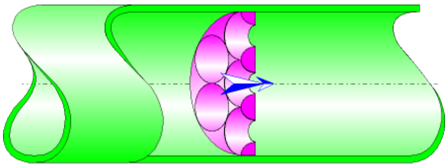
Rounded-Edged Grid
Circular Cross-Section
(IDELCHIK)



Model description:

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

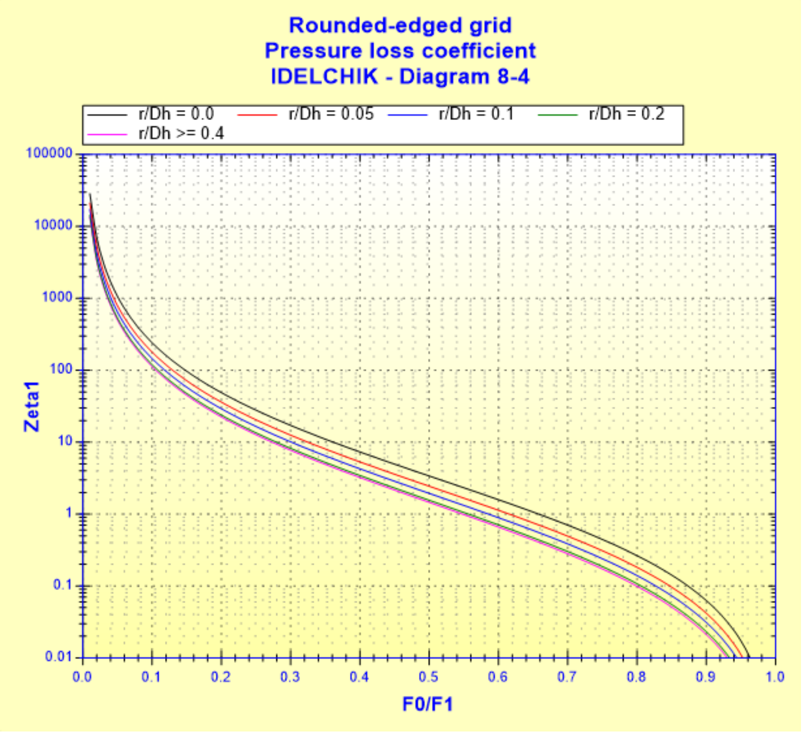
$$\boxed{\mathrm{Re}_0 = \frac{w_0 \cdot D_0}{\nu}}$$

Local resistance coefficient:

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

$$\boxed{\zeta_1 = \left[\sqrt{\zeta'} \cdot \left(1 - \frac{F_0}{F_1}\right)^{0.75} + \left(1 - \frac{F_0}{F_1}\right)\right]^2 \cdot \left(\frac{F_1}{F_0}\right)^2}$$

([1] diagram 8-4)

