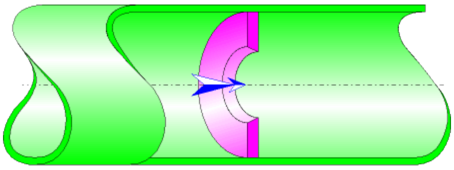
Bevelled-Edged Orifice
Circular Cross-Section
(IDELCHIK)



Model description:

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

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

Model formulation:

Hydraulic diameter (m):

$$\boxed{D_h = D_0}$$

Pipe cross-section area (m^2):

$$\boxed{F_1 = \pi \cdot \frac{D_1^{\;2}}{4}}$$

Orifice cross-section area (m^2):

$$\boxed{F_0 = \pi \cdot \frac{D_0^{\;2}}{4}}$$

Mean velocity in pipe (m/s):

$$\boxed{w_1 = \frac{Q}{F_1}}$$

Mean velocity in orifice (m/s):

$$\boxed{w_0 = \frac{Q}{F_0}}$$

Mass flow rate (kg/s):

$$\boxed{G = Q \cdot \rho}$$

Reynolds number in pipe:

$$\mathrm{Re}_1 = \frac{w_1 \cdot D_1}{\nu}$$

Reynolds number in orifice:

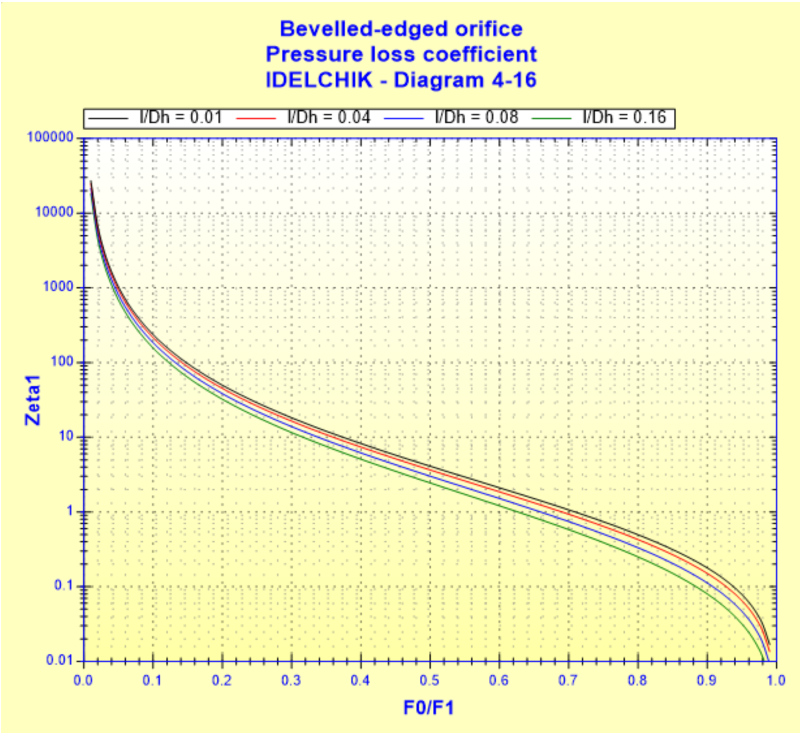
$$\mathrm{Re}_0 = \frac{w_0 \cdot D_0}{\nu}$$

Local resistance coefficient:

- $\mathrm{Re}_0 \geq 10^5$

$$\zeta_1 = \left[1 - \frac{F_0}{F_1} + \sqrt{\zeta'} \cdot \left(1 - \frac{F_0}{F_1}\right)^{0.375}\right]^2 \cdot \left(\frac{F_1}{F_0}\right)^2$$

([1] diagram 4-16)

