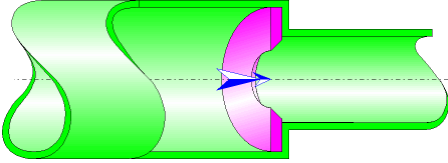




Sharp-Edged Orifice (with Transition) Circular Cross-Section (IDELCHIK)



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 with transition.

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

Model formulation:

Hydraulic diameter (m):

$$D_h = D_0$$

Major pipe cross-section area (m²):

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

Minor pipe cross-section area (m²):

$$F_2 = \pi \cdot \frac{D_2^2}{4}$$

Orifice cross-section area (m²):

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

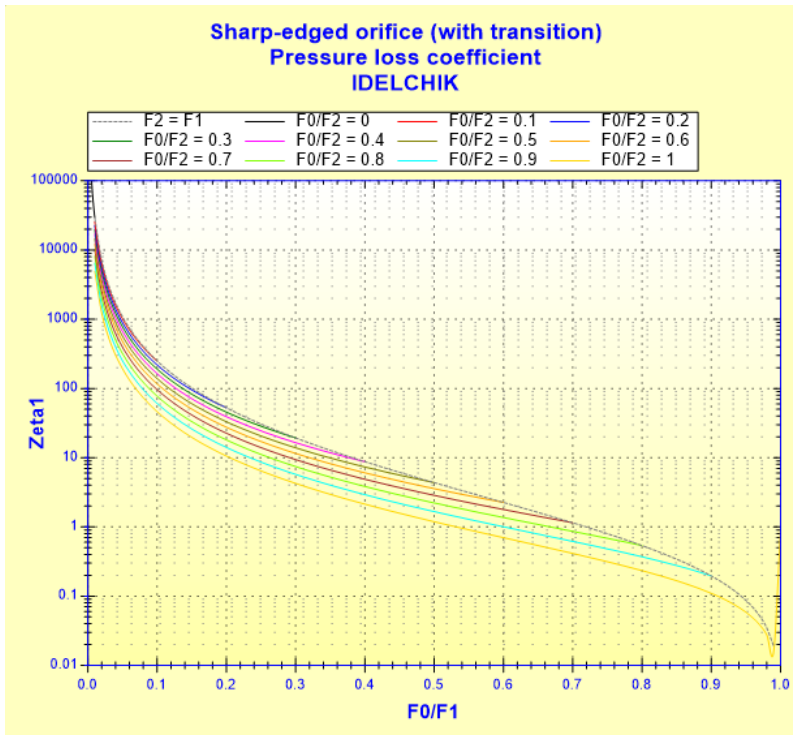
Mean velocity in major pipe (m/s):

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

Mean velocity in minor pipe (m/s):

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

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



■ $Re_0 < 10^5$

Quadratic local resistance coefficient:

$$\zeta_{quad} = \left[0.707 \cdot \left(1 - \frac{F_0}{F_1} \right)^{0.375} + \left(1 - \frac{F_0}{F_2} \right) \right]^2$$

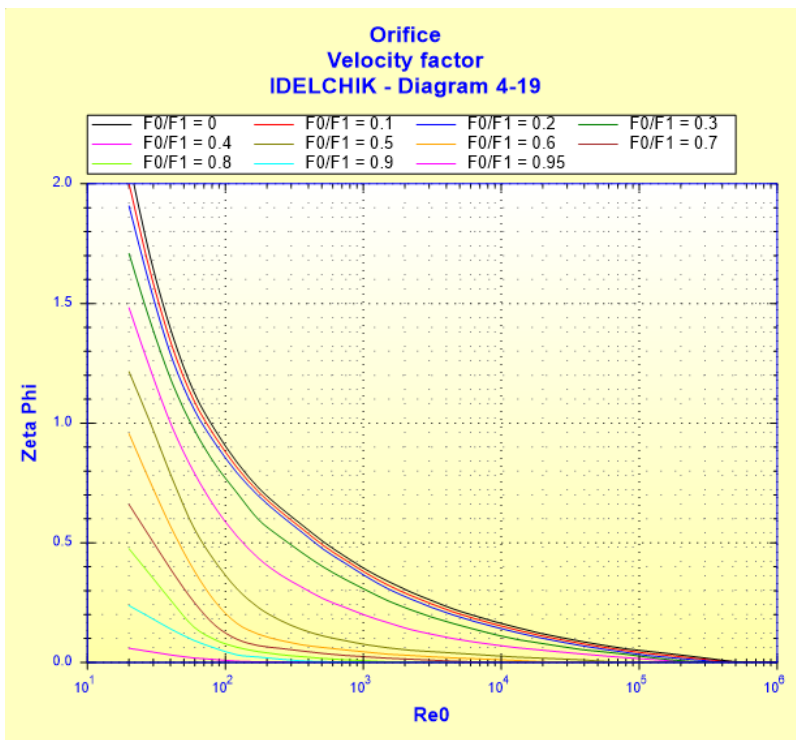
([1] diagram 4.11)