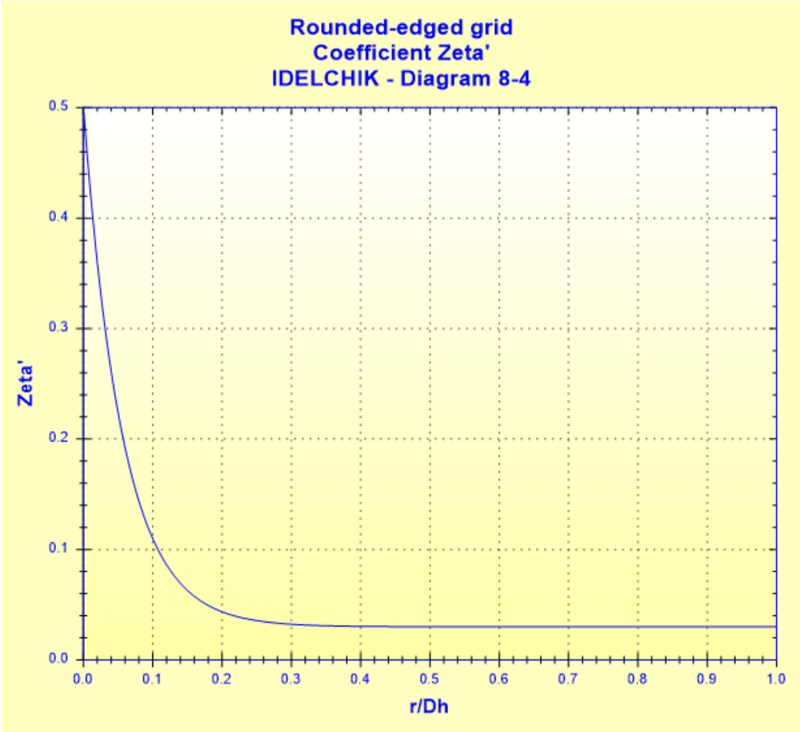


with :

Coefficient of effect of the round:

$$\boxed{\zeta' = 0.03 + 0.47 \cdot 10^{-7.7 \cdot \frac{r}{D_h}}}$$

([1] diagram 8-4)



- $Re_0 \leq 10^5$

Quadratic local resistance coefficient:

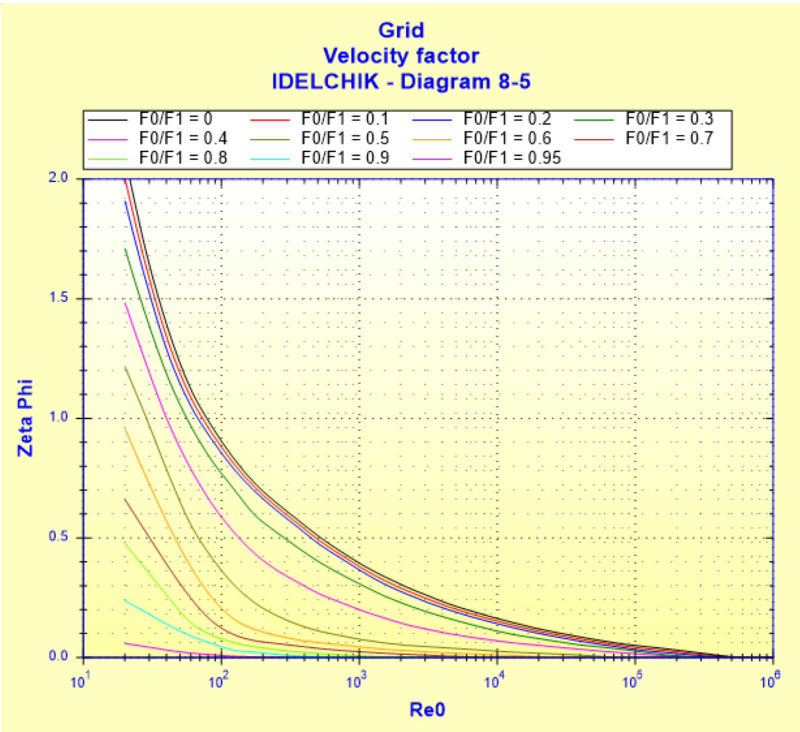
$$\zeta_{1quad} = \left[\sqrt{\zeta'} \cdot \left(1 - \frac{F_0}{F_1}\right)^{0.75} + \left(1 - \frac{F_0}{F_1}\right)\right]^2 \cdot \left(\frac{F_1}{F_0}\right)^2$$

([1] diagram 8-4)

Velocity factor:

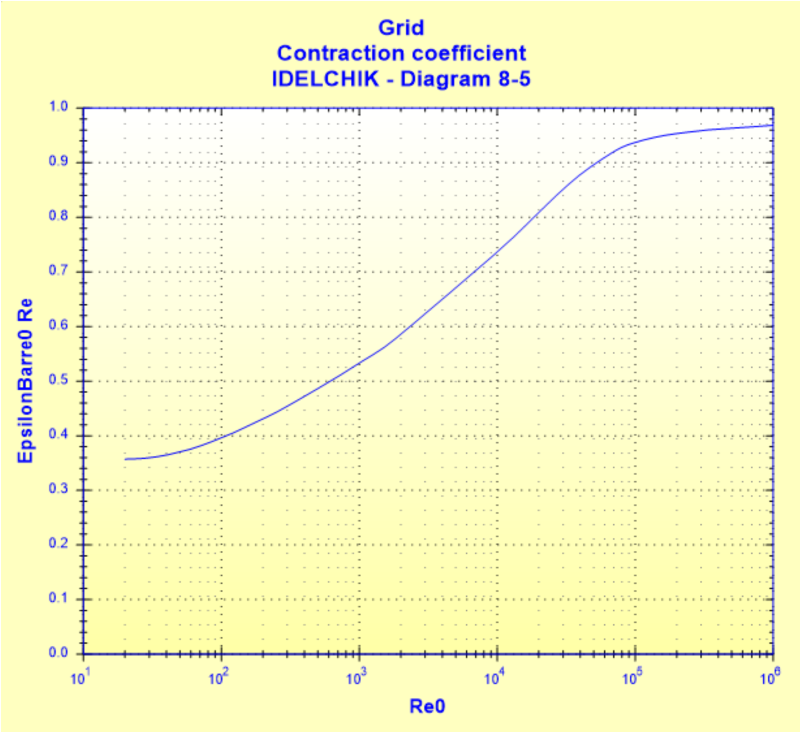
$$\zeta_\varphi = f\left(\mathrm{Re}_0, \frac{F_0}{F_1}\right)$$

([1] diagram 8-5)



Contraction factor:

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



Coefficient of local resistance:

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

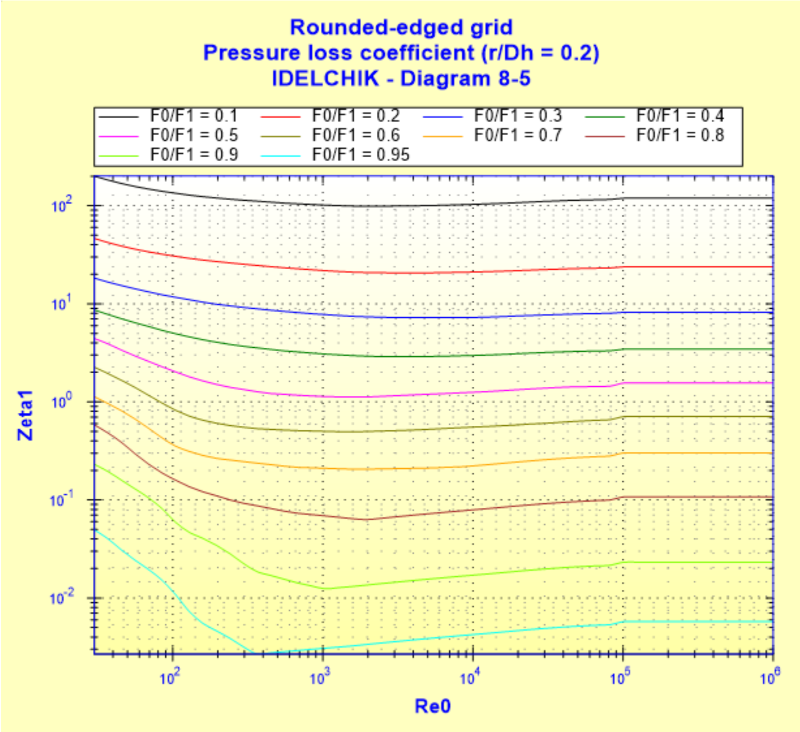
$$\zeta_1 = \zeta_\varphi \cdot \left(\frac{F_1}{F_0}\right)^2 + \bar{\varepsilon}_{0\mathrm{Re}} \cdot \zeta_{1quad}$$ ([1] diagram 8-5)

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

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

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

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



([1] diagram 8-5 with r/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:

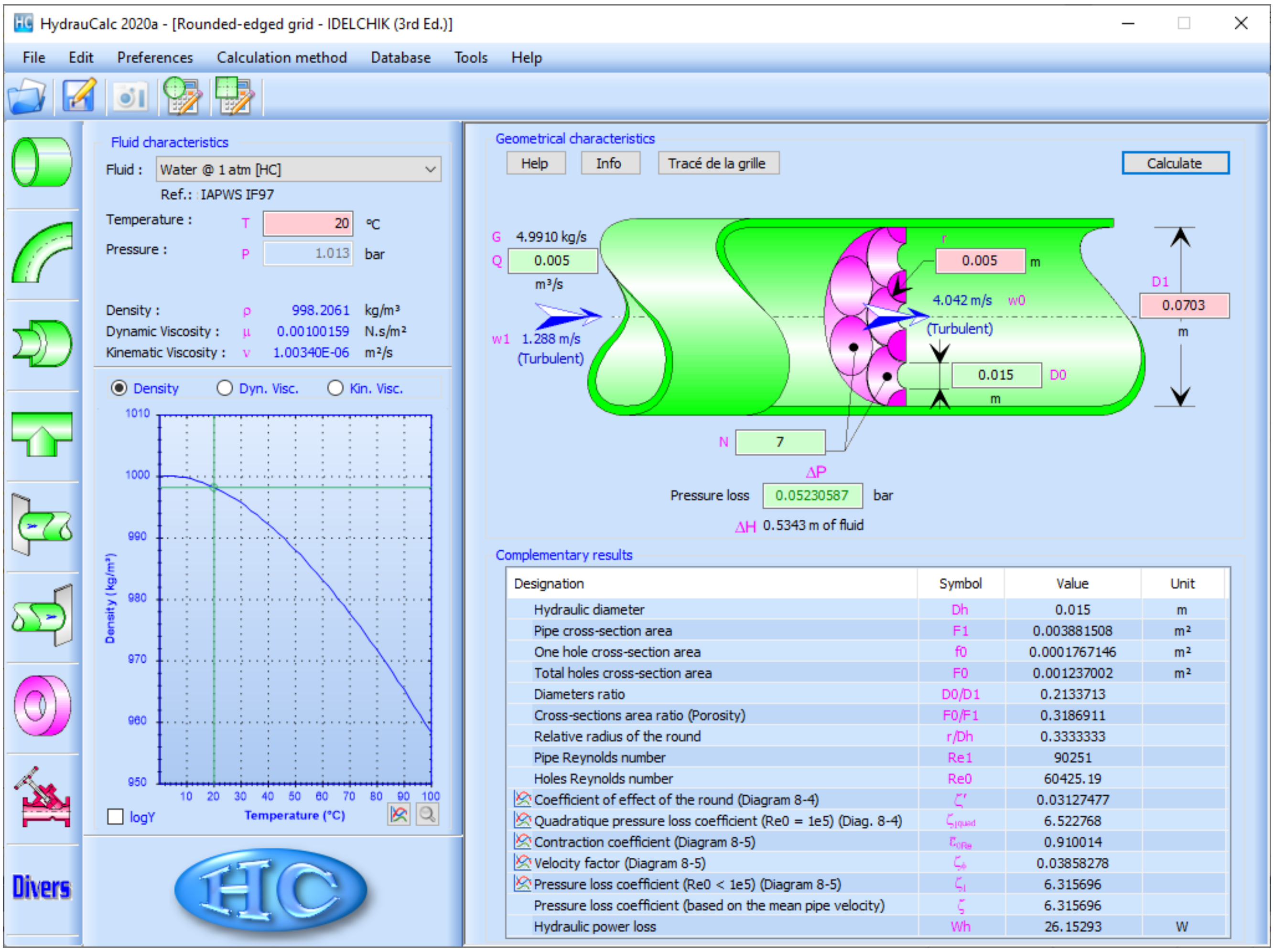
D_h	Hydraulic diameter (m)
D_1	Pipe internal diameter (m)
F_1	Pipe cross-sectional area (m^2)
N	Holes number ()
D_0	Holes diameter (m)
F_0	Clear cross-sectional area of the grid (m^2)
f_0	Cross-section area of one hole (m^2)
Q	Volume flow rate (m^3/s)
w_1	Mean velocity in pipe (m/s)
w_0	Mean velocity in holes (m/s)
G	Mass flow rate (kg/s)

r	Radius of the round (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/m³)
ν	Fluid kinematic viscosity (m²/s)
g	Gravitational acceleration (m/s²)

Validity range:

- any flow regime: laminar and turbulent
- stabilized flow upstream of the grid

Example of application:



References:

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