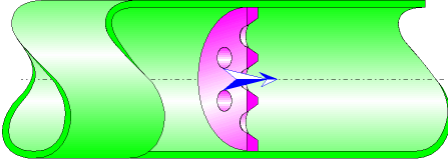




Sharp-edged Grid Circular Cross-Section (MILLER)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a sharp-edged grid (perforated plate) installed in a straight pipe.

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):

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

Cross-section area of one hole (m²):

$$a_2 = \pi \cdot \frac{d^2}{4}$$

Clear cross-sectional area of the grid (m²):

$$A_2 = a_2 \cdot N$$

Equivalent section orifice diameter (m):

$$d_e = \sqrt{\frac{4 \cdot A_2}{\pi}}$$

Mean velocity in pipe (m/s):

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

Mean velocity in holes (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 holes:

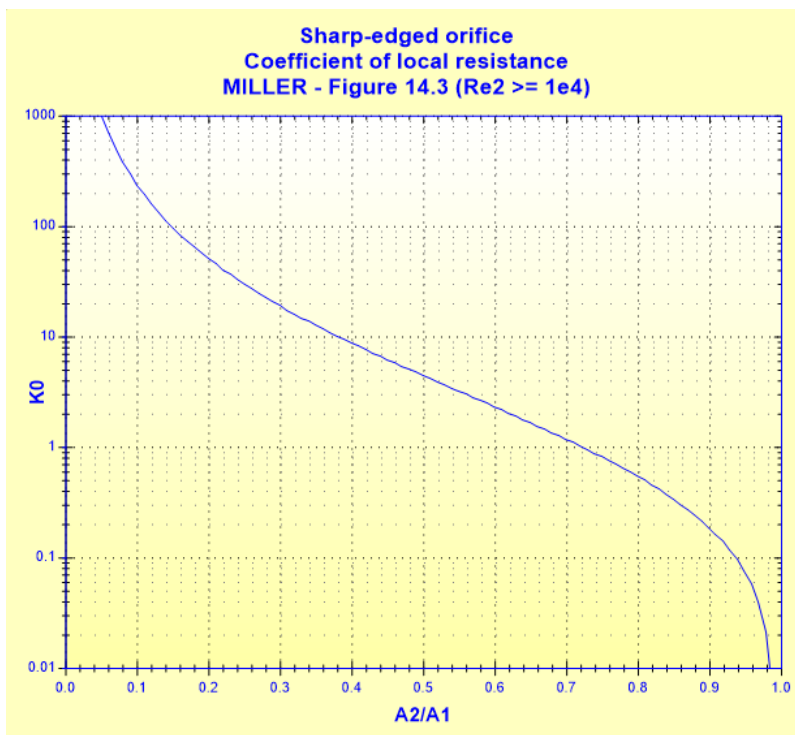
$$Re_2 = \frac{u \cdot d}{\nu}$$

Local resistance Coefficient:

■ $Re_2 \geq 10^4$

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

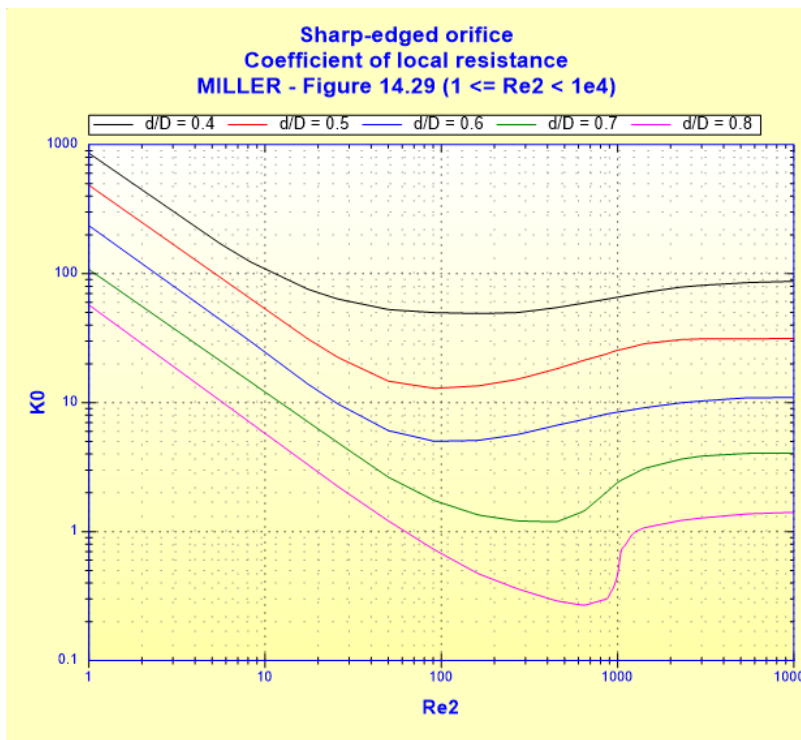
([1] figure 14.3)



■ $Re_2 < 10^4$

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

([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)
A_1	Pipe cross-sectional area (m^2)
d	Hole diameter (m)
a_2	Cross-section area of one hole (m^2)
N	Holes number ()
A_2	Clear cross-sectional area of the grid (m^2)
d_e	Equivalent section orifice diameter (m)
Q	Volume flow rate (m^3/s)
G	Mass flow rate (kg/s)
U	Mean velocity in pipe (m/s)
u	Mean velocity in holes (m/s)
Re_1	Reynolds number in pipe ()

Re_2	Reynolds number in holes ()
K_0	Local resistance coefficient ()
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_e/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

Example of application:

The screenshot shows the HydraulCalc 2020a software interface. The main window is titled "HydraulCalc 2020a - [Sharp-edged grid - MILLER (2nd Ed.)]". The interface is divided into several panels:

- 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^3
 - Dynamic Viscosity: $\mu = 0.00100159$ N.s/m^2
 - Kinematic Viscosity: $\nu = 1.00340E-06$ m^2/s
 - Radio buttons: Density, Dyn. Visc., Kn. Visc.
 - Graph: Density (kg/m^3) vs. Temperature ($^{\circ}\text{C}$)
- Geometrical characteristics:**
 - Buttons: Help, Info, Grid plot, Calculate
 - Diagram: A 3D model of a pipe with a hole. The pipe diameter is $D = 0.0703$ m. The hole diameter is $d = 0.015$ m. The number of holes is $N = 7$. The flow velocity in the pipe is $U = 1.288$ m/s (Turbulent). The flow velocity in the hole is $u = 4.042$ m/s (Turbulent). The mass flow rate is $Q = 0.005$ m^3/s . The pressure loss is $\Delta P = 0.1343354$ bar, which is equivalent to $\Delta H = 1.3723$ m of fluid.
- Complementary results:**

Designation	Symbol	Value	Unit
Pipe cross-section area	A_1	0.003881508	m^2
One hole cross-section area	A_2	0.0001767146	m^2
Total holes cross-section area	A_2	0.001237002	m^2
Diameters ratio	d/D	0.2133713	
Cross-sections area ratio	A_2/A_1	0.3186911	
Equivalent section orifice diameter	d'	0.03968627	
Pipe Reynolds number	Re_1	90251	
Holes Reynolds number	Re_2	60425.19	
<input checked="" type="checkbox"/> Coefficient of local resistance (Fig. 14.3) ($Re_2 \geq 1e4$)	K_0	16.2204	
Pressure loss coefficient (based on the mean pipe velocity)	K	16.2204	
Hydraulic power loss	Wh	67.16772	W

References:

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

