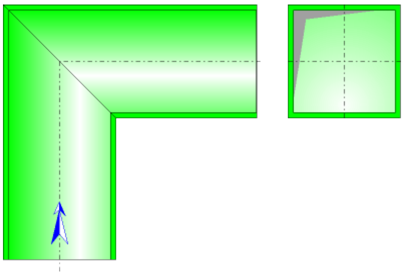
Miter Bend
Rectangular Cross-Section
(IDELCHIK)



Model description:

This model of component calculates the head loss (pressure drop) of a miter bend whose cross-section is rectangular and constant. In addition, the flow is assumed fully developed and stabilized à the entrance bend.

Model formulation:

Hydraulic diameter (m):

$$D_h = \frac{2 \cdot a_0 \cdot b_0}{a_0 + b_0}$$

([1] diagram 6-7)

Cross-section area (m^2):

$$F_0 = a_0 \cdot b_0$$

Mean velocity (m/s):

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

Mass flow rate (kg/s):

$$G = Q \cdot \rho$$

Reynolds number:

$$Re = \frac{w_0 \cdot D_h}{\nu}$$

Relative roughness:

$$\overline{\Delta} = \frac{\Delta}{D_h}$$

Coefficient of effect of the roughness:

$$k_{\Delta} = f\left(\text{Re}, \bar{\Delta}\right)$$

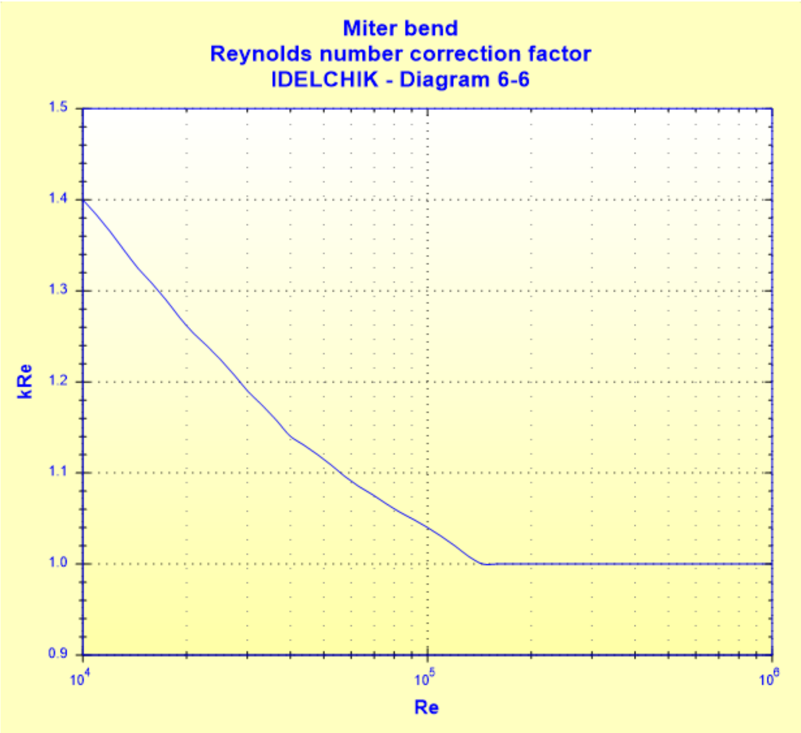
([1] diagram 6-6)

$\bar{\Delta}$	Re	
	$3 \cdot 10^3$ - $4 \cdot 10^4$	> $4 \cdot 10^4$
0	1.0	1.0
0 - 0.001	1.0	$1 + 0.5 \cdot 10^3 \cdot \bar{\Delta}$
> 0.001	1.0	1.5

