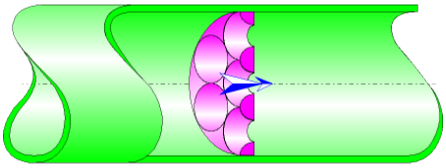
Rounded-edged Grid
Circular Cross-Section
(Pipe Flow - Guide)



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):

$$A_0 = a_0 \cdot N$$

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:

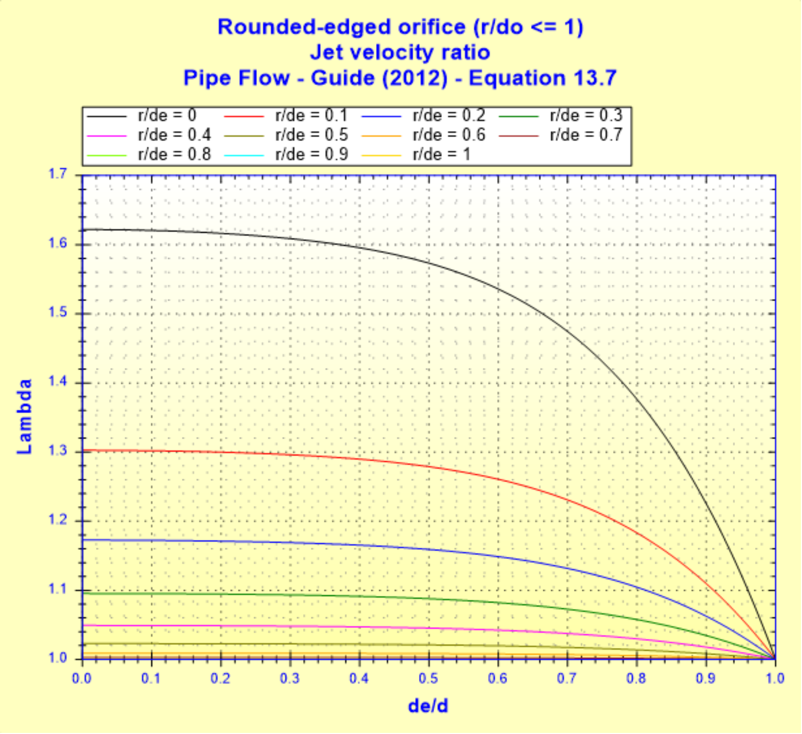
$$N_{Re_o} = \frac{V_o \cdot d_o}{\nu}$$

Jet velocity ratio:

- $r/d_e \leq 1$

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

([1] equation 13.7)



- $r/d_e > 1$

$$\lambda = 1$$ ([1] § 13.3.1)

Velocity in vena contracta:

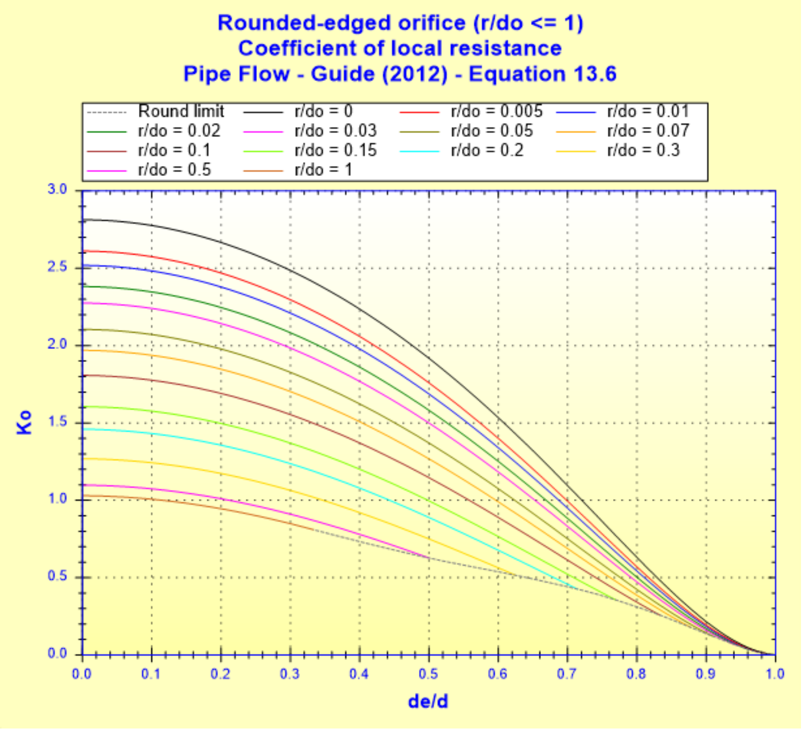
$$V_c = V_0 \cdot \lambda$$

Coefficient of local resistance:

