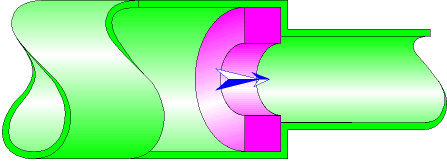




Thick-Edged Orifice (with Transition) Circular Cross-Section (IDELCHIK)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a thick-edged orifice installed in a straight pipe with transition. Moreover, the head loss due to friction of the fluid on the inner walls of the orifice is also taken into account in this component and is calculated with Darcy's formula.

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):

$$w_2 = \frac{Q}{F_2}$$

Mean velocity in orifice (m/s):

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

Mass flow rate (kg/s):

$$G = Q \cdot \rho$$

Reynolds number in major pipe:

$$Re_1 = \frac{w_1 \cdot D_1}{\nu}$$

Reynolds number in minor pipe:

$$Re_2 = \frac{w_2 \cdot D_2}{\nu}$$

Reynolds number in orifice:

$$Re_0 = \frac{w_0 \cdot D_0}{\nu}$$

Relative roughness in orifice walls:

$$\bar{\Delta} = \frac{\Delta}{D_0}$$

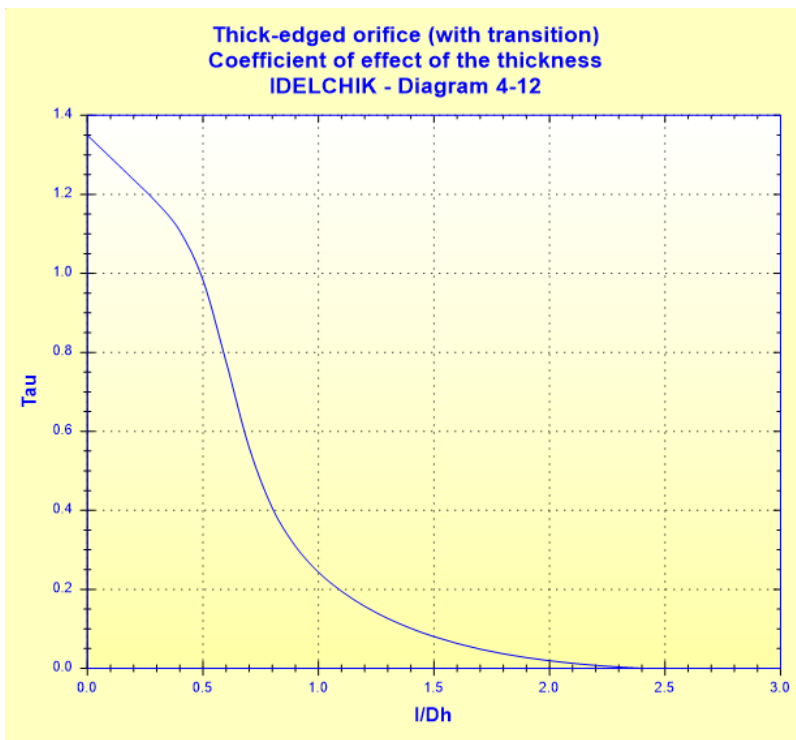
Coefficient of effect of the orifice thickness:

$$\tau = \left(2.4 - \frac{l}{D_h} \right) \cdot 10^{-\varphi \left(\frac{l}{D_h} \right)}$$

([1] diagram 4-12)

with:

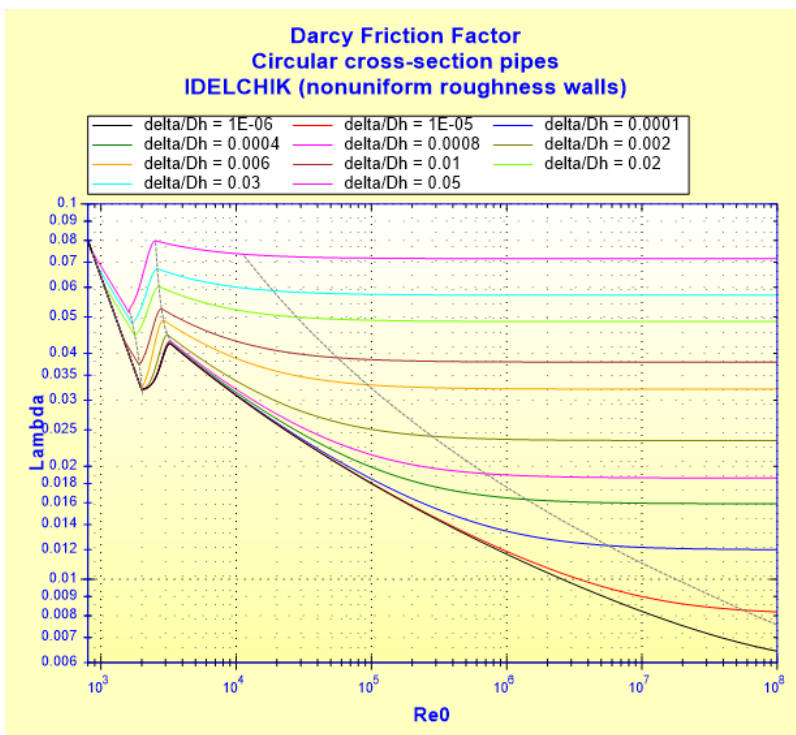
$$\varphi \left(\frac{l}{D_h} \right) = \frac{0.25 + 0.535 \cdot \left(\frac{l}{D_h} \right)^8}{0.05 + \left(\frac{l}{D_h} \right)^7}$$