Coefficient of effect of the Reynolds number (Re ≥ 10^4):

$$k_{\text{Re}} = f\left(\text{Re}\right)$$

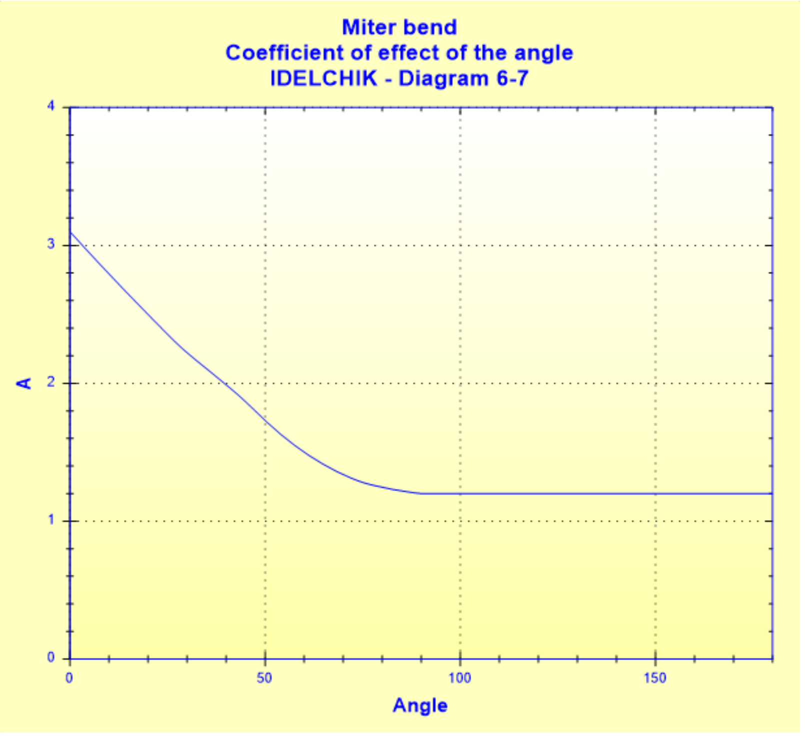
([1] diagram 6-6)



Coefficient of effect of the angle:

$$A = f\left(\delta\right)$$

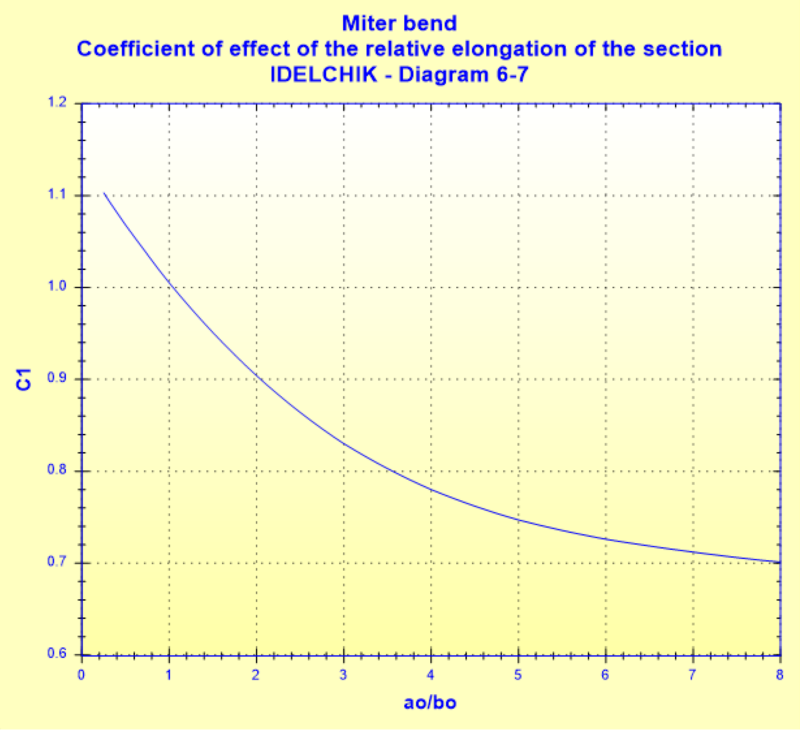
([1] diagram 6-7)



