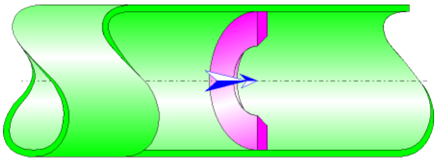
Sharp-edged Orifice
Circular Cross-Section
(MILLER)



Model description:

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

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

Model formulation:

Pipe cross-sectional area (m^2):

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

Orifice cross-sectional area (m^2):

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

Mean velocity in pipe (m/s):

$$U = \frac{Q}{A_1}$$

Mean velocity in orifice (m/s):

$$u = \frac{Q}{A_2}$$

Mass flow rate (kg/s):

$$G = Q \cdot \rho$$

Reynolds number in pipe:

$$\mathrm{Re}_1 = \frac{U \cdot D}{\nu}$$

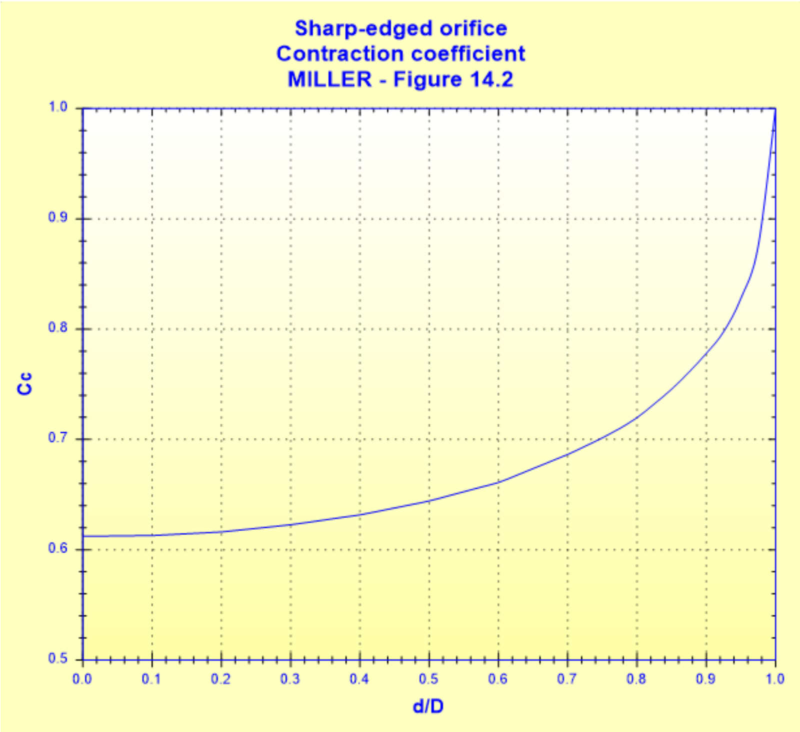
Reynolds number in orifice:

$$\mathrm{Re}_2 = \frac{u \cdot d}{\nu}$$

Contraction coefficient:

$$C_c = f\left(\frac{d}{D}\right)$$

([1] figure 14.2)



Vena contracta cross-sectional area (m²):

$$A_c = d \cdot \left(\frac{d}{D}\right)^2 \cdot C_c$$

Mean velocity in vena contracta (m/s):

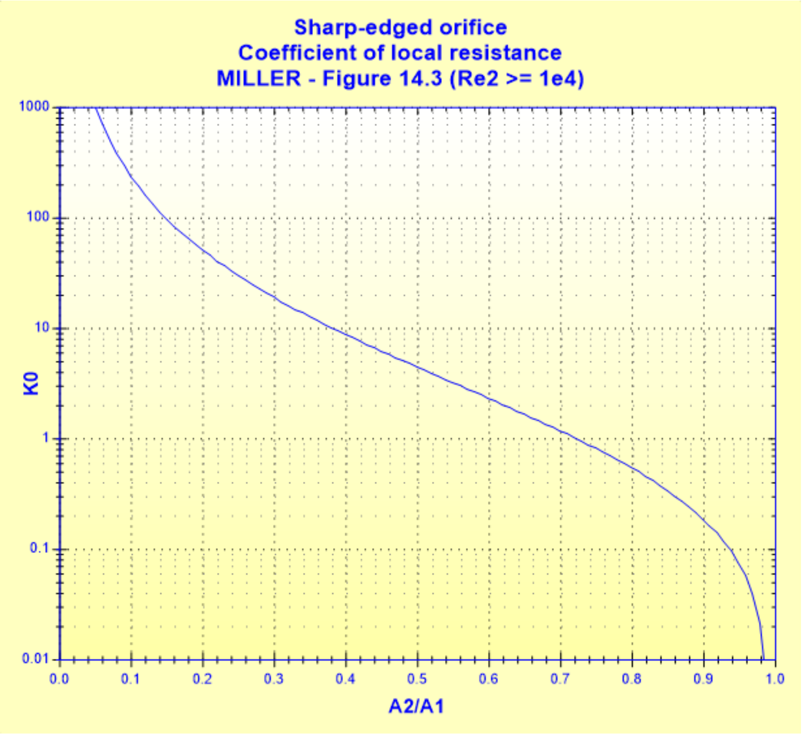
$$U_c = \frac{Q}{A_c}$$

Local resistance Coefficient:

- $\mathrm{Re}_2 \geq 10^4$

$$K_0 = f\left(\frac{A_2}{A_1}\right)$$

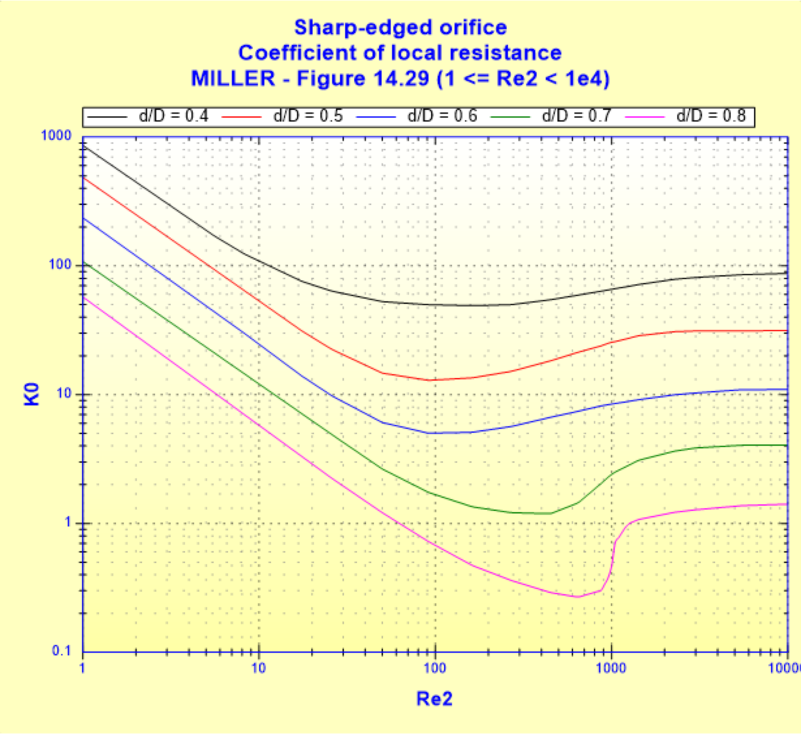
([1] figure 14.3)



■ $Re_2 < 10^4$

$$K_0 = f\left(Re_2, \frac{d}{D}\right)$$

([1] figure 14.29)



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

$$K = K_0$$

Total pressure loss (Pa):

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

Total head loss of fluid (m):

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

Hydraulic power loss (W):

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

Symbols, Definitions, SI Units:

D	Pipe internal diameter (m)
d	Orifice diameter (m)
A_1	Pipe cross-sectional area (m²)
A_2	Orifice cross-sectional area (m²)
Q	Volume flow rate (m³/s)
G	Mass flow rate (kg/s)
U	Mean velocity in pipe (m/s)
u	Mean velocity in orifice (m/s)
Re_1	Reynolds number in pipe ()
Re_2	Reynolds number in orifice ()
C_c	Contraction coefficient ()
A_c	Vena contracta cross-sectional area (m²)
U_c	Mean velocity in vena contracta (m/s)
K_0	Coefficient of local resistance ()
K	Total pressure loss coefficient (based on mean velocity in pipe) ()
ΔP	Total pressure loss (Pa)
ΔH	Total head loss of fluid (m)
Wh	Hydraulic power loss (W)
ρ	Fluid density (kg/m³)
ν	Fluid kinematic viscosity (m²/s)
g	Gravitational acceleration (m/s²)

