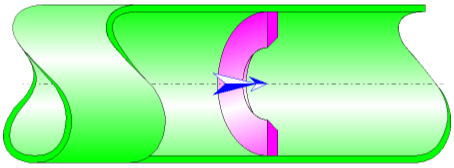
Sharp-edged Orifice
Circular Cross-Section
(IDELCHIK)



Model description:

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

Hydraulic diameter (m):

$$D_h = D_0$$

Pipe cross-section area (m²):

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

Orifice cross-section area (m²):

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

Mean velocity in pipe (m/s):

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

Mean velocity in orifice (m/s):

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

Mass flow rate (kg/s):

$$G = Q \cdot \rho$$

Reynolds number in pipe:

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

Reynolds number in orifice:

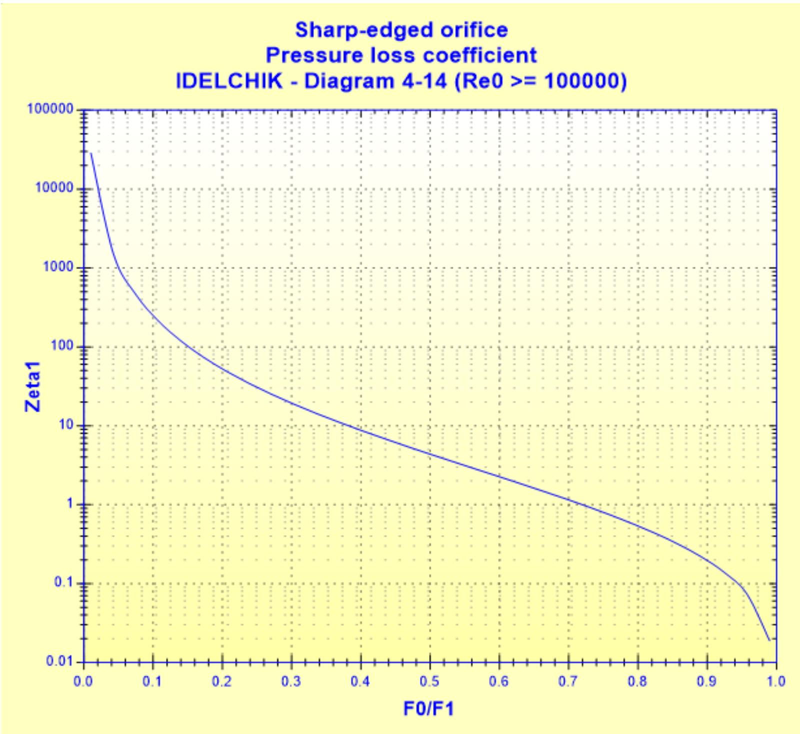
$$\mathrm{Re}_0 = \frac{w_0 \cdot D_0}{\nu}$$

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

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

$$\zeta_1 = \left[\left(1-\frac{F_0}{F_1}\right) + 0.707 \cdot \left(1-\frac{F_0}{F_1}\right)^{0.375}\right]^2 \cdot \left(\frac{F_1}{F_0}\right)^2$$

([1] diagram 4.14)



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

Quadratic pressure loss coefficient:

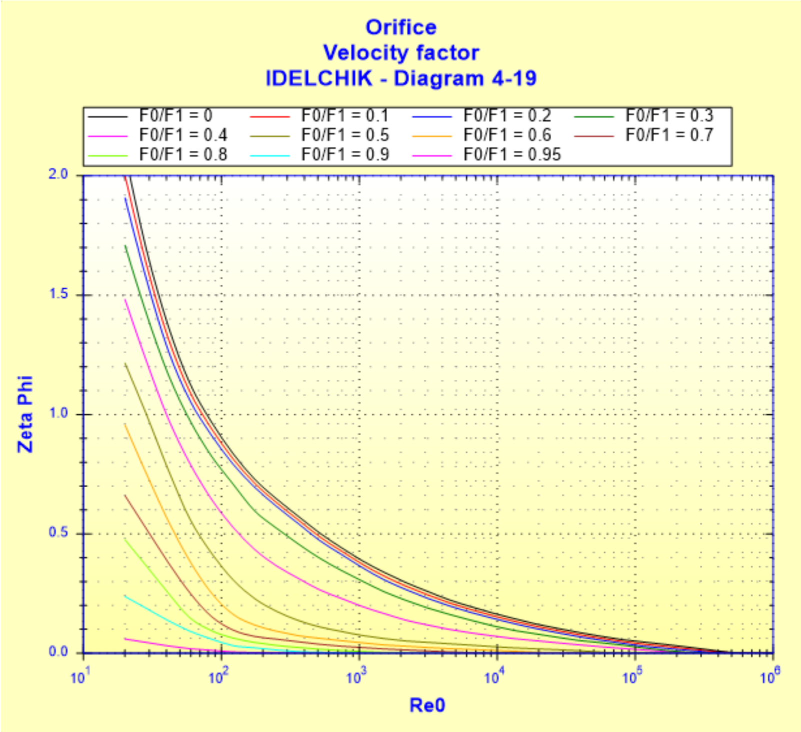
$$\zeta_{1quad} = \left[\left(1-\frac{F_0}{F_1}\right) + 0.707 \cdot \left(1-\frac{F_0}{F_1}\right)^{0.375}\right]^2 \cdot \left(\frac{F_1}{F_0}\right)^2$$

