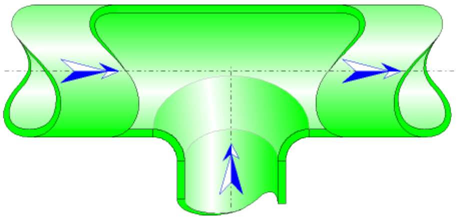
Combining radiused-edged T-junction
Circular Cross-Section
(Pipe Flow - Guide)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a combining radiused-edged T-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 common branch (m²):

$$\boxed{A_1 = \pi \cdot \frac{d_2^{\ 2}}{4}}$$

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

$$\boxed{A_2 = \pi \cdot \frac{d_2^{\ 2}}{4}}$$

Cross-sectional area of the side branch (m²):

$$\boxed{A_3 = \pi \cdot \frac{d_3^{\ 2}}{4}}$$

Volume flow rate in the common branch (m³/s):

$$\boxed{Q_1 = Q_2 + Q_3}$$

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

$$\boxed{V_1 = \frac{Q_1}{A_1}}$$

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

$$V_2 = \frac{Q_2}{A_2}$$

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

$$V_3 = \frac{Q_3}{A_3}$$

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

$$w_1 = Q_1 \cdot \rho_m$$

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

$$w_2 = Q_2 \cdot \rho_m$$

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

$$w_3 = Q_3 \cdot \rho_m$$

Reynolds number in the common branch:

$$N\mathrm{Re}_1 = \frac{V_1 \cdot d_2}{\nu}$$

Reynolds number in the straight branch:

$$N\mathrm{Re}_2 = \frac{V_2 \cdot d_2}{\nu}$$

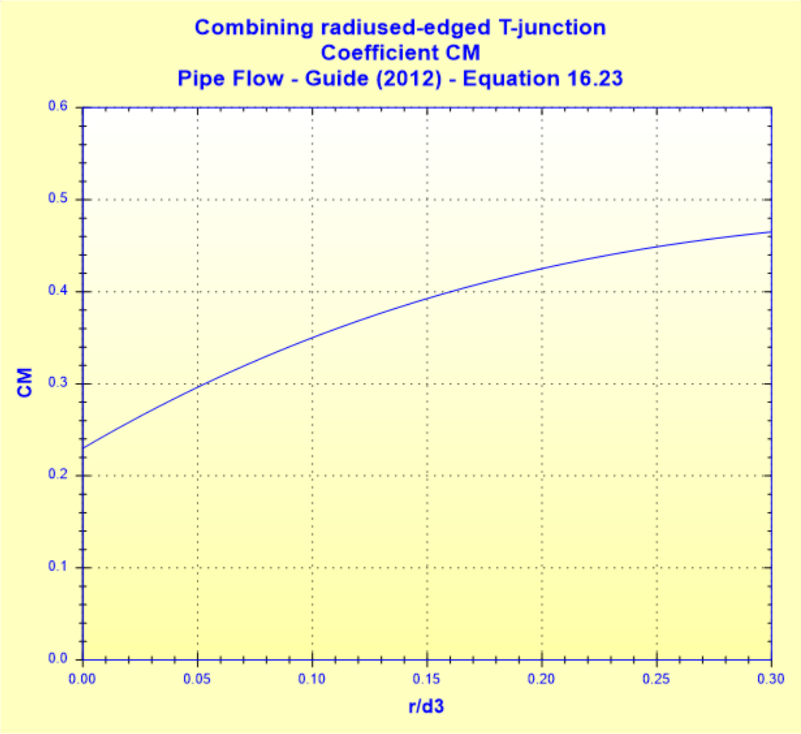
Reynolds number in the side branch:

$$N\mathrm{Re}_3 = \frac{V_3 \cdot d_3}{\nu}$$

Coefficient C_M:

$$C_M = 0.23 + 1.46 \cdot \left(\frac{r}{d_3}\right) - 2.75 \cdot \left(\frac{r}{d_3}\right)^2 + 1.65 \cdot \left(\frac{r}{d_3}\right)^3$$

