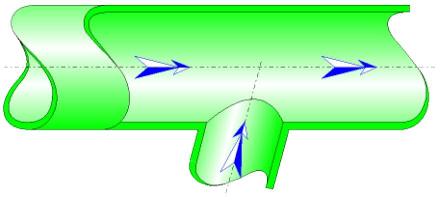
Combining sharp-edged junction
Circular Cross-Section
(CRANE)



Model description:

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

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

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

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

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

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

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

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

$$Q_c = Q_b + Q_r$$

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

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

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:

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

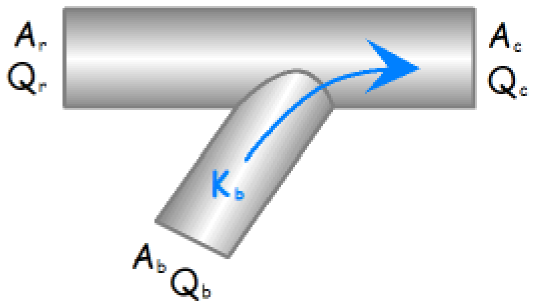
Reynolds number in the straight branch:

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

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):



$$K_b = C_b \cdot \left[1 + D_b \cdot \left(\frac{Q_b}{Q_c} \cdot \frac{1}{{\beta_b}^2} \right)^2 - E_b \cdot \left(1 - \frac{Q_b}{Q_c} \right)^2 - F_b \cdot \frac{1}{{\beta_b}^2} \cdot \left(\frac{Q_b}{Q_c} \right)^2 \right]$$

([1] equation 2-35)

with:

Values of D_b, E_b, F_b

Angle	D_b	E_b	F_b
30°	1	2	1.74
45°	1	2	1.41
60°	1	2	1
90°	1	2	0

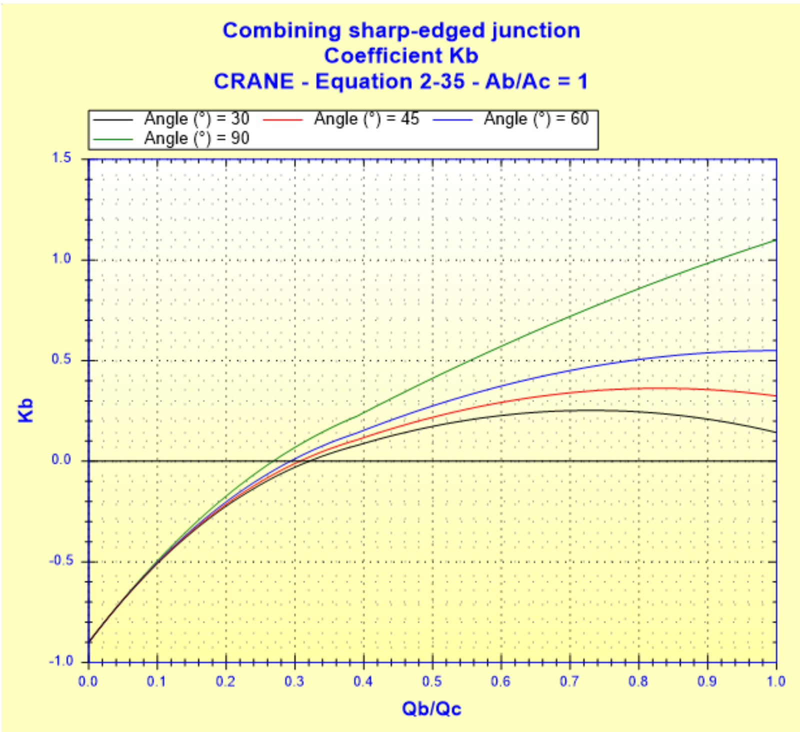
([1] table 2-1)

For any angles between 30 ° and 90 °, the coefficients D_b, E_b, F_b are obtained by linear interpolation of the coefficients of the table 2-1.

Values of C_b

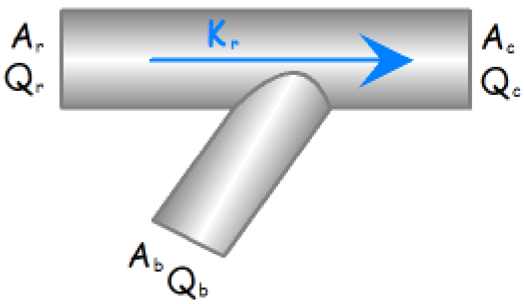
Q_b / Q_c	≤ 0.4		> 0.4	
β^2_b	≤ 0.35	> 0.35	≤ 0.35	> 0.35
C_b	1	$0.9 \cdot \left(1 - \frac{Q_b}{Q_c}\right)$	1	0.55

([1] table 2-2)



([1] equation 2-35 with Ab/Ac = 1)

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



- Angle ≤ 60°

$$K_r = C_r \cdot \left[1 + D_r \cdot \left(\frac{Q_b}{Q_c} \cdot \frac{1}{\beta_b{}^2} \right)^2 - E_r \cdot \left(1 - \frac{Q_b}{Q_c} \right)^2 - F_r \cdot \frac{1}{\beta_b{}^2} \cdot \left(\frac{Q_b}{Q_c} \right)^2 \right]$$

([1] equation 2-35)

with:

Values of C_r , D_r, E_r ,F_r

Angle	C_r	D_r	E_r	F_r
30°	1	0	1	1.74
45°	1	0	1	1.41
60°	1	0	1	1

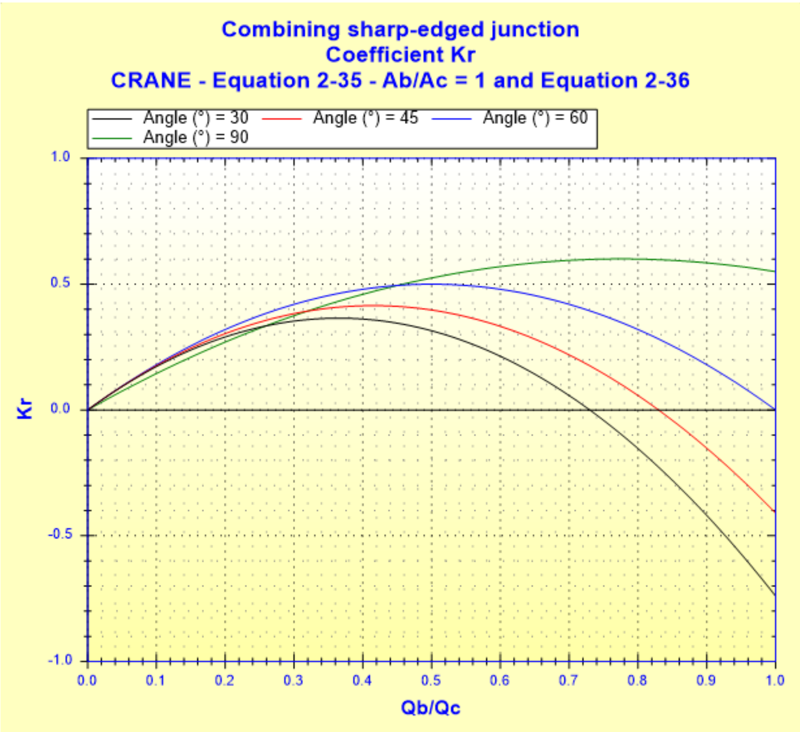
([1] table 2-1)

For arbitrary angles between 30 ° and 60 °, the coefficients C_r , D_r, E_r ,F_r are obtained by linear interpolation of the coefficients of table 2-1.

■ Angle = 90°

$$K_r = 1.55 \cdot \left(\frac{Q_b}{Q_c} \right) - \left(\frac{Q_b}{Q_c} \right)^2$$

([1] equation 2-36)



([1] equations 2-35 with Ab/Ac = 1 and 2-36)

For any angles between 60 ° and 90 °, the coefficient Kr is obtained by linear interpolation between the value of Kr calculated at 60 ° and that calculated at 90 °.