([1] diagram 4.14)

Velocity factor:

$$\zeta_\varphi = f\left(\mathrm{Re}_0, \frac{F_0}{F_1}\right)$$

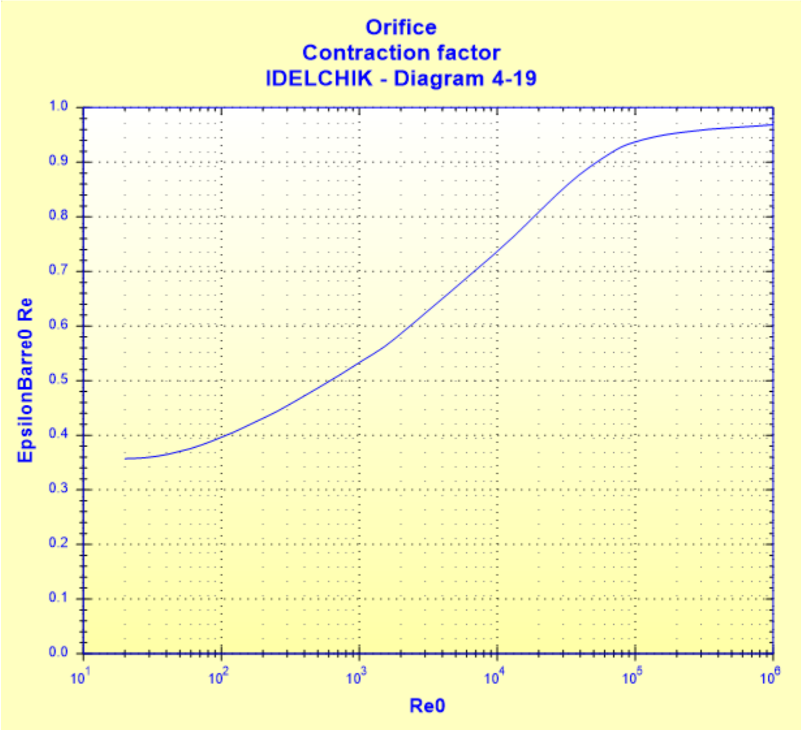
([1] diagram 4.19)



Contraction factor:

$$\bar{\varepsilon}_{0\mathrm{Re}} = f(\mathrm{Re}_0)$$

([1] diagram 4.19)



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

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

$$\zeta_1 = \zeta_\varphi \cdot \left(\frac{F_1}{F_0}\right)^2 + \bar{\varepsilon}_{0\mathrm{Re}} \cdot \zeta_{1quad}$$

([1] diagram 4.19)

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

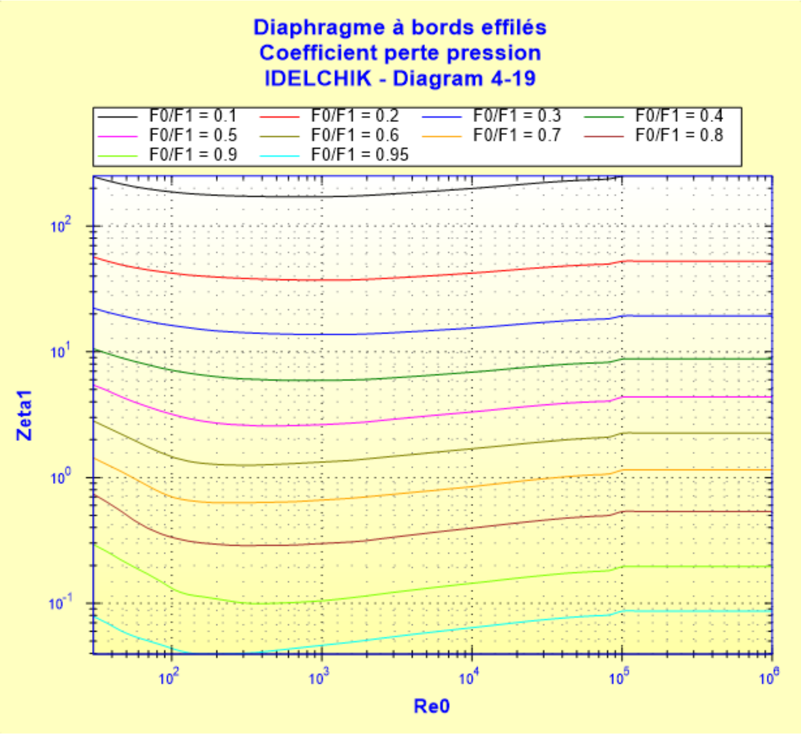
$$\zeta_1 = \frac{33}{Re_0} \cdot \left(\frac{F_1}{F_0}\right)^2 + \bar{\varepsilon}_{0Re} \cdot \zeta_{1quad}$$

([1] diagram 4.19)