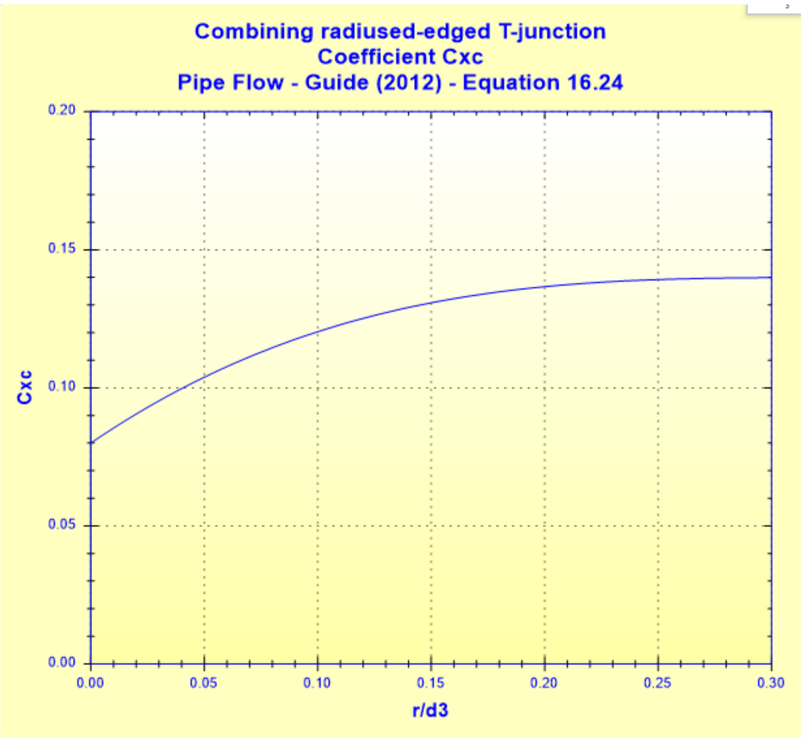
([1] equation 16.23)



Coefficient C_{xC}:

$$C_{xC} = 0.08 + 0.56 \cdot \left(\frac{r}{d_3}\right) - 1.75 \cdot \left(\frac{r}{d_3}\right)^2 + 1.83 \cdot \left(\frac{r}{d_3}\right)^3$$

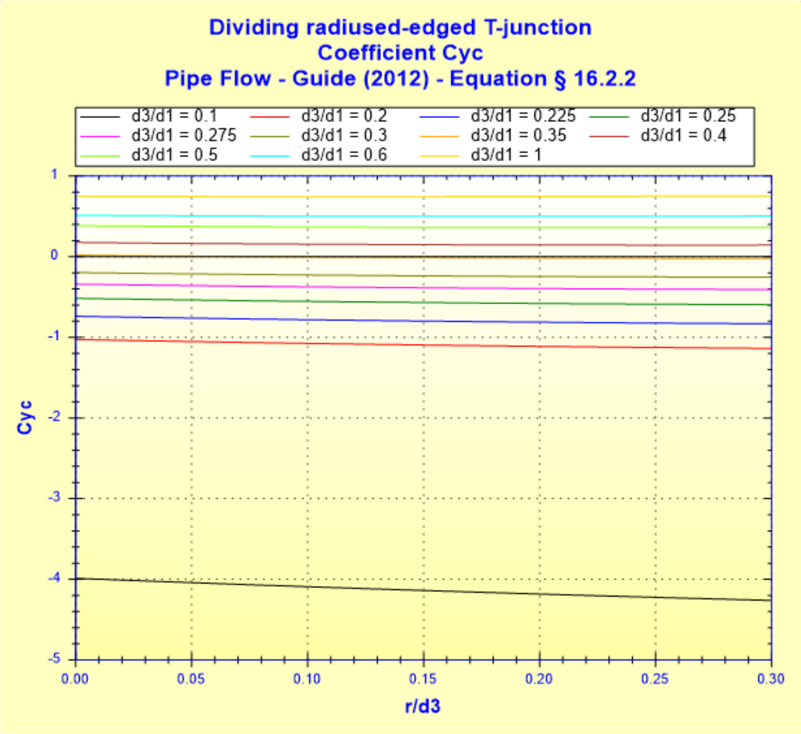
([1] equation 16.24)



