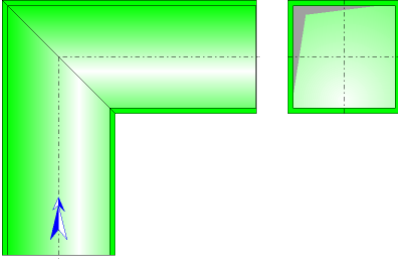




Miter Bend Rectangular Cross-Section (IDELCHIK)



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 at the entrance bend.

Model formulation:

Hydraulic diameter (m):

$$D_h = \frac{2 \cdot a_0 \cdot b_0}{a_0 + b_0} \quad ([1] \text{ diagram 6-7})$$

Cross-section area (m²):

$$F_0 = a_0 \cdot b_0$$

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:

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

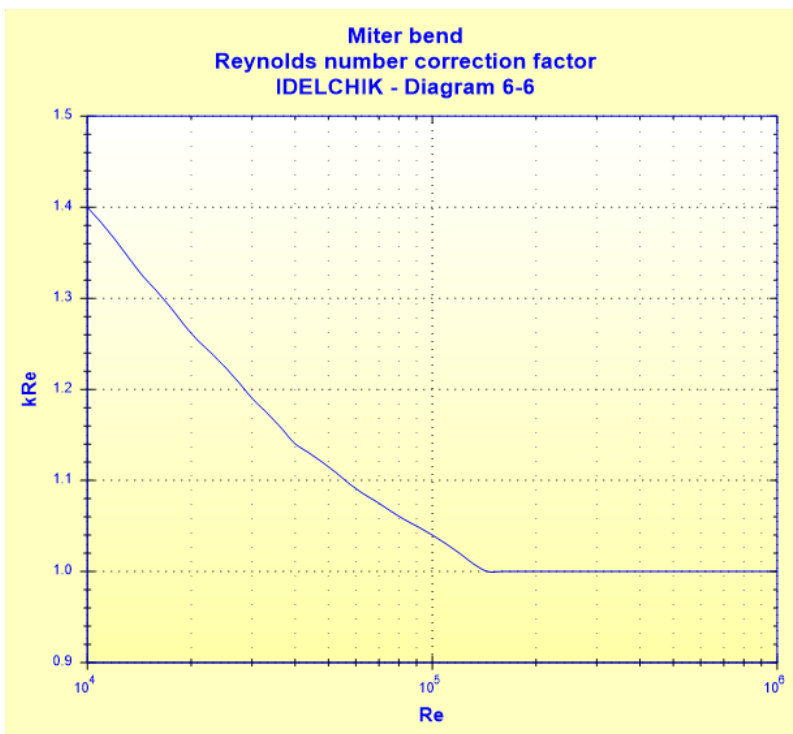
Coefficient of effect of the roughness:

$$k_{\Delta} = f(\text{Re}, \bar{\Delta}) \quad ([1] \text{ diagram 6-6})$$

| $\bar{\Delta}$ | 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 |

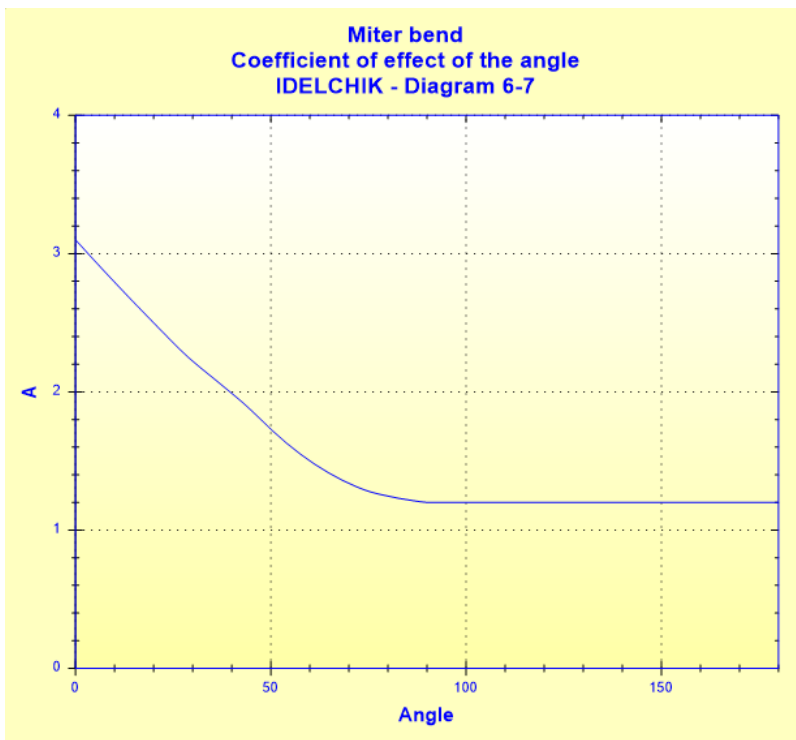
Coefficient of effect of the Reynolds number ($\text{Re} \geq 10^4$):

