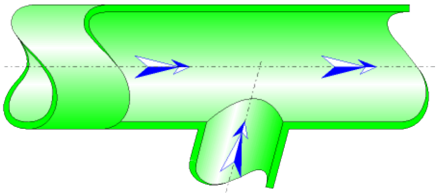
Combining sharp-edged junction
Circular Cross-Section
(MILLER)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a combining sharp-edged junction.

The head loss by friction in the inlet and outlet piping is not taken into account in this component.

Model formulation:

Cross-sectional area of the lateral branch (m^2):

$$A_1 = \pi \cdot \frac{D_1^2}{4}$$

Cross-sectional area of the common branch and the straight branch (m^2):

$$A_3 = \pi \cdot \frac{D_3^2}{4}$$

Volume flow rate in the common branch (m^3/s):

$$Q_3 = Q_1 + Q_2$$

Mean velocity in the lateral branch (m/s):

$$U_1 = \frac{Q_1}{A_1}$$

Mean velocity in the straight branch (m/s):

$$U_2 = \frac{Q_2}{A_3}$$

Mean velocity in the common branch (m/s):

$$U_3 = \frac{Q_3}{A_3}$$

Mass flow rate in the lateral branch (kg/s):

$$G_1 = Q_1 \cdot \rho$$

Mass flow rate in the straight branch (kg/s):

$$G_2 = Q_2 \cdot \rho$$

Mass flow rate in the common branch (kg/s):

$$G_3 = Q_3 \cdot \rho$$

Reynolds number in the lateral branch:

$$\mathrm{Re}_1 = \frac{U_1 \cdot D_1}{\nu}$$

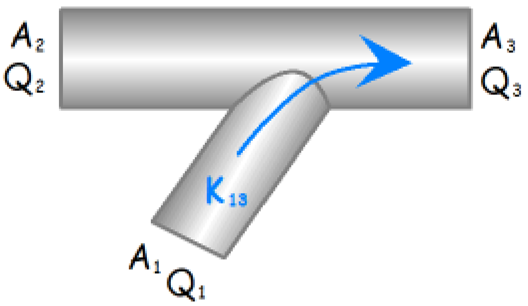
Reynolds number in the straight branch:

$$\mathrm{Re}_2 = \frac{U_2 \cdot D_3}{\nu}$$

Reynolds number in the common branch:

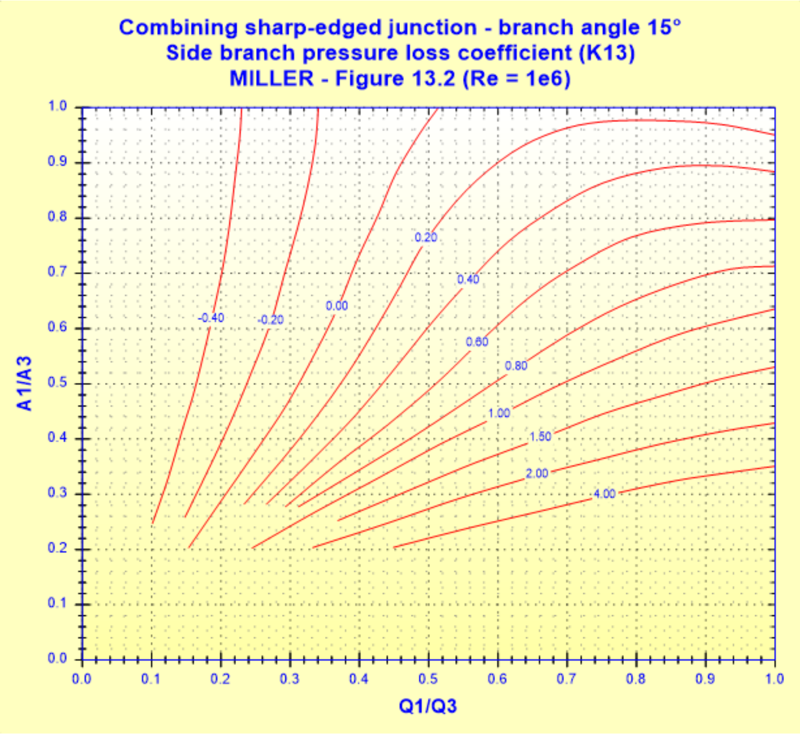
$$\mathrm{Re}_3 = \frac{U_3 \cdot D_3}{\nu}$$

Pressure loss coefficient of the lateral branch (based on mean velocity in the common branch):