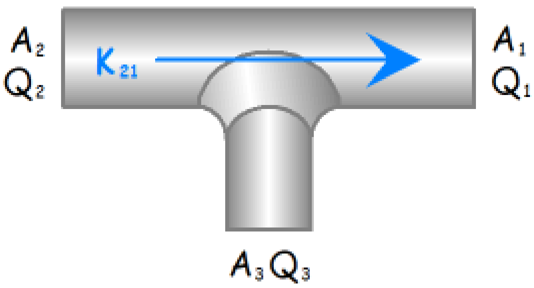
Coefficient C_{yC}:

$$C_{yC} = 1 - 0.25 \cdot \left(\frac{d_3}{d_1}\right)^{1.3} - \left(0.11 \cdot \frac{r}{d_3} - 0.65 \cdot \frac{r^2}{d_3^{\,2}} + 0.83 \cdot \frac{r^3}{d_3^{\,3}}\right) \cdot \frac{d_3^{\,2}}{d_1^{\,2}}$$

([1] equation §16.2.2)



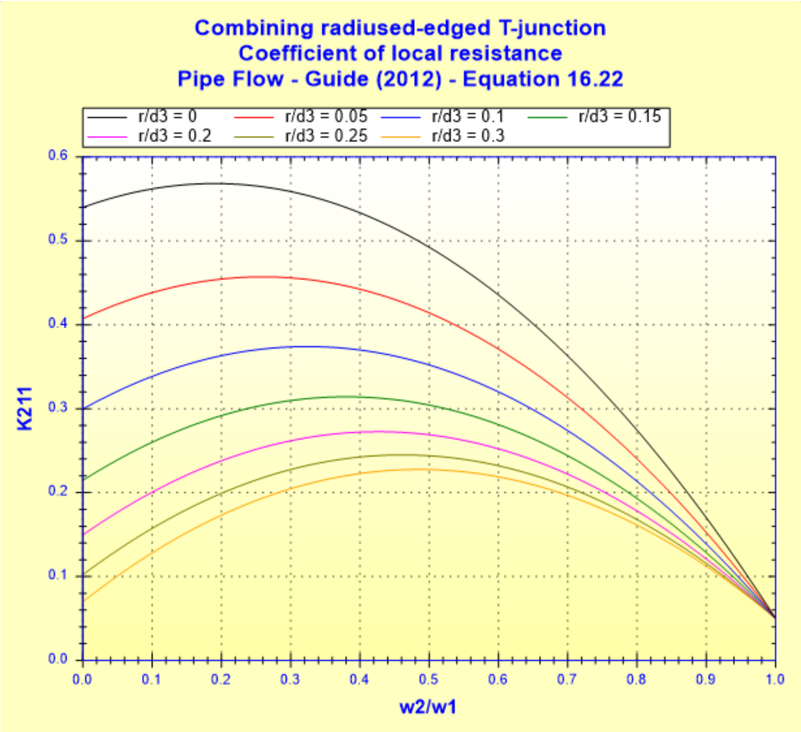
Pressure loss coefficient of the straight branch:



Coefficient based on mean velocity in the common branch:

$$K_{21_1} = 1 - 0.95 \cdot \frac{w_2{}^2}{w_1{}^2} - 2 \cdot C_{xC} \cdot \left(\frac{w_2}{w_1} - \frac{w_2{}^2}{w_1{}^2} \right) - 2 \cdot C_M \cdot \left(1 - \frac{w_2}{w_1} \right)$$

