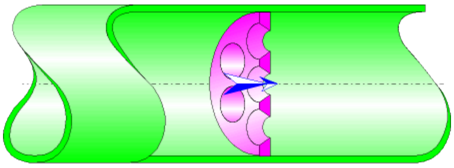
Bevelled-Edged Grid
Circular Cross-Section
(IDELCHIK)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a bevelled-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:

Hydraulic diameter (m):

$$\boxed{D_h = D_0}$$

Pipe cross-section area (m²):

$$\boxed{F_1 = \pi \cdot \frac{D_1^{\;2}}{4}}$$

Cross-section area of one hole (m²):

$$\boxed{f_0 = \pi \cdot \frac{D_0^{\;2}}{4}}$$

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

$$\boxed{F_0 = f_0 \cdot N}$$

Mean velocity in pipe (m/s):

$$\boxed{w_1 = \frac{Q}{F_1}}$$

Mean velocity in holes (m/s):

$$\boxed{w_0 = \frac{Q}{F_0}}$$

Mass flow rate (kg/s):

$$\boxed{G = Q \cdot \rho}$$

Reynolds number in pipe:

$$\boxed{\mathrm{Re}_1 = \frac{w_1 \cdot D_1}{\nu}}$$

Reynolds number in holes:

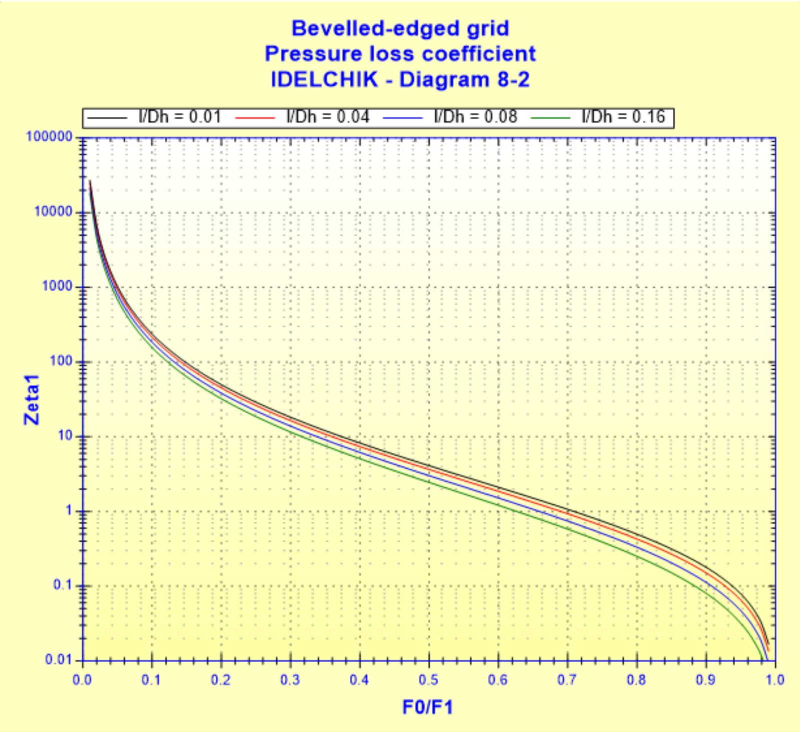
$$\boxed{\mathrm{Re}_0 = \frac{w_0 \cdot D_0}{\nu}}$$

Local resistance coefficient:

- $\mathrm{Re}_0 \geq 10^5$

$$\boxed{\zeta_1 = \left[\sqrt{\zeta'} \cdot \left(1 - \frac{F_0}{F_1}\right)^{0.375} + \left(1 - \frac{F_0}{F_1}\right)\right]^2 \cdot \left(\frac{F_1}{F_0}\right)^2}$$

([1] diagram 8-2)