- $Re_0 \leq 10$

$$\zeta_1 = \frac{33}{Re_0} \cdot \left(\frac{F_1}{F_0}\right)^2$$

([1] diagram 4.19)



([1] diagramme 4.19)

Total pressure loss (Pa):

$$\Delta P = \zeta_1 \cdot \frac{\rho \cdot w_1^2}{2}$$

Total head loss of fluid (m):

$$\Delta H = \zeta_1 \cdot \frac{w_1^2}{2 \cdot g}$$

Hydraulic power loss (W):

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

Symbols, Definitions, SI Units:

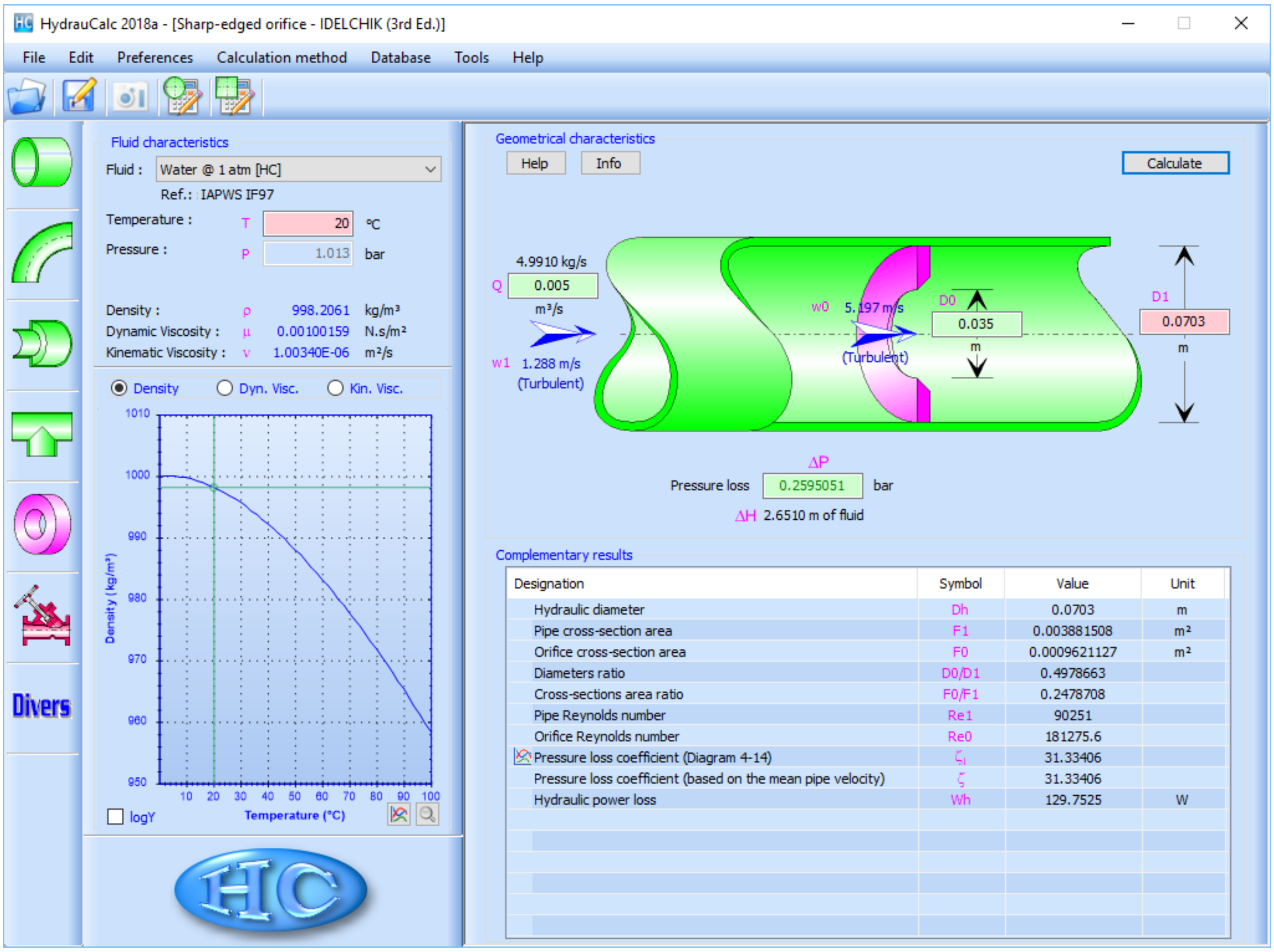
D_h	Hydraulic diameter (m)
D_1	Pipe internal diameter (m)
F_1	Pipe cross-sectional area (m^2)
D_0	Orifice diameter (m)
F_0	Orifice cross-sectional area (m^2)
Q	Volume flow rate (m^3/s)
G	Mass flow rate (kg/s)
w_1	Mean velocity in pipe (m/s)

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_{1quad}	Quadratic pressure loss coefficient determined as Re = 10^5 ()
ζ_φ	Velocity factor ()
$\bar{\varepsilon}_{0Re}$	Contraction factor ()
ζ_1	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
- thickness to orifice diameter ratio (l/D_0) lower than or equal to 0.015

Example of application:



References:

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