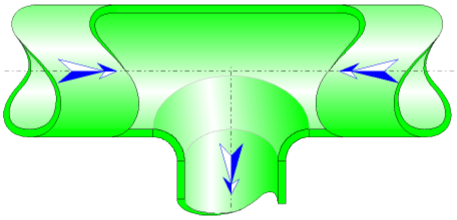
Symmetric combining radiused-edged T-junction
Circular Cross-Section
(Pipe Flow - Guide)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a symmetric combining radiused-edged T-junction with three legs of equal area.

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 three branches (m^2):

$$A_1 = \pi \cdot \frac{d_1^2}{4}$$

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

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

with $d_1 = d_2 = d_3 = d$

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

$$Q_1 = Q_2 + Q_3$$

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

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

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

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

Mean velocity in the right 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 left branch (kg/s):

$$w_2 = Q_2 \cdot \rho_m$$

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

$$w_3 = Q_3 \cdot \rho_m$$

Reynolds number in the common branch:

$$N\mathrm{Re}_1 = \frac{V_1 \cdot d_1}{\nu}$$

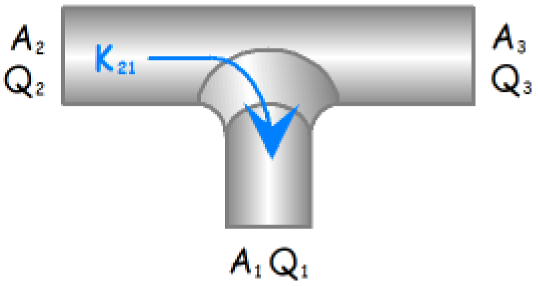
Reynolds number in the left branch:

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

Reynolds number in the right branch:

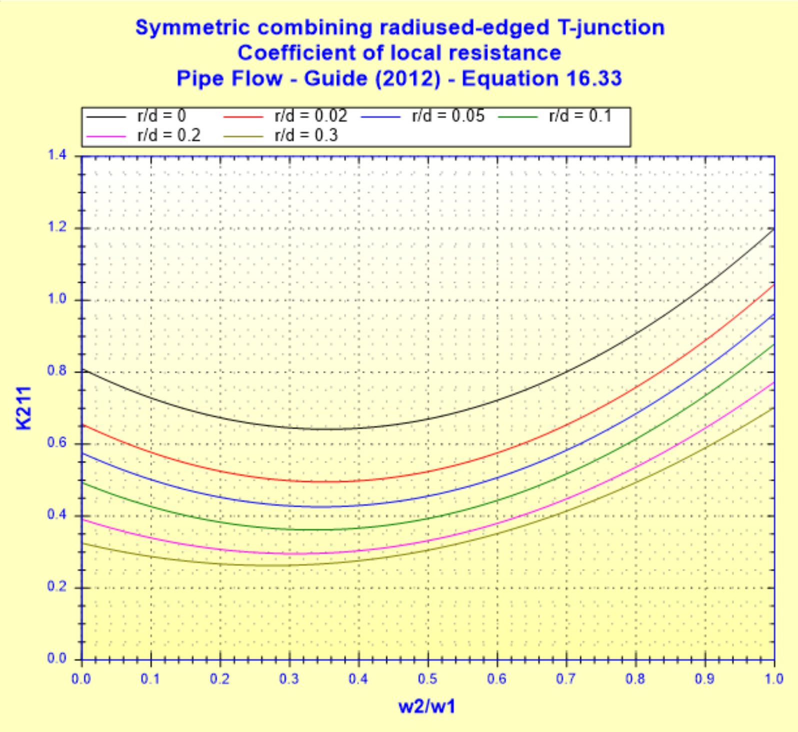
$$N\mathrm{Re}_3 = \frac{V_3 \cdot d_2}{\nu}$$

Pressure loss coefficient of the left branch:



Coefficient based on mean velocity in the common branch:

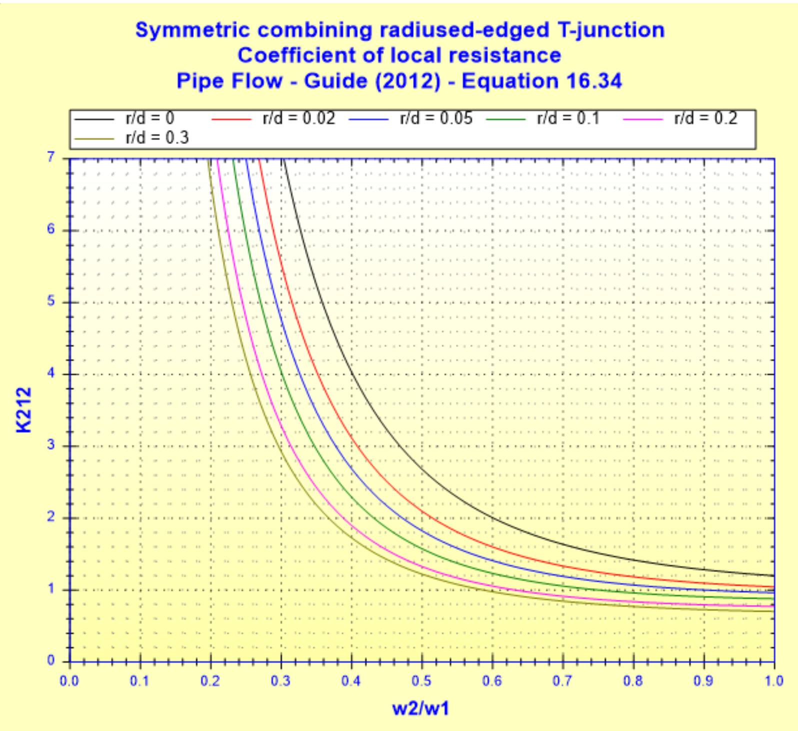
$$K_{21_1} = 0.81 - 1.16 \cdot \sqrt{\frac{r}{d}} + 0.5 \cdot \frac{r}{d} - \left(0.95 - 1.65 \cdot \frac{r}{d}\right) \cdot \frac{w_2}{w_1} + \left(1.34 - 1.69 \cdot \frac{r}{d}\right) \cdot \frac{w_2^{\;2}}{w_1^{\;2}}$$ ([1] equation 16.33)



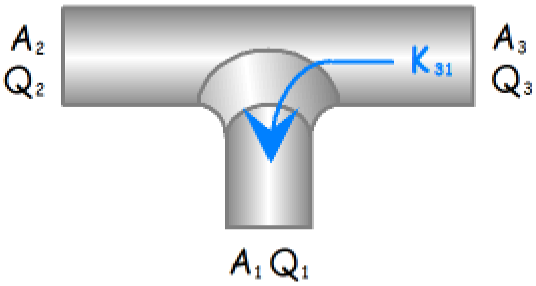
Coefficient based on mean velocity in the left branch:

$$K_{21_2} = \left(0.81 - 1.16 \cdot \sqrt{\frac{r}{d}} + 0.5 \cdot \frac{r}{d}\right) \cdot \frac{w_1^2}{w_2^2} - \left(0.95 - 1.65 \cdot \frac{r}{d}\right) \cdot \frac{w_1}{w_2} + 1.34 - 1.69 \cdot \frac{r}{d}$$

([1] equation 16.34)



Pressure loss coefficient of the right branch:

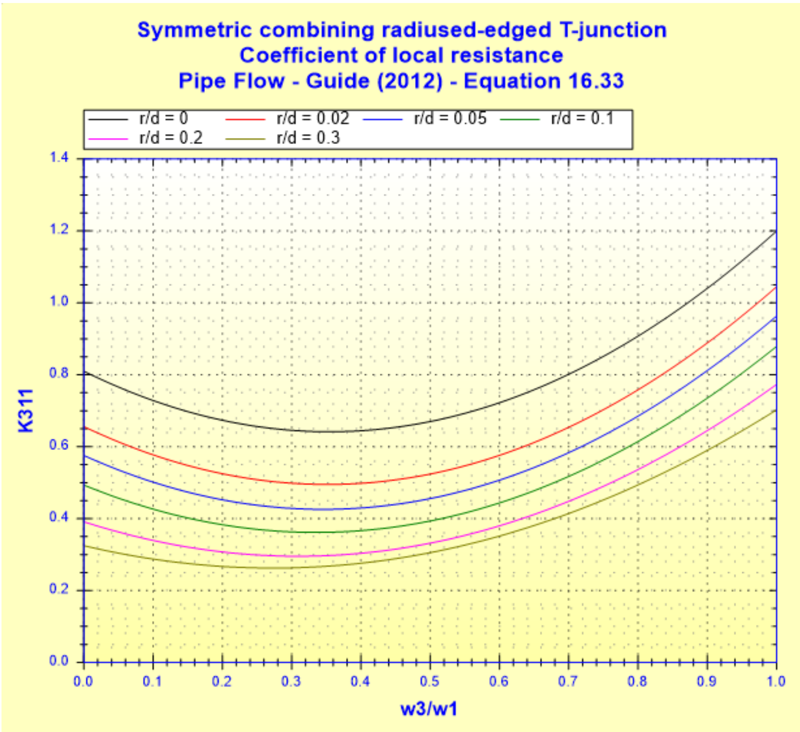


Note: for the right branch, the formulas are the same as those of the left branch, with subscript 3 instead of subscript 2.