Darcy friction factor:

$$\lambda = f\left(\text{Re}_0, \frac{\Delta}{D_h}\right)$$

See [Straight Pipe - Circular Cross-Section and Nonuniform Roughness Walls \(IDELCHIK\)](#)

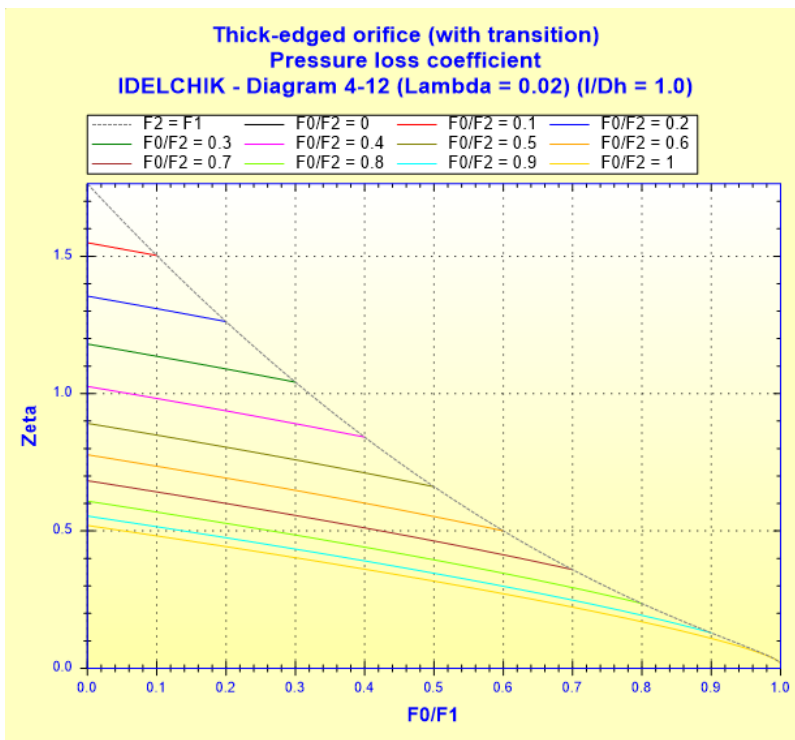


■ $\text{Re}_0 \geq 10^5$

Local resistance coefficient:

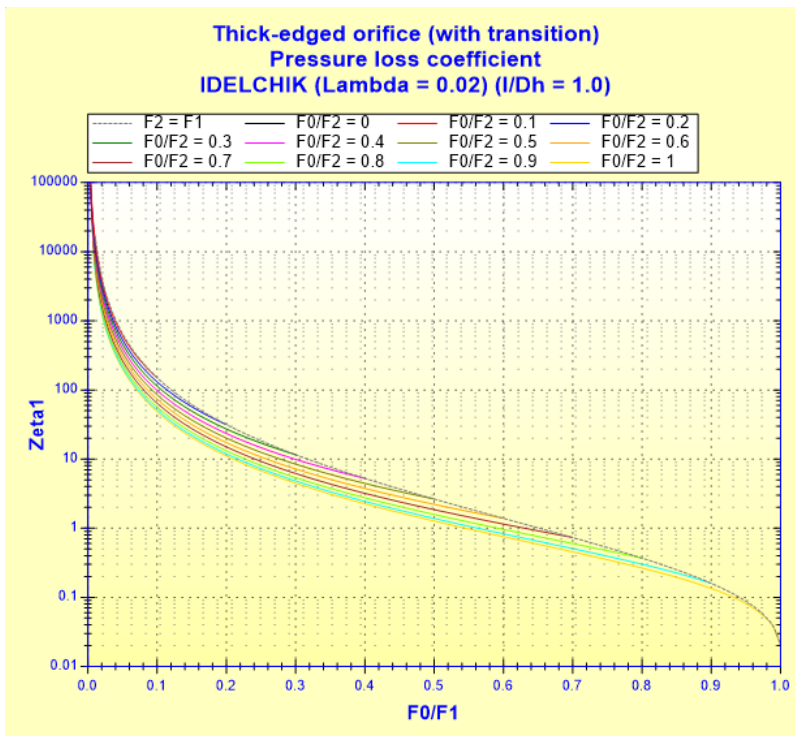
$$\zeta = \left[0.5 \cdot \left(1 - \frac{F_0}{F_1}\right)^{0.75} + \left(1 - \frac{F_0}{F_2}\right)^2 + \tau \cdot \left(1 - \frac{F_0}{F_1}\right)^{0.375} \cdot \left(1 - \frac{F_0}{F_2}\right) + \lambda \cdot \frac{l}{D_h} \right]$$