- Angle $\theta = 15°$

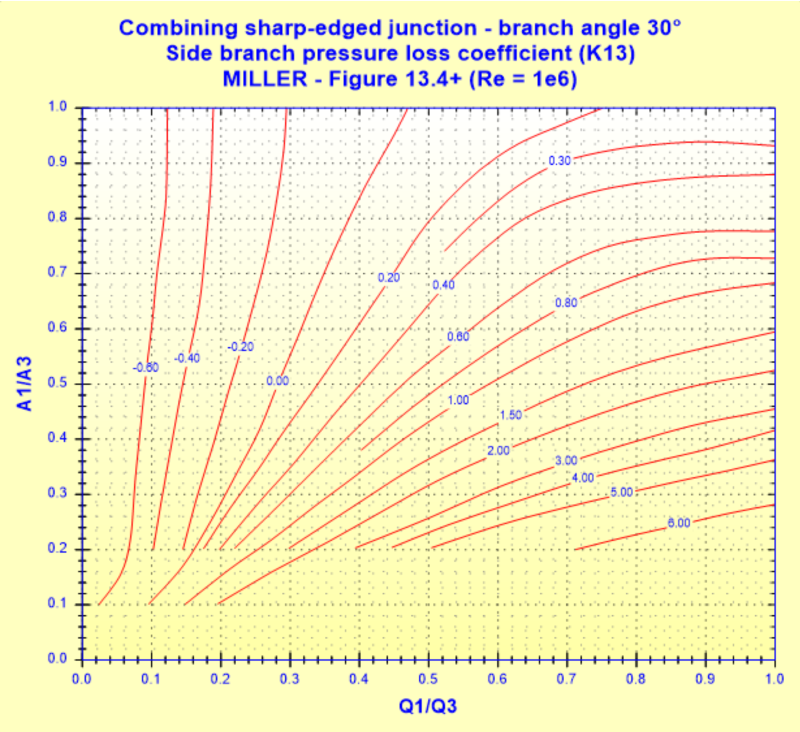
$$K_{13} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right)$$ ([1] figure 13.2)



■ Angle $\theta = 30°$

$$K_{13} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right)$$

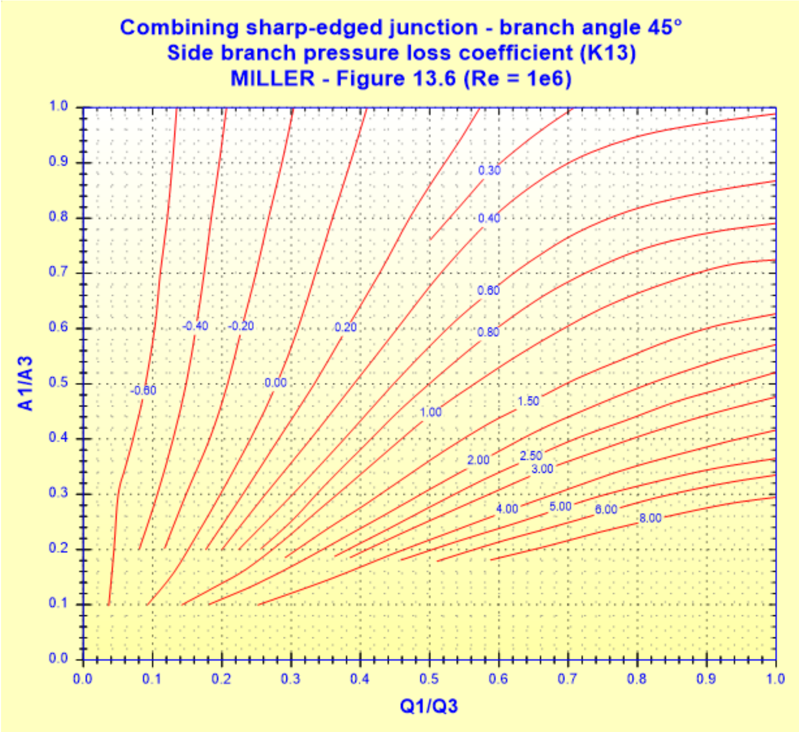
([1] figure 13.4+)



■ Angle $\theta = 45°$

$$K_{13} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right)$$

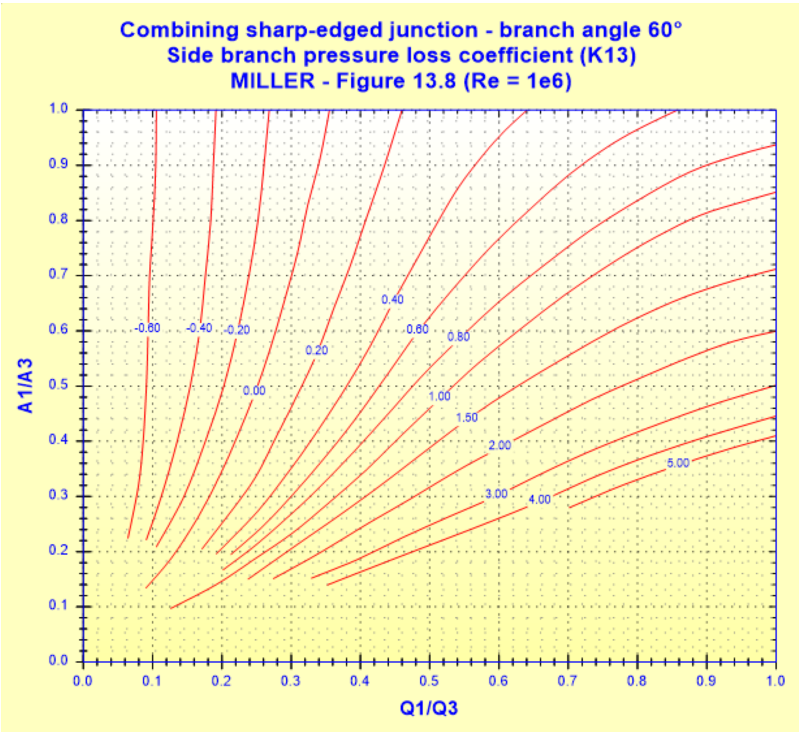
([1] figure 13.6)



■ Angle $\theta = 60°$

$$K_{13} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right)$$

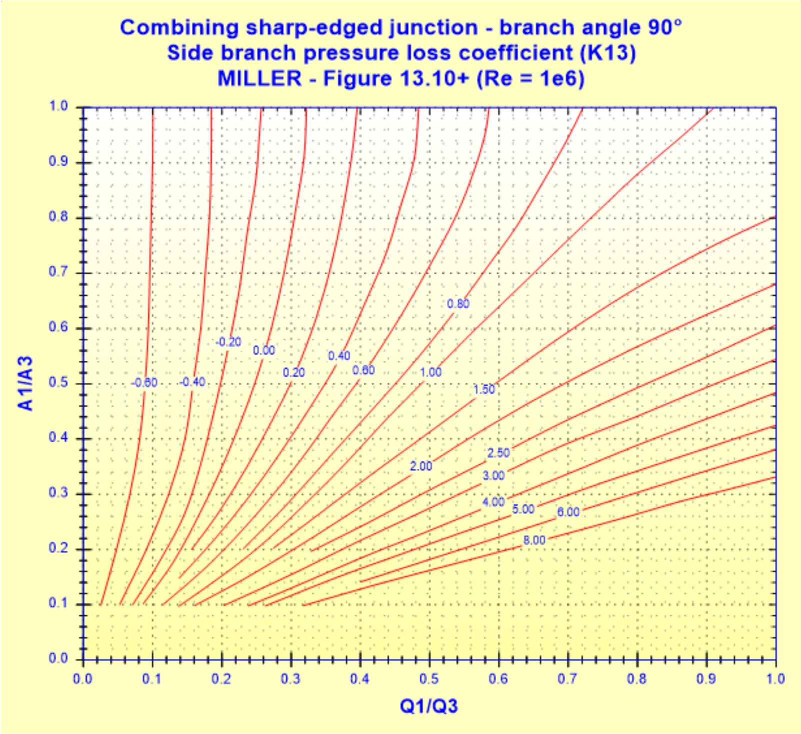
([1] figure 13.8)



■ Angle $\theta = 90°$

$$K_{13} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right)$$

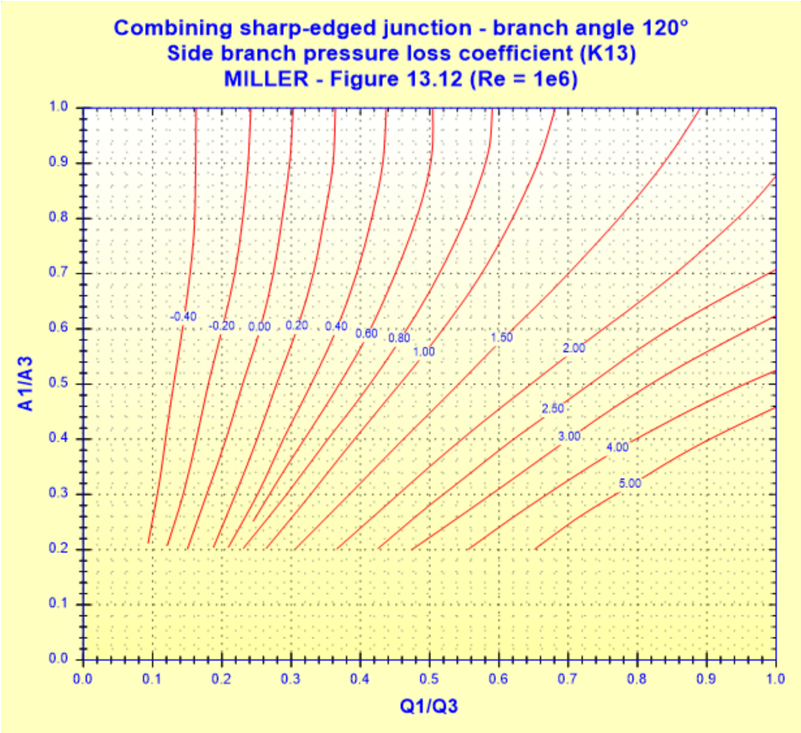
([1] figure 13.10+)



■ Angle $\theta = 120°$

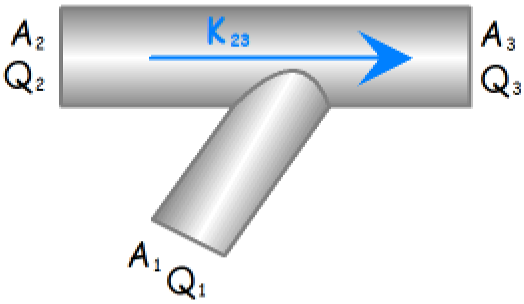
$$K_{13} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right)$$

([1] figure 13.12)



For any angles between 15 ° and 120 °, the coefficient K_{13} is obtained by linear interpolation between the values of K_{13} calculated at 15 °, 30 °, 45 °, 60 °, 90 ° and 120 °.

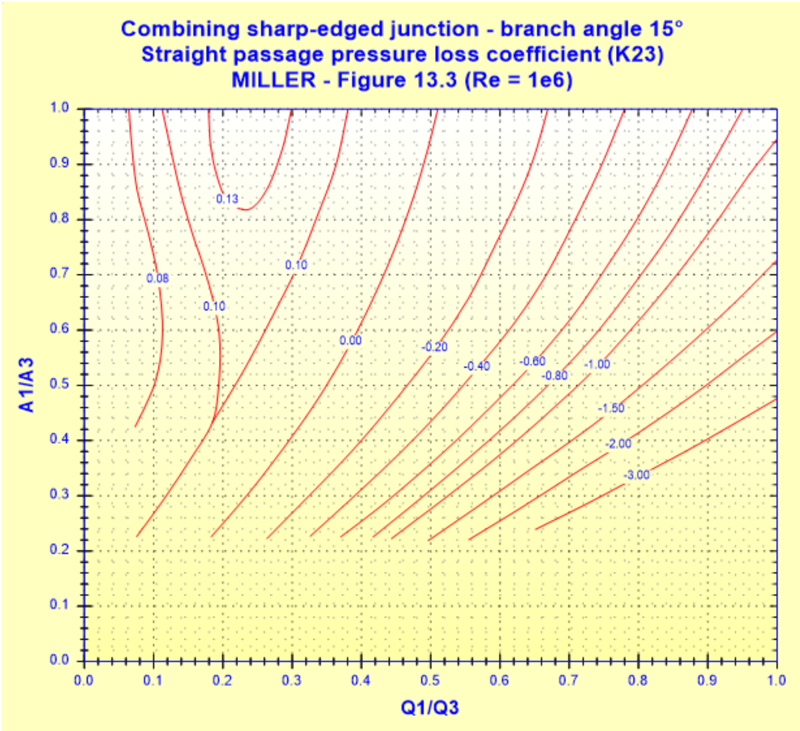
Pressure loss coefficient of the straight branch (based on mean velocity in the common branch):



- Angle $\theta = 15°$

$$K_{23} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right)$$

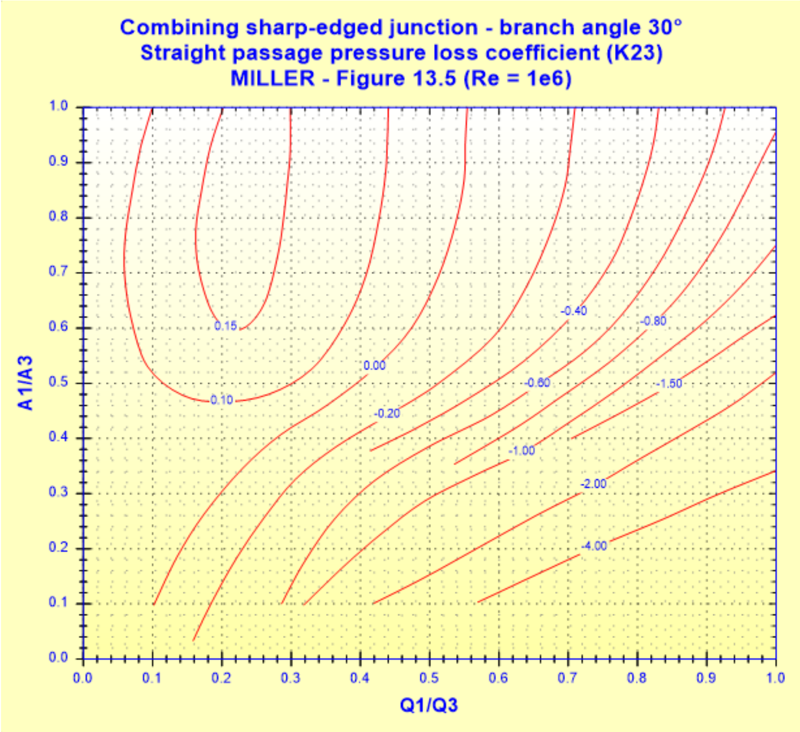
([1] figure 13.3)



- Angle $\theta = 30°$

$$K_{23} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right)$$

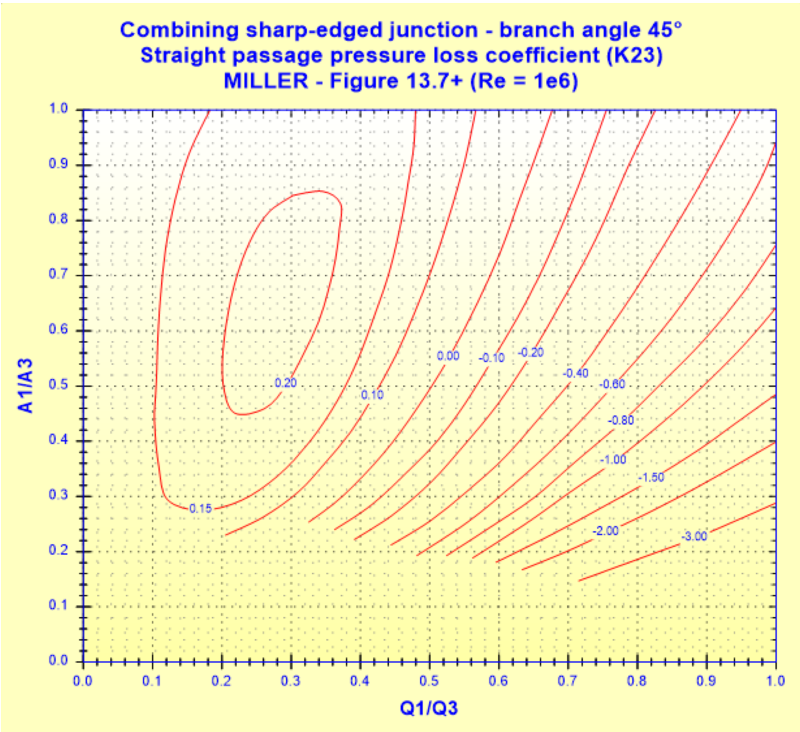
([1] figure 13.5)