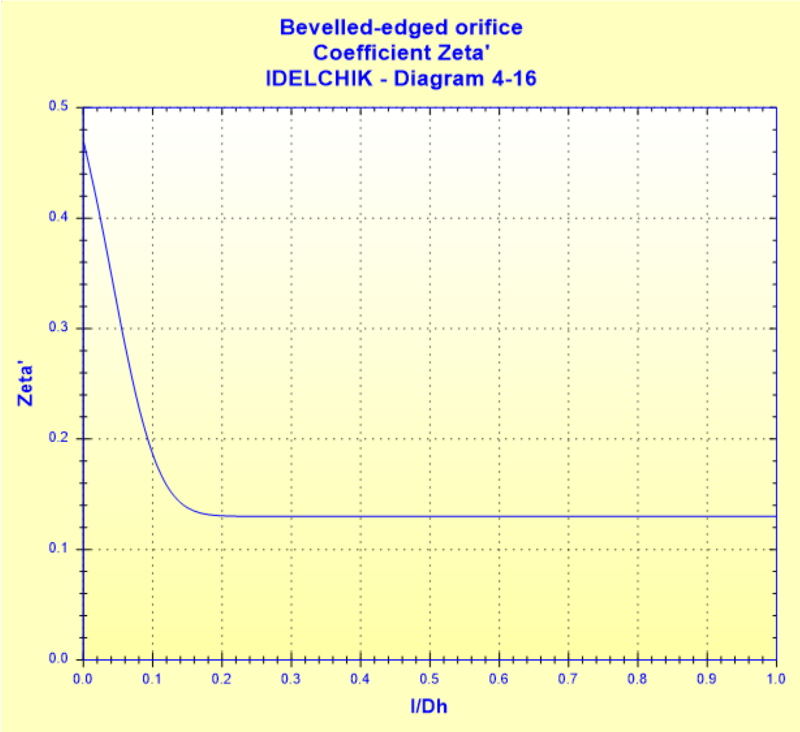


with :

Coefficient of effect of the orifice thickness:

$$\zeta' = 0.13 + 0.34 \cdot 10^{-\left(3.4 \cdot \frac{l}{D_h} + 88.4 \cdot \left(\frac{l}{D_h}\right)^{2.3}\right)}$$

([1] diagram 4-16)



■ $Re_0 \leq 10^5$

Quadratic local resistance coefficient:

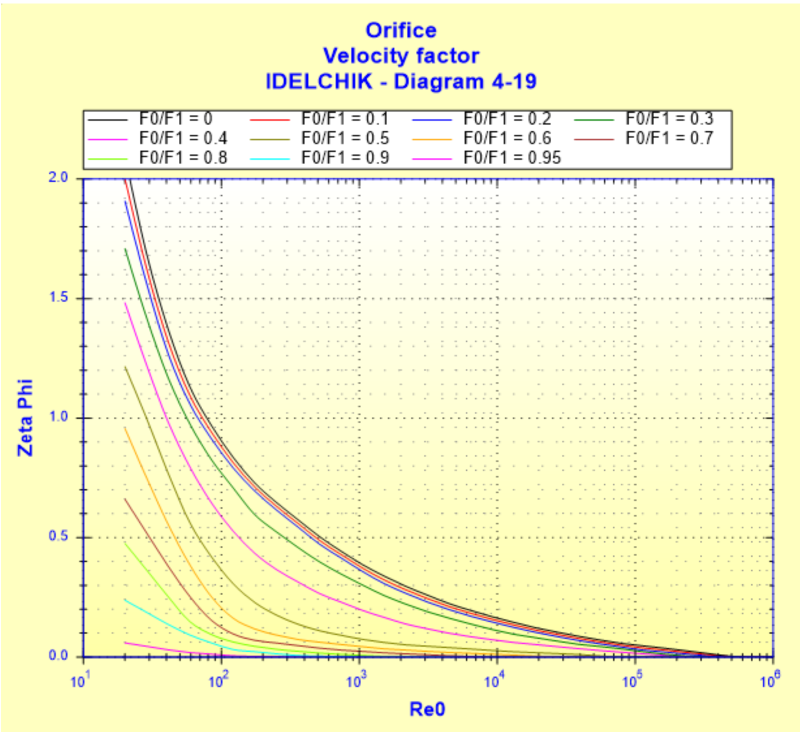
$$\zeta_{1quad} = \left[1 - \frac{F_0}{F_1} + \sqrt{\zeta'} \cdot \left(1 - \frac{F_0}{F_1}\right)^{0.375}\right]^2 \cdot \left(\frac{F_1}{F_0}\right)^2$$

([1] diagram 4-16)

Velocity factor:

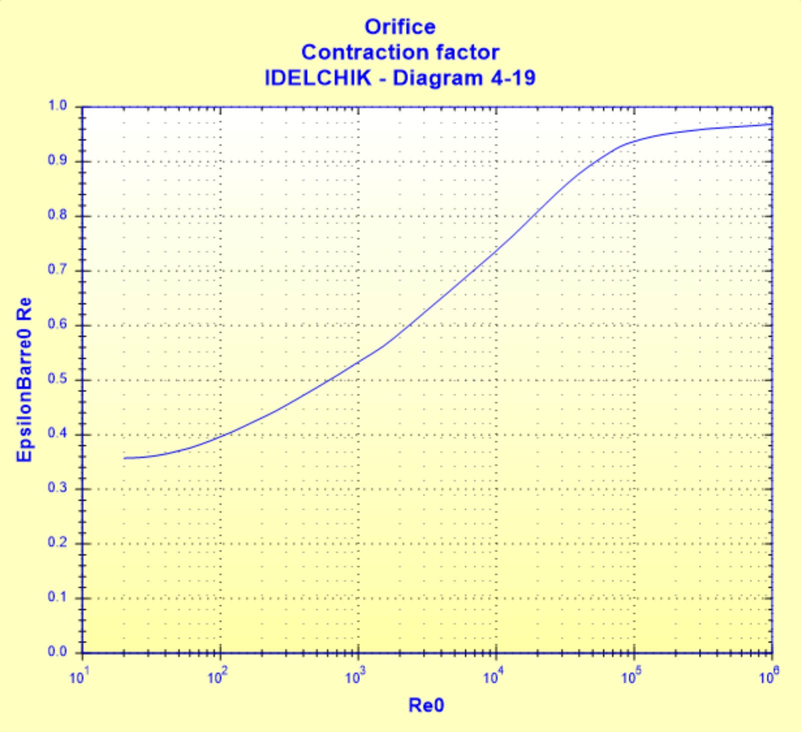
$$\zeta_\varphi = f\left(Re_0, \frac{F_0}{F_1}\right)$$