([1] diagram 4-12)



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:

$$\zeta_{quad} = \left[0.5 \cdot \left(1 - \frac{F_0}{F_1} \right)^{0.75} + \left(1 - \frac{F_0}{F_2} \right)^2 + \tau \cdot \left(1 - \frac{F_0}{F_1} \right)^{0.375} \cdot \left(1 - \frac{F_0}{F_2} \right) + \lambda \cdot \frac{l}{D_h} \right]$$

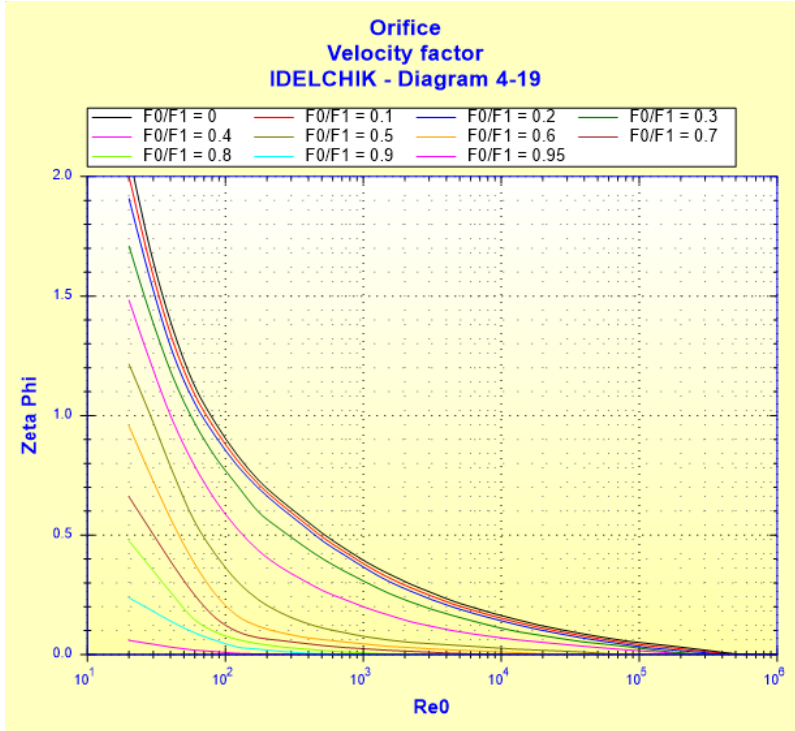
([1] diagram 4-

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

Velocity factor:

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

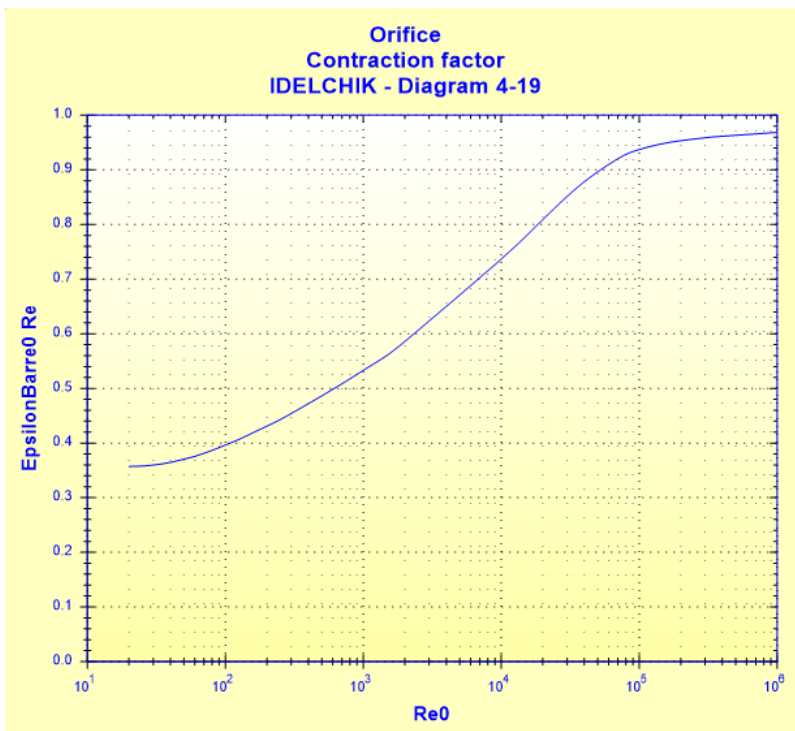
([1] diagram 4-19)



