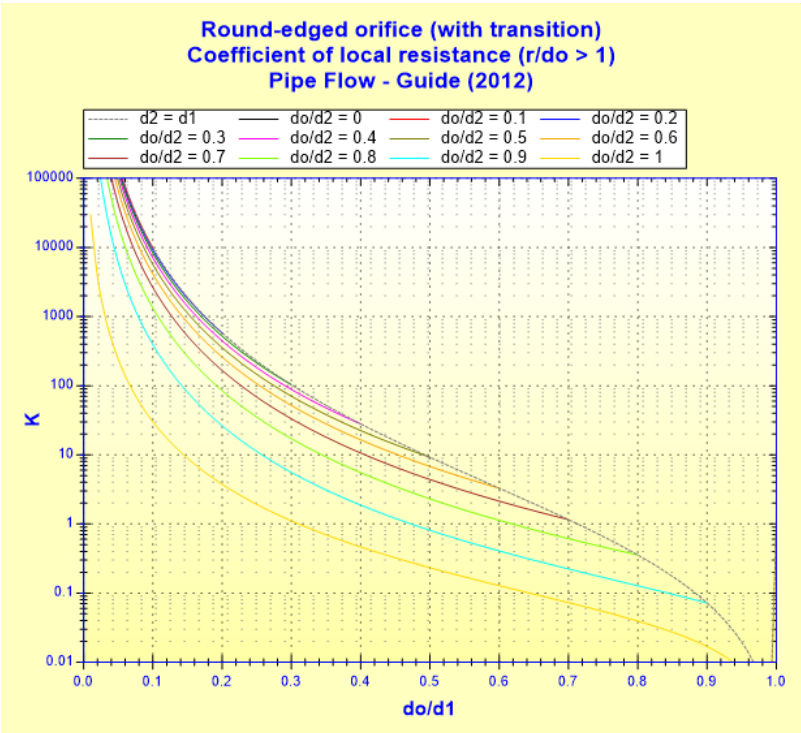
$$K = K_o \cdot \left(\frac{A_1}{A_o}\right)^2$$

■ r/$d_0$ ≤ 1




(with $d_0/d_2 = 0.5$)

■ $r/d_0 > 1$




---

Total pressure loss (Pa):

$$\boxed{\Delta P = K \cdot \frac{\rho_m \cdot V_1^2}{2}}$$

---

Total head loss of fluid (m):

$$\boxed{\Delta H = K \cdot \frac{V_1^2}{2 \cdot g}}$$

---

Hydraulic power loss (W):

