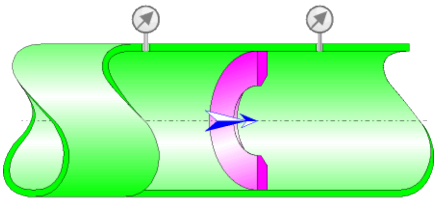
Square-Edge Orifice Flowmeter
D and D/2 pressure tapings
(CRANE)



Model description:

This model of component determines the fluid flow through a square-edge orifice flowmeter with D & D/2 pressure tappings, according to the reference document [1].

Model formulation:

Diameter ratio:

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

Orifice cross-sectional area (m^2):

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

Pipe cross-sectional area (m^2):

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

Mean velocity in orifice (m/s):

$$V_1 = \frac{q}{A_1}$$

Mean velocity in pipe (m/s):

$$V_2 = \frac{q}{A_2}$$

Reynolds number in orifice:

$$\mathrm{Re}_1 = \frac{V_1 \cdot D_1}{\nu}$$

Reynolds number in pipe:

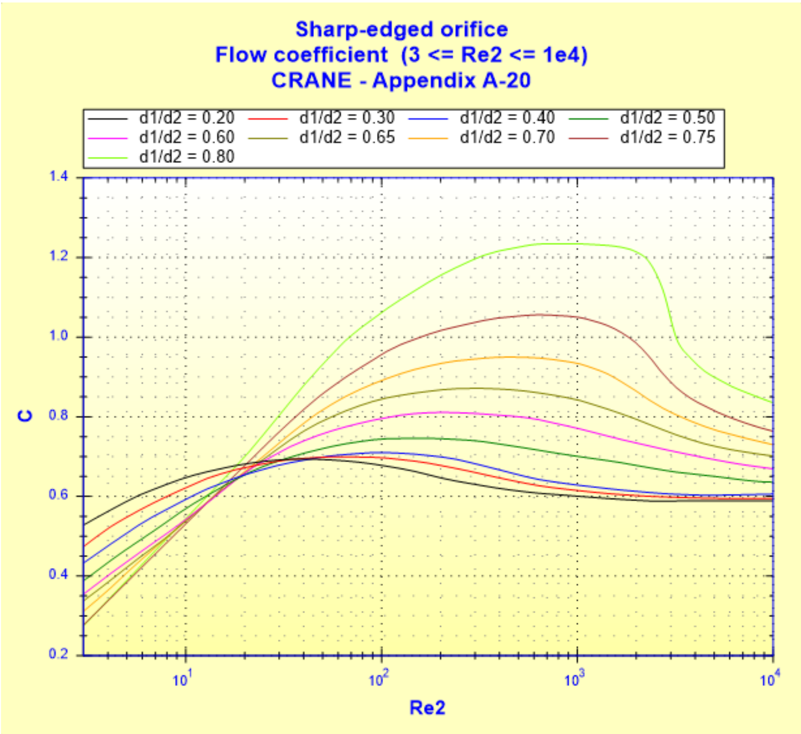
$$Re_2 = \frac{v_2 \cdot D_2}{\nu}$$

Flow coefficient:

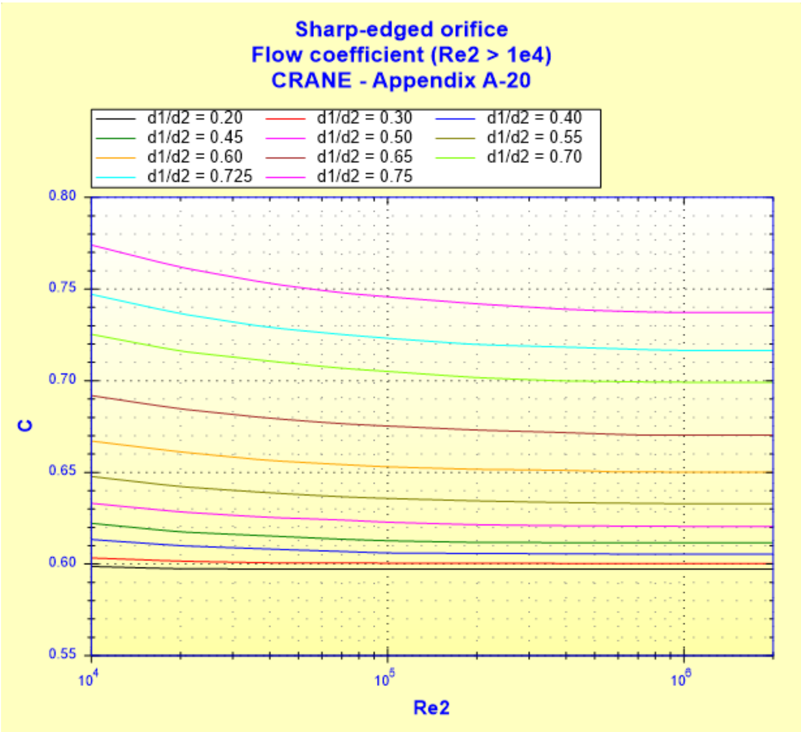
$$C = f\left(Re_2, \frac{d_1}{d_2}\right)$$