$$\zeta_{1quad} = \zeta_{quad} \cdot \left(\frac{F_1}{F_0} \right)^2$$

Velocity factor:

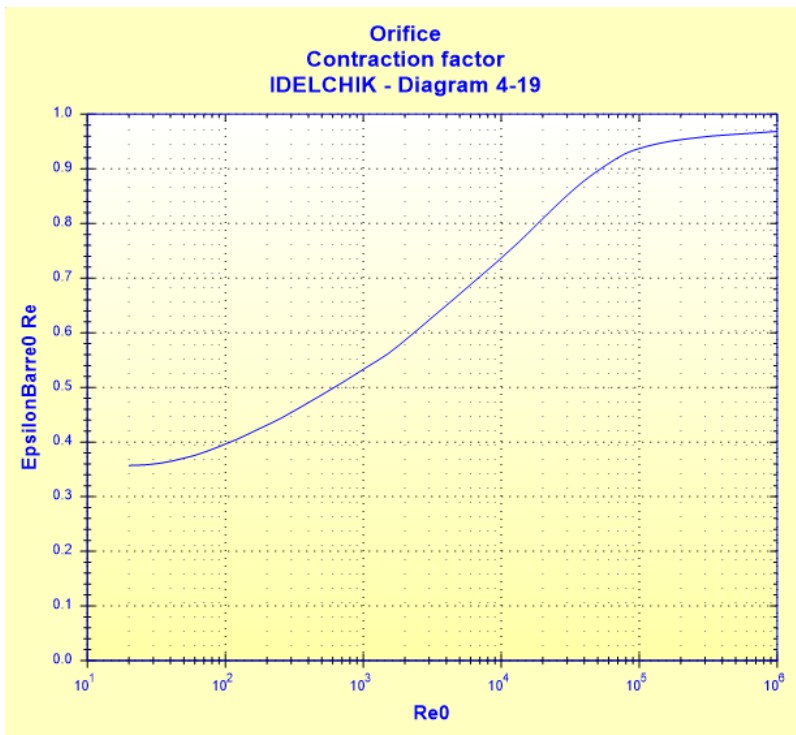
$$\zeta_\varphi = f \left(Re_0, \frac{F_0}{F_1} \right)$$

([1] diagram 4-19)



Contraction factor:

$$\bar{\varepsilon}_{0Re} = f(Re_0) \quad ([1] \text{ diagram 4-19})$$



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

- $30 < Re_0 < 10^5$

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

- $10 < Re_0 \leq 30$

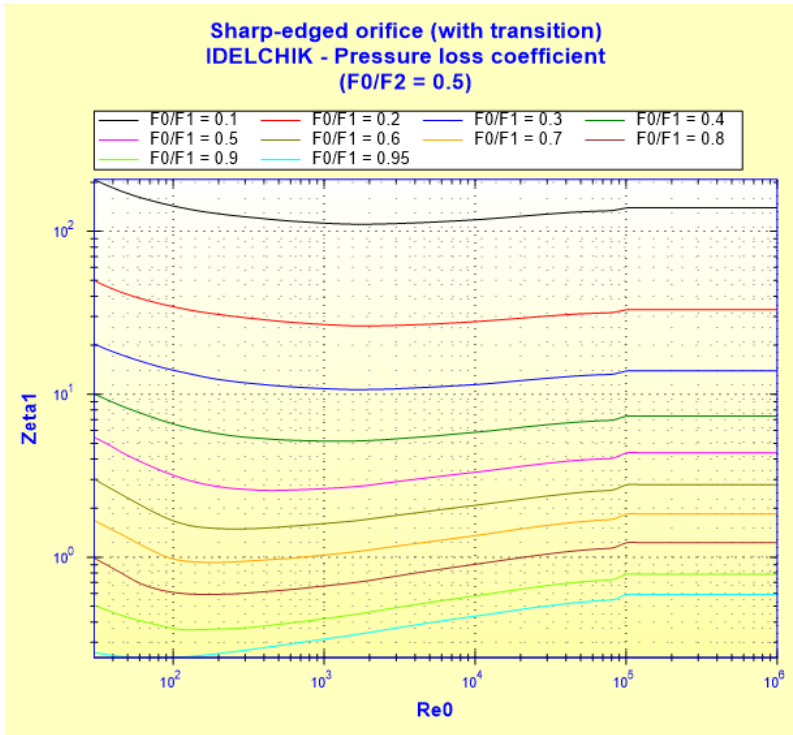
$$\zeta_1 = \frac{33}{Re_0} \cdot \left(\frac{F_1}{F_0} \right)^2 + \bar{\varepsilon}_0 Re \cdot \zeta_{1quad}$$

([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)



(with $F_0/F_2 = 0.5$)

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 Major pipe internal diameter (m)
- D_2 Minor pipe internal diameter (m)
- D_0 Orifice diameter (m)
- F_1 Major pipe cross-sectional area (m²)
- F_2 Minor pipe cross-sectional area (m²)
- F_0 Orifice cross-sectional area (m²)
- Q Volume flow rate (m³/s)

G	Mass flow rate (kg/s)
w_1	Mean velocity in major pipe (m/s)
w_2	Mean velocity in minor pipe (m/s)
w_0	Mean velocity in orifice (m/s)
Re_1	Reynolds number in major pipe ()
Re_2	Reynolds number in minor pipe ()
Re_0	Reynolds number in orifice ()
ζ	Local resistance coefficient (based on the orifice velocity) ()
ζ_{quad}	Quadratic local resistance coefficient (based on the orifice velocity) ()
ζ_{1quad}	Quadratic local resistance coefficient (based on the major pipe velocity) ()
ζ_{φ}	Velocity factor ()
$\frac{\zeta_{\varphi}}{\varepsilon_0 Re}$	Contraction factor ()
ζ_1	Pressure loss coefficient (based on the major 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

Example of application:

HydrauCalc 2020b - [Sharp-edged orifice (with transition) - IDELCHIK (3rd Ed.)]

File Edit Preferences Calculation method Database Tools Help

Fluid characteristics
 Fluid : Water @ 1 atm [HC]
 Ref.: IAPWS IF97
 Temperature : T 20 °C
 Pressure : P 1.013 bar
 Density : ρ 998.2061 kg/m³
 Dynamic Viscosity : μ 0.00100159 N.s/m²
 Kinematic Viscosity : ν 1.00340E-06 m²/s
 Density Dyn. Visc. Kin. Visc.

Geometrical characteristics
 Help Info Orifice plot Calculate

Pressure loss ΔP 0.1283838 bar
 ΔH 1.3115 m of fluid

Complementary results

Designation	Symbol	Value	Unit
Hydraulic diameter	Dh	0.035	m
Cross-sections area ratio	F0/F1	0.2478708	
Cross-sections area ratio	F0/F2	0.6594495	
Pipe Reynolds number	Re1	90251	
Pipe Reynolds number	Re2	147207.5	
Orifice Reynolds number	Re0	181275.6	
Pressure loss coefficient (Diagram 4-11)	ζ	0.9524276	
Pressure loss coefficient (based on the mean pipe velocity)	ζ_i	15.50176	
Hydraulic power loss	Wh	64.19189	W

Density (kg/m³) vs Temperature (°C) graph showing a decreasing trend from 1000 kg/m³ at 0°C to approximately 950 kg/m³ at 100°C.

Divers HC

References:

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