- $r/d_e \leq 1$

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

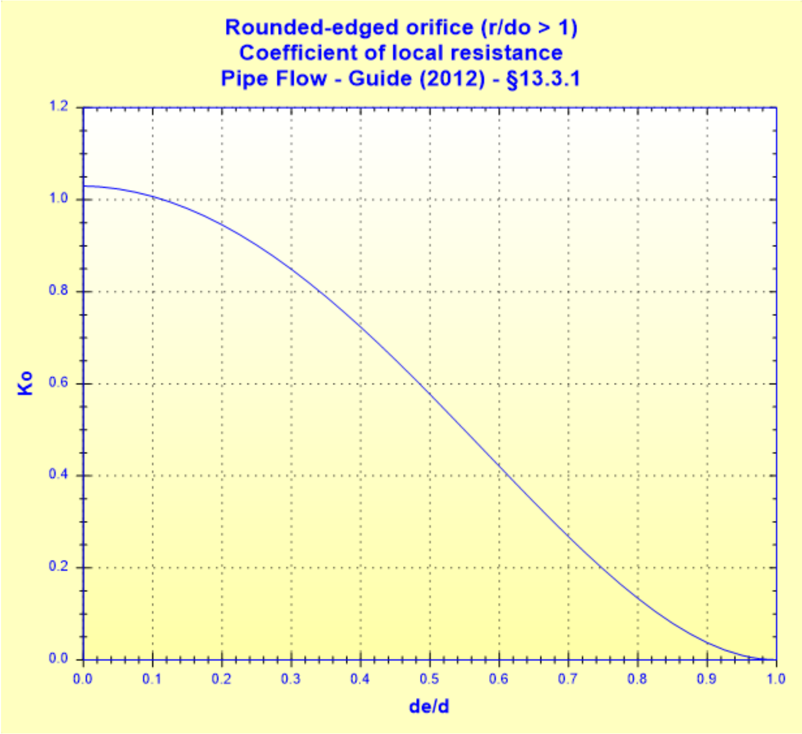
([1] equation 13.6)



- $r/d_e > 1$

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

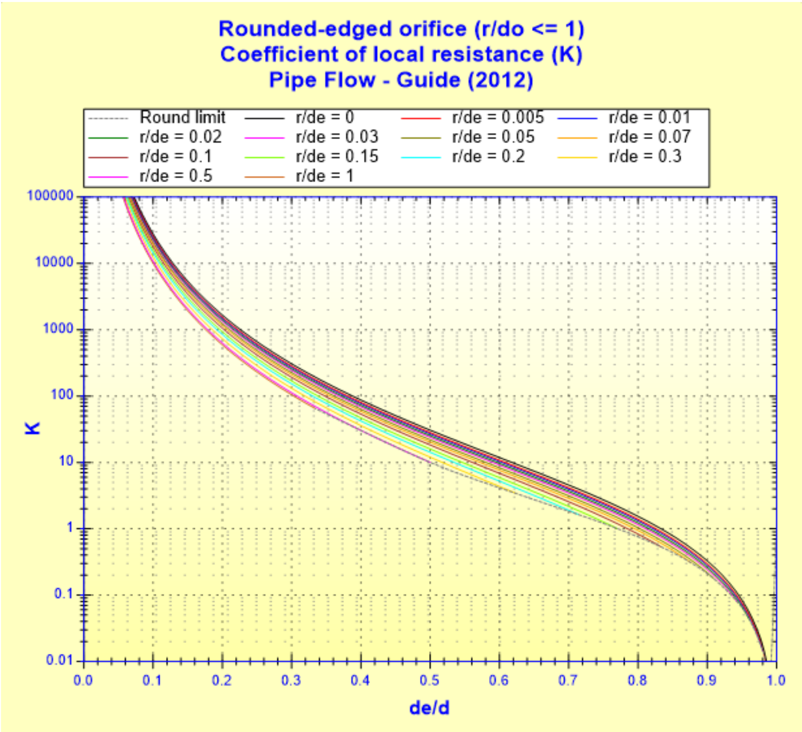
([1] § 13.3.1)



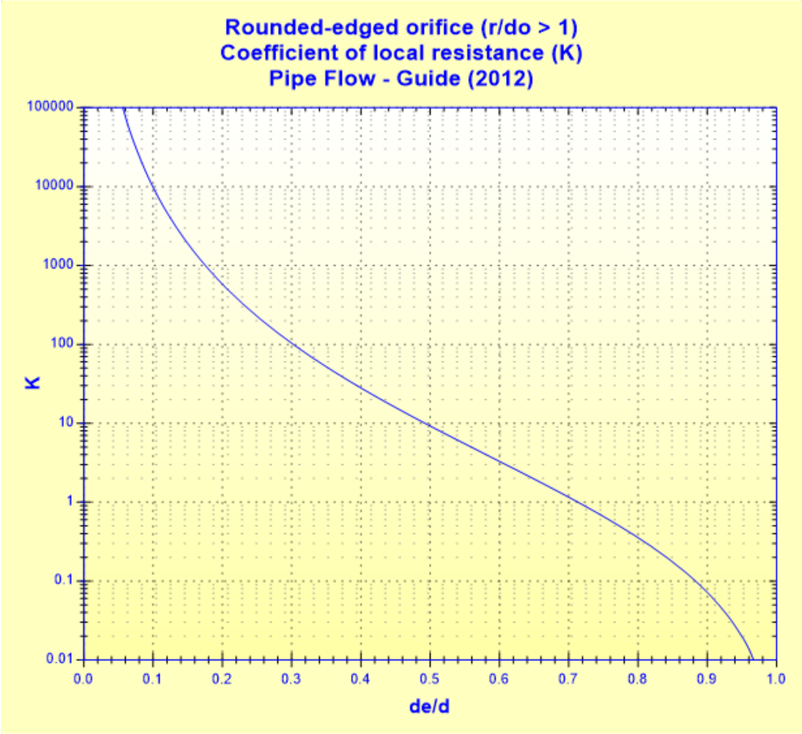
Total pressure loss coefficient (based on the mean pipe velocity):

