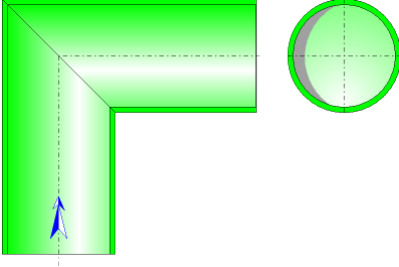




## Miter Bend Circular Cross-Section (MILLER)



### Model description:

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

An option allows to take into account the effect of the straight length at the exit of the bend. The friction loss in this straight length is not taken into account in this component.

### Model formulation:

---

Hydraulic diameter (m):

$$D = d$$

---

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

$$A = \pi \cdot \frac{D^2}{4}$$

---

Mean velocity (m/s):

$$U = \frac{Q}{A}$$

---

Mass flow rate (kg/s):

$$m = Q \cdot \rho$$

---

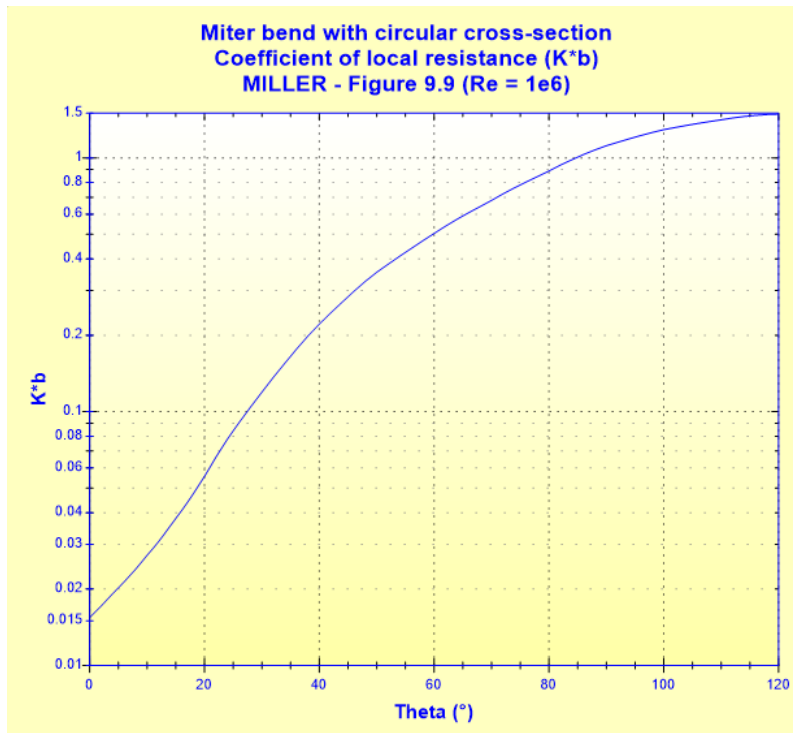
Reynolds number:

$$Re = \frac{U \cdot D}{\nu}$$

---

Basic resistance coefficient:

$$K_b^* = f(\theta_b) \quad ([1] \text{ figure 9.9})$$

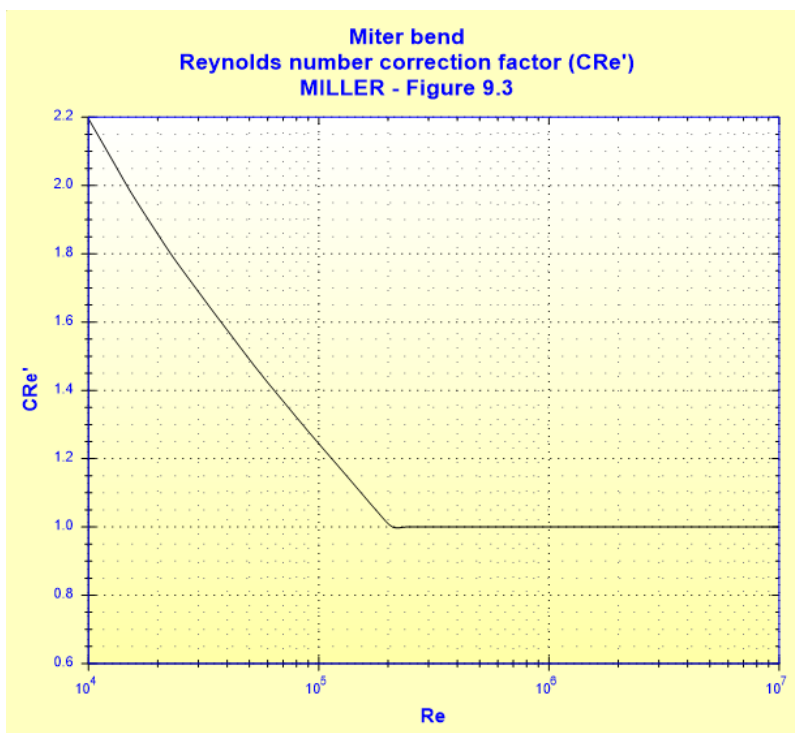


Reynolds number correction factor:

$$C_{Re} = \frac{K_b^*}{K_b^* - 0.2C'_{Re} + 0.2} \quad ([1] \text{ equation 9.2})$$

with:

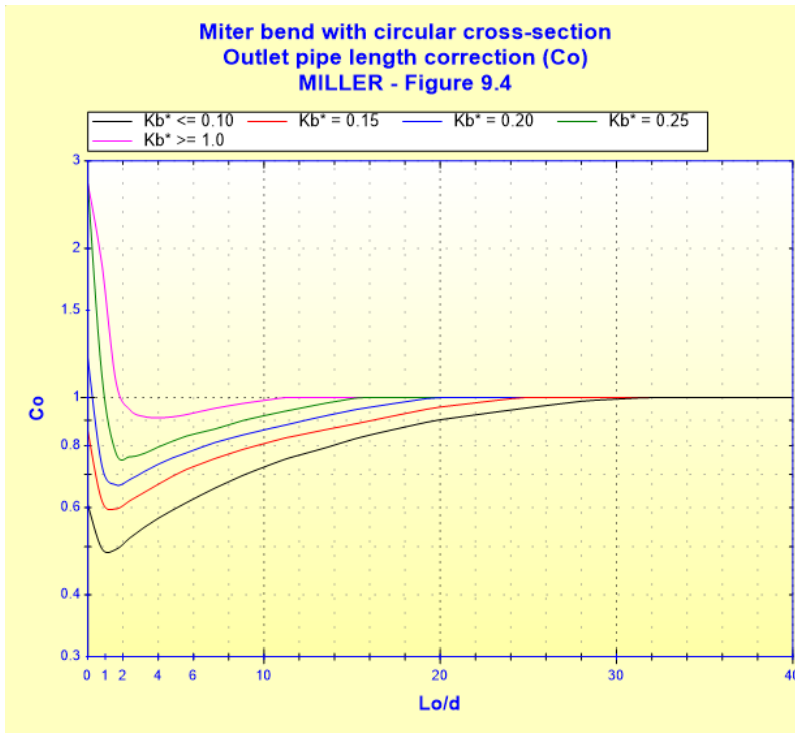
$$C'_{Re} = f\left(Re, \frac{r}{d}\right) \quad ([1] \text{ figure 9.3 with } r/d=1)$$



Outlet pipe length correction factor (optional):

$$C_o = f\left(\frac{L_o}{d}, K_b^*\right)$$

([1] figure 9.4)

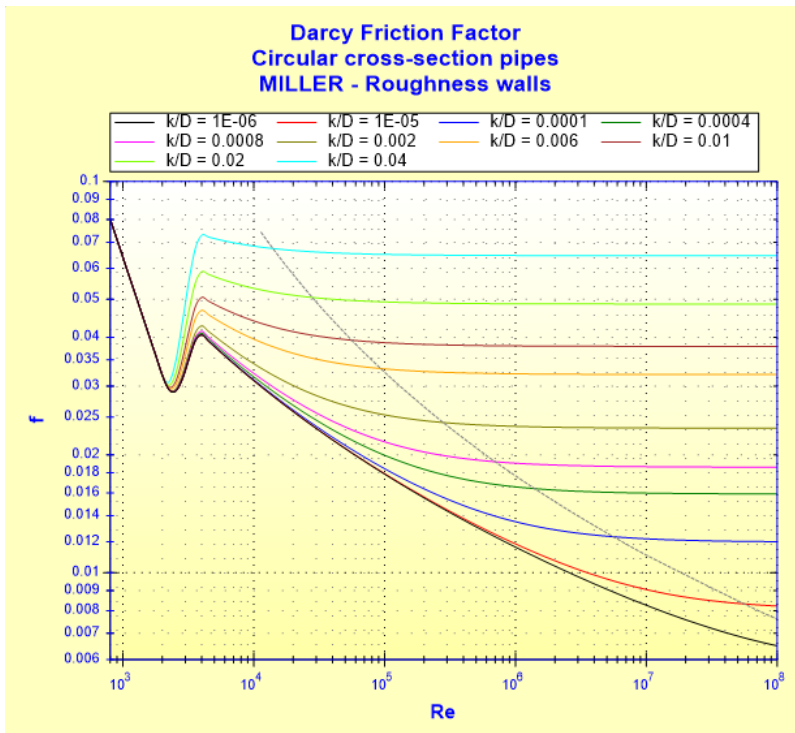


If this option is not activated, the factor  $C_o$  is equal to unity.

Darcy friction factor:

$$f = f\left(\text{Re}, \frac{k}{D}\right)$$

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



Roughness correction factor:

■  $\theta_b \leq 45$ :

$$C_f = \frac{f_{rough}}{f_{smooth}}$$

([1] equation 9.3)

with:

$f_{rough}$ : Darcy friction factor for rough pipe at  $Re$

$f_{smooth}$ : Darcy friction factor for smooth pipe ( $k = 0$ ) at  $Re$

■  $\theta_b > 45^\circ$ :

$$C_f = 1$$

---

Corrected loss coefficient:

$$K_b = K_b^* \cdot C_{Re} \cdot C_o \cdot C_f$$

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

$$K = K_b$$

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Total pressure loss (Pa):

$$\Delta P = K_b \cdot \frac{\rho \cdot U^2}{2} \quad ([1] \text{ equation 8.1b})$$

---

Total head loss of fluid (m):

$$\Delta H = K_b \cdot \frac{U^2}{2 \cdot g} \quad ([1] \text{ equation 8.1a})$$

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Hydraulic power loss (W):

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

---

Straight length of equivalent pressure loss (m):

$$L_{eq} = K_b \cdot \frac{d}{f_{rough}}$$

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**Symbols, Definitions, SI Units:**

D	Bend hydraulic diameter (m)
d	Bend internal diameter (m)
A	Cross-section area ( $m^2$ )
Q	Volume flow rate ( $m^3/s$ )
U	Mean velocity (m/s)
m	Mass flow rate (kg/s)
Re	Reynolds number ( )
$\theta_b$	Angle of the bend ( $^\circ$ )
$K_b^*$	Basic loss coefficient ( )
$C_{Re}$	Reynolds number correction factor ( )
$L_o$	Length of the straight section downstream of the bend (m)

$C_o$	Outlet pipe length correction factor ( )
$k$	Absolute roughness of walls (m)
$f$	Darcy friction factor for ( )
$C_f$	Roughness correction factor ( )
$K_b$	Corrected loss coefficient ( )
$K$	Total pressure loss coefficient (based on the mean velocity in the bend) ( )
$\Delta P$	Total pressure loss (Pa)
$\Delta H$	Total head loss of fluid (m)
$Wh$	Hydraulic power loss (W)
$L_{eq}$	Straight length of equivalent pressure loss (m)
$\rho$	Fluid density (kg/m <sup>3</sup> )
$\nu$	Fluid kinematic viscosity (m <sup>2</sup> /s)
$g$	Gravitational acceleration (m/s <sup>2</sup> )

### Validity range:

- turbulent flow regime ( $Re \geq 10^4$ )
- stabilized flow upstream bend
- curvature angle: 0 - 120°

### Example of application:

The screenshot shows the HydraulCalc 2018b software interface. The main window is titled "HydrauCalc 2018b - [Miter bend with circular cross-section - MILLER (2nd Ed.)]". The interface is divided into several panels:

- Fluid characteristics:**
  - Fluid: Water @ 1 atm [HC]
  - Ref.: IAPWS IF97
  - Temperature: T = 20 °C
  - Pressure: P = 1.013 bar
  - Density:  $\rho = 998.2061$  kg/m<sup>3</sup>
  - Dynamic Viscosity:  $\mu = 0.00100159$  N.s/m<sup>2</sup>
  - Kinematic Viscosity:  $\nu = 1.00340E-06$  m<sup>2</sup>/s
  - Graph: Density (kg/m<sup>3</sup>) vs Temperature (°C) showing a curve from 1010 to 950 kg/m<sup>3</sup> over 100 °C.
- Geometrical characteristics:**
  - Diagram of a miter bend with a 90° angle and a circular cross-section of diameter  $d = 0.0703$  m.
  - Relative roughness  $k/D = 1.0E-05$ .
  - Mass flow rate  $m = 4.9910$  kg/s, volumetric flow rate  $Q = 0.005$  m<sup>3</sup>/s, and mean velocity  $U = 1.288$  m/s (Turbulent).
  - Pressure loss:  $\Delta P = 0.009739377$  bar,  $\Delta H = 0.0995$  m of fluid.
  - Option: Outlet pipe length correction factor (unchecked).
  - Straight length:  $\geq 0.825989$  m.
- Complementary results:**

Designation	Symbol	Value	Unit
Hydraulic diameter	$D$	0.0703	m
Cross-sectional area	$A$	0.003881508	m <sup>2</sup>
Basic coefficient (Figure 9.9)	$K_b^*$	1.1173	
Reynolds number	$Re$	90251	
Reynolds number correction factor (Figure 9.3)	$CR_e'$	1.278785	
Reynolds number correction factor (Equation 9.2)	$CR_e$	1.052524	
Outlet tangent correction (Figure 9.4)	$C_o$	1	
Relative roughness	$k/D$	0.0001422475	
Roughness correction	$C_f$	1	
Corrected pressure loss coefficient	$K_b$	1.175986	
Pressure loss coefficient (based on the mean bend velocity)	$K$	1.175986	
Hydraulic power loss	$Wh$	4.869689	W
Straight length of equivalent pressure loss	$L_{eq}$	4.343779	m

## References:

[1] Internal Flow System, Second Edition, D.S. Miller

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HydrauCalc

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