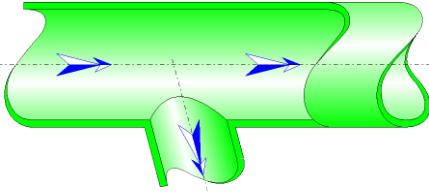




Dividing sharp-edged junction Circular Cross-Section (CRANE)



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:

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

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:

$$Re_b = \frac{v_b \cdot d_b}{\nu}$$

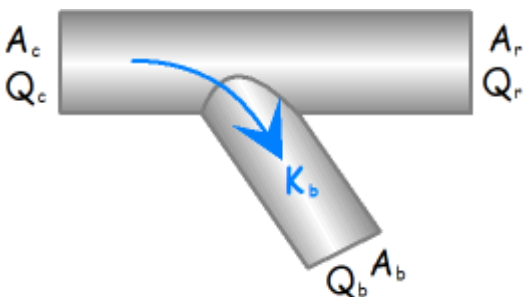
Reynolds number in the straight branch:

$$Re_r = \frac{v_r \cdot d_c}{\nu}$$

Reynolds number in the common branch:

$$Re_c = \frac{v_c \cdot d_c}{\nu}$$

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

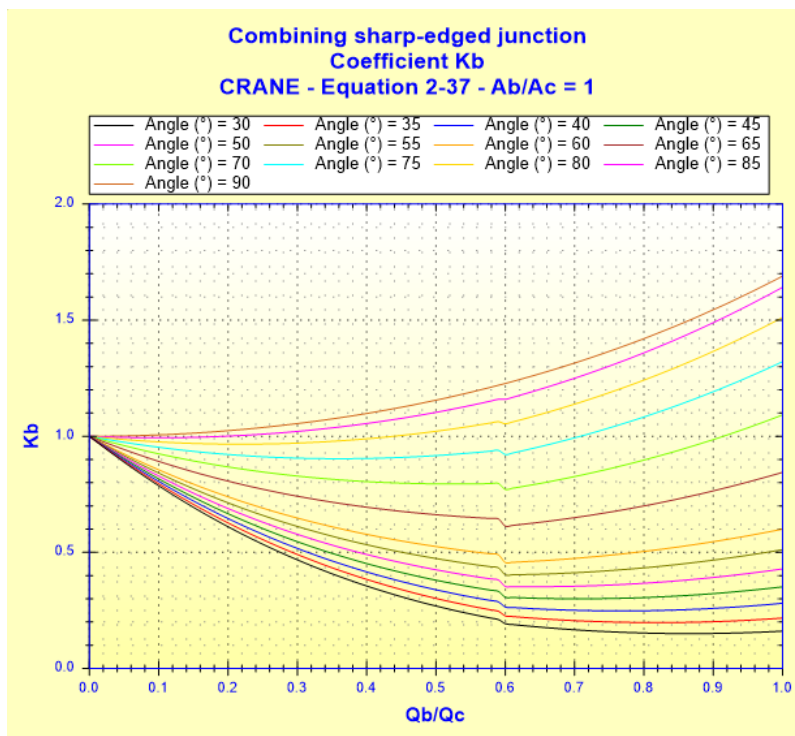
([1] table 2-

3)

Values of G for angle $\leq 60^\circ$

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

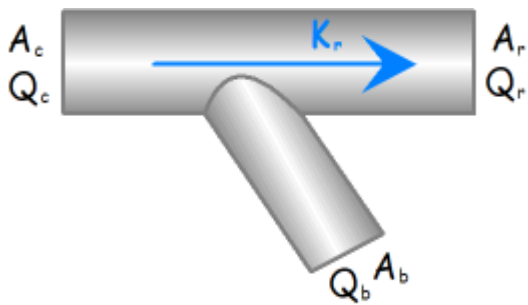
([1] table 2-4)



([1] equation 2-37 with

$Ab/Ac = 1$)

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



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

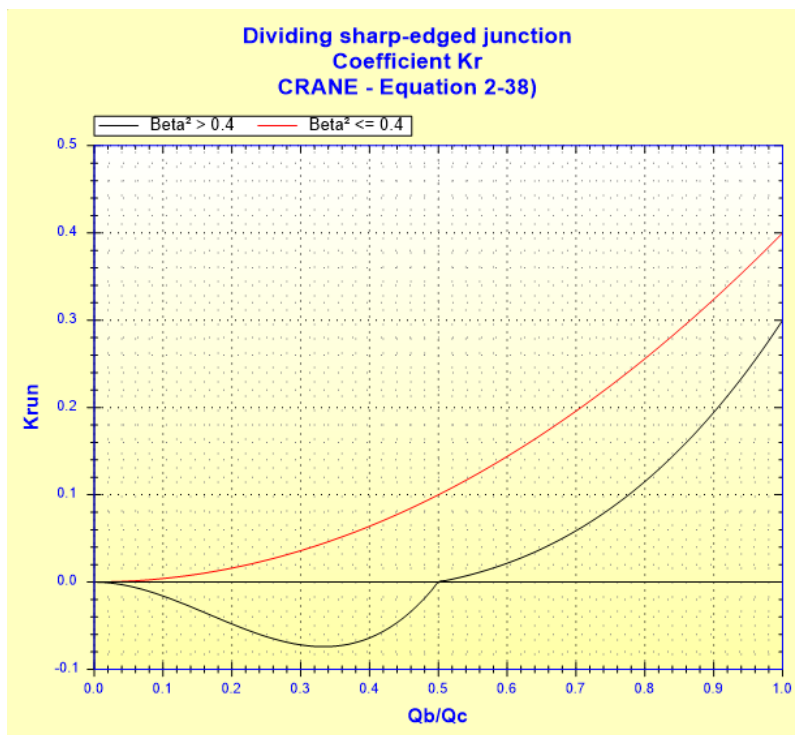
([1] equation 2-38)

with:

Values of M

Q_b / Q_c	≤ 0.5		> 0.5	
	≤ 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):

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

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/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:

The screenshot shows the HydraulCalc 2019a software interface for a 'Dividing sharp-edged junction - CRANE (2013)'. The software is set to calculate for Water @ 1 atm [HC].

Fluid characteristics:

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

Geometrical characteristics:

- Common channel diameter: $d_c = 0.0703$ m
- Side branch diameter: $d_b = 0.0431$ m
- Angle of lateral branch: $\alpha = 90^\circ$
- Common channel flow rate: $Q_c = 0.0060$ m^3/s ($v_c = 1.546$ m/s, Turbulent)
- Side branch flow rate: $Q_b = 0.001$ m^3/s ($v_b = 0.685$ m/s, Turbulent)
- Run flow rate: $Q_r = 0.005$ m^3/s ($v_r = 1.288$ m/s, Turbulent)
- Total flow rate: $Q = 4.9910$ kg/s
- Side branch pressure loss: $\Delta P_b = 0.01427069$ bar
- Side branch hydraulic head loss: $\Delta H_b = 0.1458$ m of fluid
- Straight passage pressure loss: $\Delta P_r = 0.0001325102$ bar
- Straight passage hydraulic head loss: $\Delta H_r = 0.0014$ m of fluid

Complementary results:

Designation	Symbol	Value	Unit
Diameters ratio 'Side branch / Common channel'	β_b	0.6130868	
Side branch cross-section area	A_b	0.001458963	m^2
Straight passage cross-section area	A_r	0.003881508	m^2
Common channel cross-section area	A_c	0.003881508	m^2
Cross-sections area ratio 'Side branch / Common channel'	A_b/A_c	0.3758754	
Flow rate ratio 'Side branch / Common channel'	Q_b/Q_c	0.1666667	
Side branch Reynolds number	Re_b	29441.51	
Straight passage Reynolds number	Re_r	90251	
Common channel Reynolds number	Re_c	108301.2	
Side branch pressure loss coefficient (based on v_c)	K_b	1.196612	
Straight passage pressure loss coefficient (based on v_c)	K_r	0.01111111	
Side branch hydraulic power loss	W_{hb}	1.427069	W
Straight passage hydraulic power loss	W_{hr}	0.06625509	W

References:

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