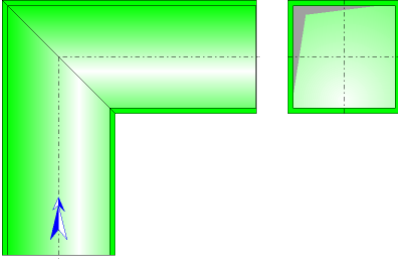




Miter Bend Rectangular Cross-Section (Pipe Flow - Guide)



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 upstream of the bend.

Model formulation:

Hydraulic diameter (m):

$$d_h = \frac{2 \cdot w \cdot h}{w + h}$$

Cross-section area (m²):

$$A = w \cdot h$$

Mean velocity (m/s):

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

Mass flow rate (kg/s):

$$G = Q \cdot \rho_m$$

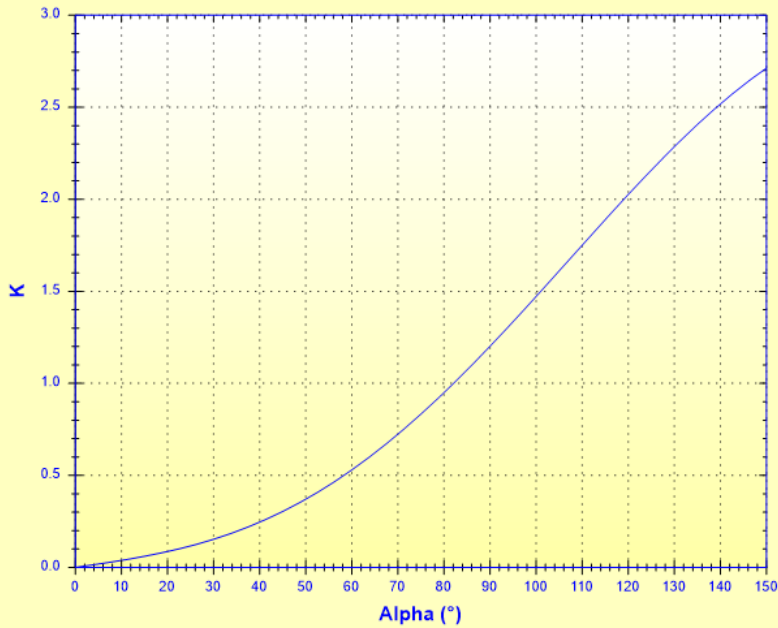
Reynolds number:

$$N_{Re} = \frac{V \cdot d_h}{\nu}$$

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

$$K = 0.42 \cdot \sin(\alpha/2) + 2.56 \cdot \left(\sin^3(\alpha/2) \right) \quad ([1] \text{ equation 15.5})$$

Miter bend with rectangular cross-section
Coefficient of local resistance
Pipe Flow - Guide (2012) - Equation 15.5



Total pressure loss (Pa):

$$\Delta P = K \cdot \frac{\rho \cdot V^2}{2}$$

Total head loss of fluid (m):

$$\Delta H = K \cdot \frac{V^2}{2 \cdot g} \quad ([1] \text{ equation 3.7})$$

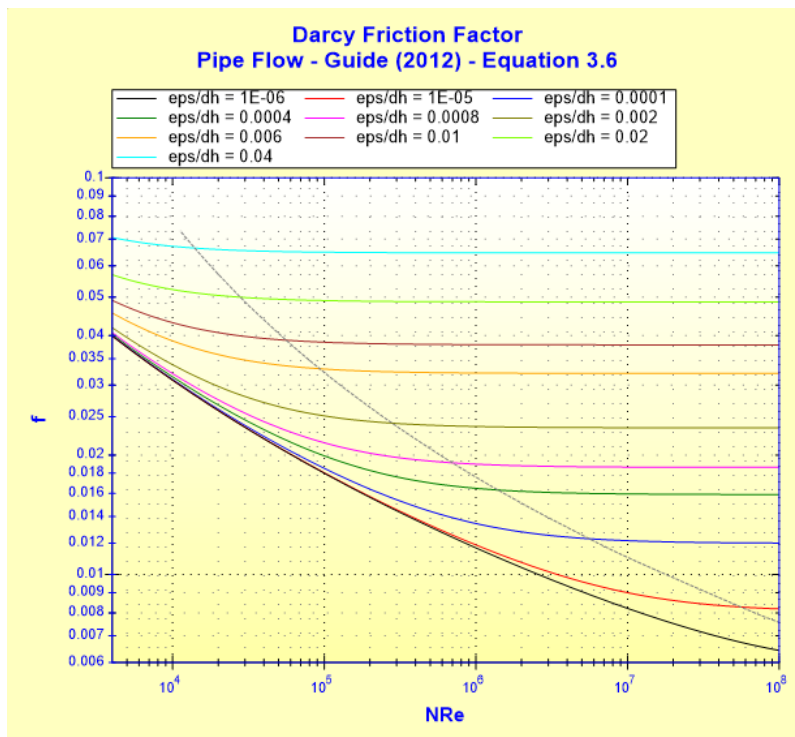
Hydraulic power loss (W):

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

Darcy friction factor:

$$f = \frac{1}{\left[2 \cdot \log \left(\frac{\varepsilon}{3.7 \cdot d_h} + \frac{2.51}{N_{Re} \cdot \sqrt{f}} \right) \right]^2}$$

Colebrook-White equation ([1] equation 3.6)



Straight length of equivalent pressure loss (m):

$$L_{eq} = K \cdot \frac{d_h}{f}$$

Symbols, Definitions, SI Units:

w	Rectangular cross-section width (m)
h	Rectangular cross-section height (m)
d_h	Bend hydraulic diameter (m)
A	Cross-section area (m^2)
Q	Volume flow rate (m^3/s)
V	Mean velocity (m/s)
α	Angle ($^\circ$)
G	Mass flow rate (kg/s)
N_{Re}	Reynolds number ()
K	Total pressure loss coefficient (based on mean velocity in bend) ()
ΔP	Total pressure loss (Pa)
ΔH	Total head loss of fluid (m)
Wh	Hydraulic power loss (W)
f	Darcy friction coefficient ()
L_{eq}	Straight length of equivalent pressure loss (m)
ρ_m	Fluid density (kg/m^3)
ν	Fluid kinematic viscosity (m^2/s)
g	Gravitational acceleration (m/s^2)

Validity range:

- turbulent flow regime ($N_{Re} \geq 10^4$)
- stabilized flow upstream of the bend

- angle between 0° and 150°
- this formulation is for circular passages, but can be reasonably applied to square ducts or to rectangular ducts of low aspect ratio

Example of application:

The screenshot displays the HydraulCalc 2020a software interface for a miter bend with a rectangular cross-section. The window title is "HydraulCalc 2020a - [Miter bend with rectangular cross-section - Pipe Flow - Guide (2012)]".

Fluid characteristics:

- Fluid: Water @ 1 atm [HC]
- Ref.: IAPWS IF97
- Temperature: $T = 20$ °C
- Pressure: $P = 1.013$ bar
- Density: $\rho = 998.2061$ kg/m³
- Dynamic Viscosity: $\mu = 0.00100159$ N.s/m²
- Kinematic Viscosity: $\nu = 1.00340E-06$ m²/s

Geometrical characteristics:

- Height: $h = 0.05$ m
- Width: $w = 0.1$ m
- Surface roughness: $\epsilon = 1.0E-05$ m
- Angle: 90°
- Mass flow rate: $G = 4.9910$ kg/s
- Volume flow rate: $Q = 0.005$ m³/s
- Mean velocity: $V = 1.0$ m/s (Turbulent)
- Pressure loss: $\Delta P = 0.005999625$ bar
- Head loss: $\Delta H = 0.0613$ m of fluid

Complementary results:

Designation	Symbol	Value	Unit
Hydraulic diameter	dh	0.06666667	m
Passage cross-section area	A	0.005	m ²
Sides ratio	h/w	0.5	
Reynolds number	NRe	66440.97	
Coefficient of local resistance (Equation 15.5)	K	1.202082	
Pressure loss coefficient (based on the mean bend velocity)	K	1.202082	
Hydraulic power loss	Wh	2.999812	W
Darcy Friction Factor (Equation 3.6)	f	0.02024362	
Straight length of equivalent pressure loss	Leq	3.958718	m

References:

[1] Pipe Flow: A Practical and Comprehensive Guide. Donald C. Rennels and Hobart M. Hudson. (2012)