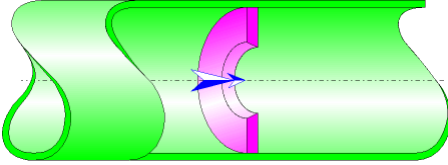




## Bevelled-Edged Orifice Circular Cross-Section (IDELCHIK)



### 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:

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Hydraulic diameter (m):

$$D_h = D_0$$

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Pipe cross-section area (m<sup>2</sup>):

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

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Orifice cross-section area (m<sup>2</sup>):

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

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Mean velocity in pipe (m/s):

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

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Mean velocity in orifice (m/s):

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

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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:

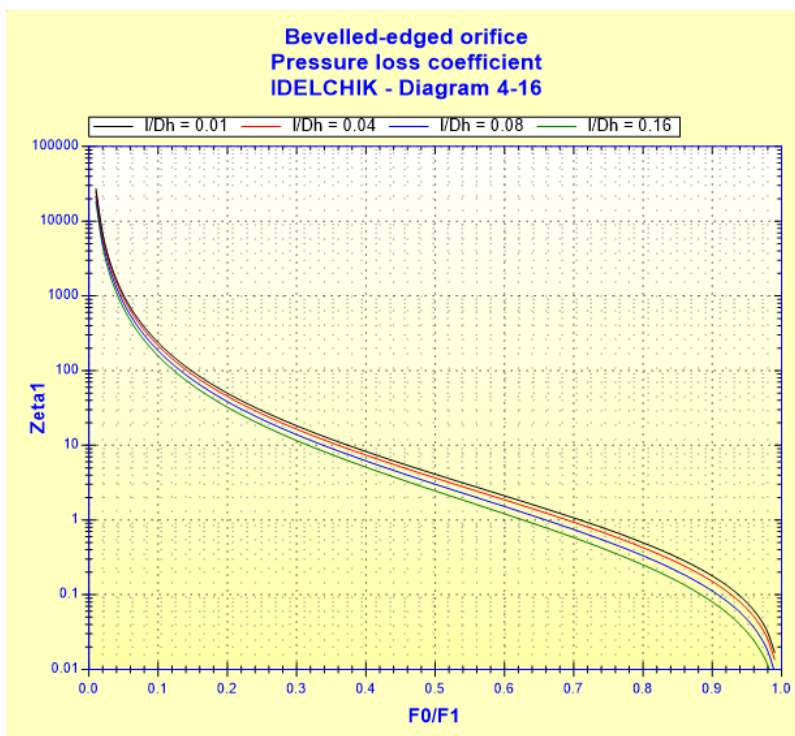
$$\text{Re}_0 = \frac{w_0 \cdot D_0}{\nu}$$

Local resistance coefficient:

■  $\text{Re}_0 \geq 10^5$

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

([1] diagram 4-16)

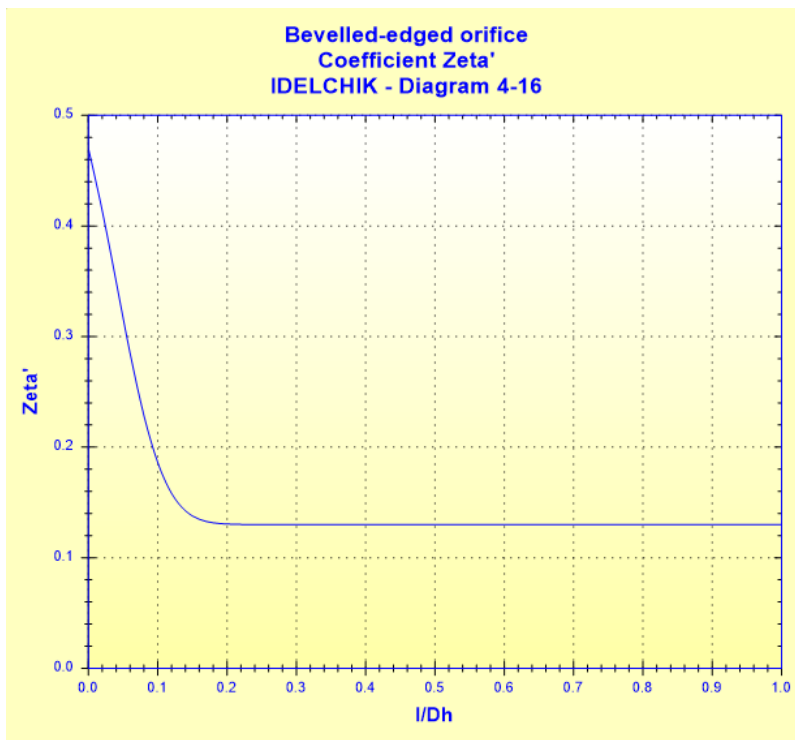


with :