Coefficient of effect of the relative elongation of the cross section:

$$C_1 = f\left(\frac{a_0}{b_0}\right)$$

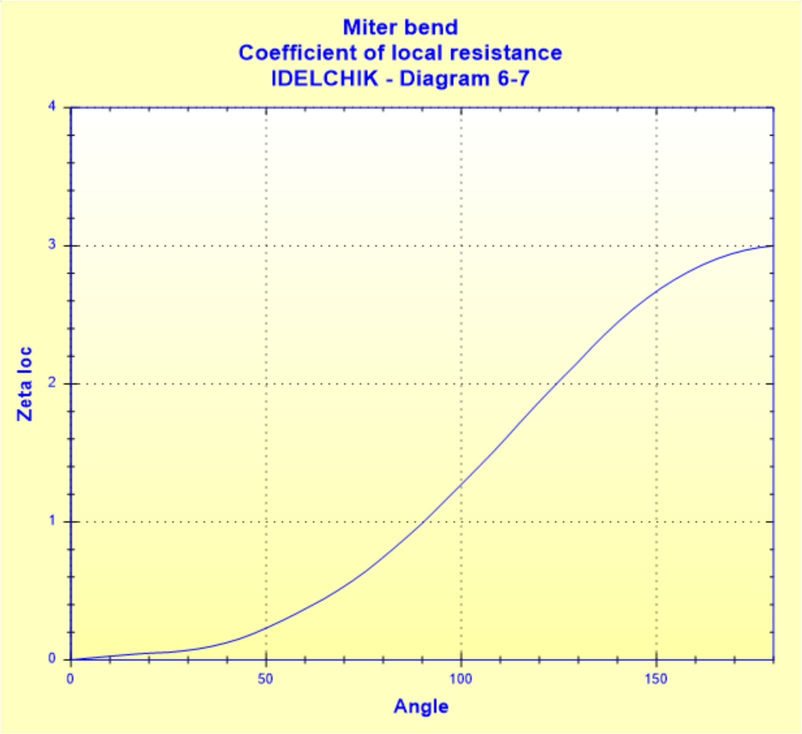
([1] diagram 6-7)



Coefficient of local resistance:

$$\zeta_{loc} = f(\delta)$$

([1] diagram 6-7)



Total pressure loss coefficient (based on the mean velocity in the bend):

$$\zeta = k_{\Delta} \cdot k_{\mathrm{Re}} \cdot C_1 \cdot A \cdot \zeta_{loc}$$

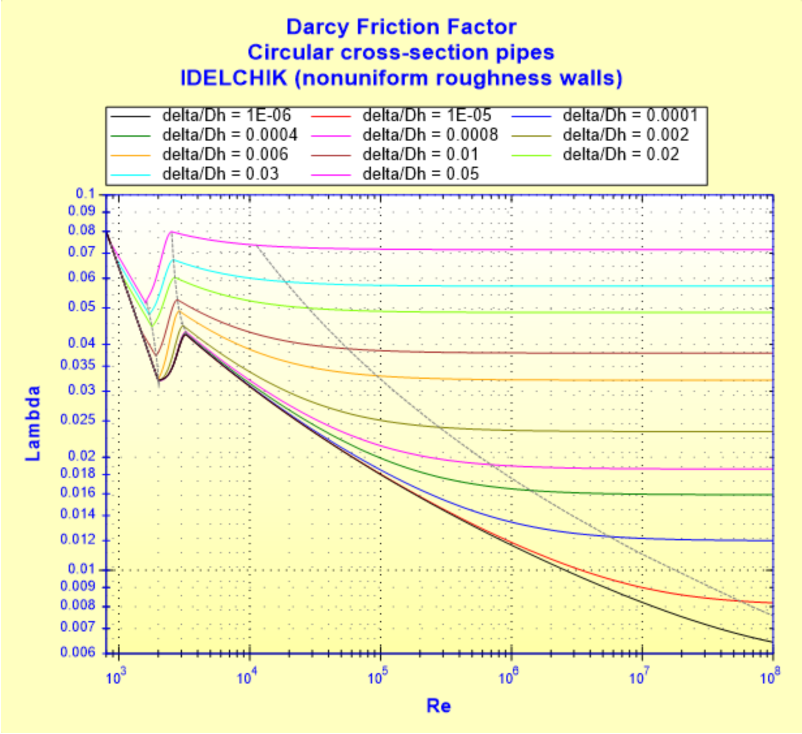
([1] diagram 6-7)

