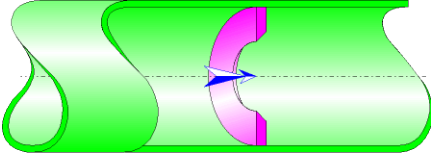




Sharp-edged Orifice Circular Cross-Section (MILLER)



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 (m²):

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

Orifice cross-sectional area (m²):

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

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:

$$Re_1 = \frac{U \cdot D}{\nu}$$

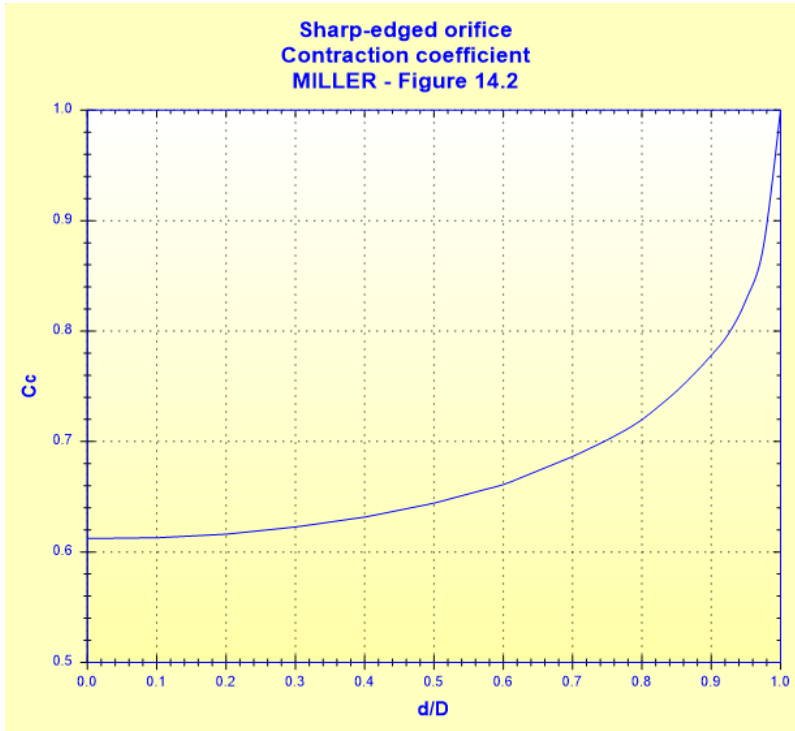
Reynolds number in orifice:

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

Contraction coefficient:

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

([1] figure 14.2)



Vena contracta cross-sectional area (m^2):

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

Mean velocity in vena contracta (m/s):

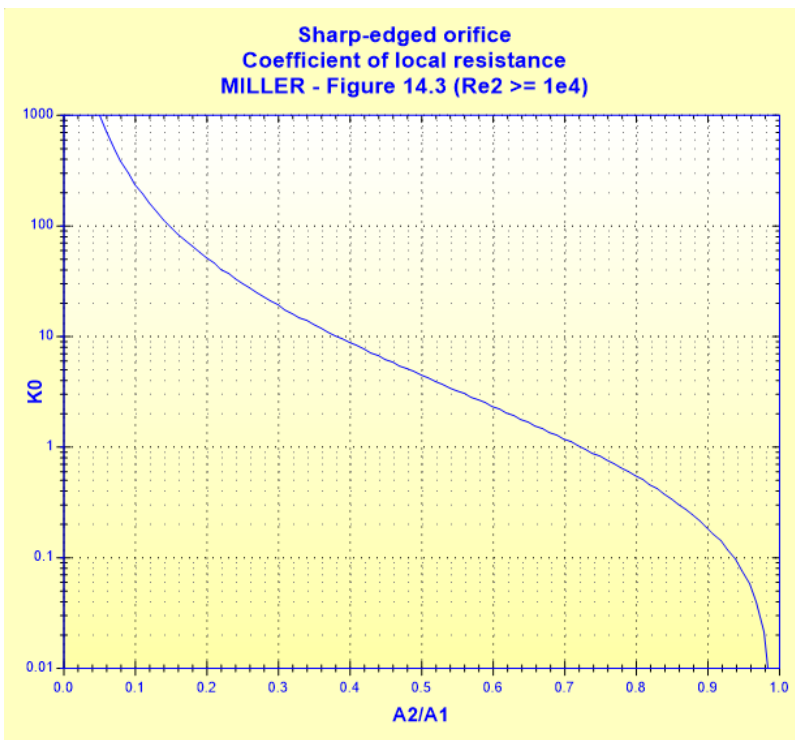
$$U_c = \frac{Q}{A_c}$$

Local resistance Coefficient:

■ $\text{Re}_2 \geq 10^4$

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

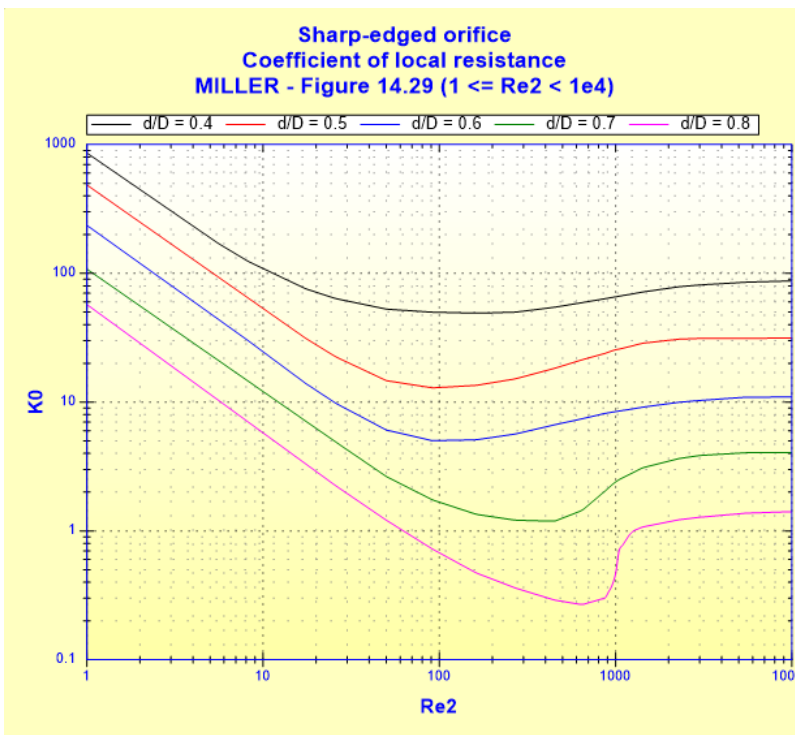
([1] figure 14.3)



■ $Re_2 < 10^4$

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

([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 (m ²)
A ₂	Orifice cross-sectional area (m ²)
Q	Volume flow rate (m ³ /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 (m ²)
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/m ³)
ν	Fluid kinematic viscosity (m ² /s)
g	Gravitational acceleration (m/s ²)

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 "Re₂" is lower than 10⁴, the local resistance coefficient "K₀" is extrapolated

Example of application:

HydrauCalc 2018a - [Sharp-edged orifice - MILLER (2nd Ed.)]

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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.

Geometrical characteristics

Help Info Calculate

4.9910 kg/s
Q 0.005 m³/s
U 1.288 m/s (Turbulent)
u 5.197 m/s
d 0.035 m
D 0.0703 m
Pressure loss ΔP 0.2520045 bar
 ΔH 2.5743 m of fluid

Complementary results

Designation	Symbol	Value	Unit
Pipe cross-section area	A1	0.003881508	m ²
Orifice cross-section area	A2	0.0009621127	m ²
Diameters ratio	D/d	0.4978663	
Cross-sections area ratio	A2/A1	0.2478708	
Pipe Reynolds number	Re1	90251	
Orifice Reynolds number	Re2	181275.6	
Contraction coefficient (Fig. 14.2)	Cc	0.6439687	
Vena contracta cross-sectional area	Ac	0.0006195705	m ²
Vena contracta velocity	Uc	8.070107	m/s
Coefficient of local resistance (Fig. 14.3) (Re2 >= 1e4)	K0	30.4284	
Pressure loss coefficient (based on the mean pipe velocity)	K	30.4284	
Hydraulic power loss	Wh	126.0022	W

References:

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