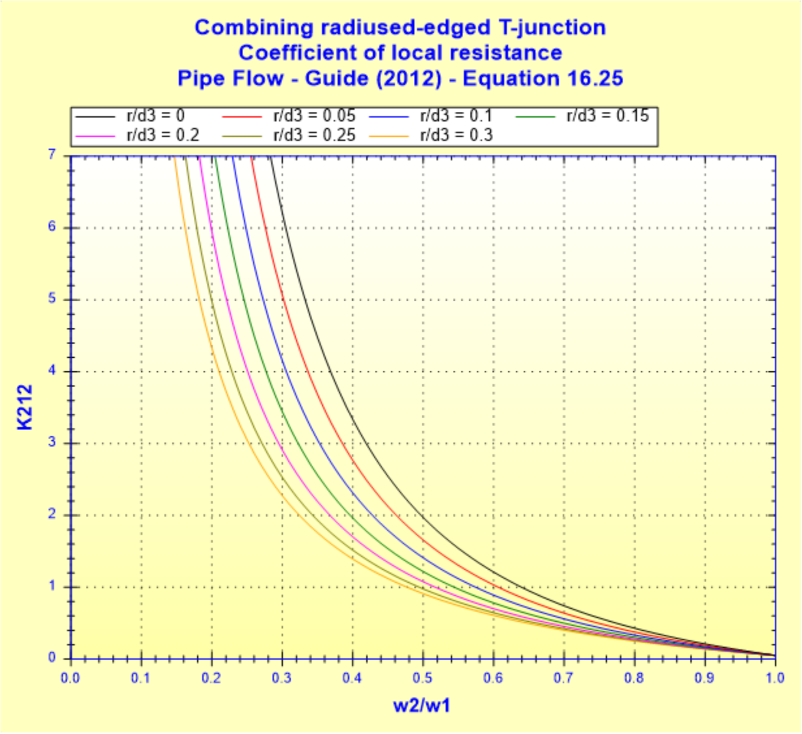
([1] equation 16.22)



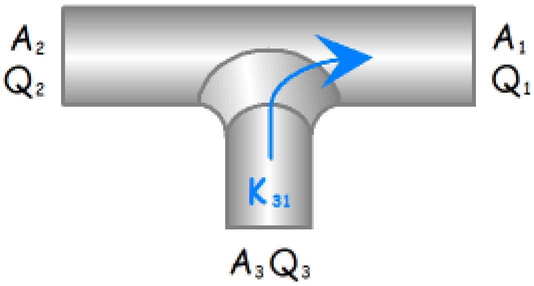
Coefficient based on mean velocity in the straight branch:

$$K_{21_2} = \frac{w_1^2}{w_2^2} - 0.95 - 2 \cdot C_{xC} \cdot \left(\frac{w_1}{w_2} - 1 \right) - 2 \cdot C_M \cdot \left(\frac{w_1^2}{w_2^2} - \frac{w_1}{w_2} \right)$$

([1] equation 16.25)