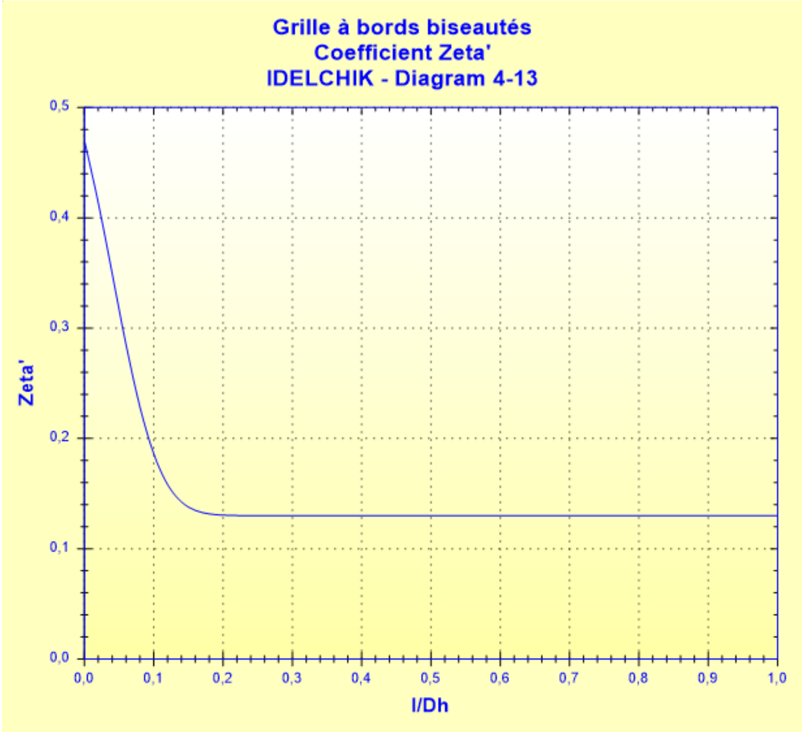


with :

Coefficient of effect of the orifice thickness:

$$\boxed{\zeta' = 0.13 + 0.34 \cdot 10^{-\left(3.4 \cdot \frac{l}{D_h} + 88.4 \cdot \left(\frac{l}{D_h}\right)^{2.3}\right)}}$$

([1] diagram 4-13)



- $Re_0 \le 10^5$

Quadratic local resistance coefficient:

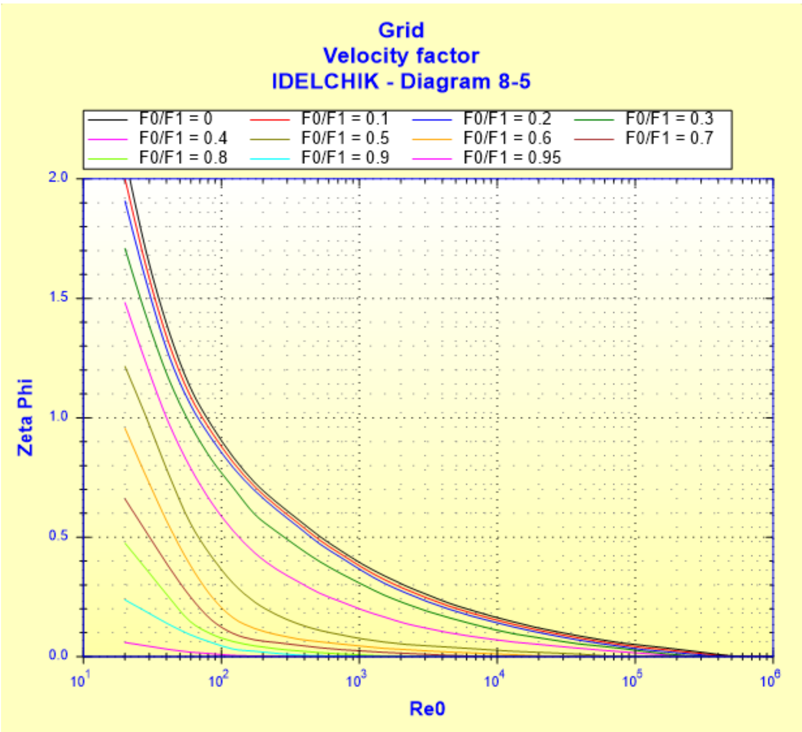
$$\zeta_{1quad} = \left[\sqrt{\zeta'} \cdot \left(1 - \frac{F_0}{F_1}\right)^{0.375} + \left(1 - \frac{F_0}{F_1}\right) \right]^2 \cdot \left(\frac{F_1}{F_0}\right)^2$$

([1] diagram 8-2)

Velocity factor:

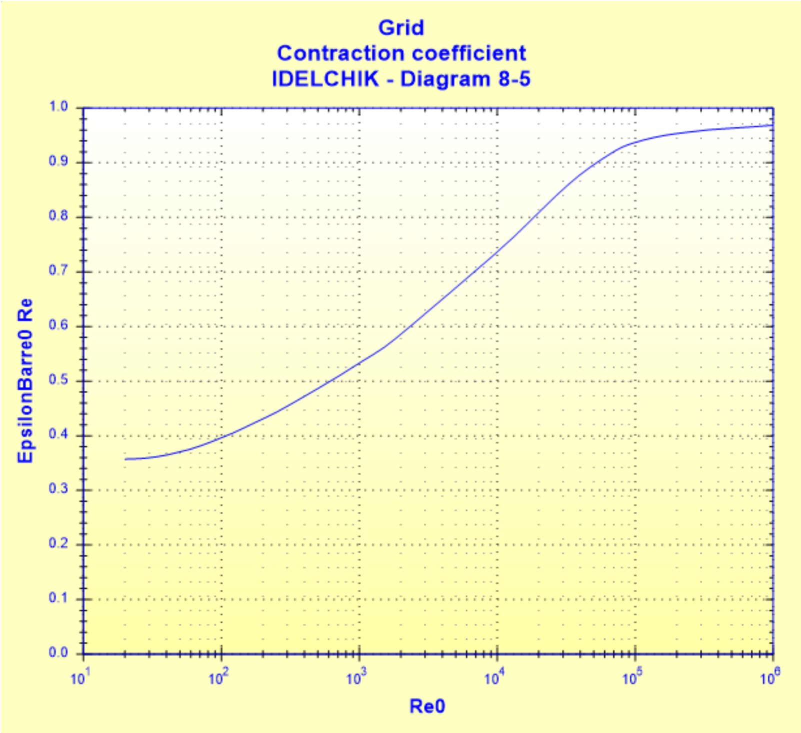
$$\zeta_\varphi = f\left(\mathrm{Re}_0, \frac{F_0}{F_1}\right)$$

([1] diagram 8-5)



Contraction factor:

$$\boxed{\bar{\varepsilon}_{0\text{Re}} = f(\text{Re}_0)}$$ ([1] diagram 8-5)



Coefficient of local resistance:

- $30 < \text{Re}_0 < 10^5$

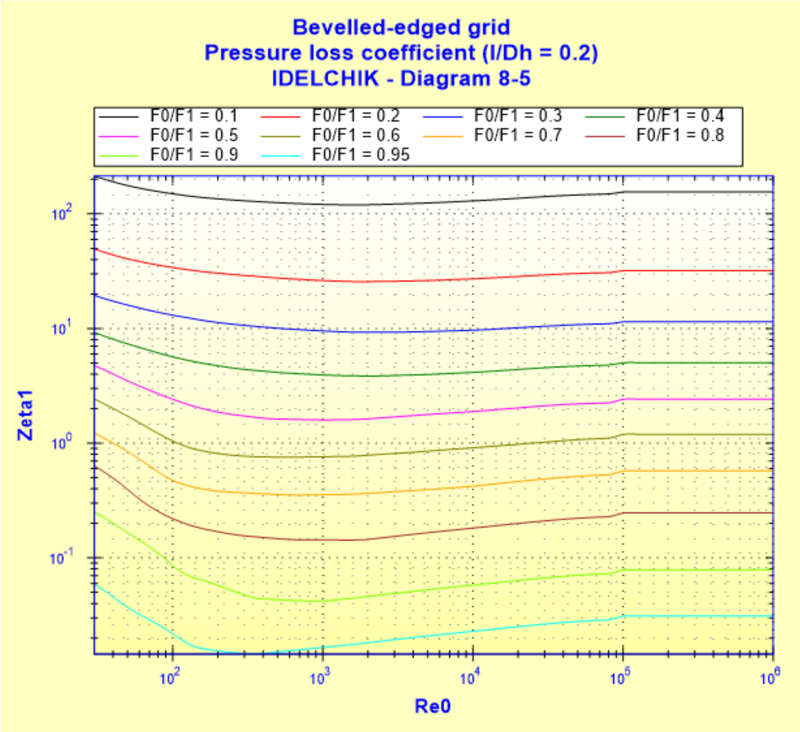
$$\boxed{\zeta_1 = \zeta_\varphi \cdot \left(\frac{F_1}{F_0}\right)^2 + \bar{\varepsilon}_{0\text{Re}} \cdot \zeta_{1quad}}$$ ([1] diagram 8-5)

- $10 < \text{Re}_0 \le 30$

$$\boxed{\zeta_1 = \frac{33}{\text{Re}_0} \cdot \left(\frac{F_1}{F_0}\right)^2 + \bar{\varepsilon}_{0\text{Re}} \cdot \zeta_{1quad}}$$ ([1] diagram 8-5)

- $\text{Re}_0 \le 10$

$$\boxed{\zeta_1 = \frac{33}{\text{Re}_0} \cdot \left(\frac{F_1}{F_0}\right)^2}$$ ([1] diagram 8-5)



([1] diagram 8-5 with l/Dh = 0.2)

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

$$\boxed{\zeta = \zeta_1}$$

Total pressure loss (Pa):

$$\boxed{\Delta P = \zeta \cdot \frac{\rho \cdot w_1^2}{2}}$$

Total head loss of fluid (m):

$$\boxed{\Delta H = \zeta \cdot \frac{w_1^2}{2 \cdot g}}$$

Hydraulic power loss (W):

$$\boxed{Wh = \Delta P \cdot Q}$$

Symbols, Definitions, SI Units:

D_h	Hydraulic diameter (m)
D_1	Pipe internal diameter (m)
F_1	Pipe cross-sectional area (m²)
N	Holes number ()
D_0	Holes diameter (m)
F_0	Clear cross-sectional area of the grid (m²)
f_0	Cross-section area of one hole (m²)
Q	Volume flow rate (m³/s)
w_1	Mean velocity in pipe (m/s)
w_0	Mean velocity in holes (m/s)
G	Mass flow rate (kg/s)

l Grid thickness (m)

Re_1 Reynolds number in pipe ()

Re_0 Reynolds number in holes ()

ζ_{1quad} Quadratic pressure loss coefficient determined as Re = 10^5 ()

ζ_φ Velocity factor ()

$\bar{\varepsilon}_{0Re}$ Contraction factor ()

ζ_1 Coefficient of local resistance ()

ζ Pressure loss coefficient (based on the mean pipe velocity) ()

ΔP Total pressure loss (Pa)

ΔH Total head loss of fluid (m)

Wh Hydraulic power loss (W)

ρ Fluid density (kg/m^3)

