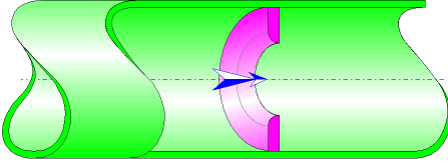




Rounded-Edged Orifice Circular Cross-Section (IDELCHIK)



Model description:

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

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

Reynolds number in orifice:

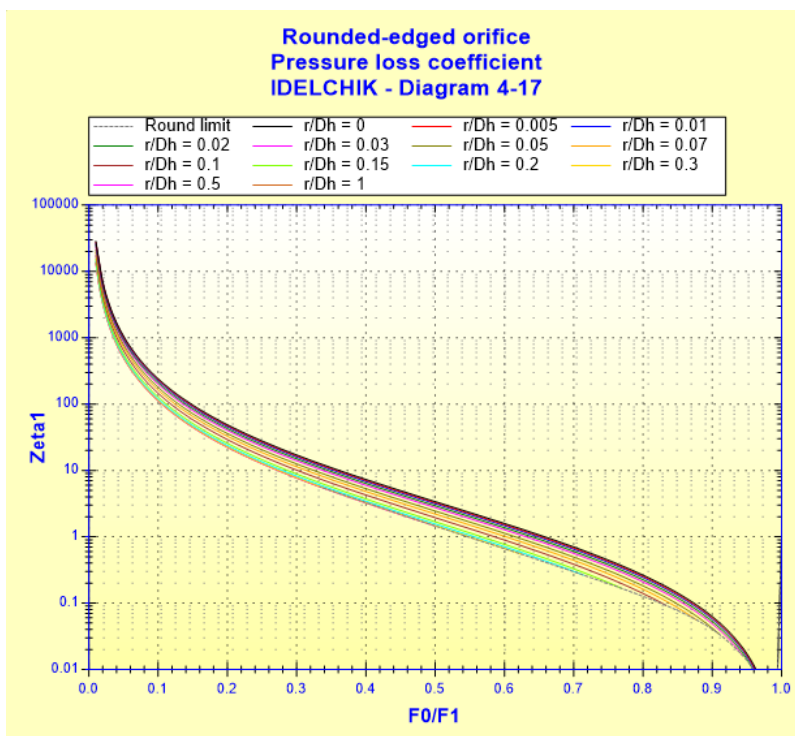
$$\text{Re}_0 = \frac{w_0 \cdot D_0}{\nu}$$

Local resistance coefficient:

■ $\text{Re}_0 \geq 10^5$

$$\zeta_1 = \left[1 - \frac{F_0}{F_1} + \sqrt{\zeta'} \cdot \left(1 - \frac{F_0}{F_1} \right)^{0.75} \right]^2 \cdot \left(\frac{F_1}{F_0} \right)^2$$

([1] diagram 4-17)

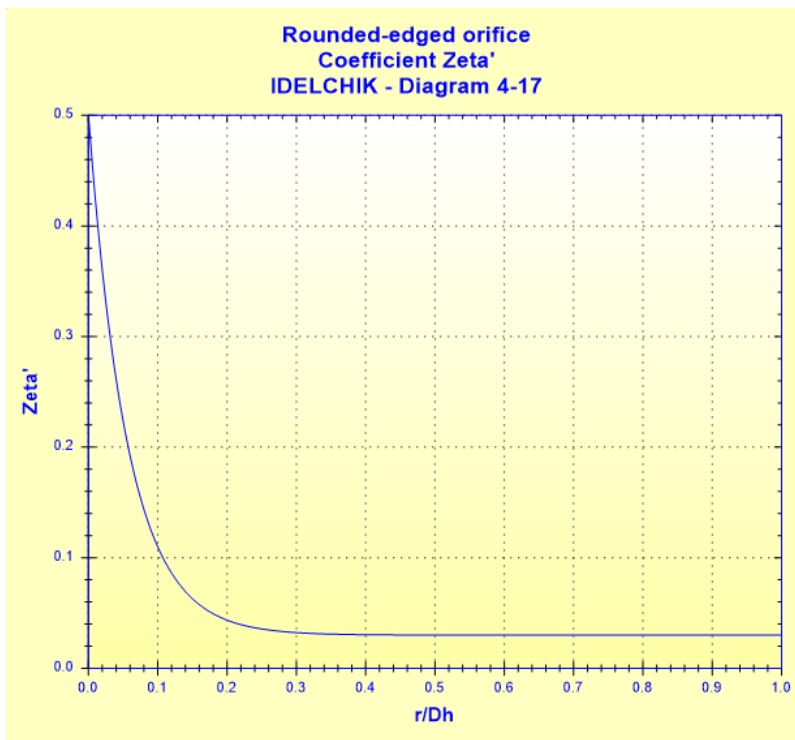


with :

Coefficient of effect of the round:

$$\zeta' = 0.03 + 0.47 \cdot 10^{-7.7 \cdot \frac{r}{D_h}}$$

([1] diagram 4-17)



