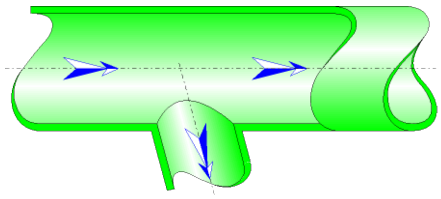
Dividing sharp-edged junction
Circular Cross-Section
(CRANE)



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:

Ratio between the diameter of the lateral branch and that of the common branch:

$$\boxed{\beta_b = \frac{d_b}{d_c}}$$

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

$$\boxed{A_b = \pi \cdot \frac{d_b^{\,2}}{4}}$$

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

$$\boxed{A_c = \pi \cdot \frac{d_c^{\,2}}{4}}$$

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

$$\boxed{Q_c = Q_b + Q_r}$$

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

$$\boxed{V_b = \frac{Q_b}{A_b}}$$

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

$$v_r = \frac{Q_r}{A_c}$$

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

$$v_c = \frac{Q_c}{A_c}$$

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

$$G_b = Q_b \cdot \rho$$

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

$$G_r = Q_r \cdot \rho$$

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

$$G_c = Q_c \cdot \rho$$

Reynolds number in the lateral branch:

$$\mathrm{Re}_b = \frac{v_b \cdot d_b}{\nu}$$

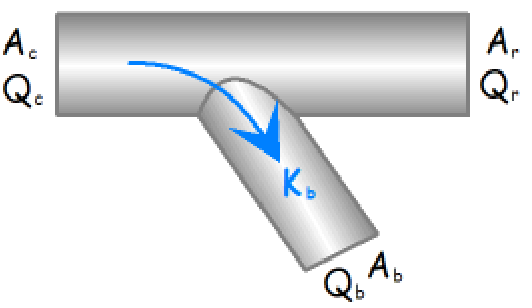
Reynolds number in the straight branch:

$$\mathrm{Re}_r = \frac{v_r \cdot d_c}{\nu}$$

Reynolds number in the common branch:

$$\mathrm{Re}_c = \frac{v_c \cdot d_c}{\nu}$$

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



$$K_b = G \cdot \left[1 + H \cdot \left(\frac{Q_b}{Q_c} \cdot \frac{1}{{\beta_b}^2} \right)^2 - J \cdot \left(\frac{Q_b}{Q_c} \cdot \frac{1}{{\beta_b}^2} \right) \cdot \cos(\alpha) \right]$$

([1] equation 2-37)

with:

Values of G, H, J

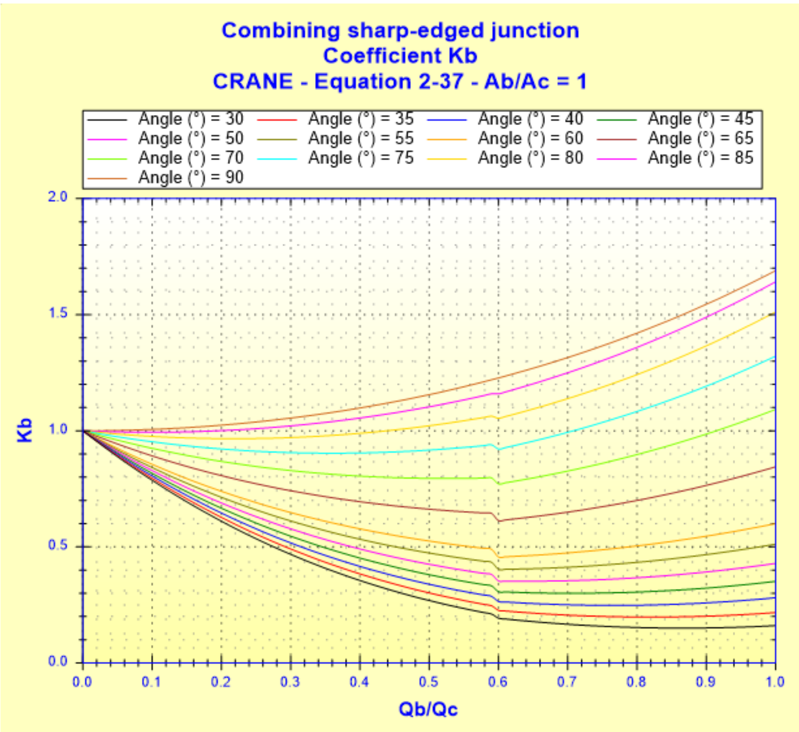
Angle	β	G	H	J
30° - 60°		Table 2-4	1	2
90°	$\leq 2/3$	1	1	2
	$> 2/3$	$1+0.3\cdot\left(\frac{Q_b}{Q_c}\right)^2$	0.3	0

([1] table 2-3)

Values of G for angle $\leq 60°$

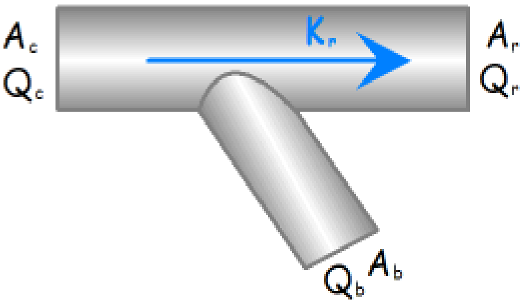
β^2_b	≤ 0.35		> 0.35	
Q_b / Q_c	≤ 0.4	> 0.4	≤ 0.6	> 0.6
G	$1.1-0.7\cdot\frac{Q_b}{Q_c}$	0.85	$1.0-0.6\cdot\frac{Q_b}{Q_c}$	0.6

([1] table 2-4)



([1] equation 2-37 with Ab/Ac = 1)

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



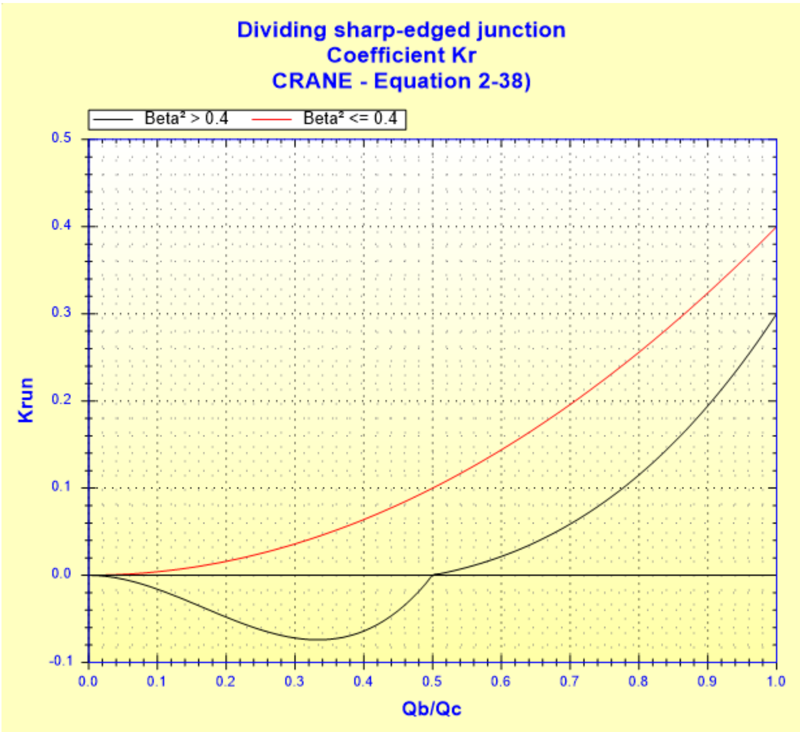
$$\boxed{K_r = M \cdot \left(\frac{Q_b}{Q_c}\right)^2}$$ ([1] equation 2-38)

with:

Values of M

Q_b / Q_c	≤ 0.5		> 0.5	
$\beta^2{}_b$	≤ 0.4	> 0.4	≤ 0.4	> 0.4
M	0.4	$2 \cdot \left(2 \cdot \frac{Q_b}{Q_c} - 1\right)$	0.4	$0.3 \cdot \left(2 \cdot \frac{Q_b}{Q_c} - 1\right)$

([1] table 2-5)



([1] equation 2-38)

Pressure loss in the lateral branch (Pa):

$$\boxed{\Delta P_b = K_b \cdot \frac{\rho \cdot V_c{}^2}{2}}$$

Pressure loss in the straight branch (Pa):

$$\boxed{\Delta P_r = K_r \cdot \frac{\rho \cdot V_c{}^2}{2}}$$

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

$$\boxed{\Delta H_b = K_b \cdot \frac{v_c^2}{2 \cdot g}}$$

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

$$\boxed{\Delta H_r = K_r \cdot \frac{v_c^2}{2 \cdot g}}$$

Hydraulic power loss in the lateral branch (W):

$$\boxed{Wh_b = \Delta P_b \cdot Q_b}$$

Hydraulic power loss in the straight branch (W):

$$\boxed{Wh_r = \Delta P_r \cdot Q_r}$$

Symbols, Definitions, SI Units:

d_b	Diameter of the lateral branch (m)
d_c	Diameter of the common branch and the straight branch (m)
β_b	Ratio between the diameter of the lateral branch and that of the common branch ()
A_b	Cross-sectional area of the lateral branch (m^2)
A_c	Cross-sectional area of the common branch and the straight branch (m^2)
Q_b	Volume flow rate in the lateral branch (m^3/s)
v_b	Mean velocity in the lateral branch (m/s)
Q_r	Volume flow rate in the straight branch (m^3/s)
v_r	Mean velocity in the straight branch (m/s)
Q_c	Volume flow rate in the common branch (m^3/s)
v_c	Mean velocity in the common branch (m/s)
G_b	Mass flow rate in the lateral branch (kg/s)
G_r	Mass flow rate in the straight branch (kg/s)
G_c	Mass flow rate in the common branch (kg/s)
Re_b	Reynolds number in the lateral branch ()
Re_r	Reynolds number in the straight branch ()
Re_c	Reynolds number in the common branch ()
α	Angle of the lateral branch (m)
K_b	Pressure loss coefficient of the lateral branch (based on mean velocity in the common branch) ()
K_r	Pressure loss coefficient of the straight branch (based on mean velocity in the common branch) ()
ΔP_b	Pressure loss in the lateral branch (Pa)
ΔP_r	Pressure loss in the straight branch (Pa)
ΔH_b	Head loss of fluid in the lateral branch (m)
ΔH_r	Head loss of fluid in the straight branch (m)
Wh_b	Hydraulic power loss in the lateral branch (W)
Wh_r	Hydraulic power loss in the straight branch (W)

