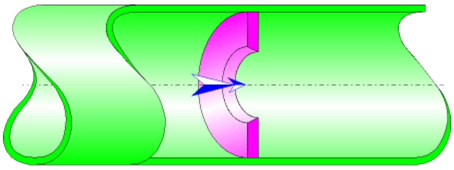
Bevelled-Edged Orifice
Circular Cross-Section
(Pipe Flow - Guide)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a bevelled-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:

Ratio of orifice to pipe diameters:

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

Pipe cross-sectional area (m²):

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

Orifice cross-sectional area (m²):

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

Pipe velocity (m/s):

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

Orifice velocity (m/s):

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

Mass flow rate (kg/s):

$$G = Q \cdot \rho_m$$

Reynolds number in pipe:

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

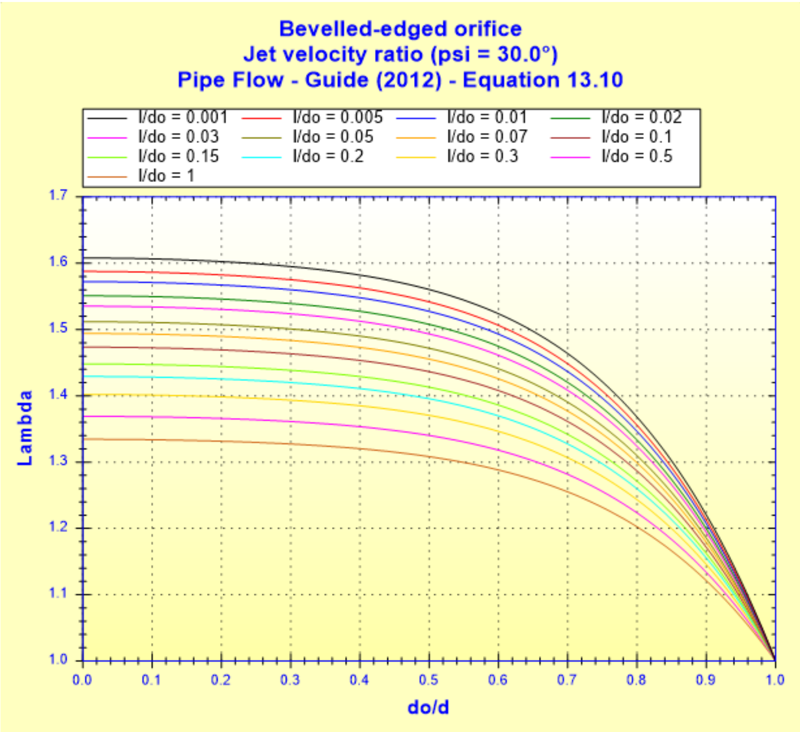
Reynolds number in orifice:

$$N_{Re_O} = \frac{V_O \cdot d_O}{\nu}$$

Jet velocity ratio:

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

([1] equation 13.10)

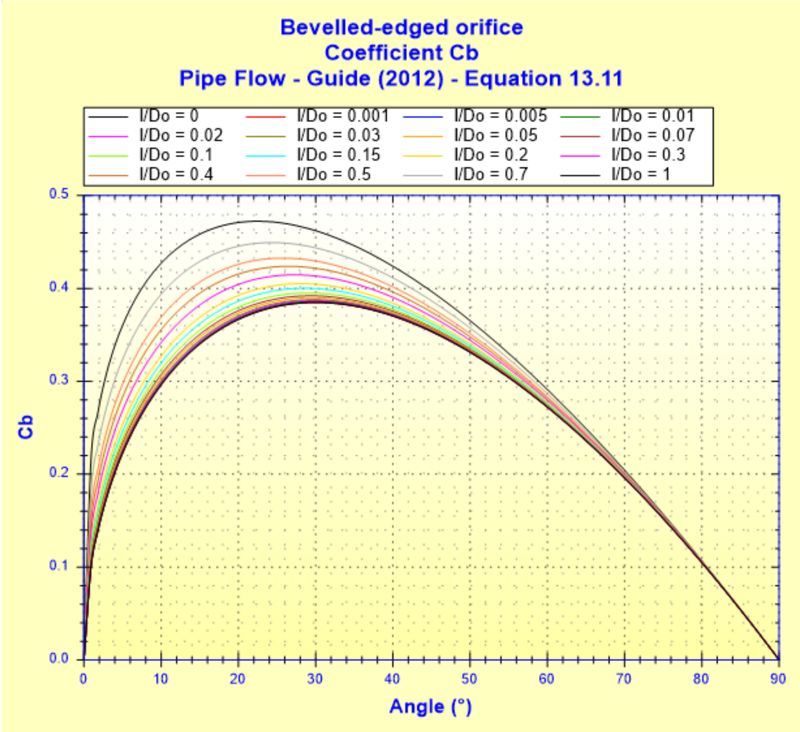


with:

Coefficient of effect of the bevel angle:

$$C_b = \left(1 - \frac{\Psi}{90} \right) \cdot \left(\frac{\Psi}{90} \right)^{\frac{1}{2 + l/d_0}}$$

([1] equation 13.11)



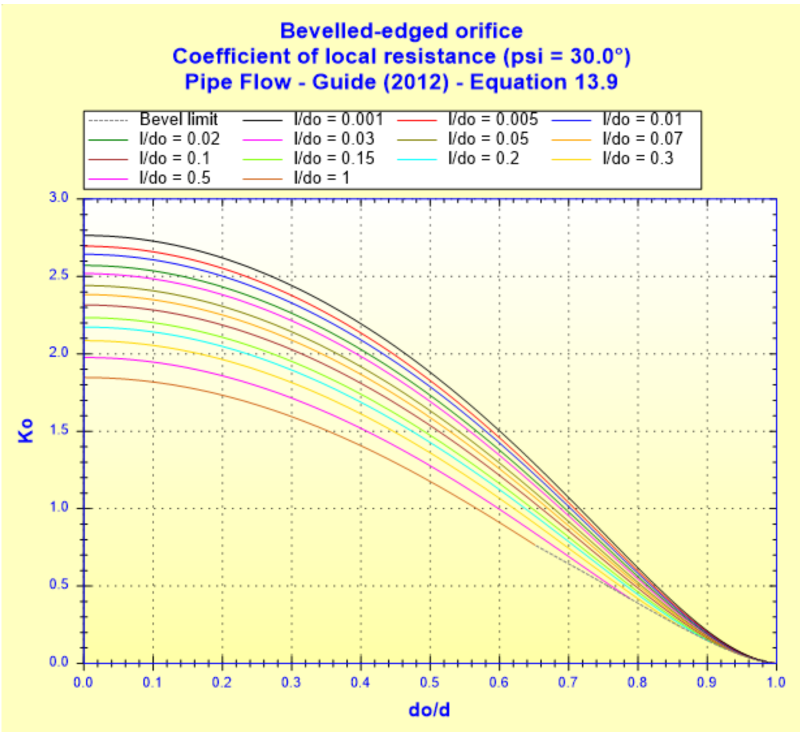
Velocity in vena contracta:

$$V_c = V_0 \cdot \lambda$$

Coefficient of local resistance ($NRe_o \geq 10^4$):

$$K_o = 0.0696 \cdot \left(1 - C_b \cdot \frac{l}{d_0}\right) \cdot \left(1 - 0.42 \cdot \sqrt{\frac{l}{d_0} \cdot \beta^2}\right) \cdot \left(1 - \beta^5\right) \cdot \lambda^2 + \left(\lambda - \beta^2\right)^2$$

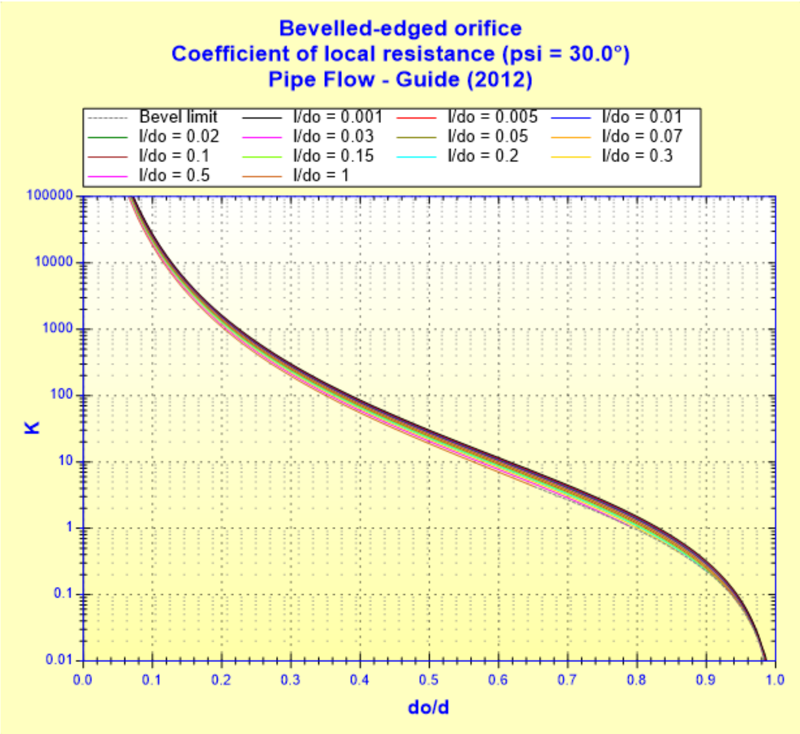
([1] equation 13.9)



(with ψ = 30°)

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

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



(with ψ = 30°)

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:

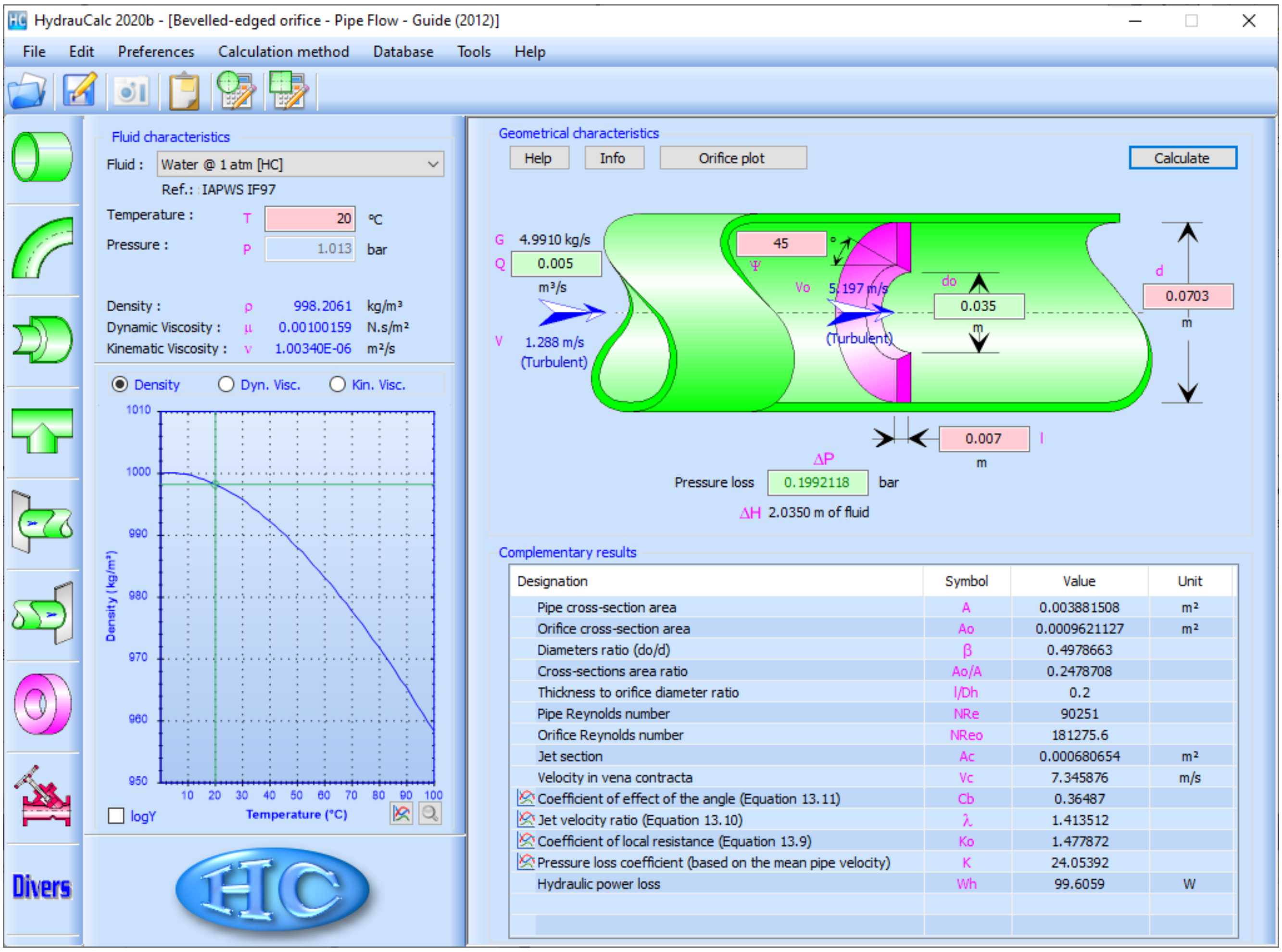
d_0	Orifice diameter (m)
d	Internal pipe diameter (m)
β	Ratio of orifice to pipe diameters ()
A_o	Orifice cross-sectional area (m^2)
A	Pipe cross-sectional area (m^2)
Q	Volume flow rate (m^3/s)
G	Mass flow rate (kg/s)
V_o	Mean velocity in orifice (m/s)
V	Mean velocity in pipe (m/s)
NRe_o	Reynolds number in orifice ()
NRe	Reynolds number in pipe ()
l	Thickness orifice (m)
ψ	Bevel angle (°)
λ	Jet velocity ratio ()
V_c	Mean velocity in vena contracta (m/s)

C_b	Coefficient of effect of the bevel angle ()
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 orifice ($NRe_o \geq 10^4$)
- stabilized flow upstream of the orifice
- bevel angle less than or equal to: $\psi \leq tg^{-1}((d - d_o) / (2\ l))$

Example of application:



References:

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