■ $Re_0 \leq 10^5$

Quadratic local resistance coefficient:

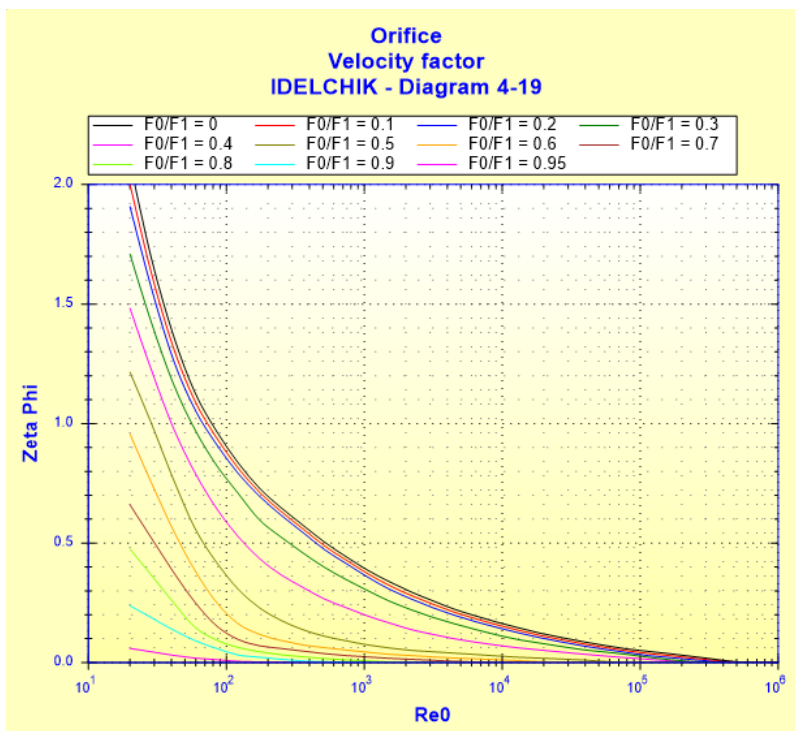
$$\zeta_{1quad} = \left[1 - \frac{F_0}{F_1} + \sqrt{\zeta'} \cdot \left(1 - \frac{F_0}{F_1} \right)^{0.75} \right]^2 \cdot \left(\frac{F_1}{F_0} \right)^2$$

([1] diagram 4-17)

Velocity factor:

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

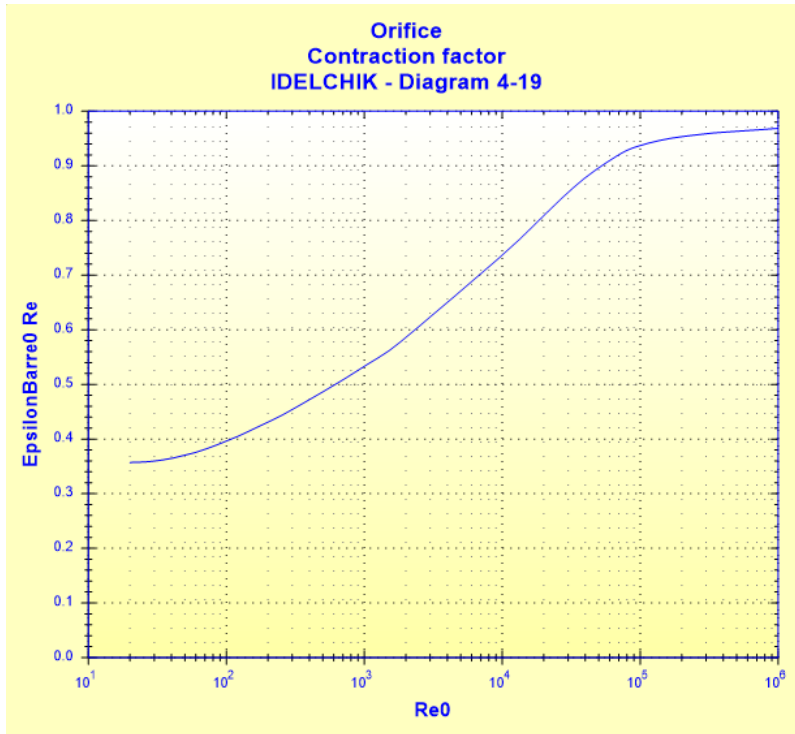
([1] diagram 4-19)



Contraction factor:

$$\bar{\varepsilon}_{0Re} = f(Re_0)$$

([1] diagram 4-19)



Local resistance coefficient:

- $30 < Re_0 < 10^5$

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

([1] diagram 4-19)