Validity range:

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

note: 1) for diameters ratios "d/D" lower than 0.4 or greater than 0.8 and when the Reynolds number in the orifice "Re_2" is lower than 10^4, the local resistance coefficient "K_0" is extrapolated

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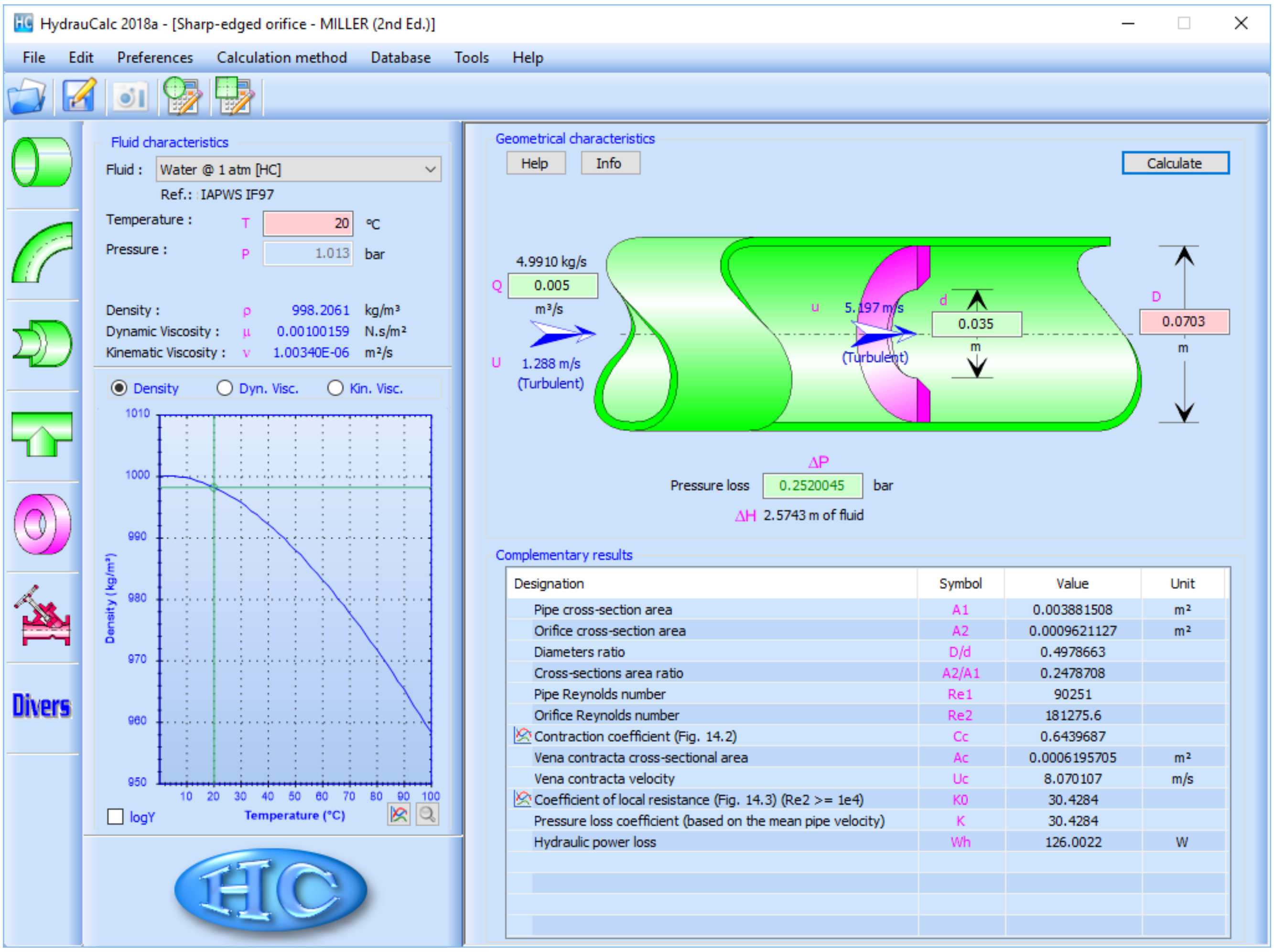
Example of application:



References:

[1] Internal Flow System, Second Edition, D.S. Miller