([1] diagram 4-19)



Contraction factor:

$\boxed{\bar{\varepsilon}_{0\text{Re}} = f(\text{Re}_0)}$ ([1] diagram 4-19)



Local resistance coefficient:

- $30 < \text{Re}_0 < 10^5$

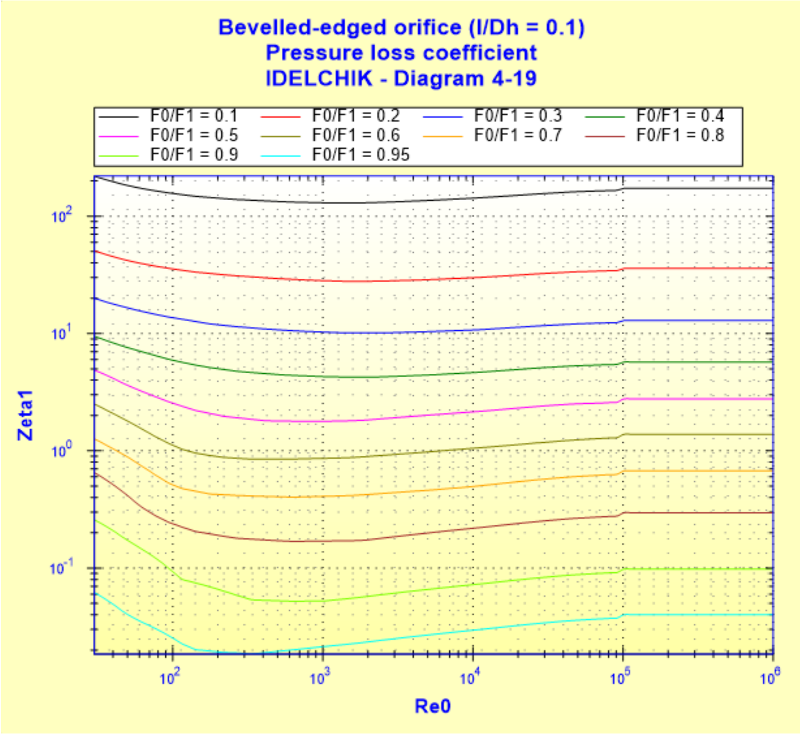
$$\boxed{\zeta_1 = \zeta_\varphi \cdot \left(\frac{F_1}{F_0}\right)^2 + \bar{\varepsilon}_{0\text{Re}} \cdot \zeta_{1quad}}$$ ([1] diagram 4-19)

- $10 < \text{Re}_0 \le 30$

$$\boxed{\zeta_1 = \frac{33}{\text{Re}_0} \cdot \left(\frac{F_1}{F_0}\right)^2 + \bar{\varepsilon}_{0\text{Re}} \cdot \zeta_{1quad}}$$ ([1] diagram 4-19)

- $\text{Re}_0 \le 10$

$$\boxed{\zeta_1 = \frac{33}{\text{Re}_0} \cdot \left(\frac{F_1}{F_0}\right)^2}$$ ([1] diagram 4-19)



([1] diagram 4-19 with l/Dh = 0.1)

Pressure loss coefficient (based on the mean pipe velocity):

$$\boxed{\zeta = \zeta_1}$$

Total pressure loss (Pa):

$$\boxed{\Delta P = \zeta \cdot \frac{\rho \cdot w_1^{\,2}}{2}}$$

Total head loss of fluid (m):

$$\boxed{\Delta H = \zeta \cdot \frac{w_1^{\,2}}{2 \cdot g}}$$

Hydraulic power loss (W):

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

Symbols, Definitions, SI Units:

D_h	Hydraulic diameter (m)
D_1	Pipe internal diameter (m)
D_0	Orifice diameter (m)
F_1	Pipe cross-sectional area (m^2)
F_0	Orifice cross-sectional area (m^2)
Q	Volume flow rate (m^3/s)
G	Mass flow rate (kg/s)
w_1	Mean velocity in pipe (m/s)
w_0	Mean velocity in orifice (m/s)
l	Orifice thickness (m)
Re_1	Reynolds number in pipe ()