Coefficient based on mean velocity in the common branch:

$$K_{31_1} = 0.81 - 1.16 \cdot \sqrt{\frac{r}{d}} + 0.5 \cdot \frac{r}{d} - \left(0.95 - 1.65 \cdot \frac{r}{d}\right) \cdot \frac{w_3}{w_1} + \left(1.34 - 1.69 \cdot \frac{r}{d}\right) \cdot \frac{{w_3}^2}{{w_1}^2}$$

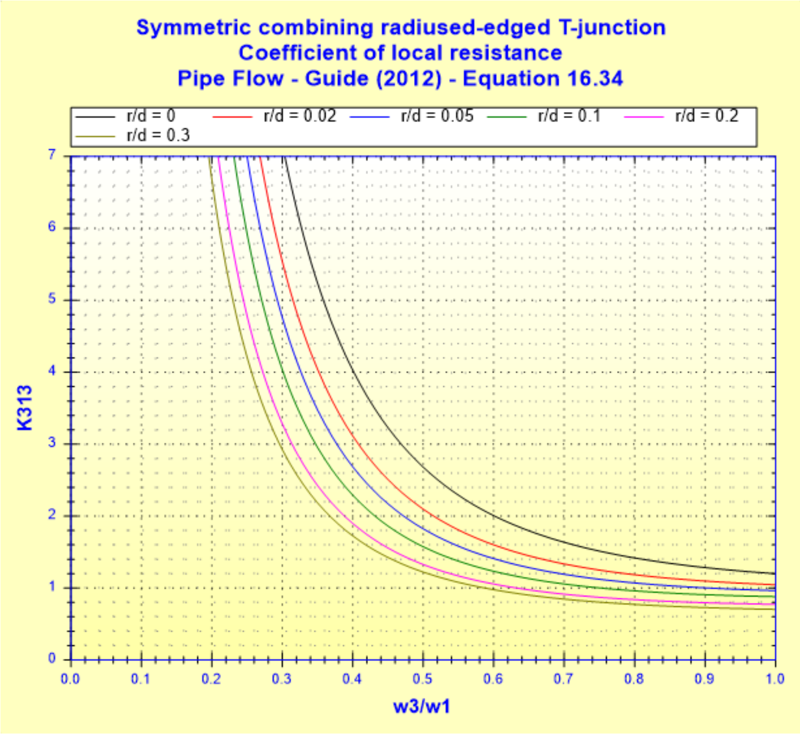
([1] equation 16.33)



Coefficient based on mean velocity in the right branch:

$$K_{31_3} = \left(0.81 - 1.16 \cdot \sqrt{\frac{r}{d}} + 0.5 \cdot \frac{r}{d}\right) \cdot \frac{{w_1}^2}{{w_3}^2} - \left(0.95 - 1.65 \cdot \frac{r}{d}\right) \cdot \frac{w_1}{w_3} + 1.34 - 1.69 \cdot \frac{r}{d}$$

([1] equation 16.34)



Pressure loss in the left branch (Pa):

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

Pressure loss in the right branch (Pa):

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

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

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

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

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

Hydraulic power loss in the left branch (W):

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

Hydraulic power loss in the right branch (W):

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

Symbols, Definitions, SI Units:

d	Inside diameter of the three branches (m)
d_1	Diameter of the common branch (m)
d_2	Diameter of the left branch (m)

d_3	Diameter of the right branch
A_1	Cross-sectional area of the common branch (m^2)
A_2	Cross-sectional area of the left branch (m^2)
A_3	Cross-sectional area of the right 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 left branch (m^3/s)
V_2	Mean velocity in the left branch (m/s)
Q_3	Volume flow rate in the right branch (m^3/s)
V_3	Mean velocity in the right branch (m/s)
w_1	Mass flow rate in the common branch (kg/s)
w_2	Mass flow rate in the left branch (kg/s)
w_3	Mass flow rate in the right branch (kg/s)
NRe_1	Reynolds number in the common branch ()
NRe_2	Reynolds number in the left branch ()
NRe_3	Reynolds number in the right branch ()
r	Rounded radius (m)
K_{211}	Pressure loss coefficient of the left branch (based on mean velocity in the common branch) ()
K_{311}	Pressure loss coefficient of the right branch (based on mean velocity in the common branch) ()
K_{212}	Pressure loss coefficient of the left branch (based on mean velocity in the left branch) ()
K_{313}	Pressure loss coefficient of the right branch (based on mean velocity in the right branch) ()
ΔP_{21}	Pressure loss in the left branch (Pa)
ΔP_{31}	Pressure loss in the right branch (Pa)
ΔH_{21}	Head loss of fluid in the left branch (m)
ΔH_{31}	Head loss of fluid in the right branch (m)
Wh_{21}	Hydraulic power loss in the left branch (W)
Wh_{31}	Hydraulic power loss in the right 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 ($NRe_1 \geq 10^4$)
- three legs of equal area ($d_1 = d_2 = d_3$)
- relative radius of the round (r/d) lower than or equal to 0.3d