$$\boxed{Wh = \Delta P \cdot Q}$$

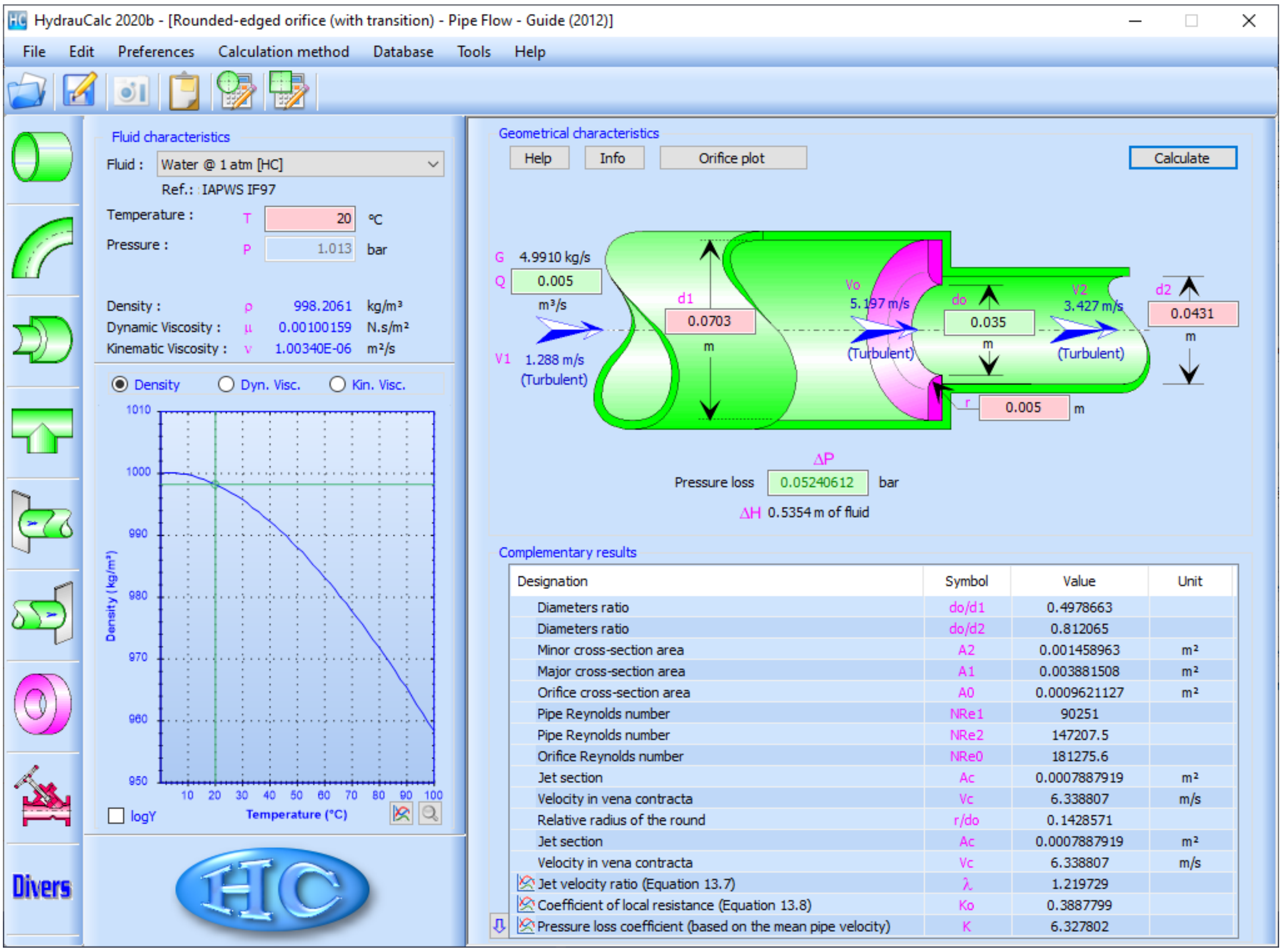
**Symbols, Definitions, SI Units:**

| | |
|---|---|
| $d_0$ | Orifice diameter (m) |
| $d_1$ | Internal major pipe diameter (m) |
| $d_2$ | Internal minor pipe diameter (m) |
| $\beta$ | Ratio of orifice to major pipe diameters () |
| $A_o$ | Orifice cross-sectional area (m²) |
| $A_1$ | Major pipe cross-sectional area (m²) |
| $A_2$ | Minor pipe cross-sectional area (m²) |
| $Q$ | Volume flow rate (m³/s) |
| $G$ | Mass flow rate (kg/s) |
| $V_o$ | Mean velocity in orifice (m/s) |
| $V_1$ | Mean velocity in major pipe (m/s) |
| $V_2$ | Mean velocity in minor pipe (m/s) |
| $NRe_o$ | Reynolds number in orifice () |
| $NRe_1$ | Reynolds number in major pipe () |
| $NRe_2$ | Reynolds number in minor pipe () |
| $r$ | Radius of the round (m) |
| $\lambda$ | Jet velocity ratio () |
| $V_c$ | Mean velocity in vena contracta (m/s) |
| $K_o$ | Coefficient of local resistance () |
| $K$ | Total pressure loss coefficient (based on the major pipe velocity) () |
| $\Delta P$ | Total pressure loss (Pa) |
| $\Delta H$ | Total head loss of fluid (m) |
| $Wh$ | Hydraulic power loss (W) |
| | |
| $\rho_m$ | Fluid density (kg/m³) |
| $\nu$ | Fluid kinematic viscosity (m²/s) |
| $g$ | Gravitational acceleration (m/s²) |

**Validity range:**

- turbulent flow regime in orifice ($NRe_o \geq 10^4$)
- stabilized flow upstream of the orifice
- round radius less than the radius difference ($r < (d_1/2 - d_0/2)$)

**Example of application:**





**References:**

[1] Pipe Flow: A Practical and Comprehensive Guide. Donald C. Rennels and Hobart M. Hudson. (2012)