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

■ $r/d_e \leq 1$



■ $r/d_e > 1$



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:

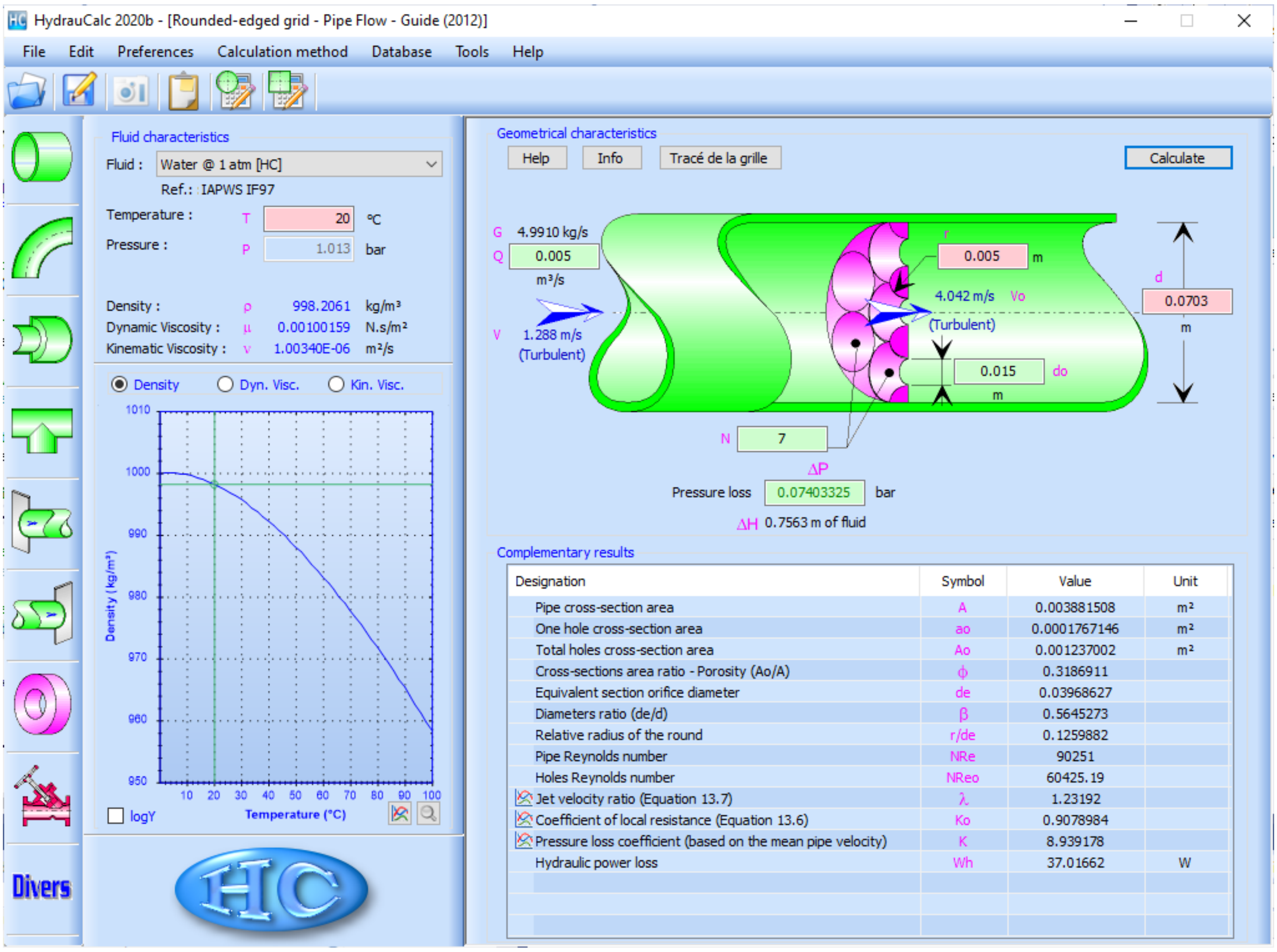
d	Internal pipe diameter (m)
A	Pipe cross-sectional area (m^2)
d_0	Holes diameter (m)
a_o	Cross-sectional area of one hole (m^2)
N	Holes number ()
A_0	Clear cross-sectional area of the grid (m^2)
ϕ	Porosity ()
d_e	Equivalent section orifice diameter (m)
β	Ratio between the diameters of the equivalent 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 ($NRe_o \geq 10^4$)
- stabilized flow upstream of the grid

Example of application:



References:

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