Pressure loss in the lateral branch (Pa):

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

Pressure loss in the straight branch (Pa):

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

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

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

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

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

Hydraulic power loss in the lateral branch (W):

$$Wh_b = \Delta P_b \cdot Q_b$$

Hydraulic power loss in the straight branch (W):

$$Wh_r = \Delta P_r \cdot Q_r$$

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)

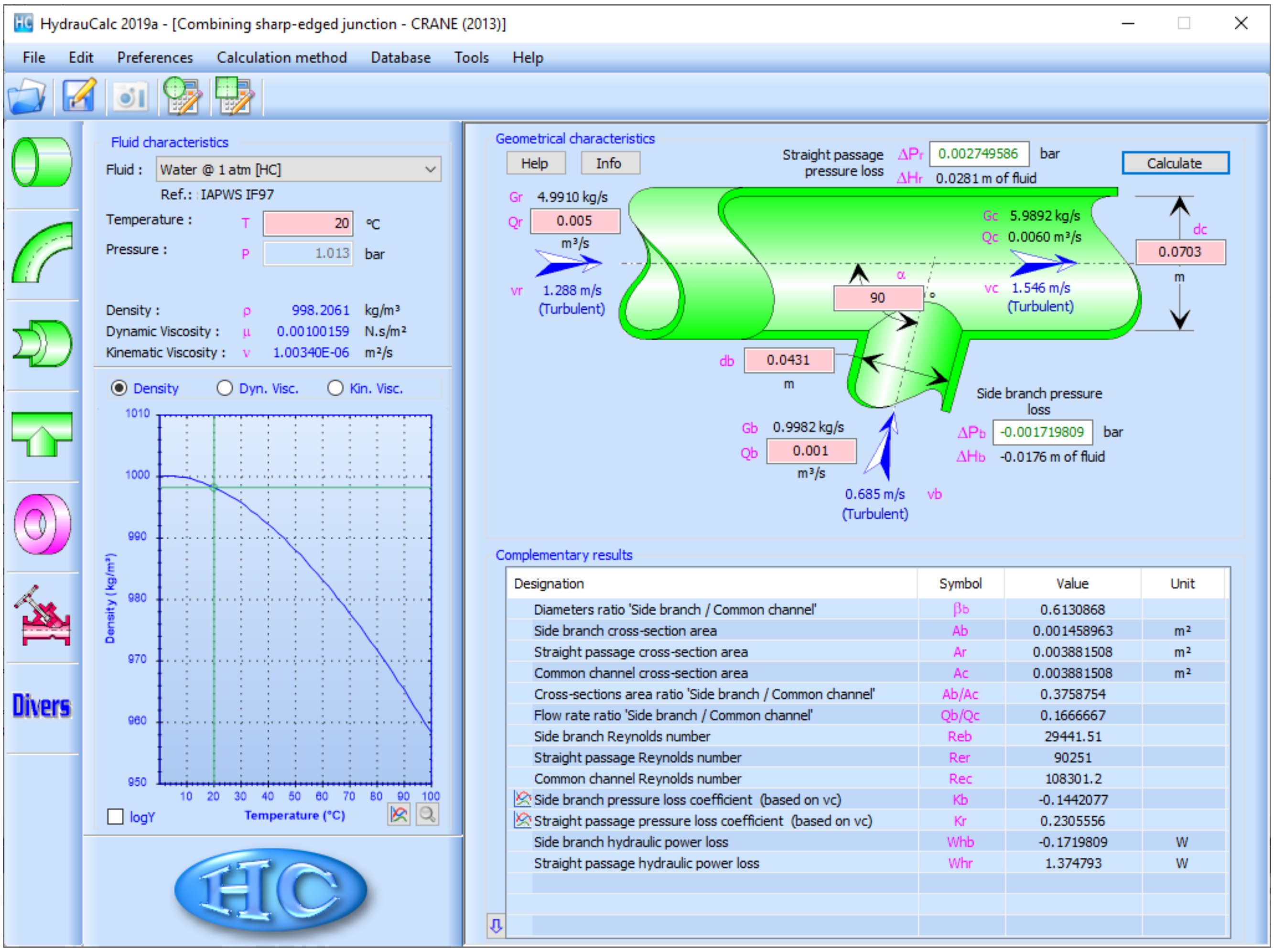
ΔH_r	Head loss of fluid in the straight branch (m)
Wh_b	Hydraulic power loss in the lateral branch (W)
Wh_r	Hydraulic power loss in the straight branch (W)
ρ	Fluid density (kg/m³)
ν	Fluid kinematic viscosity (m²/s)
g	Gravitational acceleration (m/s²)

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