([1] appendix A-20)

- $3 \le Re_2 \le 10^4$



- $Re_2 > 10^4$

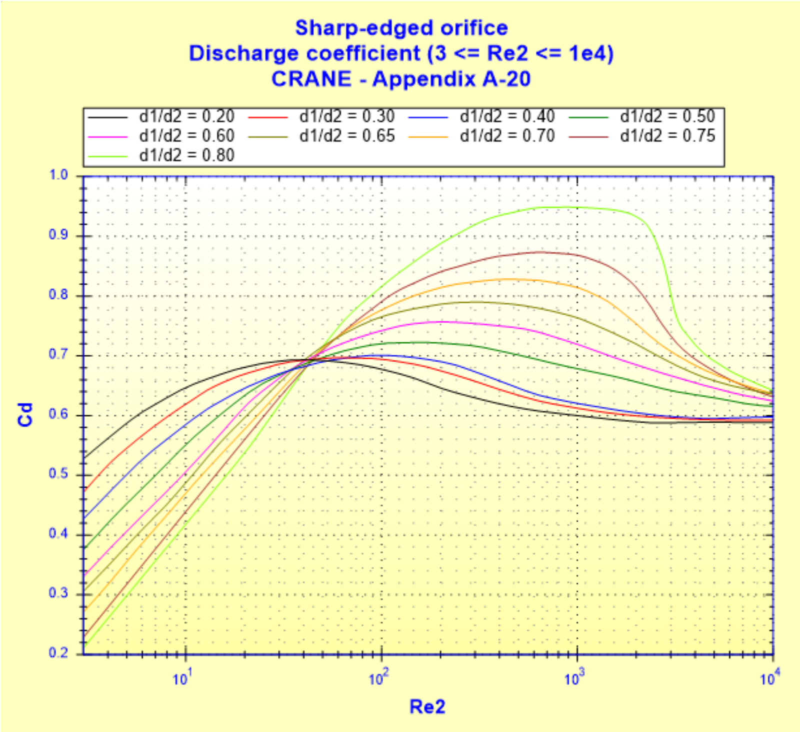


Discharge coefficient:

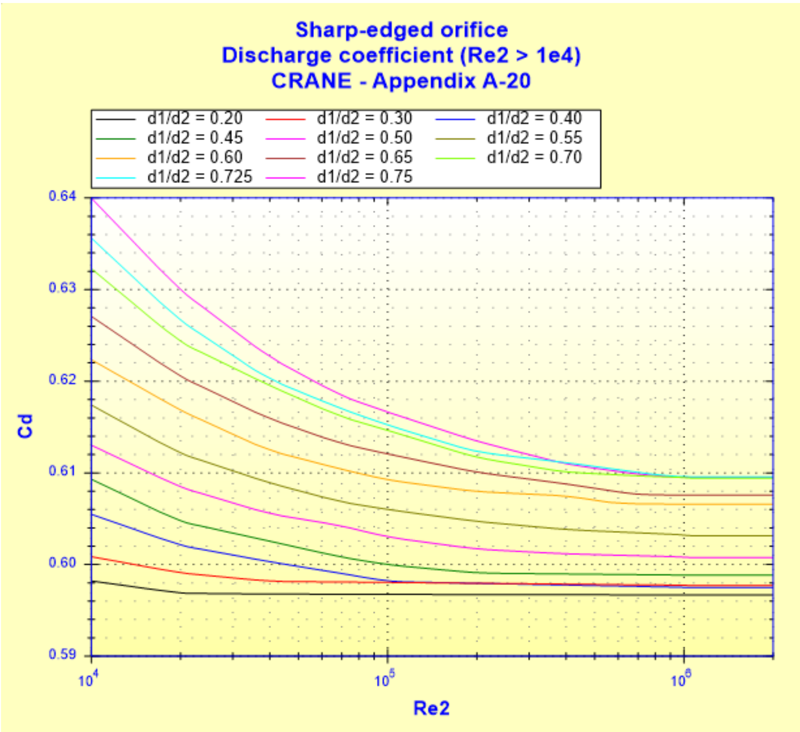
$$C_d = C \cdot \sqrt{1-\beta^4}$$

([1] appendix A-20)