Re_0 Reynolds number in orifice ()

ζ' Coefficient of effect of the orifice thickness ()

ζ_{1quad} Quadratic local resistance coefficient determined as Re = 10^5 ()

ζ_φ Velocity factor ()

$\bar{\varepsilon}_{0Re}$ Contraction factor ()

ζ_1 Local resistance coefficient ()

ζ 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 Fluid density (kg/m^3)

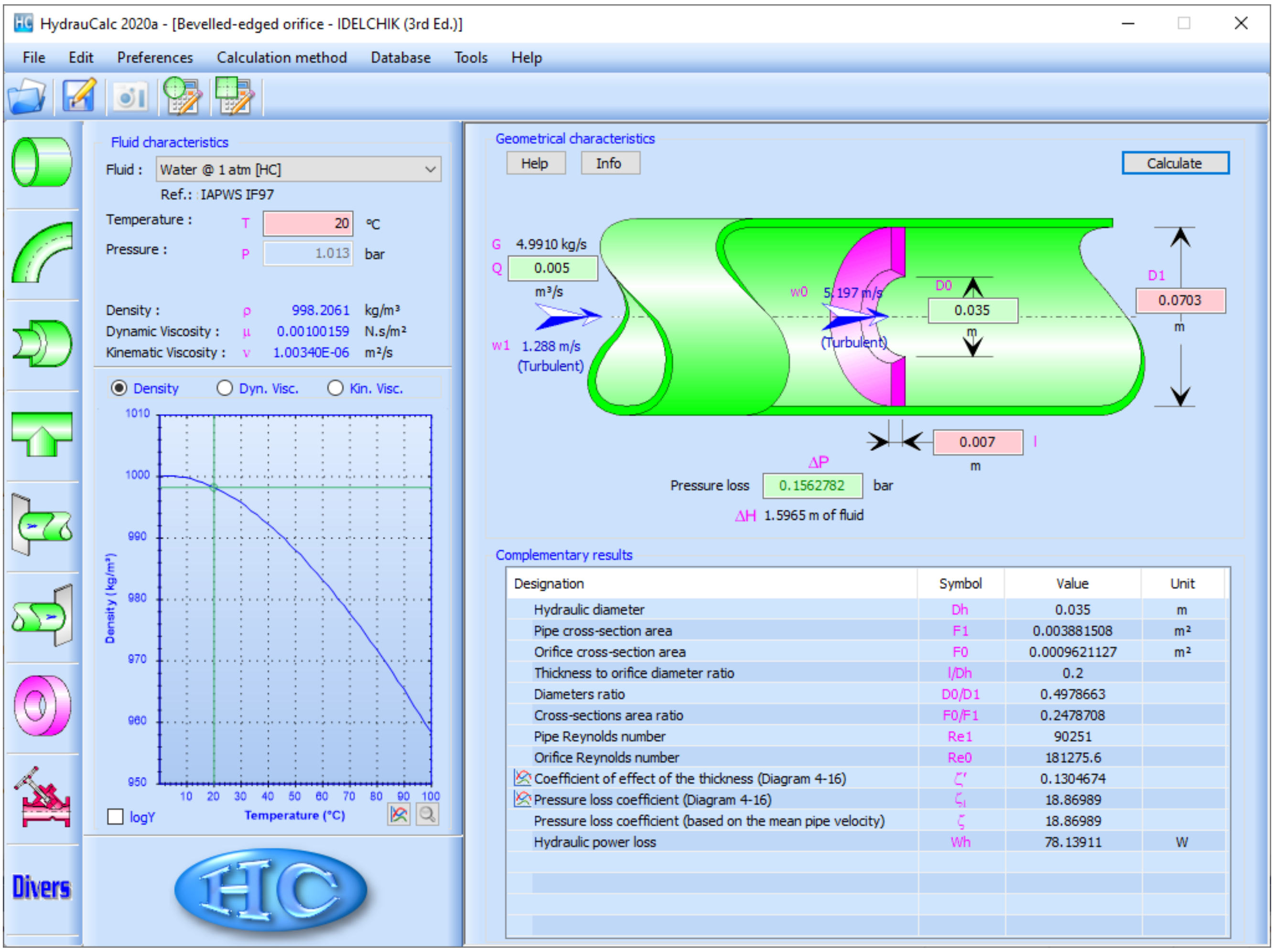
ν Fluid kinematic viscosity (m^2/s)

g Gravitational acceleration (m/s^2)

Validity range:

- any flow regime: laminar and turbulent
- stabilized flow upstream of the orifice
- angle at the top of the truncated cone between 40 ° and 60 °

Example of application:



References:

[1] Handbook of Hydraulic Resistance, 3rd Edition, I.E. Idelchik