Coefficient of effect of the orifice thickness:

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

([1] diagram 4-16)



■  $Re_0 \leq 10^5$

Quadratic local resistance coefficient:

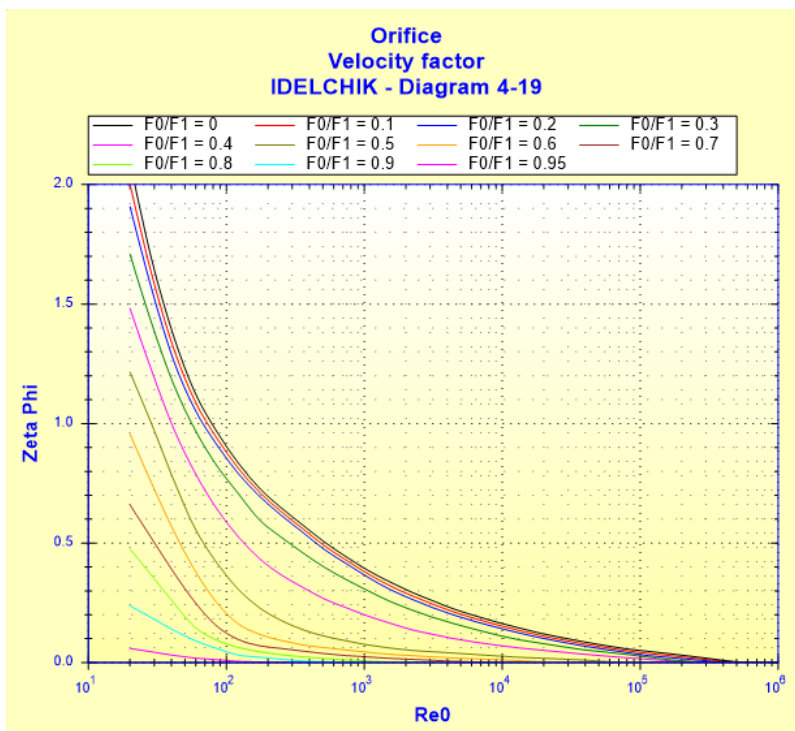
$$\zeta_{1quad} = \left[ 1 - \frac{F_0}{F_1} + \sqrt{\zeta'} \cdot \left( 1 - \frac{F_0}{F_1} \right)^{0.375} \right]^2 \cdot \left( \frac{F_1}{F_0} \right)^2$$

([1] diagram 4-16)

Velocity factor:

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

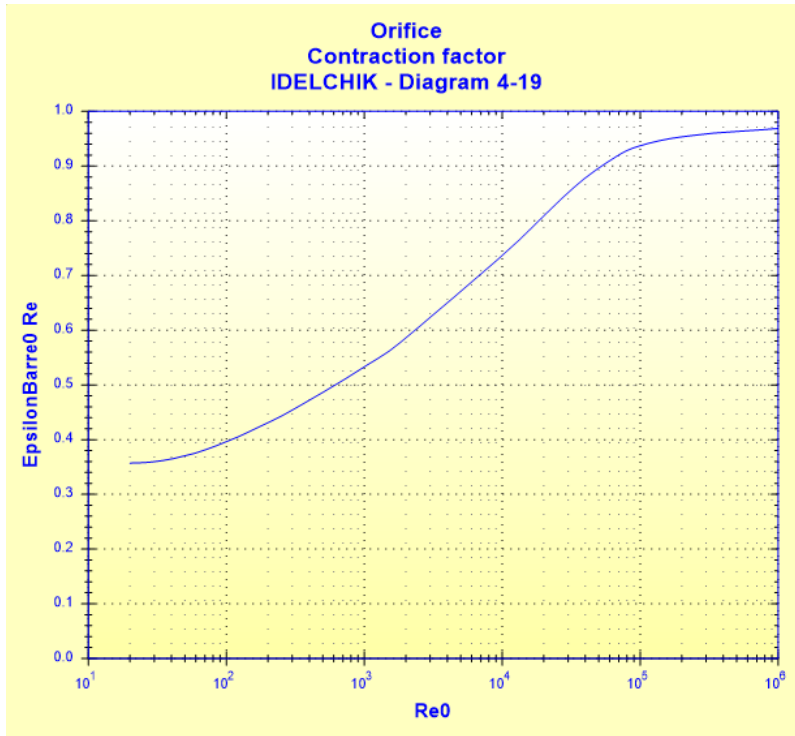
([1] diagram 4-19)



Contraction factor:

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

([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)

- $10 < Re_0 \leq 30$

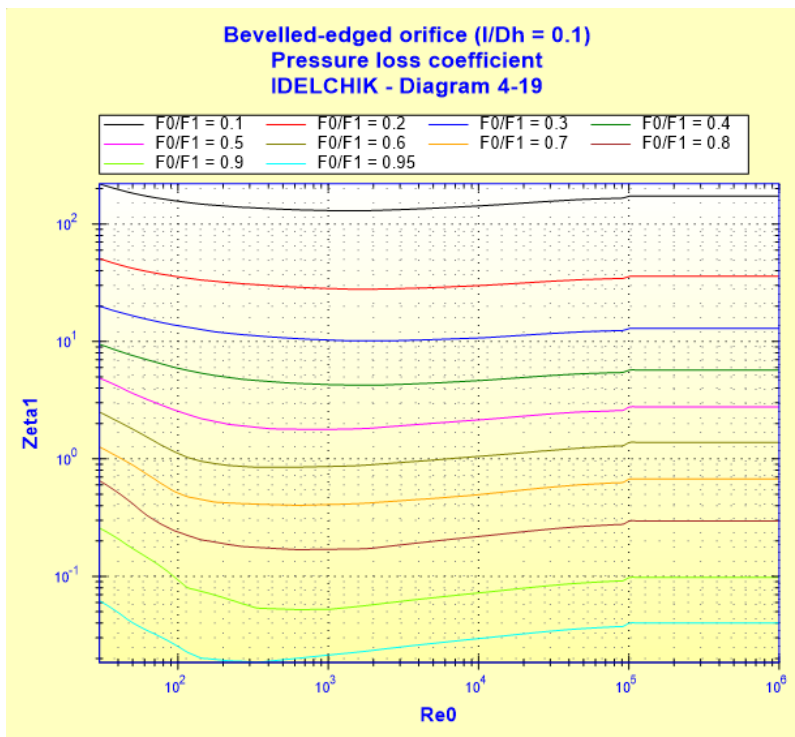
$$\zeta_1 = \frac{33}{Re_0} \cdot \left(\frac{F_1}{F_0}\right)^2 + \bar{\varepsilon}_{0Re} \cdot \zeta_{1quad}$$

([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

$l/D_h = 0.1$ )

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):

$$W_h = \Delta P \cdot Q$$

**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 <sup>2</sup> )
$F_0$	Orifice cross-sectional area (m <sup>2</sup> )
$Q$	Volume flow rate (m <sup>3</sup> /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 ( )
$\zeta'$	Coefficient of effect of the orifice thickness ( )
$\zeta_{1quad}$	Quadratic local resistance coefficient determined as $Re = 10^5$ ( )
$\zeta_{\varphi}$	Velocity factor ( )
$\varepsilon_{0Re}$	Contraction factor ( )
$\zeta_1$	Local resistance coefficient ( )
$\zeta$	Pressure loss coefficient (based on the mean pipe velocity) ( )
$\Delta P$	Total pressure loss (Pa)
$\Delta H$	Total head loss of fluid (m)
$Wh$	Hydraulic power loss (W)
$\rho$	Fluid density ( $kg/m^3$ )
$\nu$	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  $40^\circ$  and  $60^\circ$

### Example of application:

The screenshot shows the HydraulCalc 2020a software interface for a bevelled-edged orifice calculation. The fluid is Water @ 1 atm [HC] with a temperature of 20 °C and a pressure of 1.013 bar. The flow rate is 0.005 m³/s, resulting in a mean velocity of 5.197 m/s (turbulent) and a velocity at the orifice of 1.288 m/s (turbulent). The orifice has a thickness of 0.007 m and a hydraulic diameter of 0.035 m. The total pressure loss is 0.1562782 bar, and the total head loss is 1.5965 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:**

- Flow rate (G): 4.9910 kg/s
- Flow rate (Q): 0.005 m³/s
- Velocity (w0): 5.197 m/s (Turbulent)
- Velocity (w1): 1.288 m/s (Turbulent)
- Orifice thickness (l): 0.007 m
- Hydraulic diameter (D0): 0.035 m
- Pipe diameter (D1): 0.0703 m

**Pressure loss:**

- $\Delta P$ : 0.1562782 bar
- $\Delta H$ : 1.5965 m of fluid

**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
Thickness to orifice diameter ratio	l/Dh	0.2	
Diameters ratio	D0/D1	0.4978663	
Cross-sections area ratio	F0/F1	0.2478708	
Pipe Reynolds number	Re1	90251	
Orifice Reynolds number	Re0	181275.6	
Coefficient of effect of the thickness (Diagram 4-16)	$\zeta'$	0.1304674	
Pressure loss coefficient (Diagram 4-16)	$\zeta_1$	18.86989	
Pressure loss coefficient (based on the mean pipe velocity)	$\zeta$	18.86989	
Hydraulic power loss	Wh	78.13911	W

### References:

