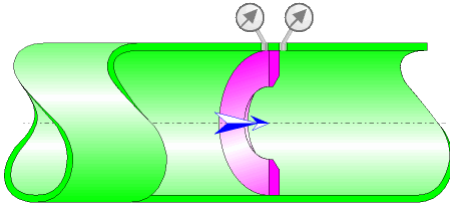




Square-Edge Orifice Flowmeter Corner pressure tapplings (ISO 5167-2:2003)



Model description:

This model of component determines the fluid flow through a square-edge orifice flowmeter with corner pressure tapplings, according to the international standard "ISO-5167-2:2003".

Model formulation:

Diameter ratio:

$$\beta = \frac{d}{D}$$

Orifice cross-sectional area (m²):

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

Pipe cross-sectional area (m²):

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

Mean velocity in orifice (m/s):

$$v = \frac{q_v}{s}$$

Mean velocity in pipe (m/s):

$$V = \frac{q_v}{S}$$

Reynolds number referred to orifice diameter:

$$Re_d = \frac{v \cdot d}{\nu}$$

Reynolds number referred to internal pipe diameter:

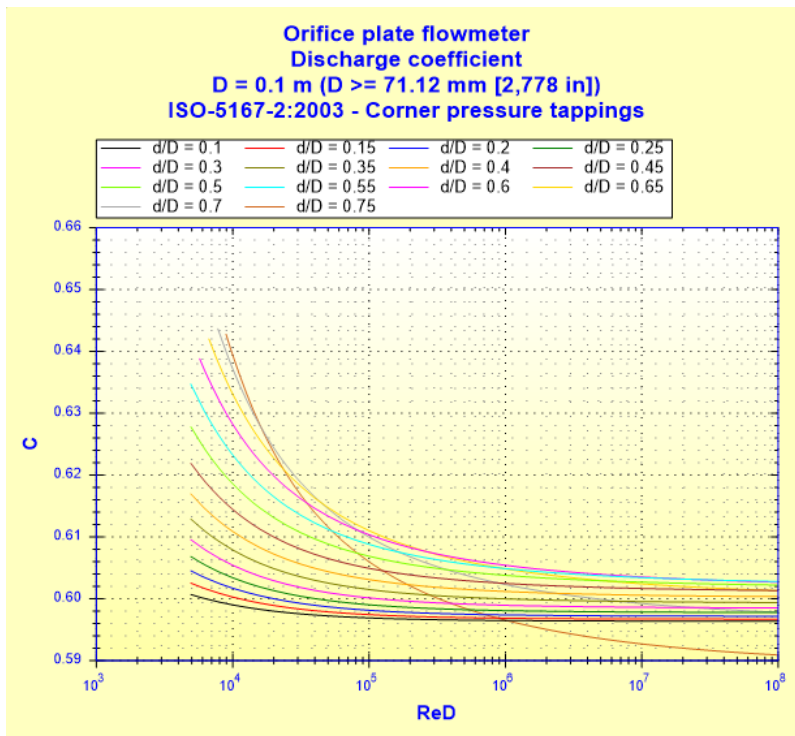
$$\text{Re}_D = \frac{V \cdot D}{\nu}$$

Discharge coefficient (Reader-Harris/Gallagher (1998) equation):

■ $D \geq 71.12$ mm (2.8 in)

$$C = 0.5961 + 0.0261 \cdot \beta^2 - 0.216 \cdot \beta^8 + 0.000521 \cdot \left(\frac{10^6 \cdot \beta}{\text{Re}_D} \right)^{0.7} \\ + (0.0188 + 0.0063 \cdot A) \cdot \beta^{3.5} \cdot \left(\frac{10^6}{\text{Re}_D} \right)^{0.3} \\ + (0.043 + 0.08 \cdot e^{-10 \cdot L1} - 0.123 \cdot e^{-7 \cdot L1}) \cdot (1 - 0.11 \cdot A) \cdot \frac{\beta^4}{1 - \beta^4} \\ - 0.031 \cdot (M'_2 - 0.8 \cdot M'_2{}^{1.1}) \cdot \beta^{1.3}$$

([2] § 5.3.2.1 eq. 4)



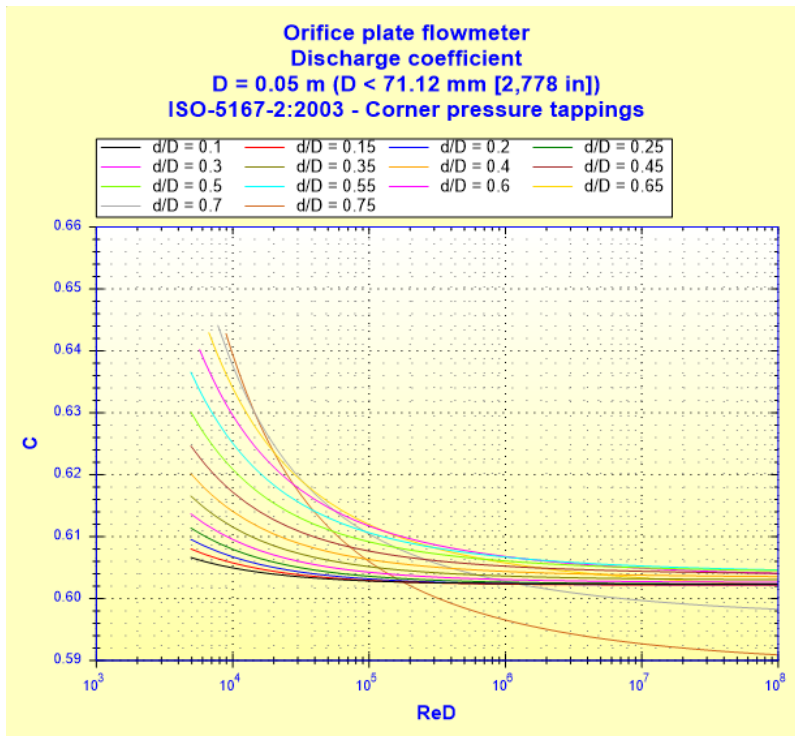
with $D = 100$ mm

■ $D < 71.12$ mm (2.8 in)

$$C = 0.5961 + 0.0261 \cdot \beta^2 - 0.216 \cdot \beta^8 + 0.000521 \cdot \left(\frac{10^6 \cdot \beta}{\text{Re}_D} \right)^{0.7} \\ + (0.0188 + 0.0063 \cdot A) \cdot \beta^{3.5} \cdot \left(\frac{10^6}{\text{Re}_D} \right)^{0.3} \\ + (0.043 + 0.08 \cdot e^{-10 \cdot L1} - 0.123 \cdot e^{-7 \cdot L1}) \cdot (1 - 0.11 \cdot A) \cdot \frac{\beta^4}{1 - \beta^4} \\ - 0.031 \cdot (M'_2 - 0.8 \cdot M'_2{}^{1.1}) \cdot \beta^{1.3} \\ + 0.011 \cdot (0.75 - \beta) \cdot \left(2.8 - \frac{D}{25.4} \right)$$

([2] § 5.3.2.1 eq. 4)

Where D is the pipe diameter in mm



with D = 50 mm

where:

$$M'_2 = \frac{2 \cdot L'_2}{1 - \beta}$$

$$A = \left(\frac{19000 \cdot \beta}{Re_D} \right)^{0.8}$$

The values of L_1 and L'_2 to be used in this equations are as follows:

$$L_1 = L'_2 = 0$$

Expansibility factor:

$$\varepsilon = 1 \quad ([1] \text{ §3.3.6) for incompressible fluid (liquid)}$$

Mass flow rate (kg/s):

$$q_m = \frac{C}{\sqrt{1 - \beta^4}} \cdot \varepsilon \cdot \frac{\pi}{4} \cdot d^2 \cdot \sqrt{2 \cdot \Delta p \cdot \rho} \quad ([2] \text{ § 4 eq. 1)}$$

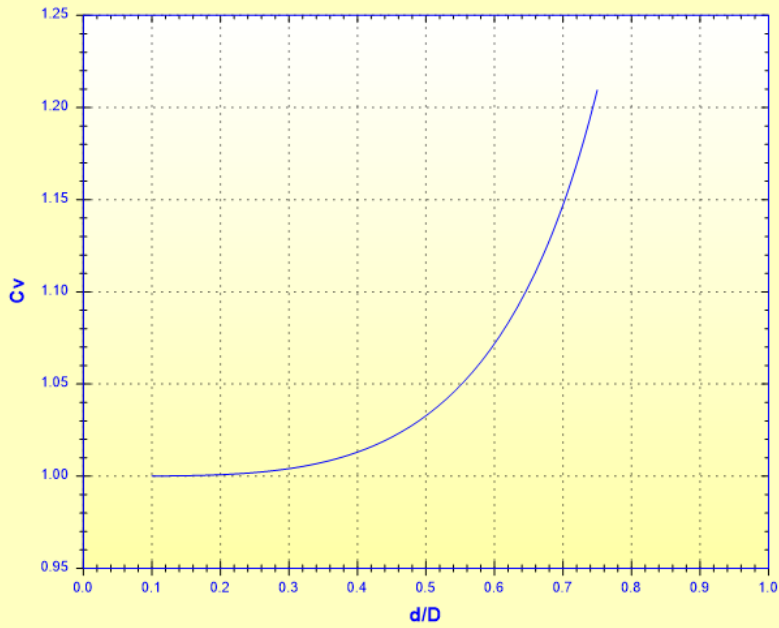
Volume flow rate (m³/s):

$$q_v = \frac{q_m}{\rho} \quad ([2] \text{ § 4 eq. 2)}$$

Velocity of approach factor:

$$C_v = \frac{1}{\sqrt{1 - \beta^4}} \quad ([1] \text{ §3.3.5)}$$

Orifice plate flowmeter
Velocity of approach factor
ISO-5167-2:2003

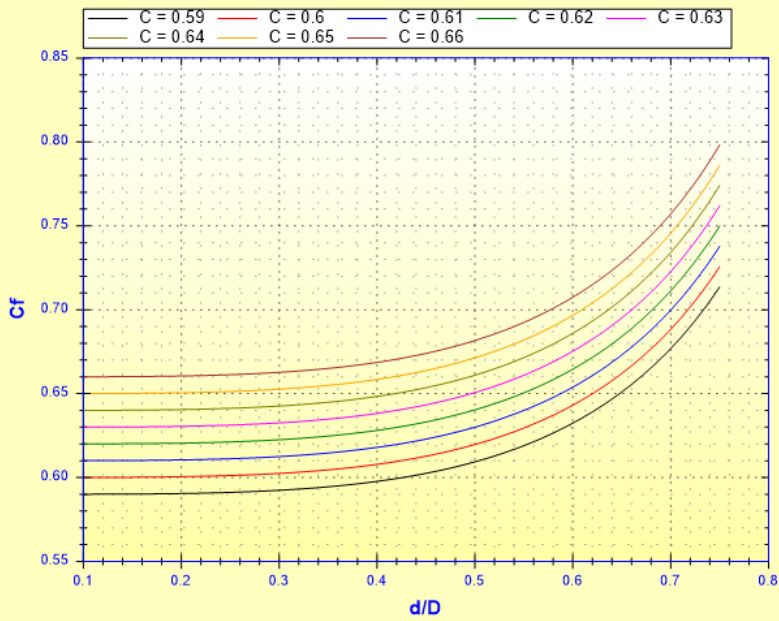


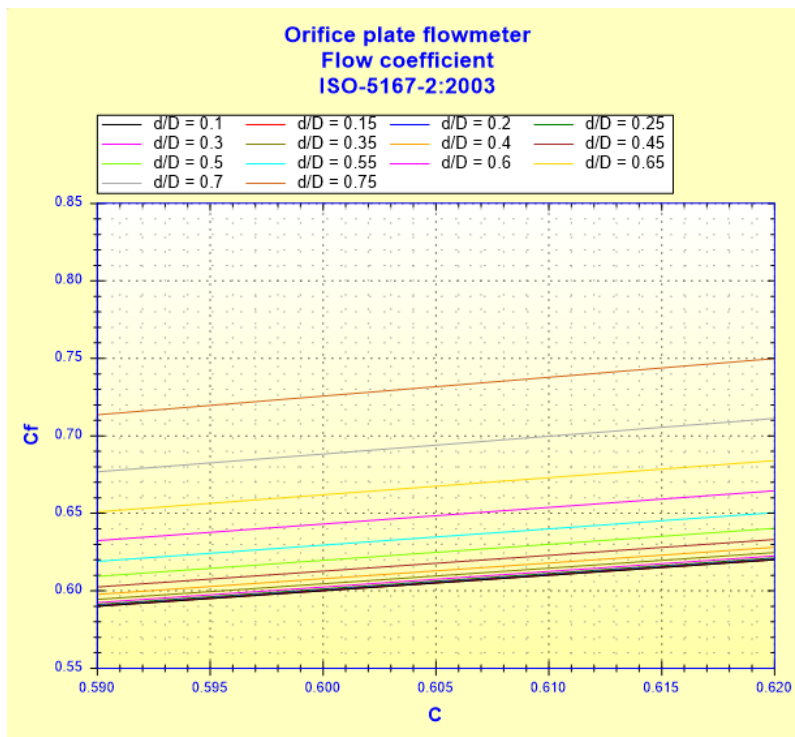
Flow coefficient:

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

([1] §3.3.5)

Orifice plate flowmeter
Flow coefficient
ISO-5167-2:2003





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

$$K = \left(\frac{\sqrt{1 - \beta^4 \cdot (1 - C^2)}}{C \cdot \beta^2} - 1 \right)^2 \quad ([2] \text{ § 5.4.3})$$

Net pressure loss (Pa):

$$\Delta \varpi = \frac{\sqrt{1 - \beta^4 \cdot (1 - C^2)} - C \cdot \beta^2}{\sqrt{1 - \beta^4 \cdot (1 - C^2)} + C \cdot \beta^2} \cdot \Delta p \quad ([2] \text{ § 5.4.1})$$

Net head loss (m):

$$\Delta h = \frac{\Delta \varpi}{\rho \cdot g}$$

Net hydraulic power loss (W):

$$Wh = \Delta \varpi \cdot q_v$$

Measured head loss (m):

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

Symbols, Definitions, SI Units:

- d Orifice diameter (m)
- D Internal pipe diameter (m)
- β Diameter ratio ()
- s Orifice cross-sectional area (m²)

S	Pipe cross-sectional area (m^2)
q_v	Volume flow rate (m^3/s)
v	Mean velocity in orifice (m/s)
V	Mean velocity in pipe (m/s)
Re_d	Reynolds number referred to orifice ($\text{}$)
Re_D	Reynolds number referred to pipe ($\text{}$)
C	Discharge coefficient ($\text{}$)
L_1	Upstream relative pressure tapping spacing from the upstream face ($\text{}$)
L'_2	Downstream relative pressure tapping spacing from the downstream face ($\text{}$)
ε	Expansibility factor ($\text{}$)
q_m	Mass flow rate (kg/s)
C_v	Velocity of approach factor ($\text{}$)
C_f	Flow coefficient ($\text{}$)
K	Pressure loss coefficient of orifice (based on the mean pipe velocity) ($\text{}$)
$\Delta\varpi$	Net pressure loss (Pa)
ΔP	Measured pressure loss (Pa)
Δh	Net head loss of fluid (m)
W_h	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)

Limit of use:

- $d \geq 12.5 \text{ mm}$
- $50 \text{ mm} \leq D \leq 1\,000 \text{ mm}$
- $0.1 \leq \beta \leq 0.75$
- $Re_D \geq 5\,000$ for $0.1 \leq \beta \leq 0.559$
- $Re_D \geq 16\,000 \beta^2$ for $\beta > 0.559$

Example of application:

HydrauCalc 2019a - [Orifice plate flowmeter - ISO 5167-2:2003 - Corner 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 : ρ 998.2061 kg/m³
Dynamic Viscosity : μ 0.00100159 N.s/m²
Kinematic Viscosity : ν 1.00340E-06 m²/s

Density Dyn. Visc. Kn. Visc.

Divers

Geometrical characteristics

Help Info Measured differential pressure ΔP 0.5 bar Calculate

ΔH 5.1077 m of fluid

qm 6.0197 kg/s
qv 0.006030469 m³/s
V 1.554 m/s (Turbulent)
6.268 m/s (Turbulent)
D 0.0703 m
d 0.035 m
Net pressure loss Δp 0.3670111 bar
 Δh 3.7492 m of fluid

Complementary results

Designation	Symbol	Value	Unit
Pipe cross-section area	S	0.003881508	m ²
Orifice cross-section area	s	0.0009621127	m ²
Diameters ratio	β	0.4978663	
Cross-sections area ratio	s/S	0.2478708	
Pipe Reynolds number	ReD	108851.2	
Orifice Reynolds number	Red	218635.4	
Discharge coefficient	C	0.6066892	
Expansibility factor	ϵ	1	
Velocity of approach factor	Cv	1.032212	
Flow coefficient	Cf	0.6262319	
Net pressure loss coefficient (based on mean pipe velocity)	K	30.46407	
Hydraulic power loss	Wh	221.3249	W

References:

- [1] ISO 5167-1:2003 - Measurement of fluid flow by means of pressure differential devices inserted in circular-cross section conduits running full
Part 1: General principles and requirements
- [2] ISO 5167-2:2003 - Measurement of fluid flow by means of pressure differential devices inserted in circular-cross section conduits running full
Part 2: Orifice plates