- $10 < Re_0 \leq 30$

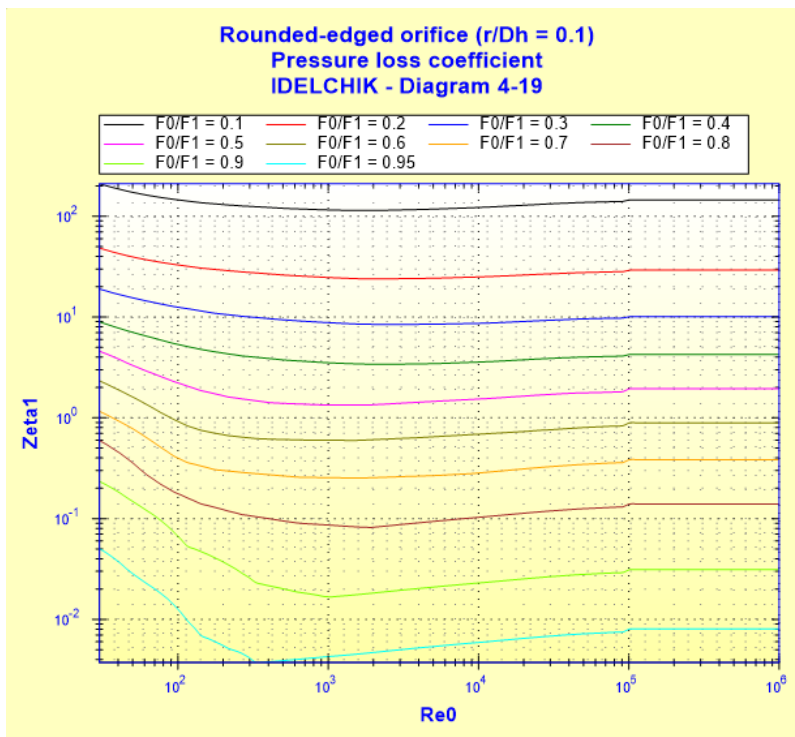
$$\zeta_1 = \frac{33}{Re_0} \cdot \left(\frac{F_1}{F_0}\right)^2 + \bar{\varepsilon}_{0Re} \cdot \zeta_{1quad}$$

([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] diagram 4-19 with

r/Dh = 0.1)

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

$$\zeta = \zeta_1$$

Total pressure loss (Pa):

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

Total head loss of fluid (m):

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

Hydraulic power loss (W):

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

Symbols, Definitions, SI Units:

D_h	Hydraulic diameter (m)
D_1	Pipe internal diameter (m)
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)
r	Radius of the round (m)
Re_1	Reynolds number in pipe ()

Re_0	Reynolds number in orifice ()
ζ'	Coefficient of effect of the round ()
ζ_{1quad}	Quadratic local resistance coefficient determined as $Re = 10^5$ ()
ζ_{φ}	Velocity factor ()
ε_{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
- round radius less than the radius difference ($r < (D_1/2 - D_0/2)$)

Example of application:

The screenshot shows the HydrCalc 2020b interface for a rounded-edged orifice calculation. The fluid is Water @ 1 atm [HC] with a temperature of 20 °C and pressure of 1.013 bar. The orifice has a diameter of 0.035 m and a round radius of 0.005 m. The flow rate is 4.9910 kg/s (0.005 m³/s) with a mean velocity of 5.197 m/s. The pressure loss is 0.1246692 bar, and the head loss is 1.2736 m of fluid.

Fluid characteristics:

- Fluid: Water @ 1 atm [HC]
- Temperature: 20 °C
- Pressure: 1.013 bar
- Density: 998.2061 kg/m³
- Dynamic Viscosity: 0.00100159 N.s/m²
- Kinematic Viscosity: 1.00340E-06 m²/s

Geometrical characteristics:

- Hydraulic diameter: 0.035 m
- Pipe cross-section area: 0.003881508 m²
- Orifice cross-section area: 0.0009621127 m²
- Cross-sections area ratio: 0.2478708
- Relative radius of the round: 0.1428571
- Pipe Reynolds number: 90251
- Orifice Reynolds number: 181275.6
- Coefficient of effect of the round: 0.06733343
- Pressure loss coefficient: 15.05324
- Pressure loss coefficient (based on the mean pipe velocity): 15.05324
- Hydraulic power loss: 62.33459 W

Complementary results:

Designation	Symbol	Value	Unit
Hydraulic diameter	Dh	0.035	m
Pipe cross-section area	F1	0.003881508	m²
Orifice cross-section area	F0	0.0009621127	m²
Cross-sections area ratio	F0/F1	0.2478708	
Relative radius of the round	r/Dh	0.1428571	
Pipe Reynolds number	Re1	90251	
Orifice Reynolds number	Re0	181275.6	
Coefficient of effect of the round (Diagram 4-17)	ζ'	0.06733343	
Pressure loss coefficient (Diagram 4-17)	ζ_1	15.05324	
Pressure loss coefficient (based on the mean pipe velocity)	ζ	15.05324	
Hydraulic power loss	Wh	62.33459	W

References:

