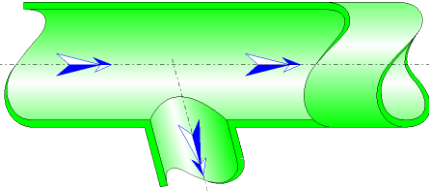




Dividing sharp-edged junction Circular Cross-Section (MILLER)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a dividing 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 (m²):

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

Cross-sectional area of the common branch and the straight branch (m²):

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

Volume flow rate in the common branch (m³/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:

$$Re_1 = \frac{U_1 \cdot D_1}{\nu}$$

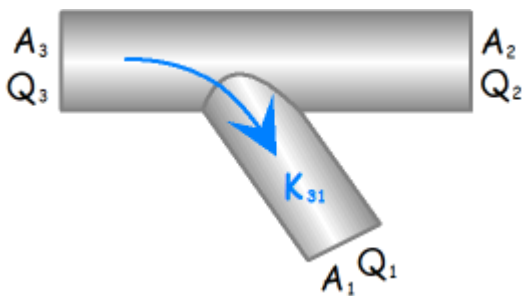
Reynolds number in the straight branch:

$$Re_2 = \frac{U_2 \cdot D_2}{\nu}$$

Reynolds number in the common branch:

$$Re_3 = \frac{U_3 \cdot D_3}{\nu}$$

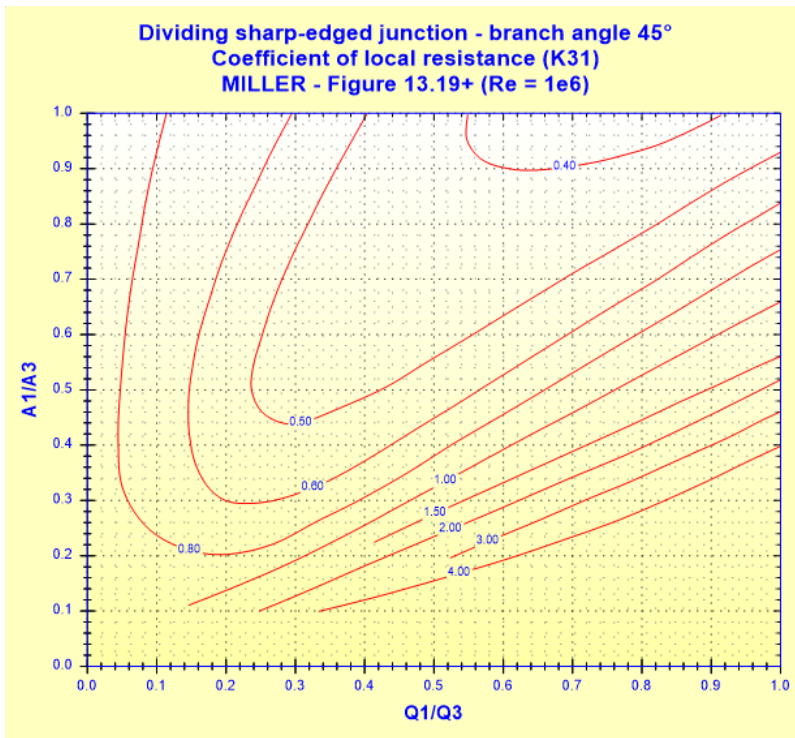
Pressure loss coefficient of the lateral branch (based on mean velocity in the common branch):



■ Angle $\theta = 45^\circ$

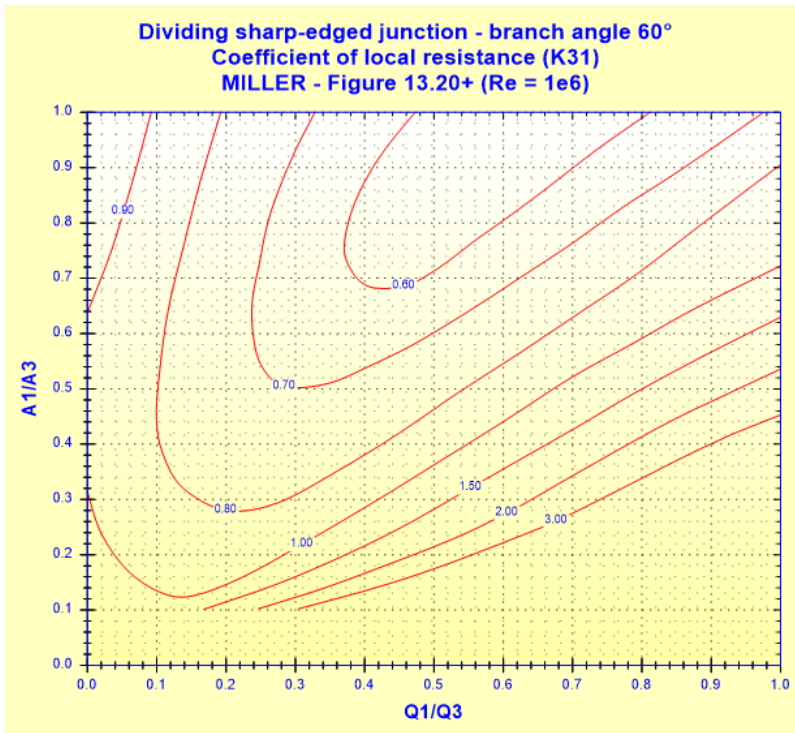
$$K_{31} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right)$$

([1] figure 13.19+)



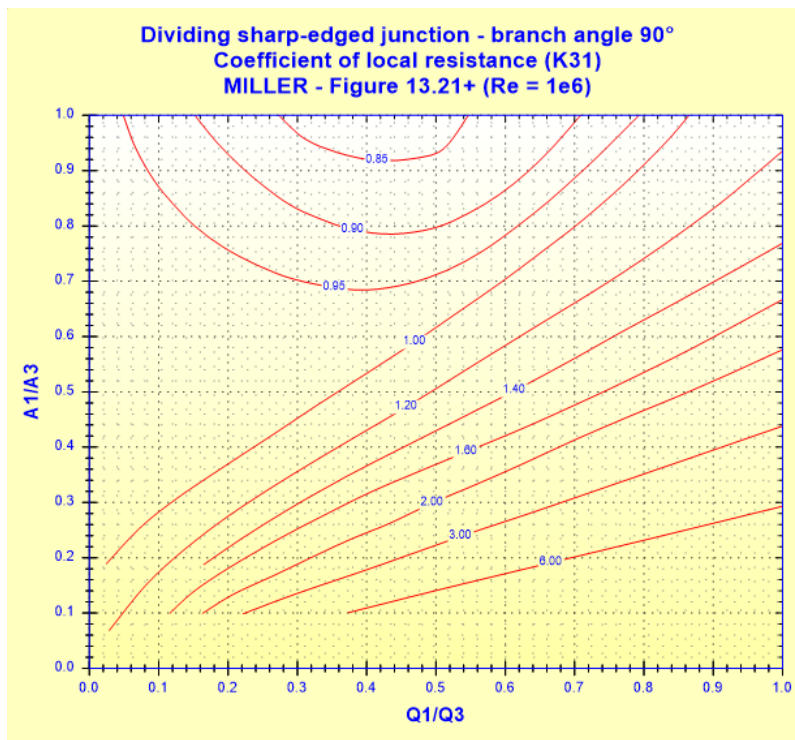
■ Angle $\theta = 60^\circ$

$$K_{31} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right) \quad ([1] \text{ figure 13.20+})$$



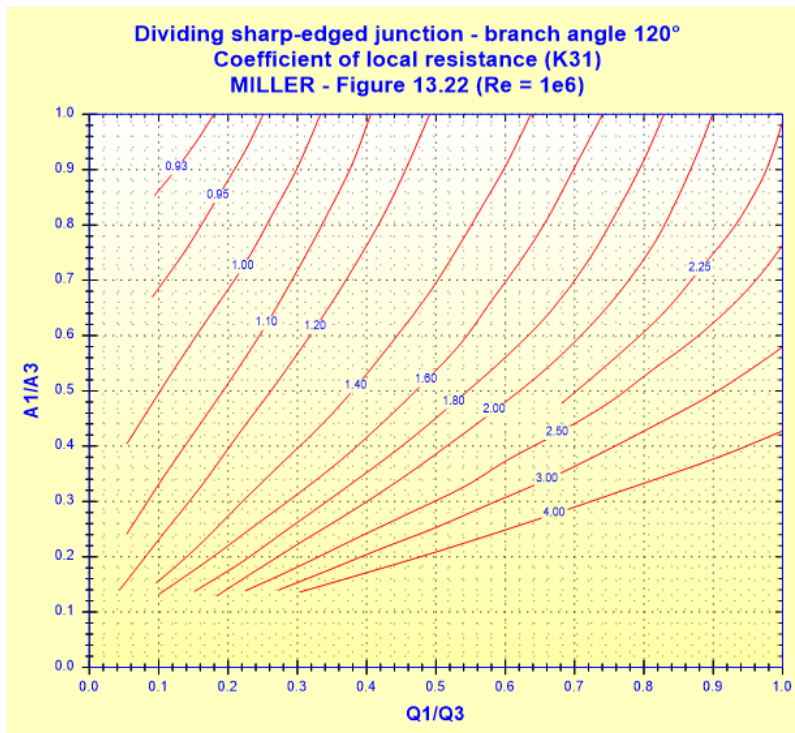
■ Angle $\theta = 90^\circ$

$$K_{31} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right) \quad ([1] \text{ figure 13.21+})$$



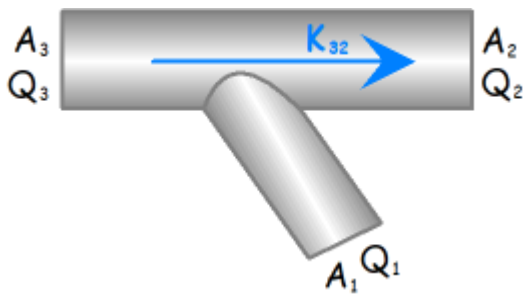
■ Angle $\theta = 120^\circ$

$$K_{31} = f\left(\frac{Q_1}{Q_3}, \frac{A_1}{A_3}\right) \quad ([1] \text{ figure } 13.22)$$



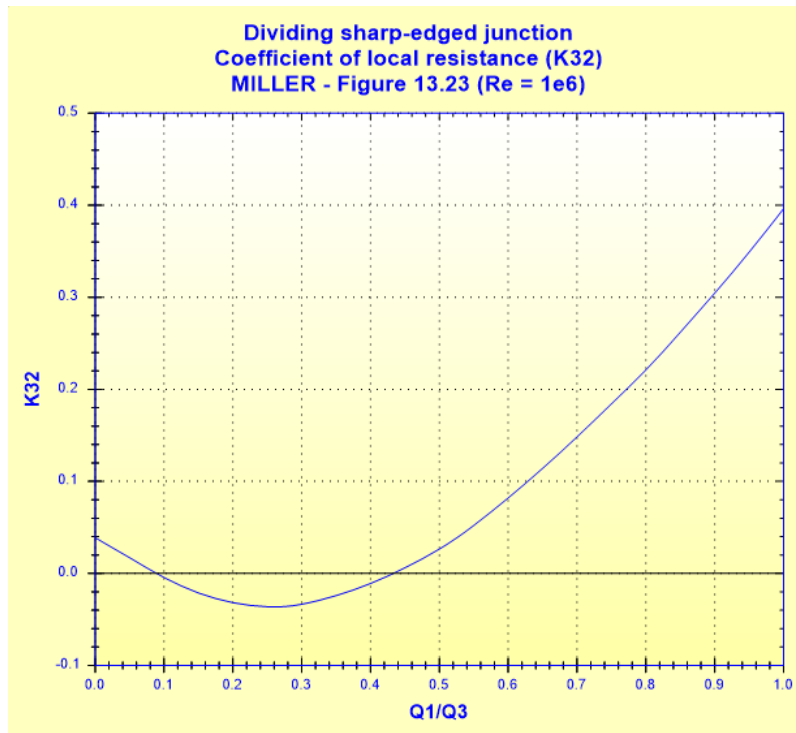
For any angles between 45° and 120° , the coefficient K_{31} is obtained by linear interpolation between the values of K_{31} calculated at 45° , 60° , 90° and 120° .

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



■ Angle $\theta = 45^\circ - 90^\circ$

$$K_{32} = f\left(\frac{Q_1}{Q_3}\right) \quad ([1] \text{ figure 13.23})$$



Pressure loss in the lateral branch (Pa):

$$\Delta P_{31} = K_{31} \cdot \frac{\rho \cdot U_3^2}{2} \quad ([1] \text{ equation 13.3})$$

Pressure loss in the straight branch (Pa):

$$\Delta P_{32} = K_{32} \cdot \frac{\rho \cdot U_3^2}{2} \quad ([1] \text{ equation 13.4})$$

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

$$\Delta H_{31} = K_{31} \cdot \frac{U_3^2}{2 \cdot g}$$

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

$$\Delta H_{32} = K_{32} \cdot \frac{U_3^2}{2 \cdot g}$$

Hydraulic power loss in the lateral branch (W):

$$Wh_{31} = \Delta P_{31} \cdot Q_1$$

Hydraulic power loss in the straight branch (W):

$$Wh_{32} = \Delta P_{32} \cdot Q_2$$

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 (m^2)
A_3	Cross-sectional area of the common branch and the straight branch (m^2)
Q_1	Volume flow rate in the lateral branch (m^3/s)
U_1	Mean velocity in the lateral branch (m/s)
Q_2	Volume flow rate in the straight branch (m^3/s)
U_2	Mean velocity in the straight branch (m/s)
Q_3	Volume flow rate in the common branch (m^3/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_{31}	Pressure loss coefficient of the lateral branch (based on mean velocity in the common branch) ()
K_{32}	Pressure loss coefficient of the straight branch (based on mean velocity in the common branch) ()
ΔP_{31}	Pressure loss in the lateral branch (Pa)
ΔP_{32}	Pressure loss in the straight branch (Pa)
ΔH_{31}	Head loss of fluid in the lateral branch (m)
ΔH_{32}	Head loss of fluid in the straight branch (m)
Wh_{31}	Hydraulic power loss in the lateral branch (W)
Wh_{32}	Hydraulic power loss in the straight branch (W)
ρ	Fluid density (kg/m^3)
ν	Fluid kinematic viscosity (m^2/s)
g	Gravitational acceleration (m/s^2)

Validity range:

- turbulent flow regime ($Re_3 \geq 10^5$)
- angle of the lateral branch:
between 45° and 120° for the pressure loss coefficient " K_{31} "
between 45° and 90° for the pressure loss coefficient " K_{32} "

- cross-sections area ratio $A_1/A_3 \geq 0.1$
 note: for cross-sections area ratios A_1/A_3 lower than 0.1 the pressure loss coefficients "K₃₁" and "K₃₂" are extrapolated

Example of application:

The screenshot displays the HydraulCalc 2019a software interface for a "Dividing sharp-edged junction - MILLER (2nd Ed.)".

Fluid characteristics:

- Fluid: Water @ 1 atm [HC]
- Ref.: IAPWS IF97
- Temperature: T = 20 °C
- Pressure: P = 1.013 bar
- Density: $\rho = 998.2061 \text{ kg/m}^3$
- Dynamic Viscosity: $\mu = 0.00100159 \text{ N.s/m}^2$
- Kinematic Viscosity: $\nu = 1.00340E-06 \text{ m}^2/\text{s}$

Geometrical characteristics:

The diagram shows a main channel with diameter D₃ = 0.0703 m and a side branch with diameter D₁ = 0.0431 m. The junction angle is 90°. The main channel flow is U₃ = 1.546 m/s (Turbulent) with mass flow G₃ = 5.9892 kg/s and volume flow Q₃ = 0.0060 m³/s. The side branch flow is U₁ = 0.685 m/s (Turbulent) with mass flow G₁ = 0.9982 kg/s and volume flow Q₁ = 0.001 m³/s. The straight passage flow is U₂ = 1.288 m/s (Turbulent) with mass flow G₂ = 4.9910 kg/s and volume flow Q₂ = 0.005 m³/s.

Pressure losses and head losses are calculated as follows:

- Side branch pressure loss: $\Delta P_{31} = 0.01187491 \text{ bar}$, $\Delta H_{31} = 0.1213 \text{ m of fluid}$
- Straight passage pressure loss: $\Delta P_{32} = -0.0003040763 \text{ bar}$, $\Delta H_{32} = -0.0031 \text{ m of fluid}$

Complementary results:

Designation	Symbol	Value	Unit
Side branch cross-section area	A ₁	0.001458963	m ²
Straight passage cross-section area	A ₂	0.003881508	m ²
Common channel cross-section area	A ₃	0.003881508	m ²
Cross-sections area ratio 'Side branch / Common channel'	A ₁ /A ₃	0.3758754	
Flow rate ratio 'Side branch / Common channel'	Q ₁ /Q ₃	0.1666667	
Side branch Reynolds number	Re ₁	29441.51	
Straight passage Reynolds number	Re ₂	90251	
Common channel Reynolds number	Re ₃	108301.2	
Side branch pressure loss coefficient (based on U ₃)	K ₃₁	0.9957232	
Straight passage pressure loss coefficient (based on U ₃)	K ₃₂	-0.0254971	
Side branch hydraulic power loss	Wh ₁	1.187491	W
Straight passage hydraulic power loss	Wh ₂	-0.1520382	W

References:

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