Darcy friction factor:

See Straight Pipe - Rectangular Cross-Section and Nonuniform Roughness Walls (IDELCHIK)

- Darcy friction factor for circular cross-section

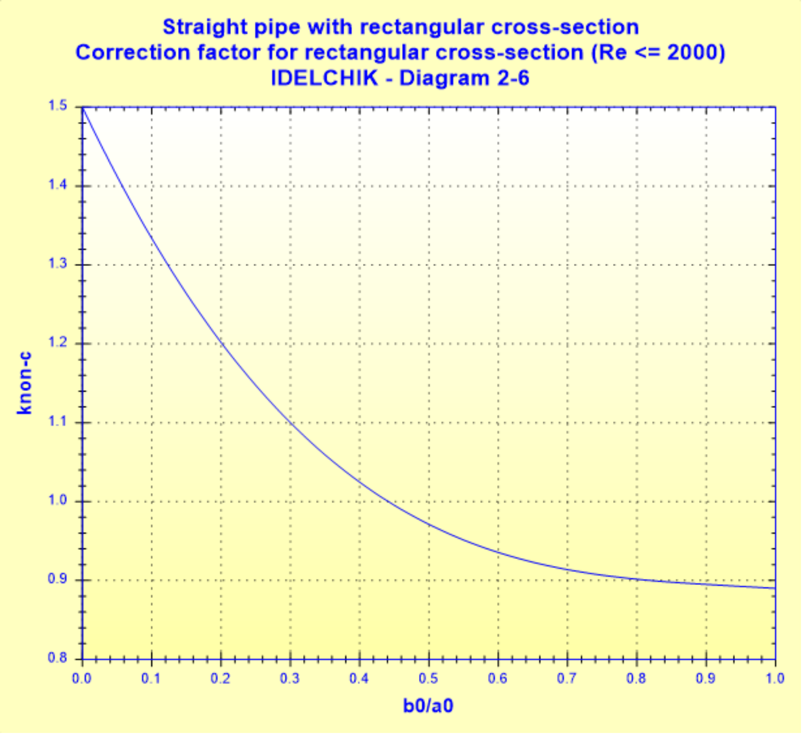
$$\lambda_{circ} = f\left(\mathrm{Re}, \frac{\Delta}{D_h}\right)$$