■ $3 \leq Re_2 \leq 10^4$



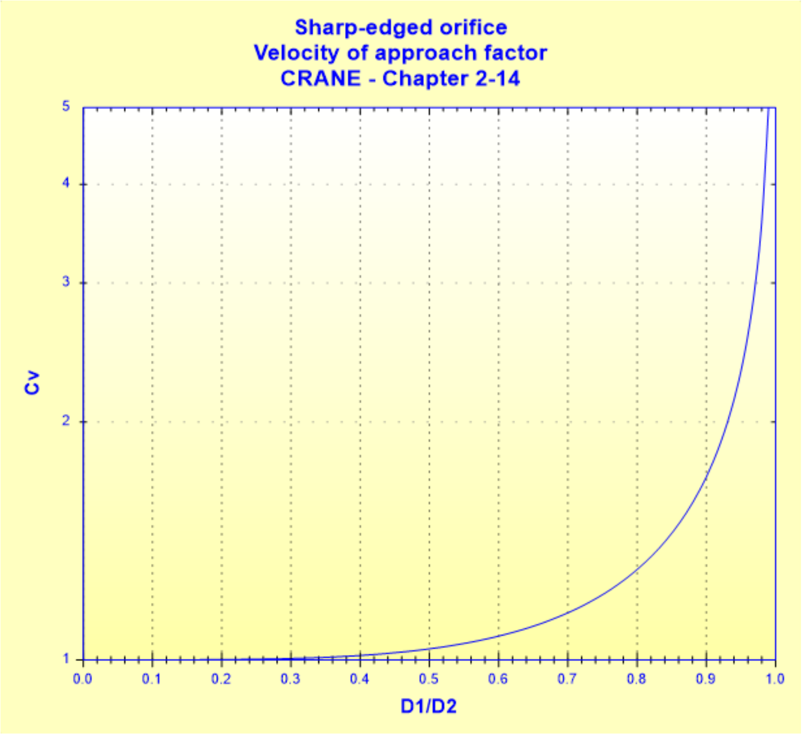
■ $Re_2 > 10^4$



Velocity of approach factor:

$$C_v = \frac{1}{\sqrt{1-\beta^4}}$$

([1] 2-14)



Volume flow rate (m^3/s):

$$q = A_1 \cdot C \cdot \sqrt{\frac{2 \cdot \Delta p}{\rho}}$$

([1] Equation 2-23)

Mass flow rate (kg/s):

$$w = q \cdot \rho$$

Resistance coefficient of orifice (based on the mean pipe velocity):

$$K_o = \frac{1 - \beta^2}{C^2 \cdot \beta^4}$$

([1] appendix A-20)

Net pressure loss (Pa):

$$\Delta \varpi = K_o \cdot \frac{\rho \cdot v_2^2}{2}$$

Net head loss (m):

$$\Delta h = K_o \cdot \frac{v_2^2}{2 \cdot g}$$

Net hydraulic power loss (W):

$$Wh = \Delta w \cdot q$$

Measured head loss (m):

$$\Delta H = \frac{\Delta P}{\rho \cdot g}$$

Symbols, Definitions, SI Units:

D_1	Orifice diameter (m)
D_2	Internal pipe diameter (m)
β	Diameter ratio ()
A_1	Orifice cross-sectional area (m^2)
A_2	Pipe cross-sectional area (m^2)
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 ()
C_d	Discharge coefficient ()
C_v	Velocity of approach factor ()
q	Volume flow rate (m^3/s)
ΔP	Measured pressure loss (Pa)
w	Mass flow rate (kg/s)
K_o	Resistance coefficient of orifice (based on the mean pipe velocity) ()
$\Delta\varpi$	Net pressure loss (Pa)
Δh	Net head loss of fluid (m)
Wh	Hydraulic power loss (W)
ΔH	Measured head loss of fluid (m)
ρ	Fluid density (kg/m^3)
ν	Fluid kinematic viscosity (m^2/s)
g	Gravitational acceleration (m/s^2)

Notation of equations according to sources.