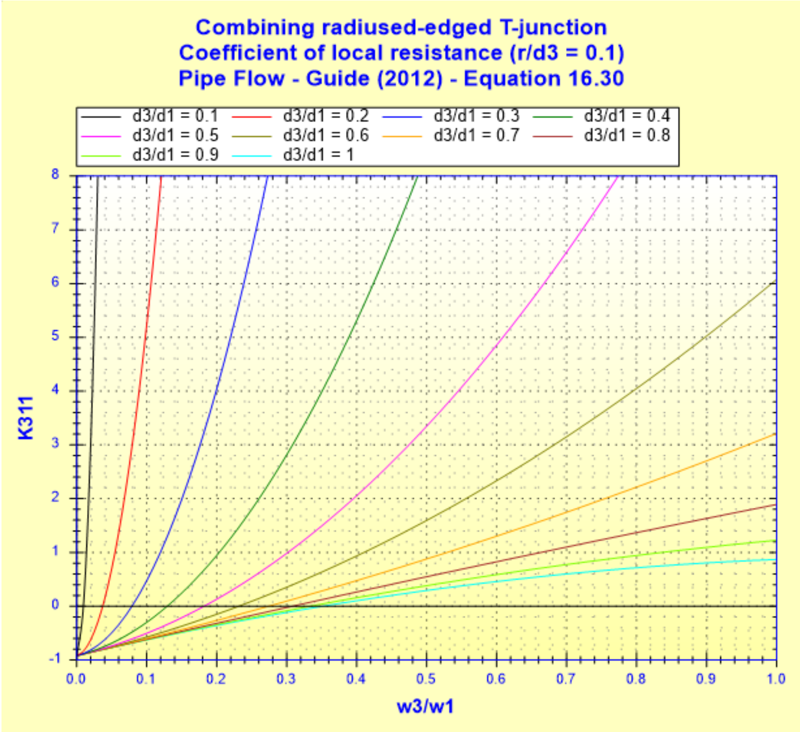
Pressure loss coefficient of the side branch:



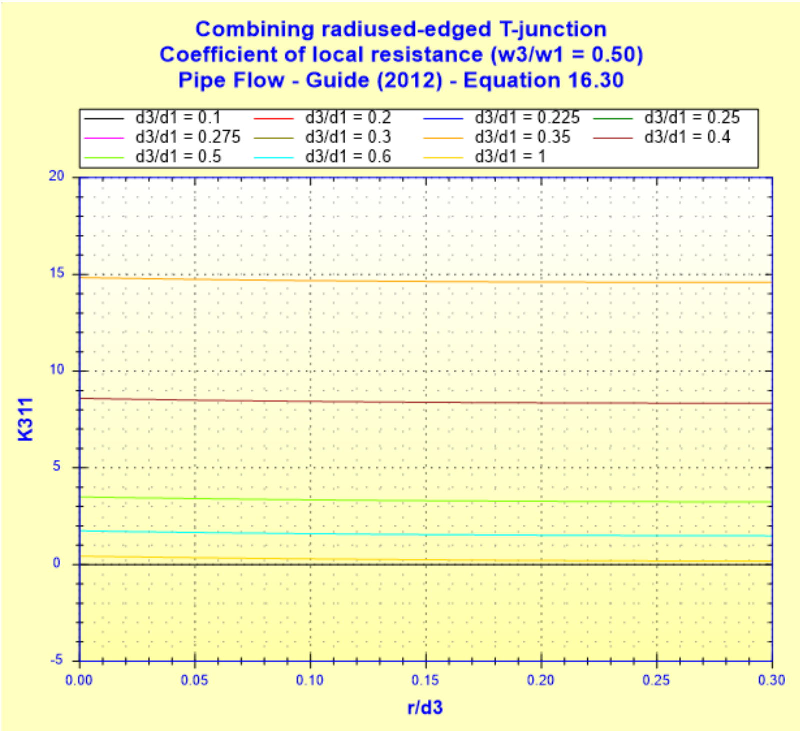
Coefficient based on mean velocity in the common branch:

$$K_{31_1} = -0.92 + 2 \cdot (2 - C_{xC} - C_M) \cdot \frac{w_3}{w_1} + \left[(2 \cdot C_{yC} - 1) \cdot \frac{d_1^4}{d_3^4} + 2 \cdot (C_{xC} - 1) \right] \cdot \frac{w_3^2}{w_1^2}$$