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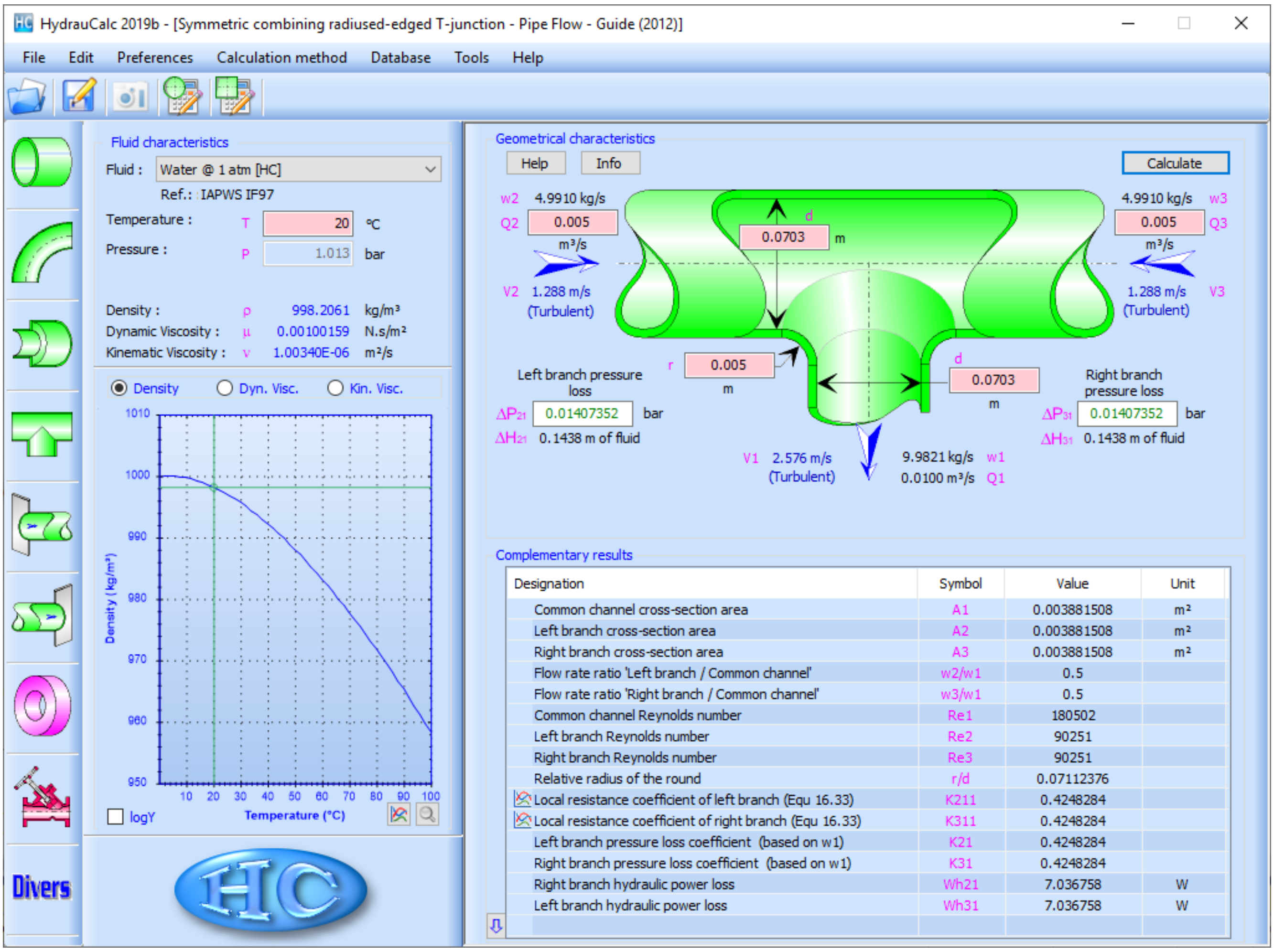
Example of application:



References:

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