- Correction for Darcy friction factor for noncircular cross-section

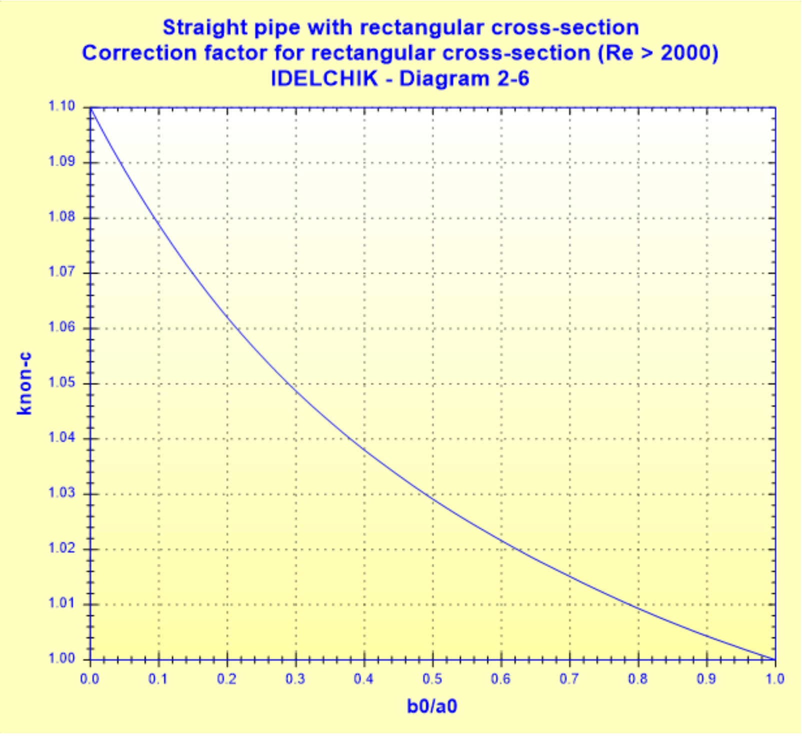
- laminar flow (Re ≤ 2000):

$$k_{non-c} = f(b_0/a_0)$$ ([1] diagram 2.6)



- turbulent flow (Re > 2000):

$$k_{non-c} = f(b_0/a_0)$$ ([1] diagram 2.6)



- Darcy friction factor for rectangular cross-section

$$\lambda_{rect} = \lambda_{circ} \cdot k_{non-c}$$ ([1] diagram 2.6)

Straight length of equivalent pressure loss (m):

$$L_{eq} = \zeta \cdot \frac{D_h}{\lambda_{rect}}$$

Total pressure loss (Pa):

$$\Delta P = \zeta \cdot \frac{\rho \cdot w_0^2}{2}$$

([1] diagram 6-7)

Total head loss of fluid (m):

$$\Delta H = \zeta \cdot \frac{w_0^2}{2 \cdot g}$$

Hydraulic power loss (W):

