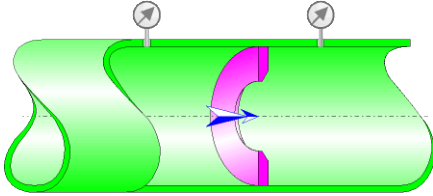




## Square-Edge Orifice Flowmeter D and D/2 pressure tapings (CRANE)



### Model description:

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

### Model formulation:

Diameter ratio:

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

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):

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

Reynolds number in orifice:

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

Reynolds number in pipe:

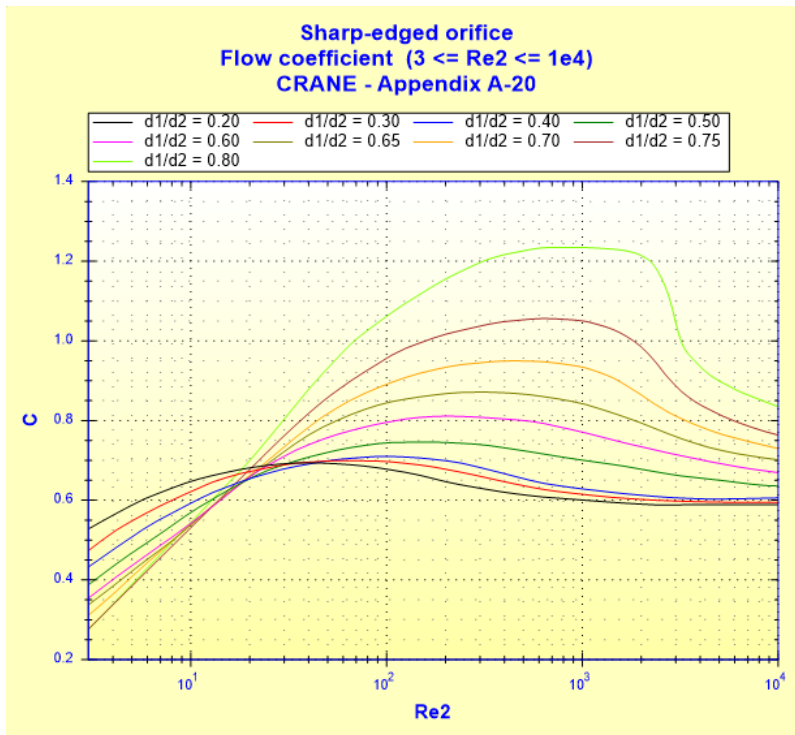
$$\text{Re}_2 = \frac{v_2 \cdot D_2}{\nu}$$

Flow coefficient:

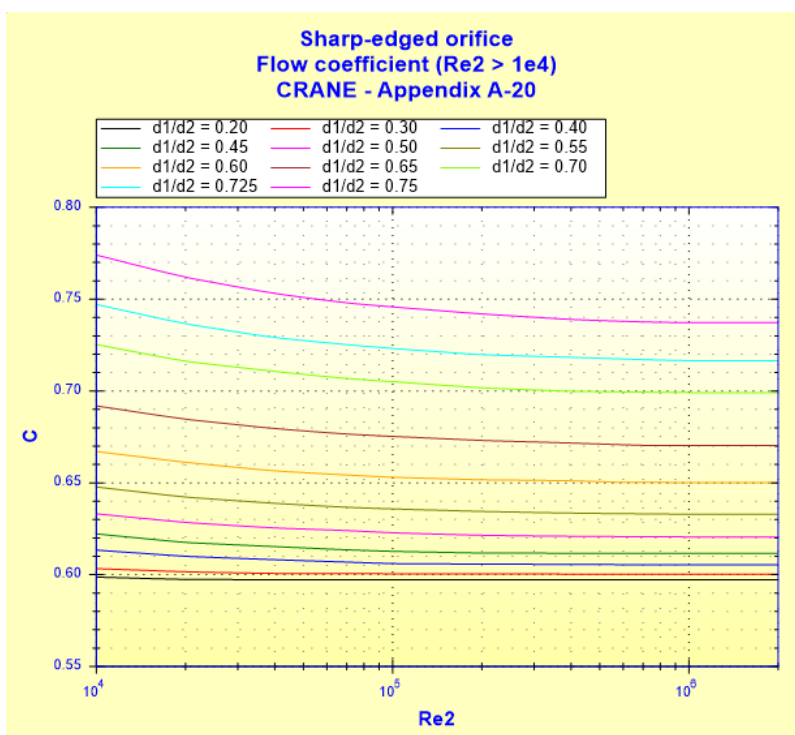
$$C = f\left(\text{Re}_2, \frac{d_1}{d_2}\right)$$