Contraction factor:

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

([1] diagram 4-19)



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

- $30 < Re_0 < 10^5$

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

([1] diagram 4-19)

- $10 < Re_0 \leq 30$

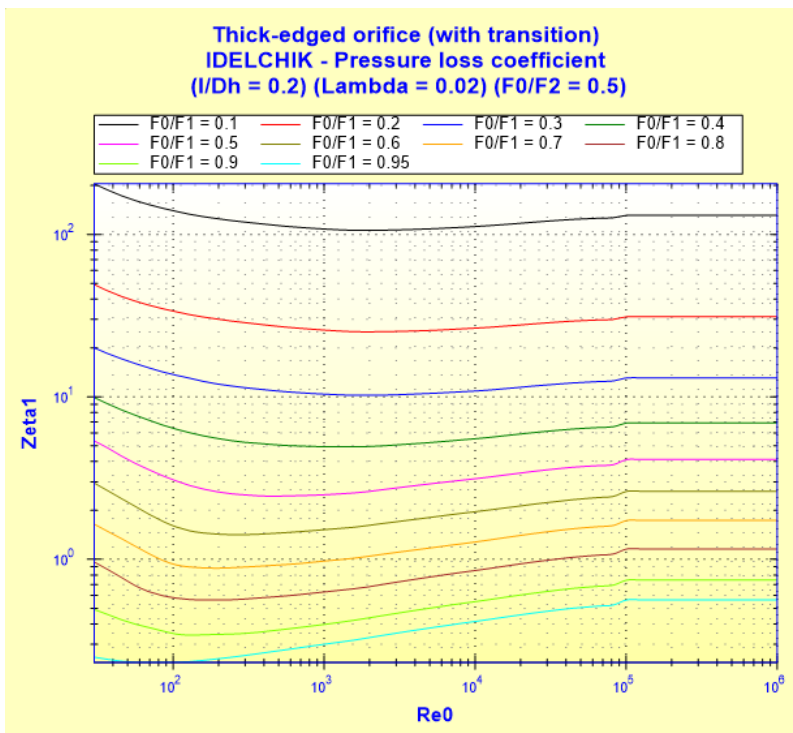
$$\zeta_1 = \frac{33}{Re_0} \cdot \left(\frac{F_1}{F_0}\right)^2 + \bar{\varepsilon}_0 Re \cdot \zeta_{1quad}$$

([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 $l/D_h = 0.2$, $\lambda = 0.02$ and

$F_0/F_2 = 0.5$)

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 (m ²)
F_2	Minor 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 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 ()
Δ	Absolute roughness of orifice walls (m)
$\bar{\Delta}$	Relative roughness of orifice walls ()
l	Orifice thickness (m)
τ	Coefficient of effect of the orifice thickness ()
λ	Darcy friction coefficient 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_{cp}	Velocity factor ()
ε_{0Re}	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
- thickness to orifice diameter ratio (l/D_0) greater than 0.015

Example of application:

HydrauCalc 2020b - [Thick-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 0.1215824 bar
 ΔH 1.2420 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	
Thickness to orifice diameter ratio	l/D0	0.2	
Relative roughness	Δ	0.0002857143	
Pipe Reynolds number	Re1	90251	
Pipe Reynolds number	Re2	147207.5	
Orifice Reynolds number	Re0	181275.6	
<input checked="" type="checkbox"/> Darcy Friction Factor	λ	0.01784769	
<input checked="" type="checkbox"/> Coefficient of effect of the thickness (Diagram 4-12)	τ	1.237073	
<input checked="" type="checkbox"/> Pressure loss coefficient (Diagram 4-12)	ζ	0.9019707	
<input checked="" type="checkbox"/> Pressure loss coefficient (based on the mean pipe velocity)	ζ_1	14.68052	
Hydraulic power loss	Wh	60.79119	W

References:

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