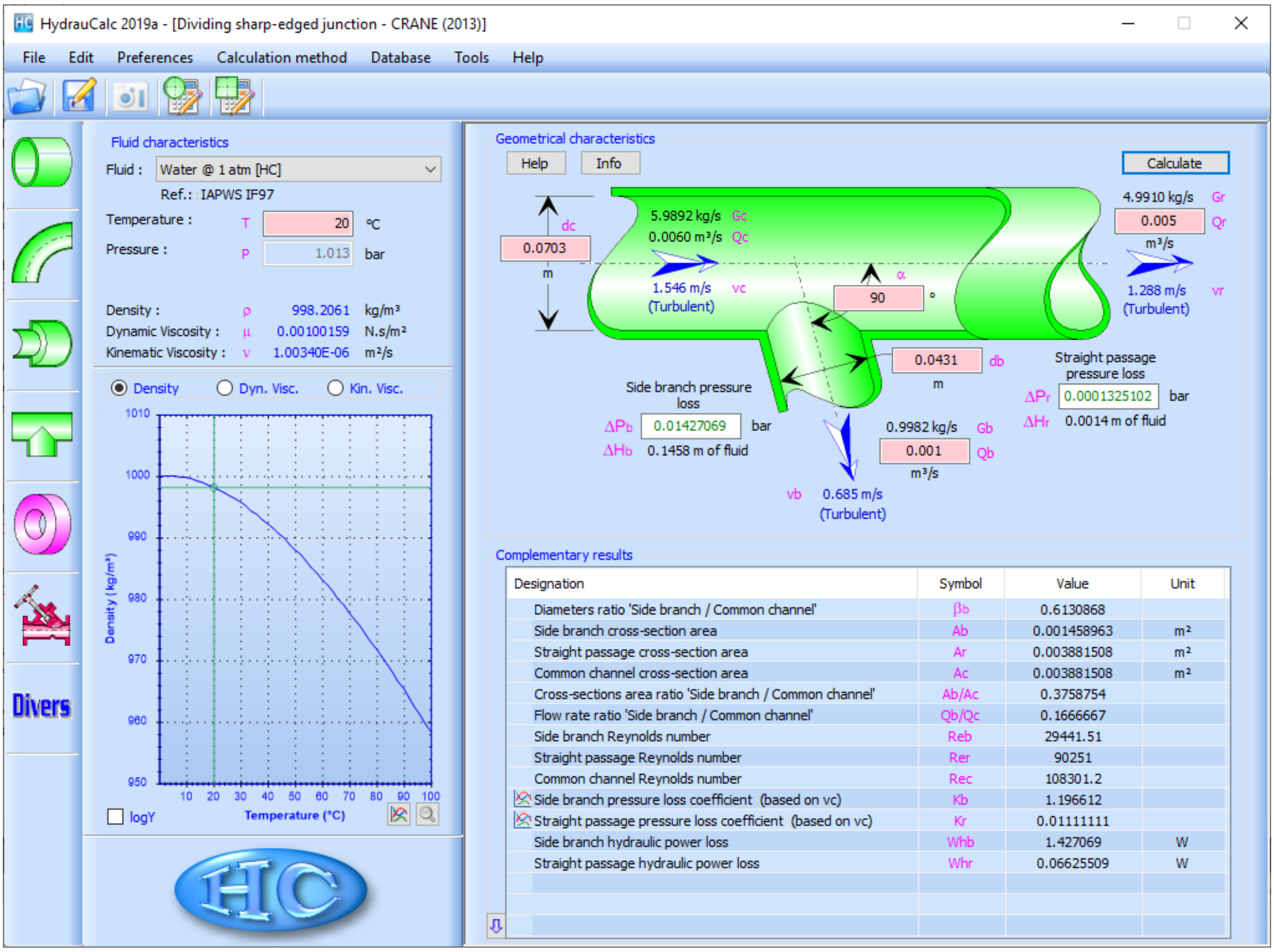
ρ	Fluid density (kg/m^3)
ν	Fluid kinematic viscosity (m^2/s)
g	Gravitational acceleration (m/s^2)

note: the indices $_b$, $_r$ and $_c$ correspond respectively to the indices $_{branch}$, $_{run}$ and $_{combined}$ of the reference document.

Validity range:

- turbulent flow regime ($Re_c \geq 10^4$)
- angle of the lateral branch: between 30° and 90°

Example of application:



References:

[1] CRANE - Flow of Fluids Through Valves, Fitting and Pipe - Technical Paper No. 410 - Edition 2013