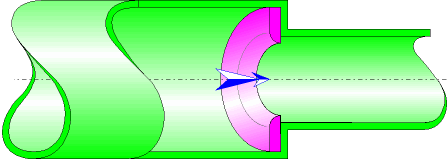




Round-Edged Orifice (with Transition) Circular Cross-Section (Pipe Flow - Guide)



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):

■ $r/d_0 > 1$

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

Velocity in vena contracta:

$$V_c = V_0 \cdot \lambda$$

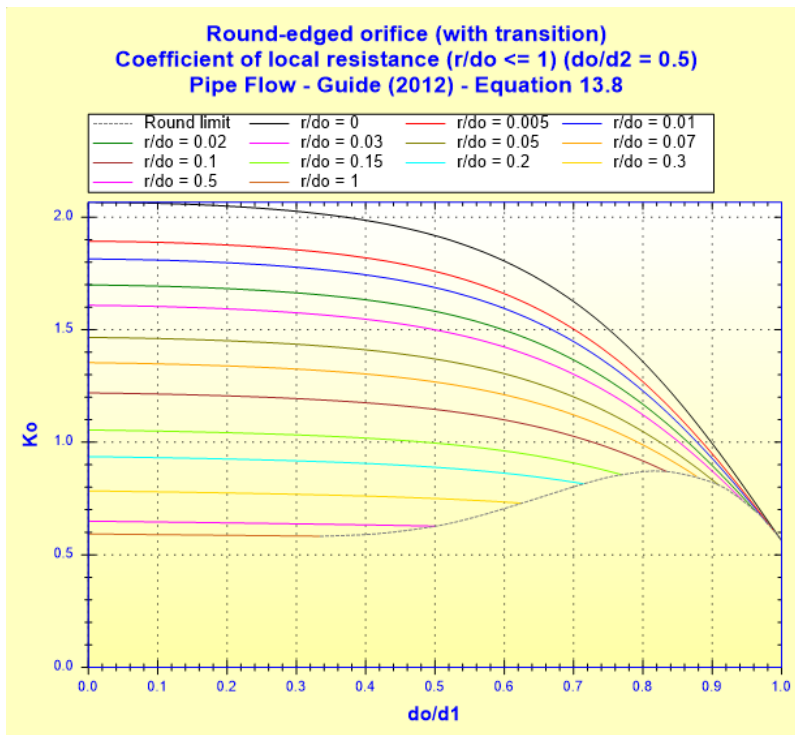
Coefficient of local resistance:

■ $r/d_0 \leq 1$

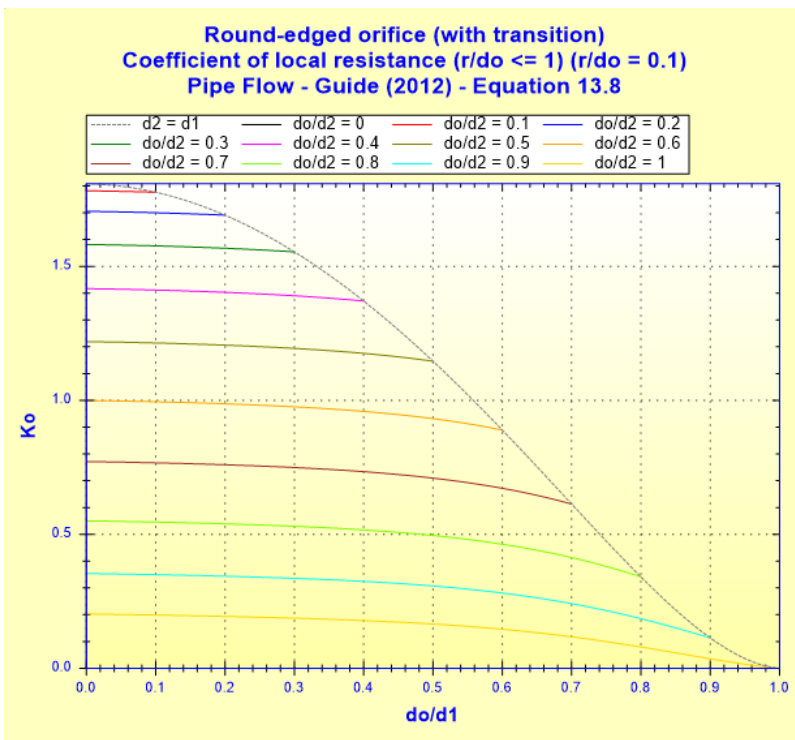
$$K_o = 0.0696 \cdot \left(1 - 0.569 \cdot \frac{r}{d_0}\right) \cdot \left(1 - \sqrt{\frac{r}{d_0}} \cdot \beta\right) \cdot (1 - \beta^5) \cdot \lambda^2 + \left[\lambda - \left(\frac{d_0}{d_2}\right)^2\right]^2$$

([1] equation

13.8)