■ Angle $\theta = 45°$

$$K_{23} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right)$$

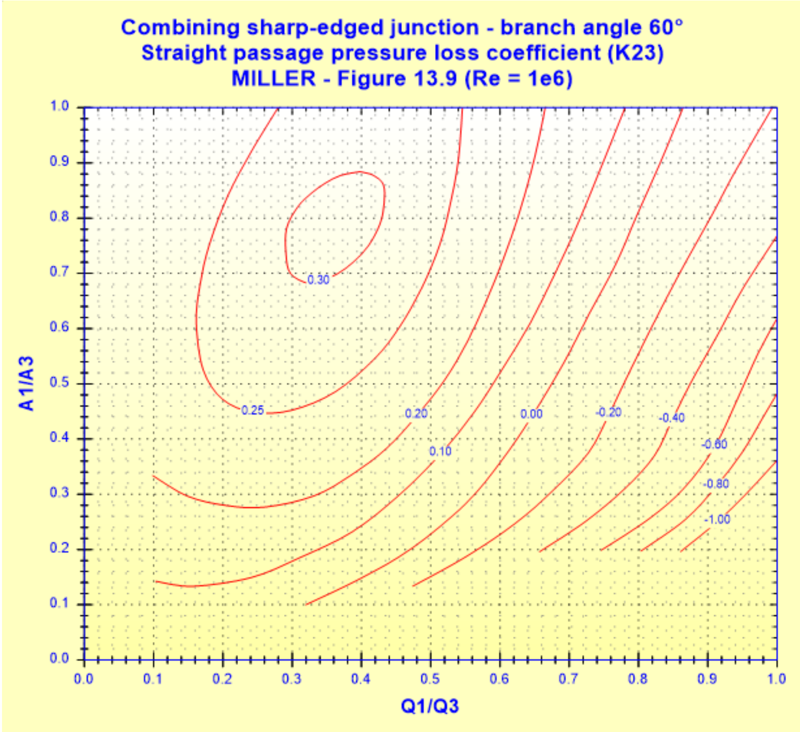
([1] figure 13.7+)



■ Angle $\theta = 60°$

$$K_{23} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right)$$

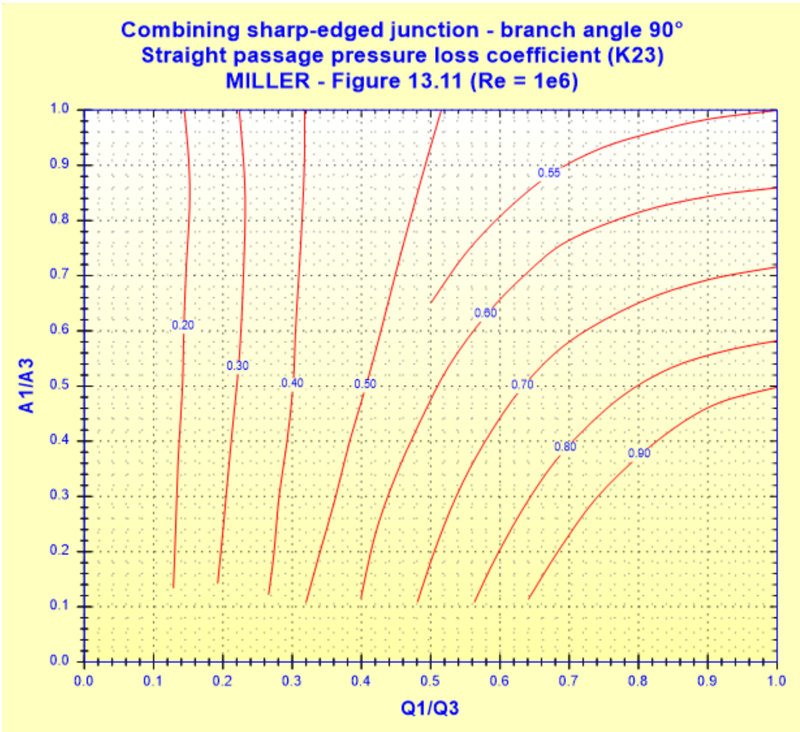
([1] figure 13.9)



- Angle $\theta = 90°$

$$K_{23} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right)$$

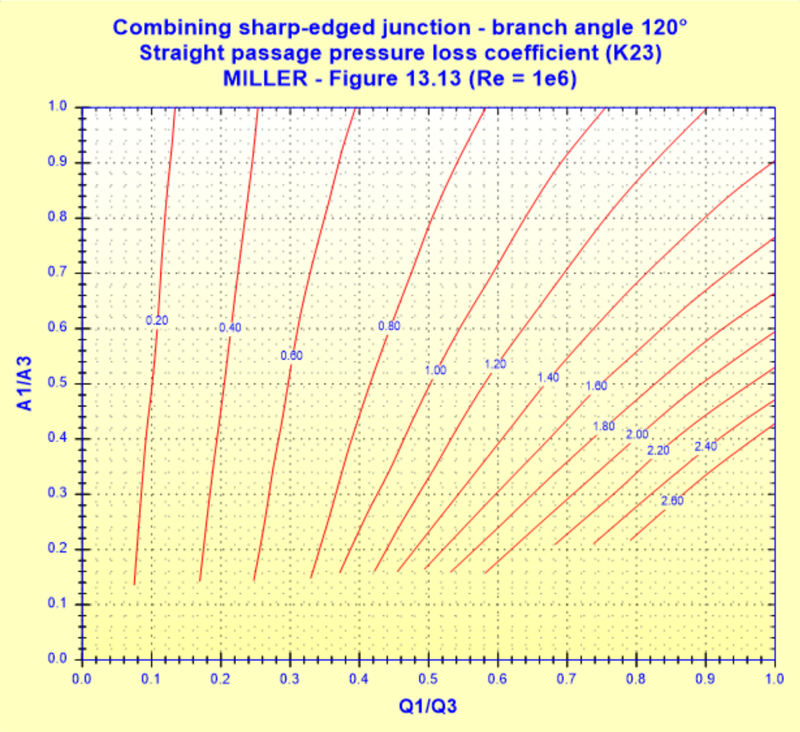
([1] figure 13.11)



