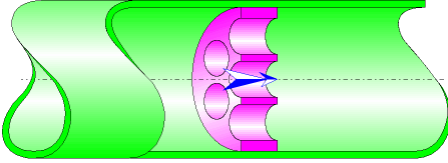




Thick-edged Grid Circular Cross-Section (Pipe Flow - Guide)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a thick-edged grid (perforated plate). Moreover, when the thickness of the grid is greater than 1.4 times the diameter of the equivalent section orifice of the holes, the head loss due to friction in the holes is also taken into account because it becomes significant.

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):

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

Cross-sectional area of one hole (m²):

$$a_o = \pi \cdot \frac{d_o^2}{4}$$

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

$$A_0 = a_o \cdot N$$

Porosity:

$$\phi = \frac{a_o}{A}$$

Equivalent section orifice diameter (m):

$$d_e = \sqrt{\frac{4 \cdot A_0}{\pi}}$$

Ratio between the diameters of the equivalent section orifice and the pipe:

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

Pipe velocity (m/s):

$$V = \frac{Q}{A}$$

Holes velocity (m/s):

$$V_o = \frac{Q}{A_o}$$

Mass flow rate (kg/s):

$$G = Q \cdot \rho_m$$

Reynolds number in pipe:

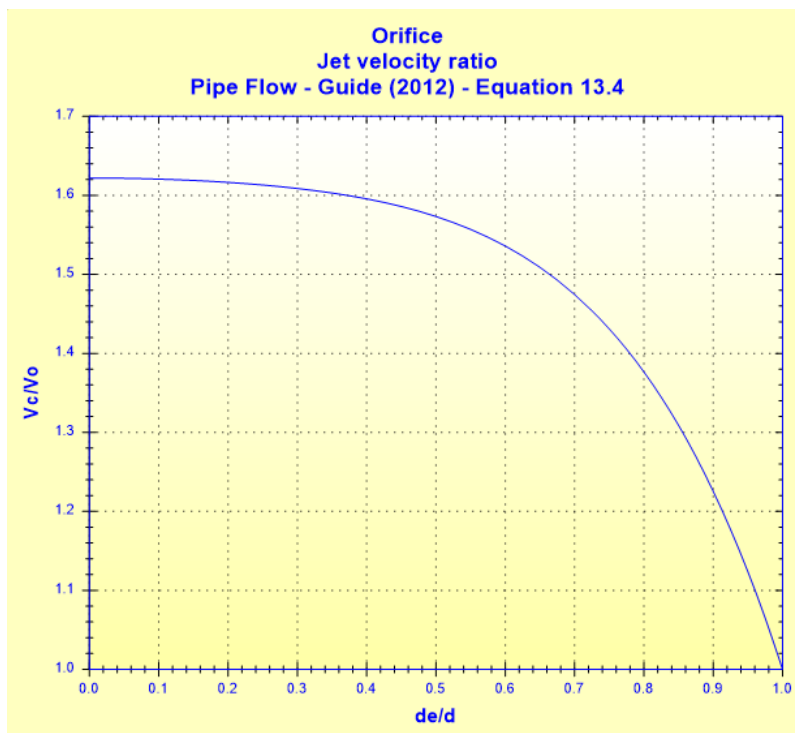
$$N_{Re} = \frac{V \cdot d}{\nu}$$

Reynolds number in holes:

$$N_{Re_o} = \frac{V_o \cdot d_o}{\nu}$$

Jet velocity ratio:

$$\lambda = 1 + 0.622 \cdot (1 - 0.215\beta^2 - 0.785\beta^5) \quad ([1] \text{ equation 13.4})$$



Velocity in vena contracta:

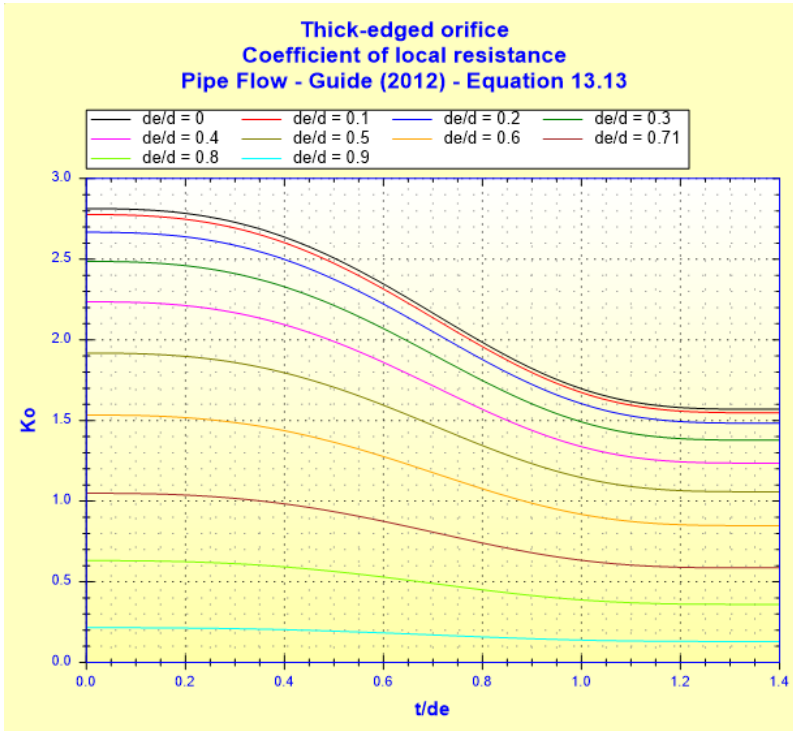
$$V_c = V_0 \cdot \lambda$$

Coefficient of local resistance:

- Thickness to equivalent diameter ratio ($t/d_e \leq 1.4$):

$$K_o = 0.0696 \cdot (1 - \beta^5) \cdot \lambda^2 + C_{th} \cdot (\lambda - \beta^2)^2 + (1 - C_{th}) \cdot [(\lambda - 1)^2 + (1 - \beta^2)^2] \quad ([1] \text{ equation } 13.13)$$

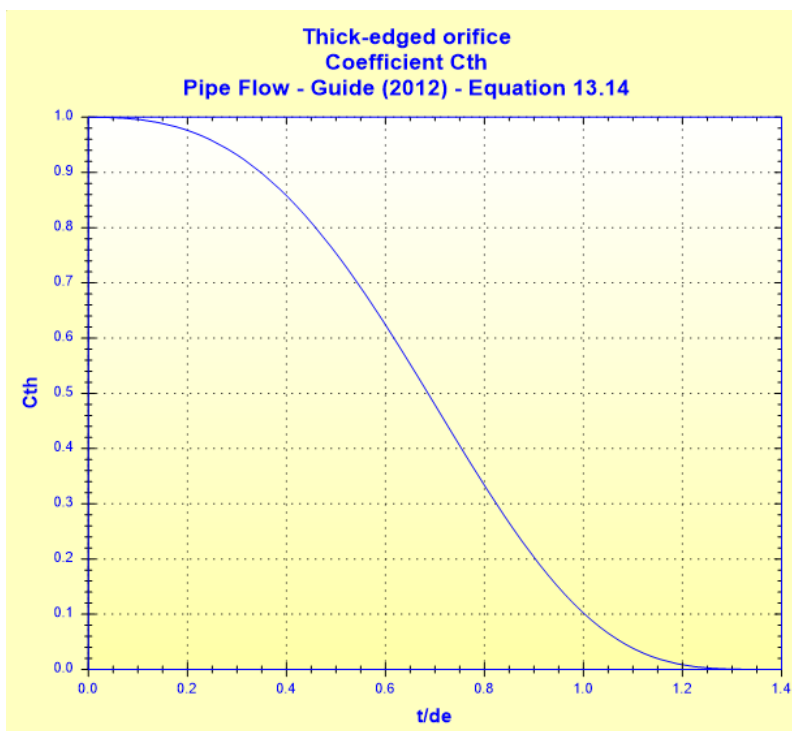
13.13)



with:

$$C_{th} = \left[1 - 0.50 \cdot \left(\frac{t}{1.4d_e} \right)^{2.5} - 0.50 \cdot \left(\frac{t}{1.4d_e} \right)^3 \right]^{4.5}$$

