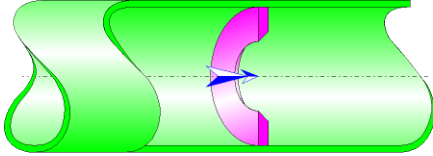




## Square-Edged Orifice Circular Cross-Section (CRANE)



### Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a square-edged orifice.

The head loss by friction in the inlet and outlet piping is not taken into account in this component.

### Model formulation:

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Diameter ratio:

$$\beta = \frac{D_1}{D_2}$$

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Orifice cross-sectional area (m<sup>2</sup>):

$$A_1 = \pi \cdot \frac{D_1^2}{4}$$

---

Pipe cross-sectional area (m<sup>2</sup>):

$$A_2 = \pi \cdot \frac{D_2^2}{4}$$

---

Mean velocity in orifice (m/s):

$$v_1 = \frac{q}{A_1}$$

---

Mean velocity in pipe (m/s):

$$v_2 = \frac{q}{A_2}$$

---

Mass flow rate (kg/s):

$$w = q \cdot \rho$$

Reynolds number in orifice:

$$Re_1 = \frac{v_1 \cdot D_1}{\nu}$$

Reynolds number in pipe:

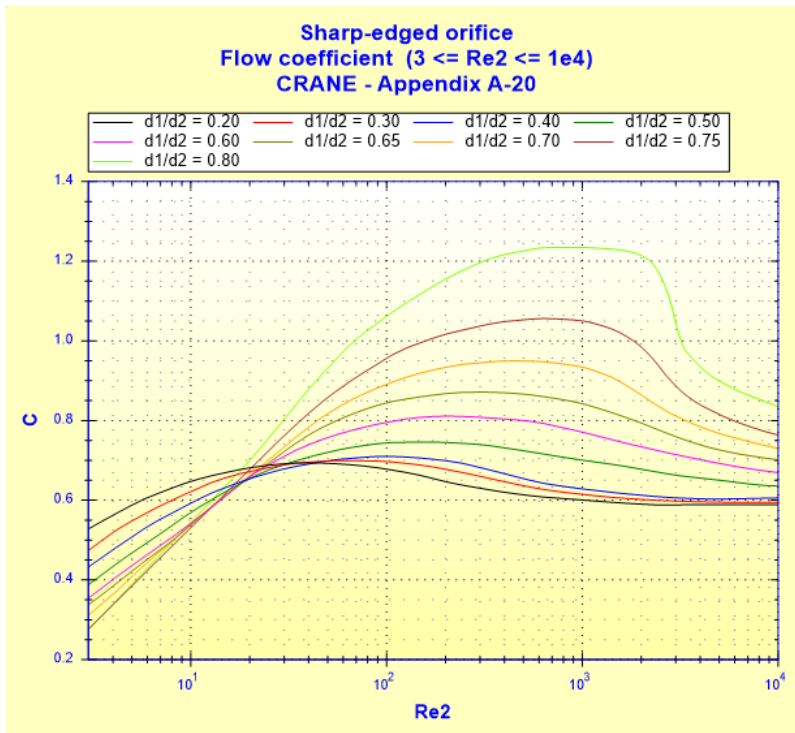
$$Re_2 = \frac{v_2 \cdot D_2}{\nu}$$

Flow coefficient:

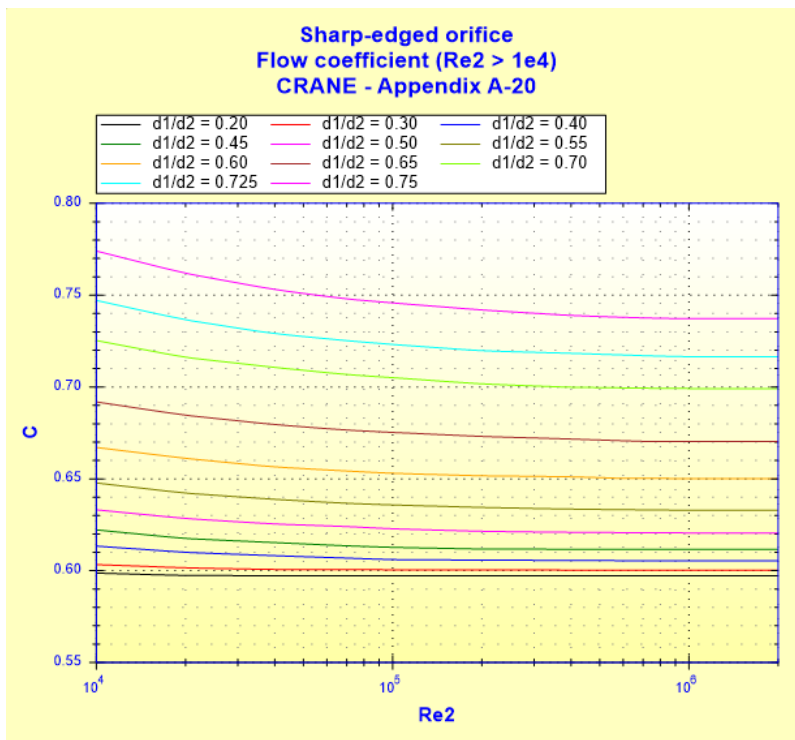
$$C = f\left(Re_2, \frac{d_1}{d_2}\right)$$

([1] appendix A-20)

■  $3 \leq Re_2 \leq 10^4$



■  $Re_2 > 10^4$



Resistance coefficient of orifice:

$$K_o = \frac{1 - \beta^2}{C^2 \cdot \beta^4} \quad ([1] \text{ appendix A-20})$$

Total pressure loss coefficient (based on mean velocity in pipe):

$$K = K_o$$

Total pressure loss (Pa):

$$\Delta P = K \cdot \frac{\rho \cdot v_2^2}{2}$$

Total head loss of fluid (m):

$$\Delta H = K \cdot \frac{v_2^2}{2 \cdot g}$$

Hydraulic power loss (W):

$$Wh = \Delta P \cdot Q$$

**Symbols, Definitions, SI Units:**

- D<sub>1</sub> Orifice diameter (m)
- D<sub>2</sub> Pipe diameter (m)
- β Diameter ratio ( )
- A<sub>1</sub> Orifice cross-sectional area (m<sup>2</sup>)
- A<sub>2</sub> Pipe cross-sectional area (m<sup>2</sup>)
- q Volume flow rate (m<sup>3</sup>/s)
- w Mass flow rate (kg/s)

$v_1$	Mean velocity in orifice (m/s)
$v_2$	Mean velocity in pipe (m/s)
$Re_1$	Reynolds number in orifice ( )
$Re_2$	Reynolds number in pipe ( )
$C$	Flow coefficient ( )
$K_o$	Resistance coefficient of orifice ( )
$K$	Total pressure loss coefficient (based on mean velocity in pipe) ( )
$\Delta P$	Total pressure loss (Pa)
$\Delta H$	Total head loss of fluid (m)
$Wh$	Hydraulic power loss (W)
$\rho$	Fluid density ( $\text{kg/m}^3$ )
$\nu$	Fluid kinematic viscosity ( $\text{m}^2/\text{s}$ )
$g$	Gravitational acceleration ( $\text{m/s}^2$ )

#### Validity range:

- any flow regime: laminar and turbulent
- stabilized flow upstream of the orifice

note: 1) for Reynolds number " $Re_2$ " between 3 and  $10^4$ , and diameter ratio " $D_1/D_2$ " lower than 0.2 or greater than 0.8, the flow coefficient " $C$ " is extrapolated

2) for Reynolds number " $Re_2$ " between  $10^4$  and  $2 \cdot 10^6$ , and diameter ratio " $D_1/D_2$ " lower than 0.2 or greater than 0.75, the flow coefficient " $C$ " is extrapolated

#### Example of application:

HydrauCalc 2018a - [Sharp-edged orifice - CRANE (1999)]

File Edit Preferences Calculation method Database Tools Help

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<sup>3</sup>  
Dynamic Viscosity :  $\mu$  0.00100159 N.s/m<sup>2</sup>  
Kinematic Viscosity :  $\nu$  1.00340E-06 m<sup>2</sup>/s

Density  Dyn. Visc.  Kn. Visc.

Geometrical characteristics

Help Info Calculate

4.9910 kg/s  
Q 0.005 m<sup>3</sup>/s  
V1 5.197 m/s  
V2 1.288 m/s (Turbulent)  
D1 0.035 m  
D2 0.0703 m  
Pressure loss  $\Delta P$  0.2614716 bar  
 $\Delta H$  2.6711 m of fluid

Complementary results

Designation	Symbol	Value	Unit
Pipe cross-section area	S2	0.003881508	m <sup>2</sup>
Orifice cross-section area	S1	0.0009621127	m <sup>2</sup>
Diameters ratio	$\beta$	0.4978663	
Cross-sections area ratio	S1/S2	0.2478708	
Pipe Reynolds number	Re2	90251	
Orifice Reynolds number	Re1	181275.6	
Flow coefficient - Appendix A-20	C	0.6226917	
Pressure loss coefficient (based on the mean pipe velocity)	Ko	31.57151	
Hydraulic power loss	Wh	130.7358	W

## References:

[1] CRANE - Flow of Fluids Through Valves, Fitting and Pipe - Technical Paper No. 410 - Edition 1999