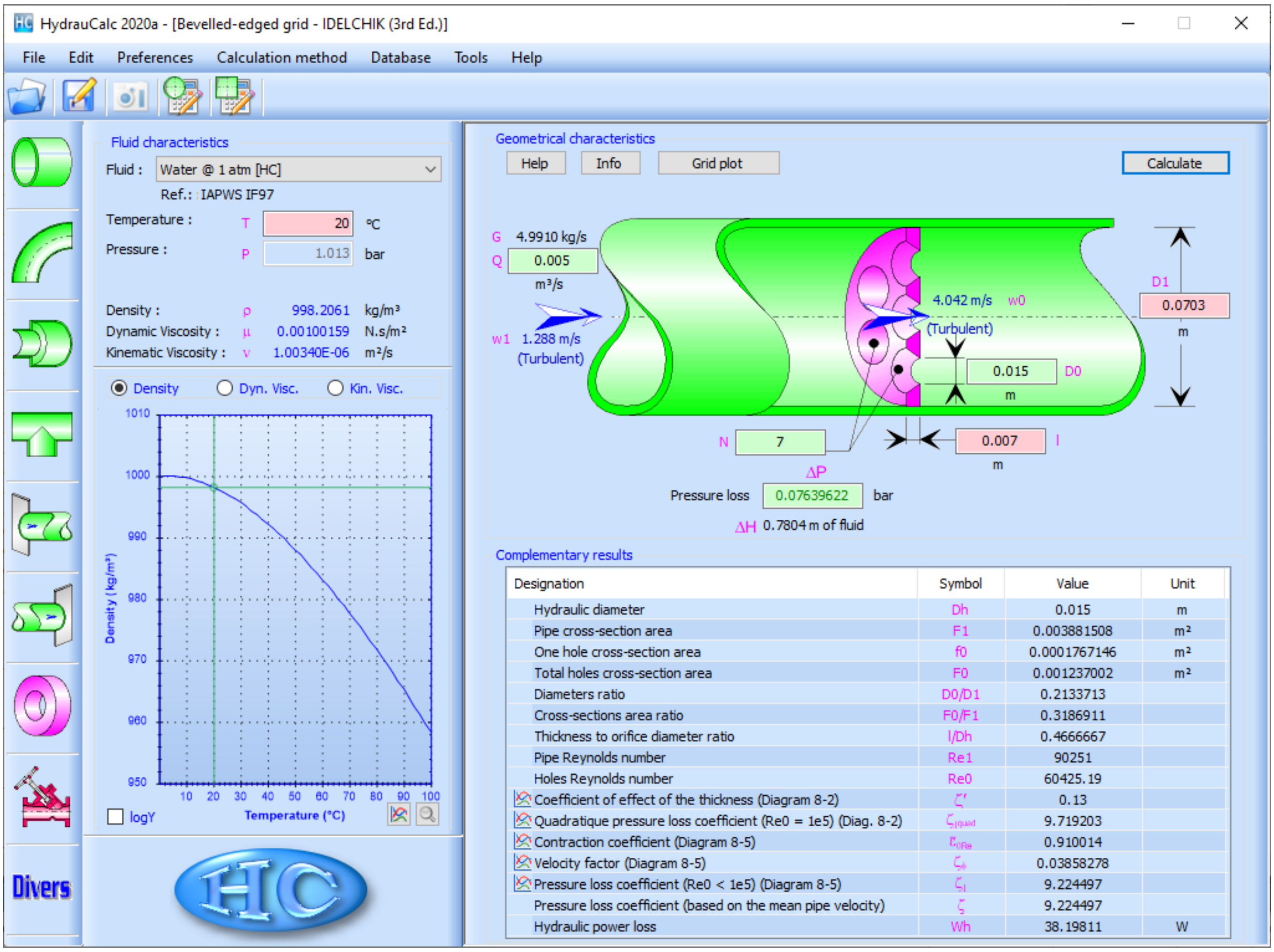
ν Fluid kinematic viscosity (m^2/s)

g Gravitational acceleration (m/s^2)

Validity range:

- any flow regime: laminar and turbulent
- stabilized flow upstream of the grid
- thickness to hole diameter ratio (l/D_0) greater than 0.015
- top angle of the holes between 40° and 90°

Example of application:



References:

[1] Handbook of Hydraulic Resistance, 3rd Edition, I.E. Idelchik