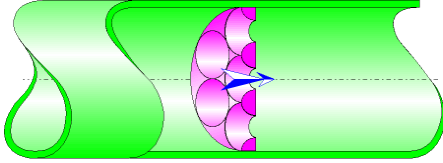




Rounded-edged Grid Circular Cross-Section (Pipe Flow - Guide)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a rounded-edged grid (perforated plate) 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:

Pipe cross-sectional area (m²):

$$A = \pi \cdot \frac{d^2}{4}$$

Cross-sectional area of one hole (m²):

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

Clear cross-sectional area of the grid (m²):

$$A_0 = a_o \cdot N$$

Porosity:

$$\phi = \frac{A_0}{A}$$

Equivalent section orifice diameter (m):

$$d_e = \sqrt{\frac{4 \cdot A_0}{\pi}}$$

Ratio between the diameters of the equivalent section orifice and the pipe:

$$\beta = \frac{d_e}{d}$$

Pipe velocity (m/s):

$$V = \frac{Q}{A}$$

Holes velocity (m/s):

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

Mass flow rate (kg/s):

$$G = Q \cdot \rho_m$$

Reynolds number in pipe:

$$N_{Re} = \frac{V \cdot d}{\nu}$$

Reynolds number in holes:

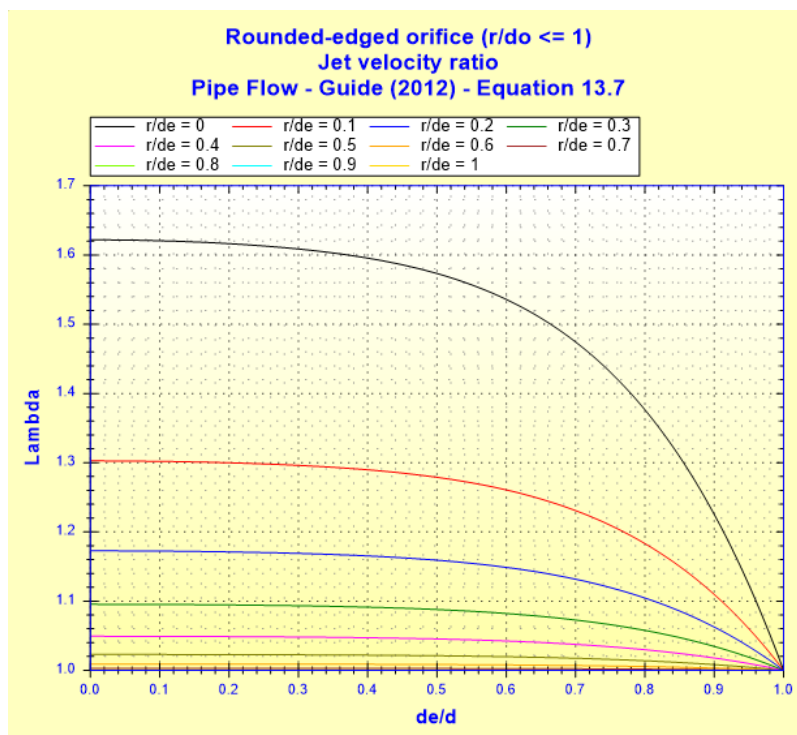
$$N_{Re_o} = \frac{V_o \cdot d_o}{\nu}$$

Jet velocity ratio:

■ $r/d_e \leq 1$

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

([1] equation 13.7)



■ $r/d_e > 1$

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

Velocity in vena contracta:

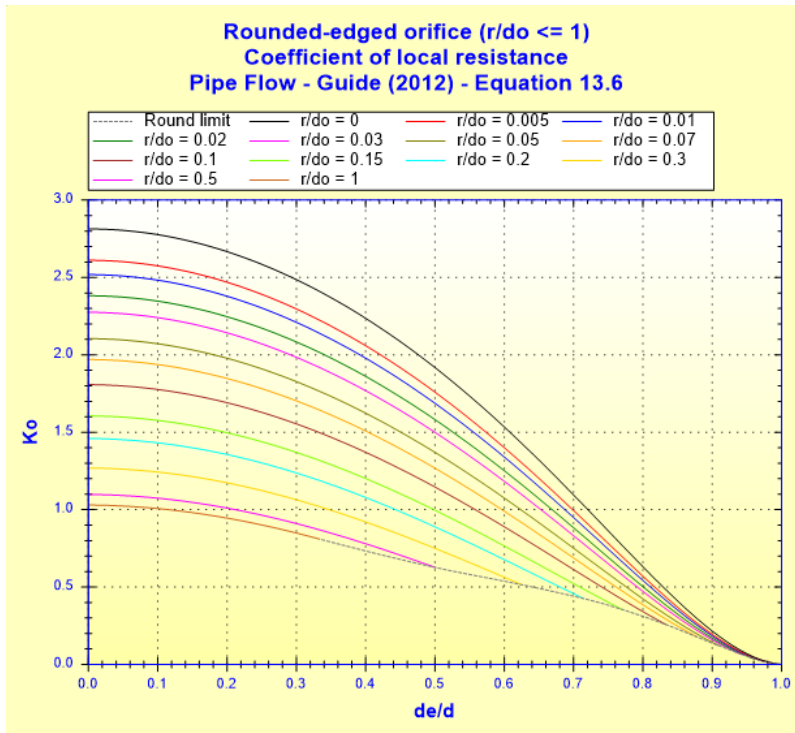
$$V_c = V_0 \cdot \lambda$$

Coefficient of local resistance:

■ $r/d_e \leq 1$

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

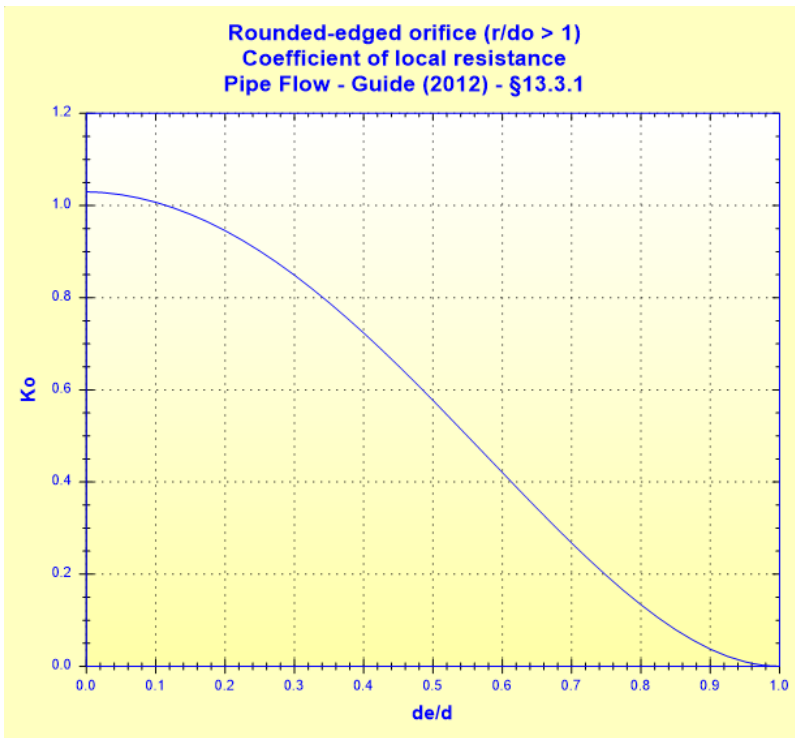
([1] equation 13.6)



■ $r/d_e > 1$

$$K_o = 0.03 \cdot (1 - \beta) \cdot (1 - \beta^5) + (1 - \beta^2)^2$$

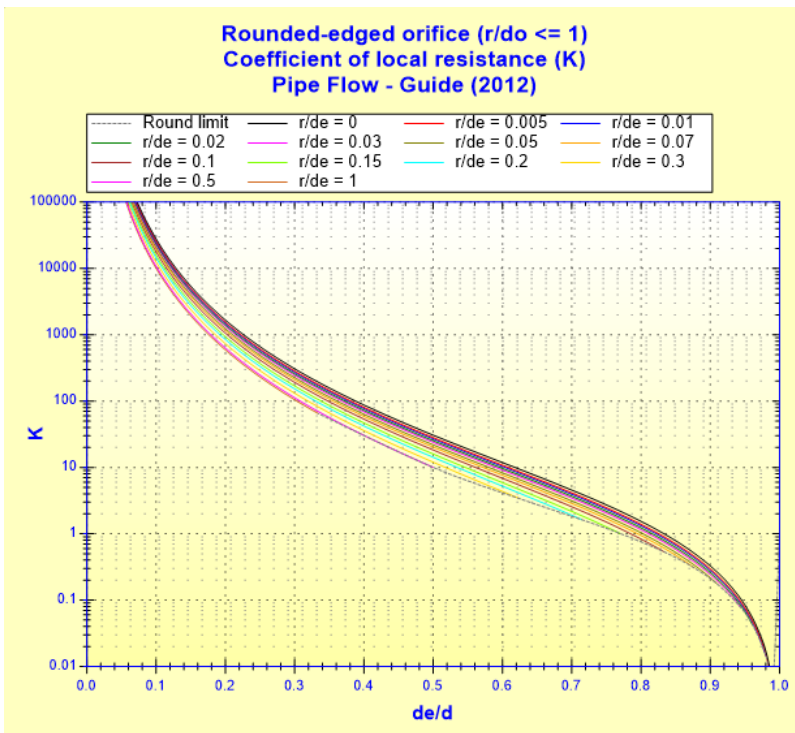
([1] § 13.3.1)