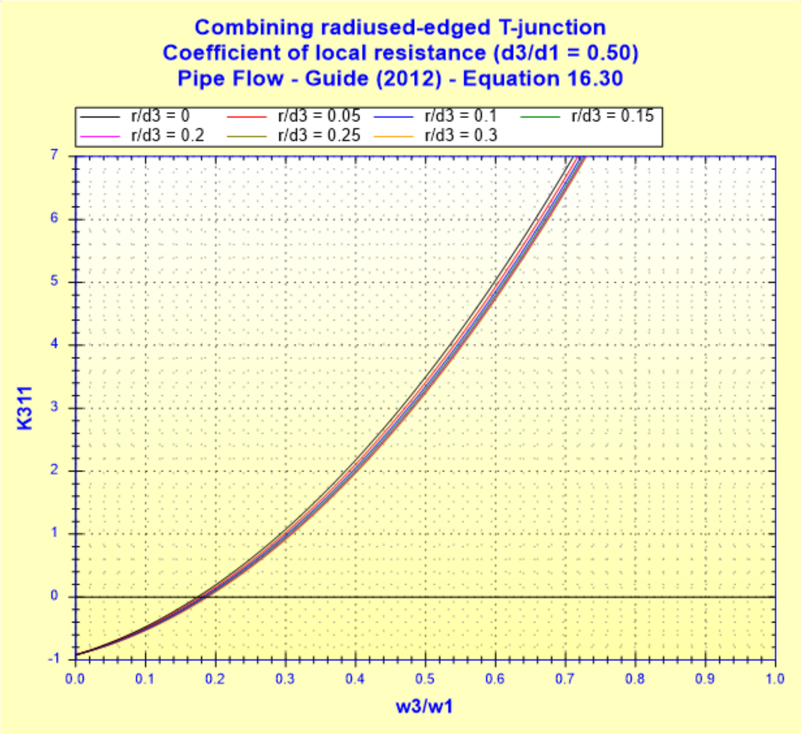
([1] equation 16.30)



([1] Equation 16.30 with r/d3 = 0.1)



([1] Equation 16.30 with w3/w1 = 0.5)

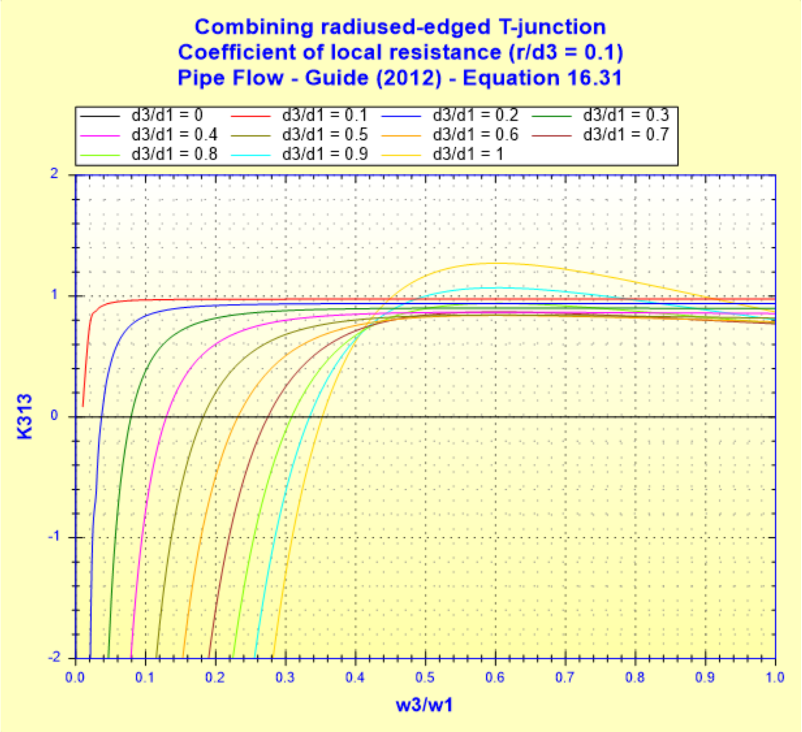


([1] Equation 16.30 with d3/d1 = 0.5)