$$k_{\text{Re}} = f(\text{Re}) \quad ([1] \text{ diagram 6-6})$$



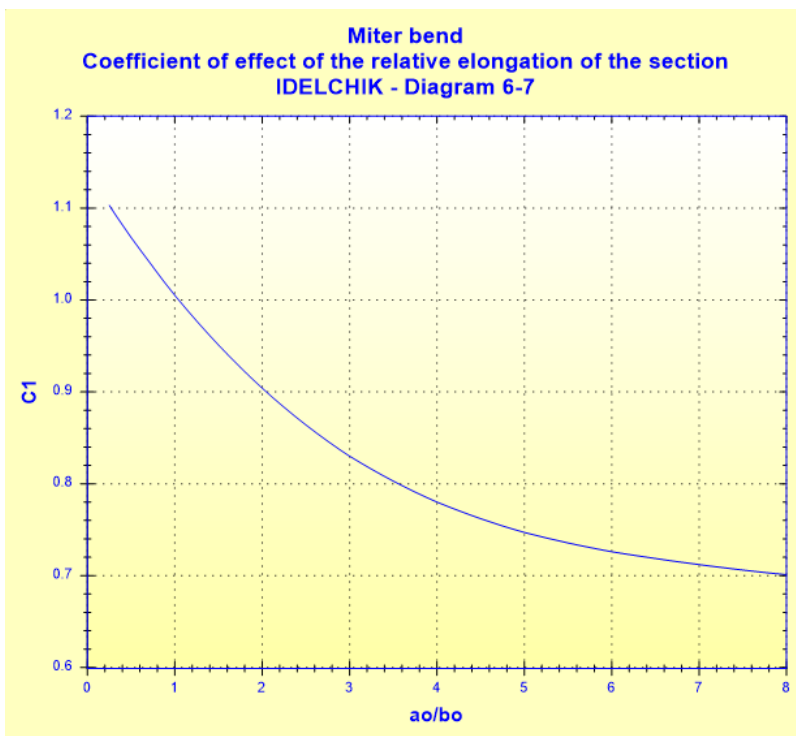
Coefficient of effect of the angle:

$$A = f(\delta) \quad ([1] \text{ diagram 6-7})$$



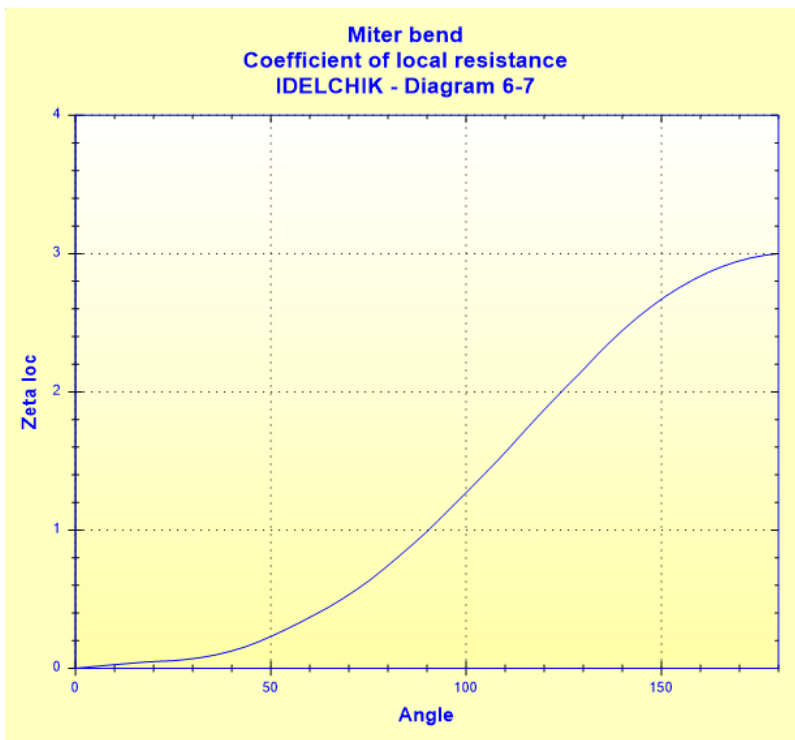
Coefficient of effect of the relative elongation of the cross section:

$$C_1 = f\left(\frac{a_0}{b_0}\right) \quad ([1] \text{ diagram 6-7})$$



Coefficient of local resistance:

$$\zeta_{loc} = f(\delta) \quad ([1] \text{ diagram 6-7})$$



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

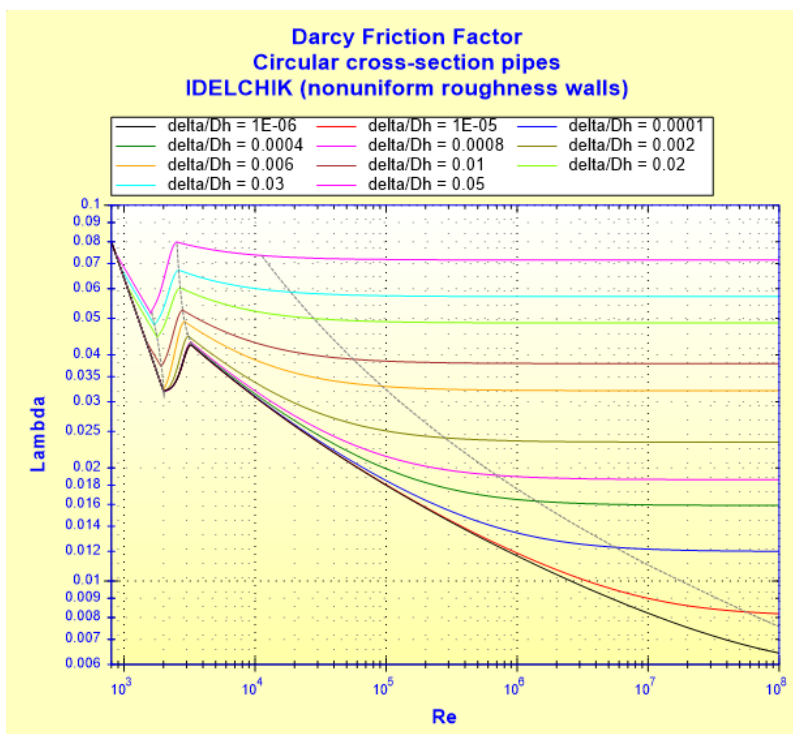
$$\zeta = k_{\Delta} \cdot k_{Re} \cdot C_1 \cdot A \cdot \zeta_{loc} \quad ([1] \text{ diagram 6-7})$$

Darcy friction factor:

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

- Darcy friction factor for circular cross-section

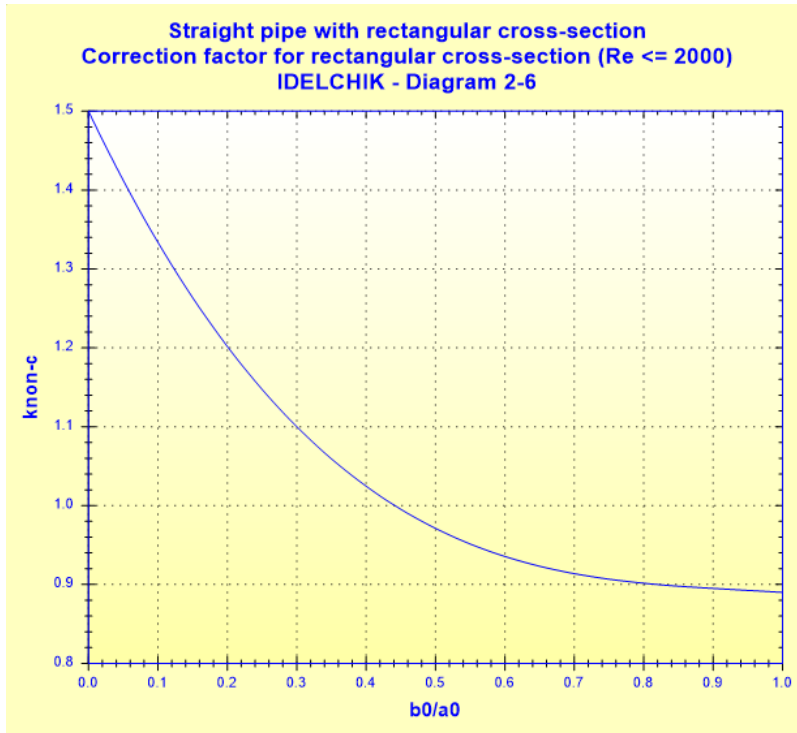
$$\lambda_{circ} = f\left(\text{Re}, \frac{\Delta}{D_h}\right)$$



- Correction for Darcy friction factor for noncircular cross-section

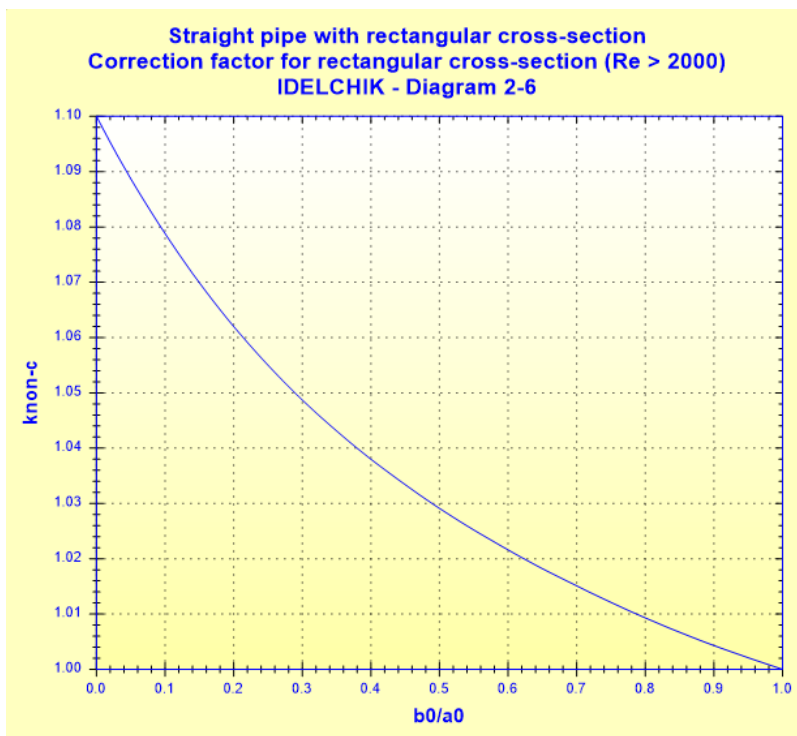
- laminar flow ($Re \leq 2000$):

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



- turbulent flow ($Re > 2000$):

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



- Darcy friction factor for rectangular cross-section

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

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 (m ²) |
| Q | Volume flow rate (m ³ /s) |
| w_0 | Mean velocity (m/s) |
| G | Mass flow rate (kg/s) |
| Re | Reynolds number () |
| Δ | Absolute roughness of walls (m) |
| $\bar{\Delta}$ | 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/m ³) |
| ν | Fluid kinematic viscosity (m ² /s) |
| g | Gravitational acceleration (m/s ²) |

Validity range:

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

Example of application:

The screenshot displays the HydraulCalc 2020a software interface for a miter bend with a rectangular cross-section. The interface is divided into several sections:

- Fluid characteristics:**
 - Fluid: Water @ 1 atm [HC]
 - Ref.: IAPWS IF97
 - 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
 - Graph: Density (kg/m³) vs Temperature (°C) showing a decreasing trend from 1000 at 10°C to approximately 950 at 100°C.
- Geometrical characteristics:**
 - Diagram of a 90° miter bend with dimensions: b₀ = 0.05 m, a₀ = 0.1 m.
 - Flow parameters: G = 4.9910 kg/s, Q = 0.005 m³/s, w₀ = 1.0 m/s (Turbulent).
 - Pressure loss: ΔP = 0.006225057 bar, ΔH = 0.0636 m of fluid.
- Complementary results:**

| Designation | Symbol | Value | Unit |
|---|--------------------------------|------------|----------------|
| Hydraulic diameter | D _h | 0.06666667 | m |
| Passage cross-section area | F ₀ | 0.005 | m ² |
| Sides ratio | b ₀ /a ₀ | 0.5 | |
| Reynolds number | Re | 66440.97 | |
| Coefficient of effect of the relative elongation of the section ... | C ₁ | 0.904 | |
| Coefficient of local resistance | ζ _{loc} | 0.99 | |
| Coefficient of effect of the angle | A | 1.2 | |
| Roughness correction (Diagram 6-6) | K _s | 1.075 | |
| Reynolds number correction factor (Diagram 6-6) | K _{Re} | 1.080339 | |
| Pressure loss coefficient (based on the mean bend velocity) | ζ | 1.247249 | |
| Hydraulic power loss | Wh | 3.112529 | W |
| Friction factor for circular cross-section | λ _{circ} | 0.02024362 | |
| Correction factor for rectangular cross-section | k _{non-c} | 1.0291 | |
| Friction factor for rectangular cross-section | λ _{rect} | 0.0208327 | |
| Straight length of equivalent pressure loss | Leq | 3.991318 | m |

References:

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