([1] appendix A-20)

■  $3 \leq \text{Re}_2 \leq 10^4$



■  $\text{Re}_2 > 10^4$

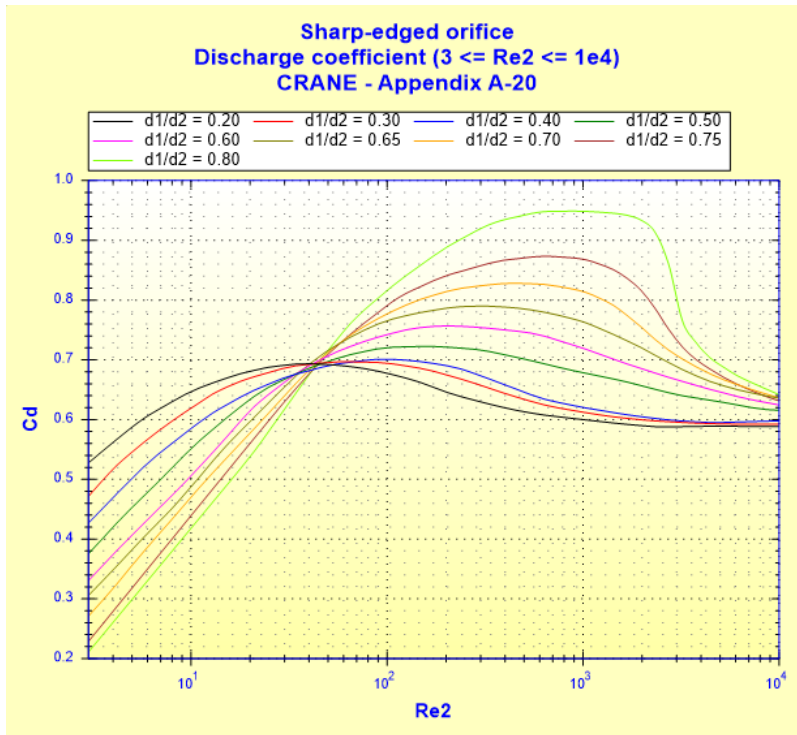


Discharge coefficient:

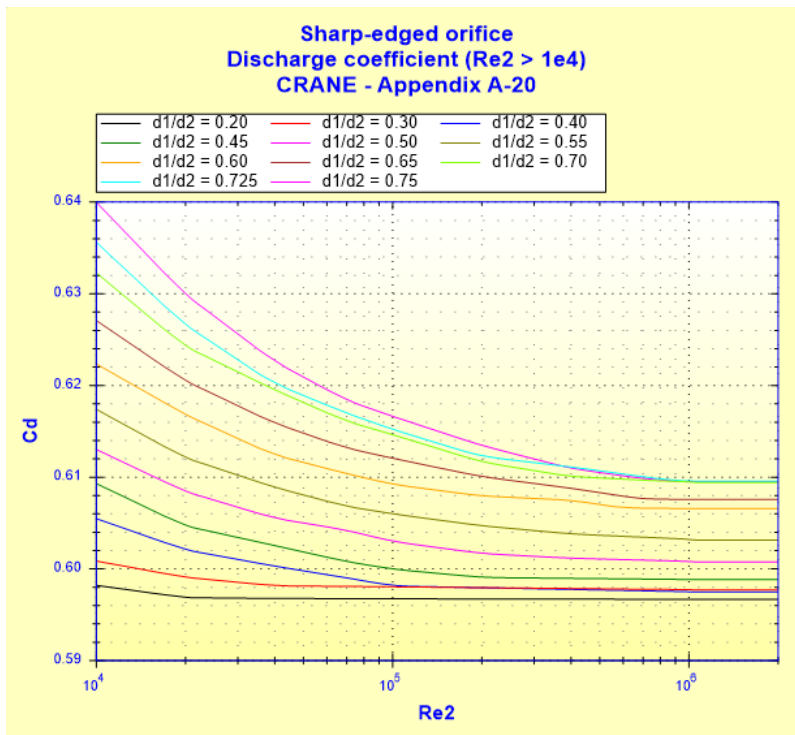
$$C_d = C \cdot \sqrt{1 - \beta^4}$$

([1] appendix A-20)

■  $3 \leq Re_2 \leq 10^4$



■  $Re_2 > 10^4$

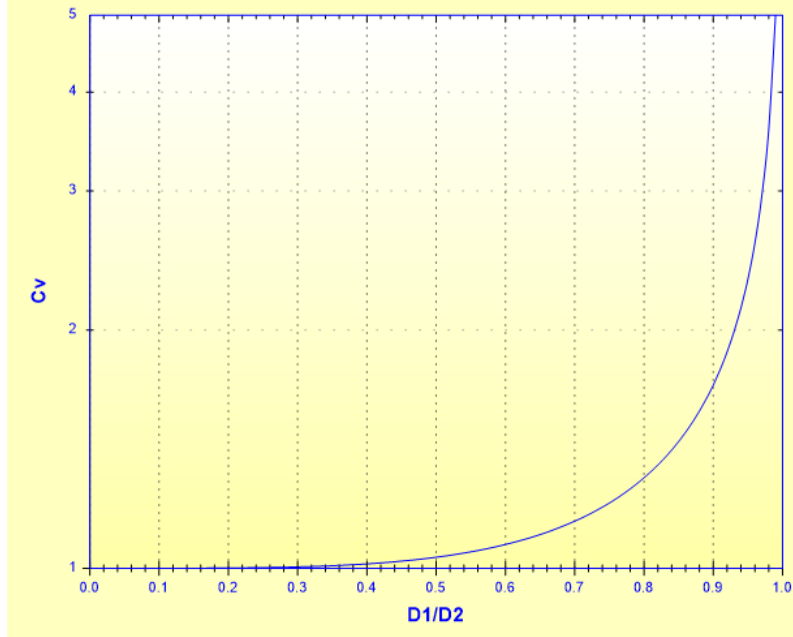


Velocity of approach factor:

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

([1] 2-14)

Sharp-edged orifice  
Velocity of approach factor  
CRANE - Chapter 2-14



Volume flow rate (m<sup>3</sup>/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)
$\beta$	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 ( $m^3/s$ )
$\Delta P$	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)
$\Delta h$	Net head loss of fluid (m)
$Wh$	Hydraulic power loss (W)
$\Delta H$	Measured head loss of fluid (m)
$\rho$	Fluid density ( $kg/m^3$ )
$\nu$	Fluid kinematic viscosity ( $m^2/s$ )
$g$	Gravitational acceleration ( $m/s^2$ )

Notation of equations according to sources.

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### 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

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### Example of application:

HydrauCalc 2019a - [Orifice plate flowmeter - CRANE 1999 - D and D/2 pressure tapings]

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.

Divers

**Geometrical characteristics**

Help Info Measured differential pressure  $\Delta P$  0.5 bar Calculate

$\Delta H$  5.1077 m of fluid

w 5.9807 kg/s  
q 0.005991444 m<sup>3</sup>/s

Net pressure loss  $\Delta p$  0.3760646 bar  
 $\Delta h$  3.8417 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	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