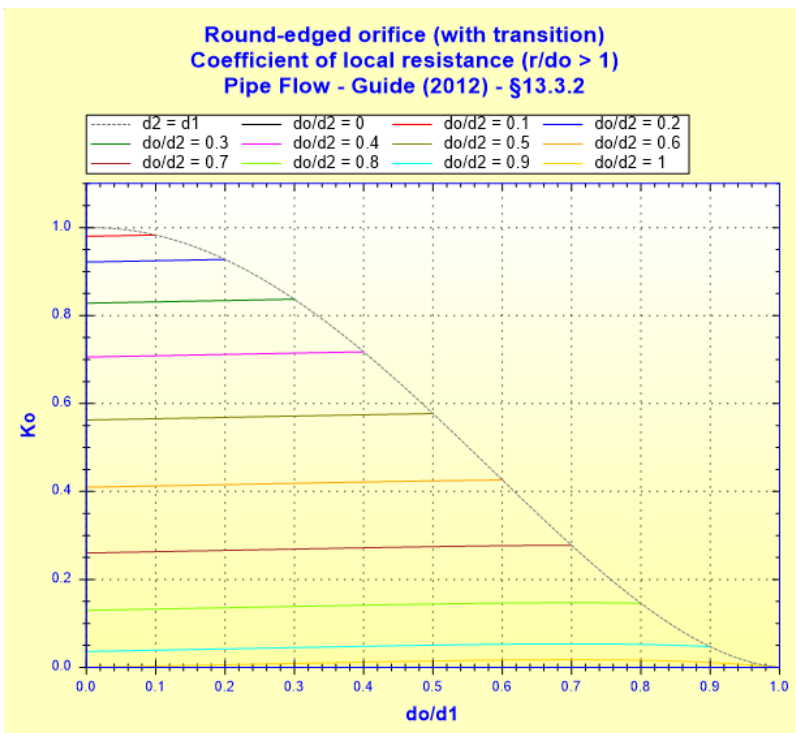
(with $d_0/d_2 = 0.5$)



(with $r/d_0 = 0.1$)

■ $r/d_0 > 1$

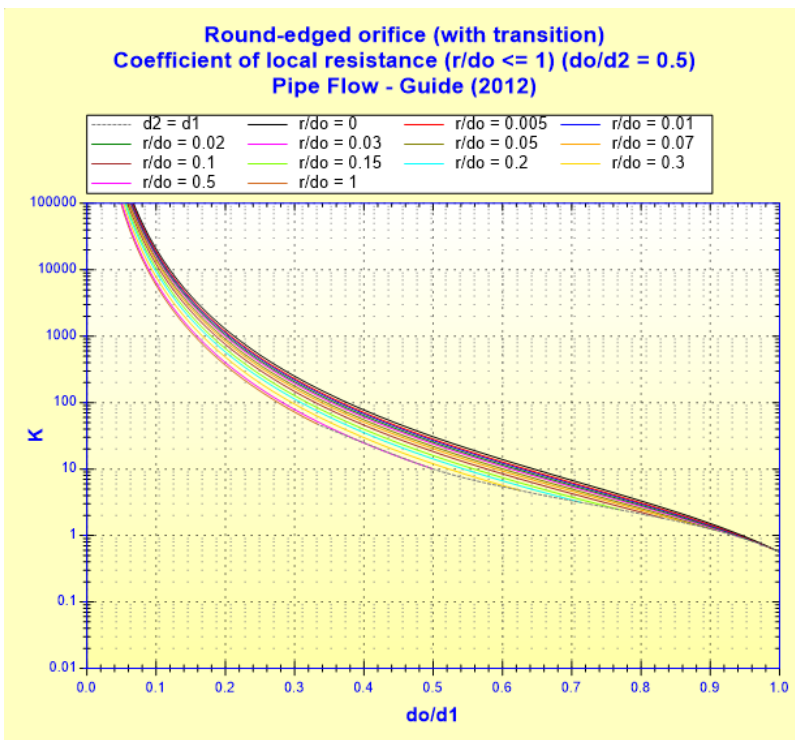
$$K_o = 0.03 \cdot (1 - \beta) \cdot (1 - \beta^5) + \left[1 - \left(\frac{d_0}{d_2} \right)^2 \right]^2 \quad ([1] \text{ § 13.3.2})$$