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 2.10^6, and diameter ratio "D_1/D_2" lower than 0.2 or greater than 0.75, the flow coefficient "*C*" is extrapolated

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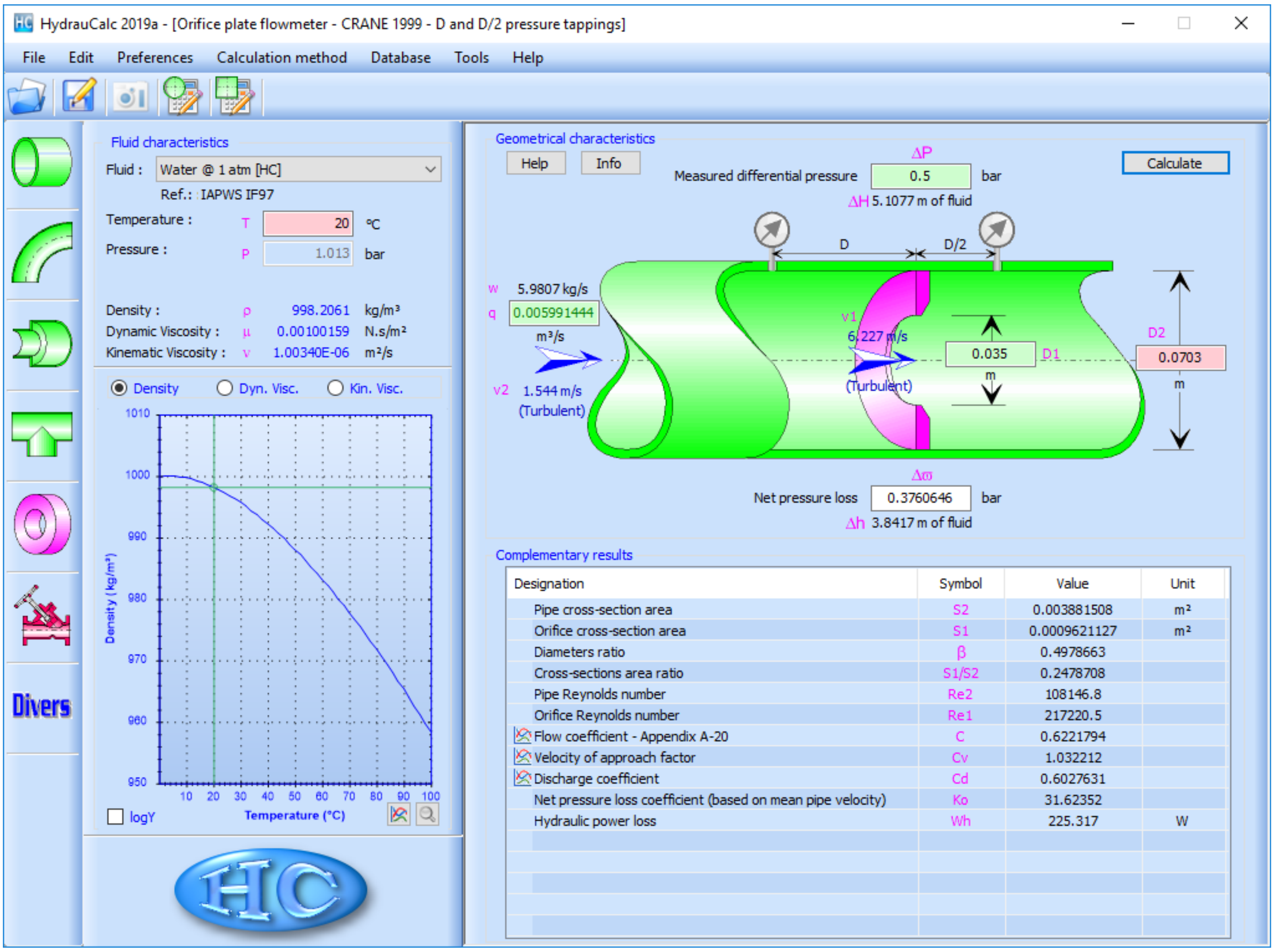
Example of application:



Designation	Symbol	Value	Unit
Pipe cross-section area	S2	0.003881508	m²
Orifice cross-section area	S1	0.0009621127	m²
Diameters ratio	β	0.4978663	
Cross-sections area ratio	S1/S2	0.2478708	
Pipe Reynolds number	Re2	108146.8	
Orifice Reynolds number	Re1	217220.5	
Flow coefficient - Appendix A-20	C	0.6221794	
Velocity of approach factor	Cv	1.032212	
Discharge coefficient	Cd	0.6027631	
Net pressure loss coefficient (based on mean pipe velocity)	Ko	31.62352	
Hydraulic power loss	Wh	225.317	W

References:

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