- Angle $\theta = 120°$

$$K_{23} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right)$$

([1] figure 13.13)



For any angles θ between 15 ° and 120 °, the coefficient K_{23} is obtained by linear interpolation between the values of K_{23} calculated at 15 °, 30 °, 45 °, 60 °, 90 ° and 120 °.

Pressure loss in the lateral branch (Pa):

$$\Delta P_{13} = K_{13} \cdot \frac{\rho \cdot U_3^2}{2}$$

([1] equation 13.1)

Pressure loss in the straight branch (Pa):

$$\Delta P_{23} = K_{23} \cdot \frac{\rho \cdot U_3^2}{2}$$

([1] equation 13.2)

Head loss of fluid in the lateral branch (m):

$$\Delta H_{13} = K_{13} \cdot \frac{U_3^2}{2 \cdot g}$$

Head loss of fluid in the straight branch (m):

$$\Delta H_{23} = K_{23} \cdot \frac{U_3^2}{2 \cdot g}$$

Hydraulic power loss in the lateral branch (W):

$$Wh_{13} = \Delta P_{13} \cdot Q_1$$

Hydraulic power loss in the straight branch (W):

$$Wh_{23} = \Delta P_{23} \cdot Q_2$$

Symbols, Definitions, SI Units:

D_1	Diameter of the lateral branch (m)
D_3	Diameter of the common branch and the straight branch (m)
A_1	Cross-sectional area of the lateral branch (m²)
A_3	Cross-sectional area of the common branch and the straight branch (m²)
Q_1	Volume flow rate in the lateral branch (m³/s)
U_1	Mean velocity in the lateral branch (m/s)
Q_2	Volume flow rate in the straight branch (m³/s)
U_2	Mean velocity in the straight branch (m/s)
Q_3	Volume flow rate in the common branch (m³/s)
U_3	Mean velocity in the common branch (m/s)
G_1	Mass flow rate in the lateral branch (kg/s)
G_2	Mass flow rate in the straight branch (kg/s)
G_3	Mass flow rate in the common branch (kg/s)
Re_1	Reynolds number in the lateral branch ()
Re_2	Reynolds number in the straight branch ()
Re_3	Reynolds number in the common branch ()
θ	Angle of the lateral branch (m)
K_{13}	Pressure loss coefficient of the lateral branch (based on mean velocity in the common branch) ()
K_{23}	Pressure loss coefficient of the straight branch (based on mean velocity in the common branch) ()
ΔP_{13}	Pressure loss in the lateral branch (Pa)
ΔP_{23}	Pressure loss in the straight branch (Pa)
ΔH_{13}	Head loss of fluid in the lateral branch (m)
ΔH_{23}	Head loss of fluid in the straight branch (m)
Wh_{13}	Hydraulic power loss in the lateral branch (W)
Wh_{23}	Hydraulic power loss in the straight branch (W)
ρ	Fluid density (kg/m³)
ν	Fluid kinematic viscosity (m²/s)
g	Gravitational acceleration (m/s²)

Validity range:

- turbulent flow regime ($Re_3 \geq 10^5$)
- angle of the lateral branch: between 15 ° and 120 °
- cross-sections area ratio $A_1/A_3 \geq 0.2$

  note: for cross-sections area ratios A_1/A_3 lower than 0.2 the pressure loss coefficients "K_{13}" and "K_{23}" are extrapolated