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

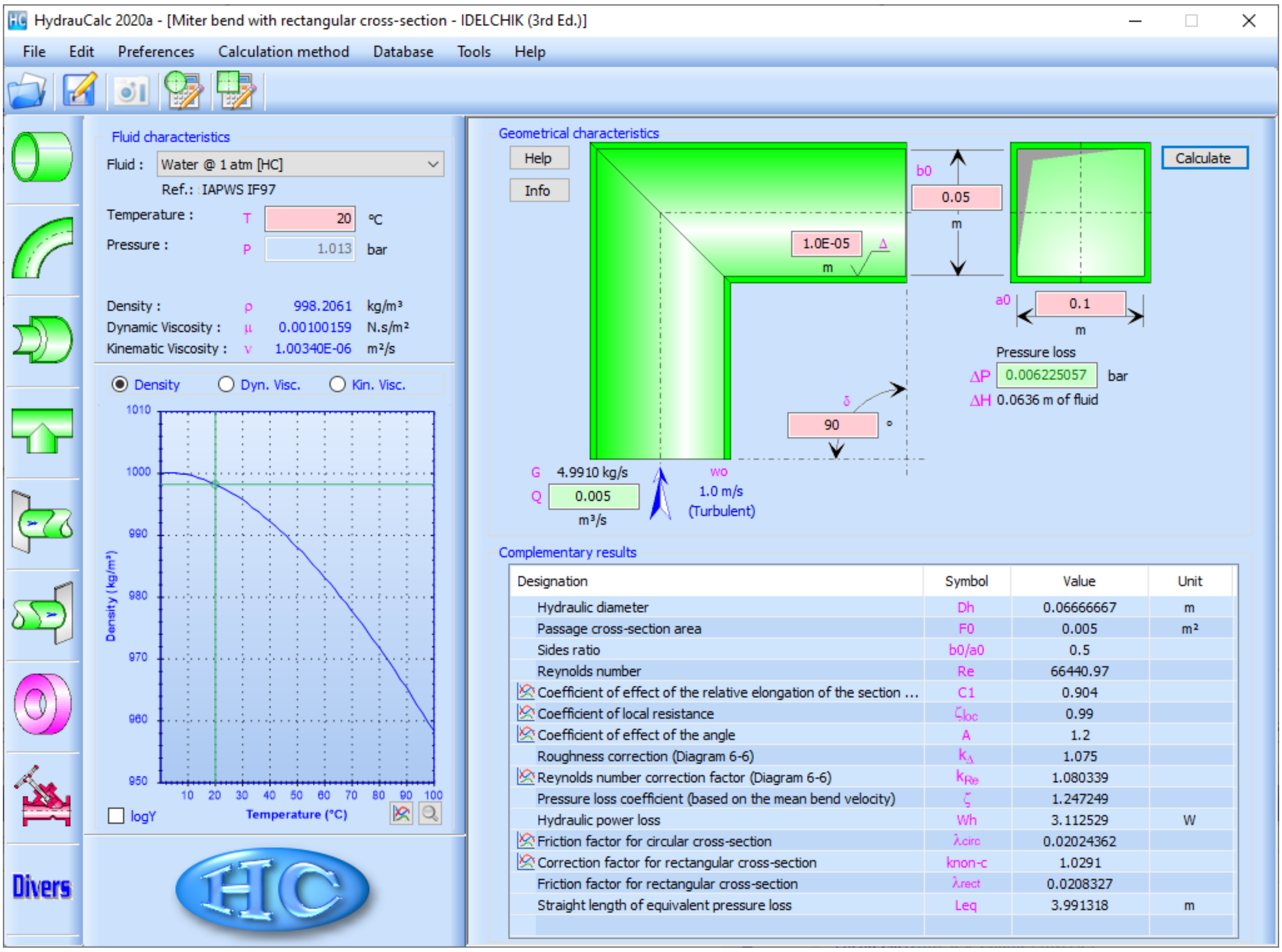
Symbols, Definitions, SI Units:

a_0	Rectangular cross-section width (m)
b_0	Rectangular cross-section height (m)
D_h	Bend hydraulic diameter (m)
F_0	Cross-sectional area (m²)
Q	Volume flow rate (m³/s)
w_0	Mean velocity (m/s)
G	Mass flow rate (kg/s)
Re	Reynolds number ()
Δ	Absolute roughness of walls (m)
$\overline{\Delta}$	Relative roughness of walls ()
k_Δ	Coefficient that allows for the effect of the roughness
k_{Re}	Coefficient that allows for the effect of the Reynolds number
δ	Angle of the bend (°)
A	Coefficient that allows for the effect of the angle
C_1	Coefficient that allows for the effect of the relative elongation of the cross section
ζ_{loc}	Coefficient of local resistance ()
ζ	Total pressure loss coefficient (based on the mean velocity in the bend) ()
λ_{circ}	Darcy friction coefficient for circular cross-section ()
λ_{rect}	Darcy friction coefficient for rectangular cross-section ()
k_{non-c}	Correction for Darcy friction factor for noncircular cross-section ()
L_{eq}	Straight length of equivalent pressure loss (m)
ΔP	Total pressure loss (Pa)
ΔH	Total head loss of fluid (m)
Wh	Hydraulic power loss (W)
ρ	Fluid density (kg/m³)
ν	Fluid kinematic viscosity (m²/s)
g	Gravitational acceleration (m/s²)

Validity range:

- stabilized flow upstream bend
- length of the straight section downstream: ≥ 10 D_h
- curvature angle: 0 to 180°
- flow regime: Re ≥ 10^4

Example of application:



References:

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