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

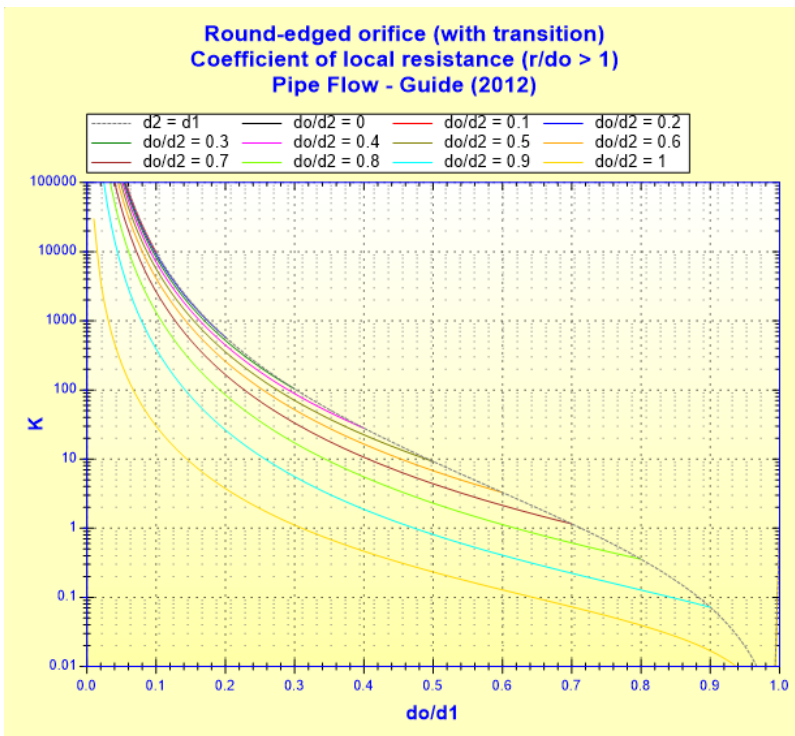
$$K = K_o \cdot \left(\frac{A_1}{A_0} \right)^2$$

■ $r/d_0 \leq 1$



(with $d_0/d_2 = 0.5$)

■ $r/d_0 > 1$



Total pressure loss (Pa):

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

Total head loss of fluid (m):

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

Hydraulic power loss (W):

$$Wh = \Delta P \cdot Q$$

Symbols, Definitions, SI Units:

d_0	Orifice diameter (m)
d_1	Internal major pipe diameter (m)
d_2	Internal minor pipe diameter (m)
β	Ratio of orifice to major pipe diameters ()
A_0	Orifice cross-sectional area (m ²)
A_1	Major pipe cross-sectional area (m ²)
A_2	Minor pipe cross-sectional area (m ²)
Q	Volume flow rate (m ³ /s)
G	Mass flow rate (kg/s)
V_0	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_0	Reynolds number in orifice ()
NRe_1	Reynolds number in major pipe ()
NRe_2	Reynolds number in minor pipe ()
r	Radius of the round (m)
λ	Jet velocity ratio ()
V_c	Mean velocity in vena contracta (m/s)
K_0	Coefficient of local resistance ()
K	Total pressure loss coefficient (based on the major pipe velocity) ()
ΔP	Total pressure loss (Pa)
ΔH	Total head loss of fluid (m)
Wh	Hydraulic power loss (W)
ρ_m	Fluid density (kg/m ³)
ν	Fluid kinematic viscosity (m ² /s)
g	Gravitational acceleration (m/s ²)

Validity range:

- turbulent flow regime in orifice ($NRe_0 \geq 10^4$)
- stabilized flow upstream of the orifice
- round radius less than the radius difference ($r < (d_1/2 - d_0/2)$)

Example of application:

HydrauCalc 2020b - [Rounded-edged orifice (with transition) - Pipe Flow - Guide (2012)]

File Edit Preferences Calculation method Database Tools Help

Fluid characteristics
 Fluid : Water @ 1 atm [HC]
 Ref.: IAPWS IF97
 Temperature : T 20 °C
 Pressure : P 1.013 bar
 Density : ρ 998.2061 kg/m³
 Dynamic Viscosity : μ 0.00100159 N.s/m²
 Kinematic Viscosity : ν 1.00340E-06 m²/s
 Density Dyn. Visc. Kin. Visc.

Geometrical characteristics
 Help Info Orifice plot Calculate

Pressure loss ΔP 0.05240612 bar
 ΔH 0.5354 m of fluid

Complementary results

Designation	Symbol	Value	Unit
Diameters ratio	d_0/d_1	0.4978663	
Diameters ratio	d_0/d_2	0.812065	
Minor cross-section area	A_2	0.001458963	m²
Major cross-section area	A_1	0.003881508	m²
Orifice cross-section area	A_0	0.0009621127	m²
Pipe Reynolds number	NRe_1	90251	
Pipe Reynolds number	NRe_2	147207.5	
Orifice Reynolds number	NRe_0	181275.6	
Jet section	A_c	0.0007887919	m²
Velocity in vena contracta	V_c	6.338807	m/s
Relative radius of the round	r/d_0	0.1428571	
Jet section	A_c	0.0007887919	m²
Velocity in vena contracta	V_c	6.338807	m/s
Jet velocity ratio (Equation 13.7)	λ	1.219729	
Coefficient of local resistance (Equation 13.8)	K_0	0.3887799	
Pressure loss coefficient (based on the mean pipe velocity)	K	6.327802	

References:

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