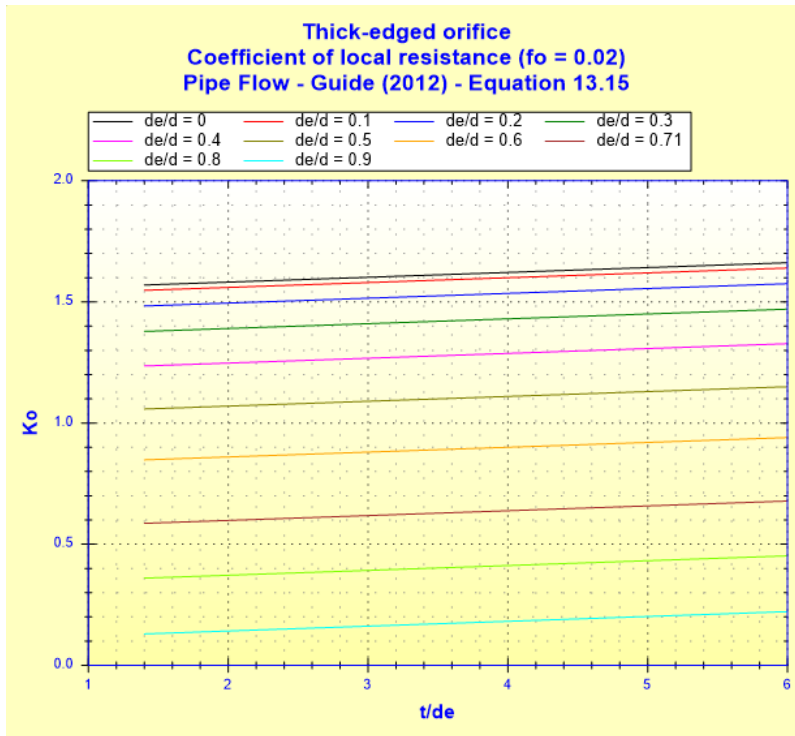
([1] equation 13.14)



- Thickness to equivalent diameter ratio (t/d_e) > 1.4:

$$K_o = 0.0696 \cdot (1 - \beta^5) \cdot \lambda^2 + (\lambda - 1)^2 + (1 - \beta^2)^2 + f_o \cdot \left(\frac{t}{d_e} - 1.4 \right)$$

([1] equation 13.15)



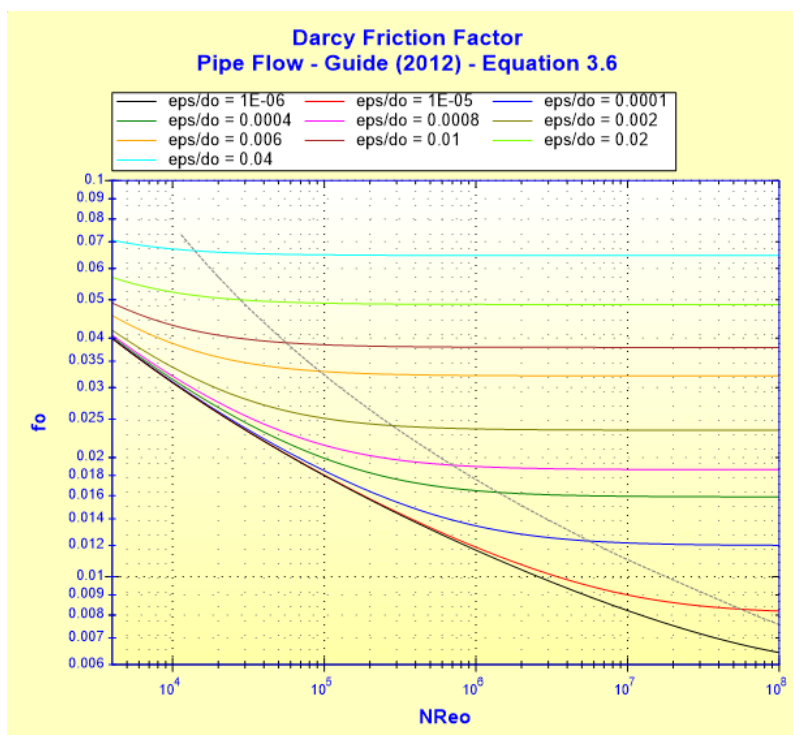
([1] equation 13.15 with

$f_o = 0.02$)

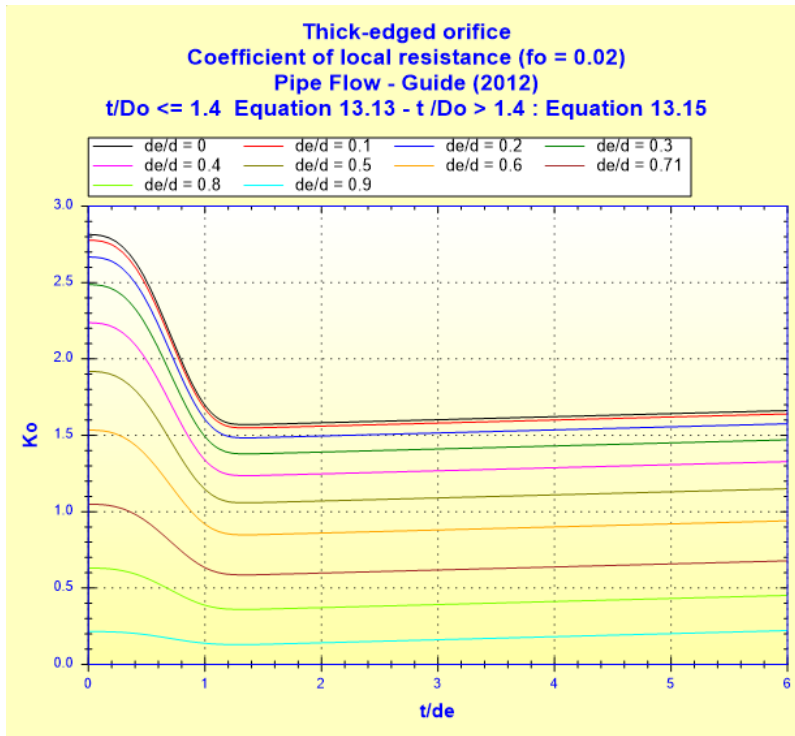
with:

$$f_o = \frac{1}{\left[2 \cdot \log \left(\frac{\varepsilon}{3.7 \cdot d_o} + \frac{2.51}{NRe_0 \cdot \sqrt{f_o}} \right) \right]^2}$$

Colebrook-White equation ([1] equation 3.6)



■ All thickness to equivalent diameter ratios (t/d_e):



([1] equations 13.13 and

13.15 with $f_o = 0.02$)

Total pressure loss coefficient (based on the mean pipe velocity):

$$K = K_o \cdot \left(\frac{A}{A_o} \right)^2$$

Total pressure loss (Pa):

$$\Delta P = K \cdot \frac{\rho_m \cdot V^2}{2}$$

Total head loss of fluid (m):

$$\Delta H = K \cdot \frac{V^2}{2 \cdot g}$$

Hydraulic power loss (W):

$$Wh = \Delta P \cdot Q$$

Symbols, Definitions, SI Units:

d	Internal pipe diameter (m)
A	Pipe cross-sectional area (m^2)
d_o	Holes diameter (m)
a_o	Cross-sectional area of one hole (m^2)
N	Holes number ()
A_o	Clear cross-sectional area of the grid (m^2)
ϕ	Porosity ()
d_e	Equivalent section orifice diameter (m)

β	Ratio between the diameters of the equivalent section orifice and the pipe ()
Q	Volume flow rate (m^3/s)
G	Mass flow rate (kg/s)
V_o	Mean velocity in holes (m/s)
V	Mean velocity in pipe (m/s)
NRe_o	Reynolds number in holes ()
NRe	Reynolds number in pipe ()
λ	Jet velocity ratio ()
V_c	Mean velocity in vena contracta (m/s)
t	Thickness grid (m)
K_o	Coefficient of local resistance ()
C_{th}	Coefficient ()
f_o	Darcy Friction factor ()
K	Total pressure loss coefficient (based on the mean pipe velocity) ()
ΔP	Total pressure loss (Pa)
ΔH	Total head loss of fluid (m)
W_h	Hydraulic power loss (W)
ρ_m	Fluid density (kg/m^3)
ν	Fluid kinematic viscosity (m^2/s)
g	Gravitational acceleration (m/s^2)

Validity range:

- turbulent flow regime in holes ($NRe_o \geq 10^4$)
- stabilized flow upstream of the grid

Example of application:

HydrauCalc 2019a - [Thick-edged grid - Pipe Flow - Guide (2012)]

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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. Kin. Visc.

Geometrical characteristics

Help Info Grid plot Calculate

Pressure loss ΔP 0.1357395 bar
 ΔH 1.3866 m of fluid

Complementary results

Designation	Symbol	Value	Unit
Pipe cross-section area	A	0.003881508	m ²
Total holes cross-section area	Ao	0.001237002	m ²
Cross-sections area ratio - Porosity (Ao/A)	ϕ	0.3186911	
Equivalent section orifice diameter	de	0.03968627	
Diameters ratio (de/d)	β	0.5645273	
Thickness to equivalent orifice diameter ratio	t/de	0.1763834	
Ratio between diameters of equivalent section orifice and pipe	de/d	0.5645273	
Pipe Reynolds number	NRe	90251	
Holes Reynolds number	NReo	60425.19	
Velocity in vena contracta	Vc	6.27075	m/s
Jet velocity ratio (Vc/Vo) (Equation 13.4)	λ	1.551386	
Coefficient Cth (Equation 13.14)	Cth	0.9829381	
Coefficient of local resistance (Equation 13.13)	Ko	1.664627	
Pressure loss coefficient (based on the mean pipe velocity)	K	16.38993	
Hydraulic power loss	Wh	67.86974	W

References:

[1] Pipe Flow: A Practical and Comprehensive Guide. Donald C. Rennels and Hobart M. Hudson. (2012)