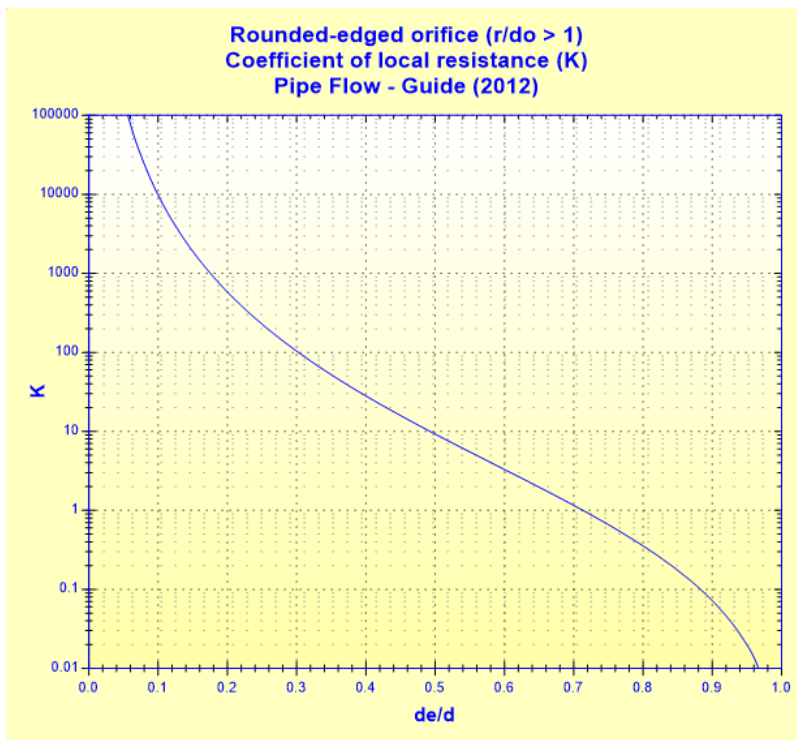
Total pressure loss coefficient (based on the mean pipe velocity):

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

■ $r/d_e \leq 1$



■ $r/d_e > 1$



Total pressure loss (Pa):

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

Total head loss of fluid (m):

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

Hydraulic power loss (W):

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

Symbols, Definitions, SI Units:

d	Internal pipe diameter (m)
A	Pipe cross-sectional area (m ²)
d _o	Holes diameter (m)
a _o	Cross-sectional area of one hole (m ²)
N	Holes number ()
A _o	Clear cross-sectional area of the grid (m ²)
φ	Porosity ()
d _e	Equivalent section orifice diameter (m)
β	Ratio between the diameters of the equivalent section orifice and the pipe ()
Q	Volume flow rate (m ³ /s)
G	Mass flow rate (kg/s)
V _o	Mean velocity in holes (m/s)
V	Mean velocity in pipe (m/s)
NRe _o	Reynolds number in holes ()
NRe	Reynolds number in pipe ()

λ	Jet velocity ratio ()
r	Rounding radius (m)
V_c	Mean velocity in vena contracta (m/s)
K_o	Coefficient of local resistance ()
K	Total pressure loss coefficient (based on the mean 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 holes ($NR_{e0} \geq 10^4$)
- stabilized flow upstream of the grid

Example of application:

The screenshot displays the HydraulCalc 2020b software interface for a rounded-edged grid pipe flow calculation. The window title is "HydrauCalc 2020b - [Rounded-edged grid - Pipe Flow - Guide (2012)]".

Fluid characteristics:

- Fluid: Water @ 1 atm [HC]
- Ref.: IAPWS IF97
- Temperature: T = 20 °C
- Pressure: P = 1.013 bar
- Density: $\rho = 998.2061 \text{ kg/m}^3$
- Dynamic Viscosity: $\mu = 0.00100159 \text{ N.s/m}^2$
- Kinematic Viscosity: $\nu = 1.00340E-06 \text{ m}^2/\text{s}$

Geometrical characteristics:

- Mass flow rate: G = 4.9910 kg/s
- Volume flow rate: Q = 0.005 m³/s
- Mean velocity: v = 1.288 m/s (Turbulent)
- Orifice diameter: d = 0.005 m
- Mean velocity in vena contracta: $V_o = 4.042 \text{ m/s}$ (Turbulent)
- Equivalent section orifice diameter: $d_o = 0.015 \text{ m}$
- Number of holes: N = 7
- Pressure loss: $\Delta P = 0.07403325 \text{ bar}$
- Total head loss: $\Delta H = 0.7563 \text{ m of fluid}$

Complementary results:

Designation	Symbol	Value	Unit
Pipe cross-section area	A	0.003881508	m ²
One hole cross-section area	ao	0.0001767146	m ²
Total holes cross-section area	Ao	0.001237002	m ²
Cross-sections area ratio - Porosity (Ao/A)	ϕ	0.3186911	
Equivalent section orifice diameter	de	0.03968627	
Diameters ratio (de/d)	β	0.5645273	
Relative radius of the round	r/de	0.1259882	
Pipe Reynolds number	NRe	90251	
Holes Reynolds number	NReo	60425.19	
Jet velocity ratio (Equation 13.7)	λ	1.23192	
Coefficient of local resistance (Equation 13.6)	K_o	0.9078984	
Pressure loss coefficient (based on the mean pipe velocity)	K	8.939178	
Hydraulic power loss	Wh	37.01662	W

References:

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