Coefficient based on mean velocity in the straight branch:

$$K_{31_3} = 2 \cdot C_{yC} - 1 + \frac{d_3^{\ 4}}{d_1^{\ 4}} \cdot \left[2 \cdot (C_{xC} - 1) + 2 \cdot (2 - C_{xC} - C_M) \cdot \frac{w_1}{w_3} - 0.92 \cdot \frac{w_1^{\ 2}}{w_3^{\ 2}} \right]$$

([1] equation 16.31)



Pressure loss in the straight branch (Pa):

$$\Delta P_{21} = K_{21_1} \cdot \frac{\rho_m \cdot w_1^{\ 2}}{2}$$

Pressure loss in the side branch (Pa):

$$\Delta P_{31} = K_{31_1} \cdot \frac{\rho_m \cdot w_1^2}{2}$$

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

$$\Delta H_{21} = K_{21_1} \cdot \frac{w_1^2}{2 \cdot g}$$

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

$$\Delta H_{31} = K_{31_1} \cdot \frac{w_1^2}{2 \cdot g}$$

Hydraulic power loss in the straight branch (W):

$$Wh_{21} = \Delta P_{21} \cdot Q_2$$

Hydraulic power loss in the side branch (W):

$$Wh_{31} = \Delta P_{31} \cdot Q_3$$

Symbols, Definitions, SI Units:

d_2	Diameter of the straight and side branches (m)
d_3	Diameter of the side branch (m)
A_1	Cross-sectional area of the common branch (m^2)
A_2	Cross-sectional area of the straight branch (m^2)
A_3	Cross-sectional area of the side branch (m^2)
Q_1	Volume flow rate in the common branch (m^3/s)
V_1	Mean velocity in the common branch (m/s)
Q_2	Volume flow rate in the straight branch (m^3/s)
V_2	Mean velocity in the straight branch (m/s)
Q_3	Volume flow rate in the side branch (m^3/s)
V_3	Mean velocity in the side branch (m/s)
w_1	Mass flow rate in the common branch (kg/s)
w_2	Mass flow rate in the straight branch (kg/s)
w_3	Mass flow rate in the side branch (kg/s)
NRe_1	Reynolds number in the common branch ()
NRe_2	Reynolds number in the straight branch ()
NRe_3	Reynolds number in the side branch ()
r	Rounded radius (m)
C_M	Coefficient ()
C_{xC}	Coefficient ()
C_{yC}	Coefficient ()
K_{211}	Pressure loss coefficient of the straight branch (based on mean velocity in the common branch) ()
K_{311}	Pressure loss coefficient of the side branch (based on mean velocity in the common branch) ()

K_{212} Pressure loss coefficient of the straight branch (based on mean velocity in the straight branch) ()

K_{313} Pressure loss coefficient of the side branch (based on mean velocity in the side branch) ()

ΔP_{21} Pressure loss in the straight branch (Pa)

ΔP_{31} Pressure loss in the side branch (Pa)

ΔH_{21} Head loss of fluid in the straight branch (m)

ΔH_{31} Head loss of fluid in the side branch (m)

Wh_{21} Hydraulic power loss in the straight branch (W)

Wh_{31} Hydraulic power loss in the side branch (W)

ρ_m Fluid density (kg/m^3)

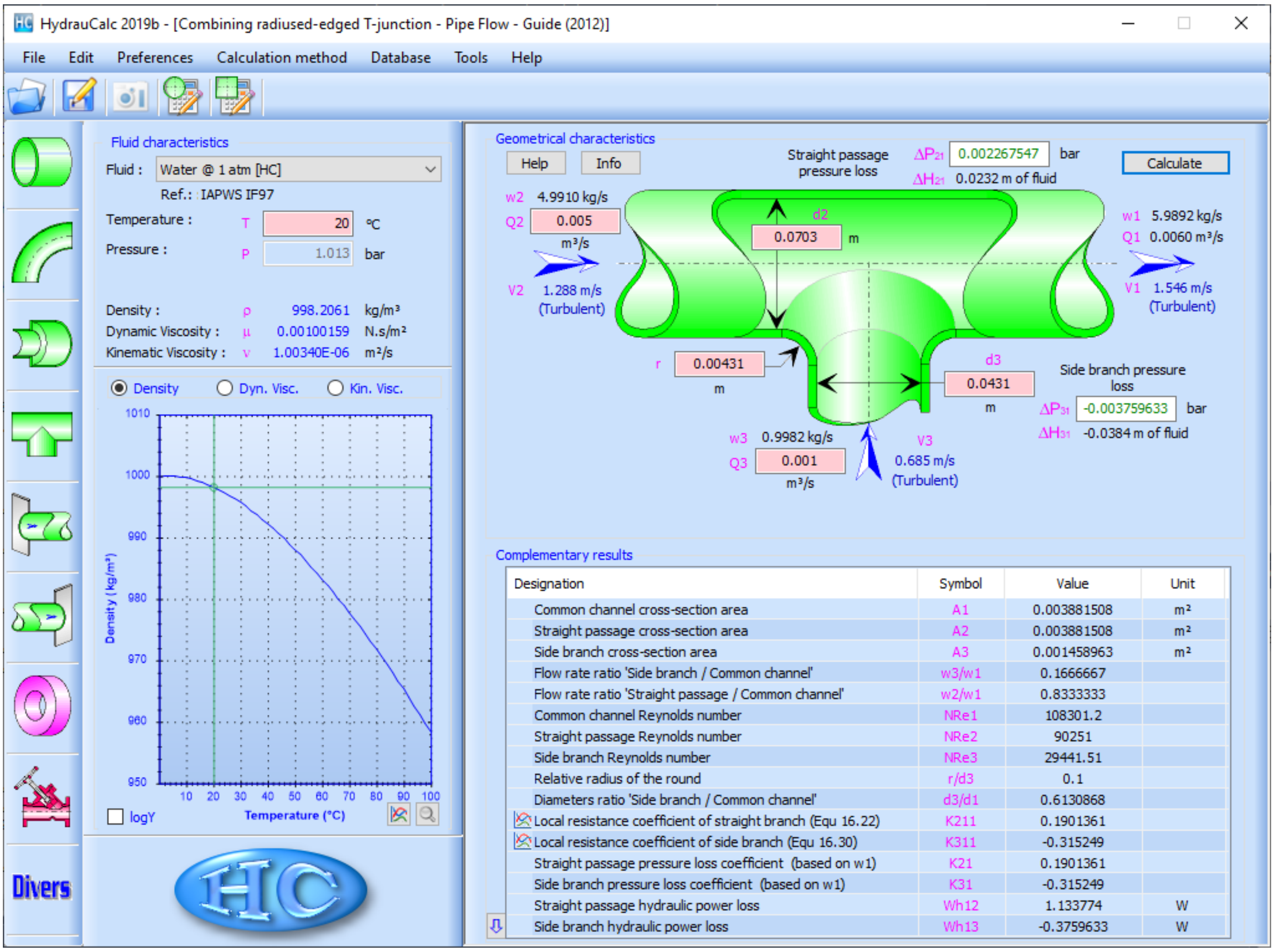
ν Fluid kinematic viscosity (m^2/s)

g Gravitational acceleration (m/s^2)

Validity range:

- turbulent flow regime ($NRe_1 \geq 10^4$)
- diameter of common branch lower than or equal to diameter of right and straight branches ($d_3 \leq d_2$)
- rounding ratio lower than or equal to 0.4 ($r/d_3 \leq 0.4$)

Example of application:



References:

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