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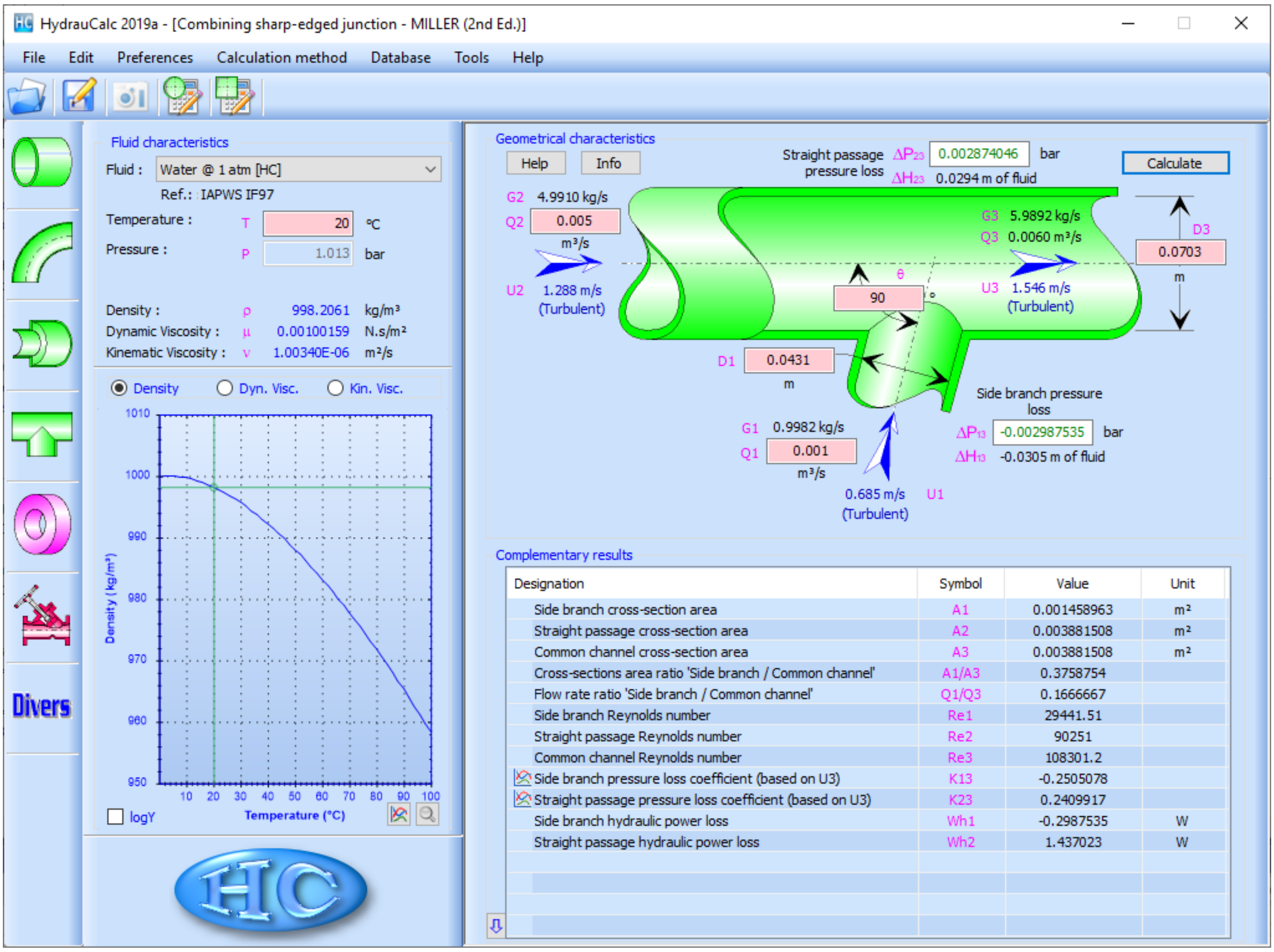
Example of application:



Designation	Symbol	Value	Unit
Side branch cross-section area	A1	0.001458963	m²
Straight passage cross-section area	A2	0.003881508	m²
Common channel cross-section area	A3	0.003881508	m²
Cross-sections area ratio 'Side branch / Common channel'	A1/A3	0.3758754	
Flow rate ratio 'Side branch / Common channel'	Q1/Q3	0.1666667	
Side branch Reynolds number	Re1	29441.51	
Straight passage Reynolds number	Re2	90251	
Common channel Reynolds number	Re3	108301.2	
Side branch pressure loss coefficient (based on U3)	K13	-0.2505078	
Straight passage pressure loss coefficient (based on U3)	K23	0.2409917	
Side branch hydraulic power loss	Wh1	-0.2987535	W
Straight passage hydraulic power loss	Wh2	1.437023	W

References:

[1] Internal Flow System, Second Edition, D.S. Miller (1990)