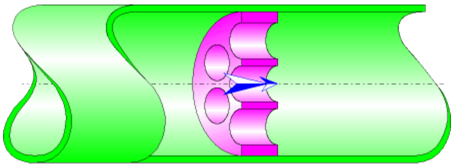
Thick-Edged Grid
Circular Cross-Section
(IDELCHIK)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a thick-edged grid (perforated plate) installed in a straight pipe. Moreover, the head loss due to friction of the fluid on the inner walls of the holes is also taken into account in this component and is calculated with Darcy's formula.

The head loss by friction in the inlet and outlet piping is not taken into account in this component.

Model formulation:

Hydraulic diameter (m):

$$D_h = D_0$$

Pipe cross-section area (m²):

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

Cross-section area of one hole (m²):

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

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

$$F_0 = f_0 \cdot N$$

Mean velocity in pipe (m/s):

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

Mean velocity in holes (m/s):

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

Mass flow rate (kg/s):

$$G = Q \cdot \rho$$

Reynolds number in pipe:

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

Reynolds number in holes:

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

Relative roughness in holes walls:

$$\overline{\Delta} = \frac{\Delta}{D_0}$$

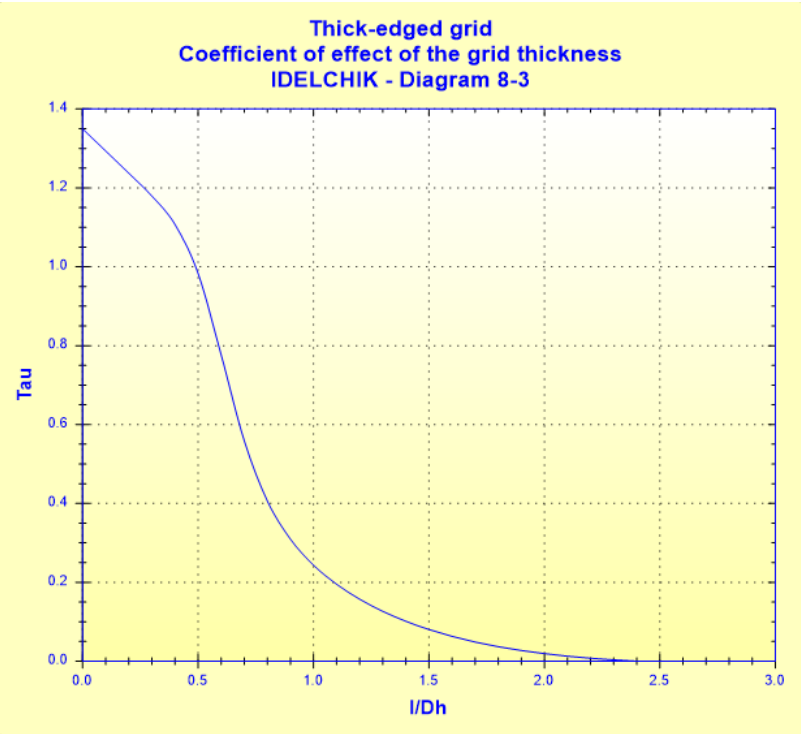
Coefficient of effect of the grid thickness:

$$\tau = \left(2.4 - \frac{l}{D_h}\right) \cdot 10^{-\varphi\left(\frac{l}{D_h}\right)}$$

([1] diagram 8-3)

with:

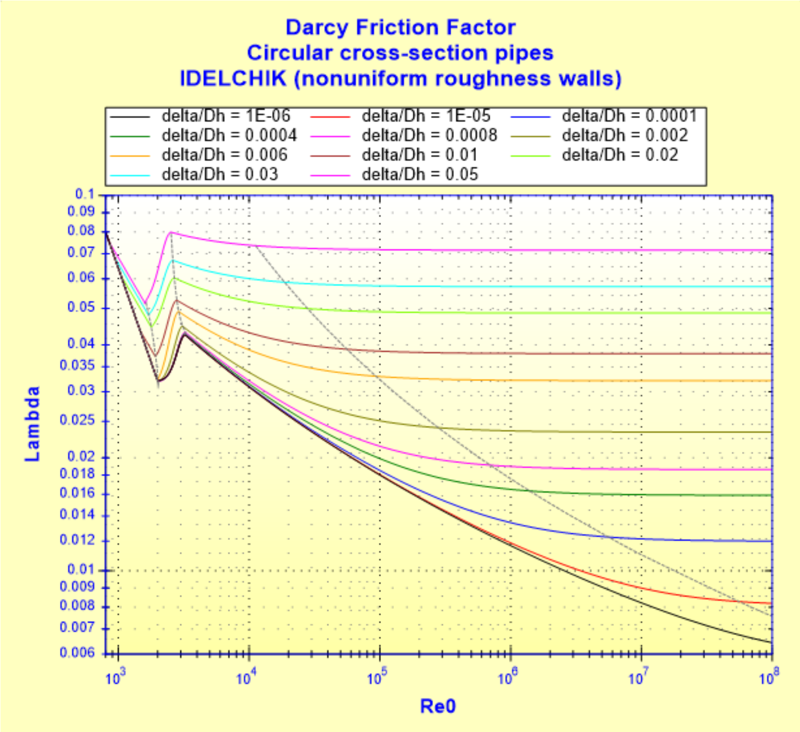
$$\varphi\left(\frac{l}{D_h}\right) = 0.25 + \frac{0.535 \cdot \left(\frac{l}{D_h}\right)^8}{0.05 \cdot \left(\frac{l}{D_h}\right)^7}$$



Darcy friction factor:

$$\lambda = f\left(\mathrm{Re}_0, \frac{\Delta}{D_h}\right)$$

See Straight Pipe - Circular Cross-Section and Nonuniform Roughness Walls (IDELCHIK)

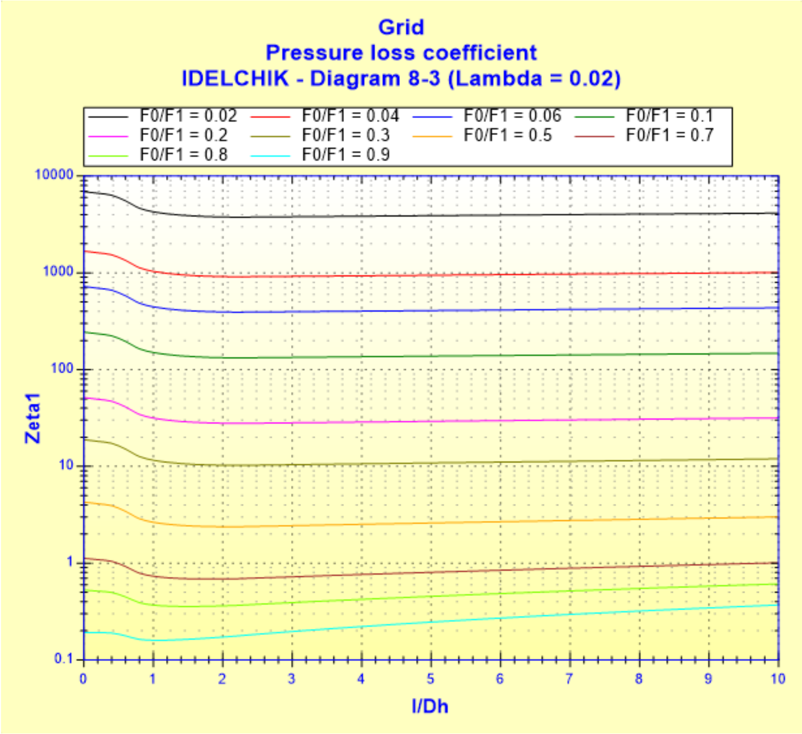


Coefficient of local resistance:

■ $\mathrm{Re}_0 \geq 10^5$

$$\zeta_1 = \frac{0.5 \cdot \left(1 - \frac{F_0}{F_1}\right)^{0.75} + \tau \cdot \left(1 - \frac{F_0}{F_1}\right)^{1.375} + \left(1 - \frac{F_0}{F_1}\right)^2 + \lambda \cdot \frac{l}{D_h}}{\left(\frac{F_0}{F_1}\right)^2}$$

([1] diagram 8-3)



([1] diagram 8-3 with λ = 0.02)

- $Re_0 < 10^5$

Quadratic coefficient of local resistance:

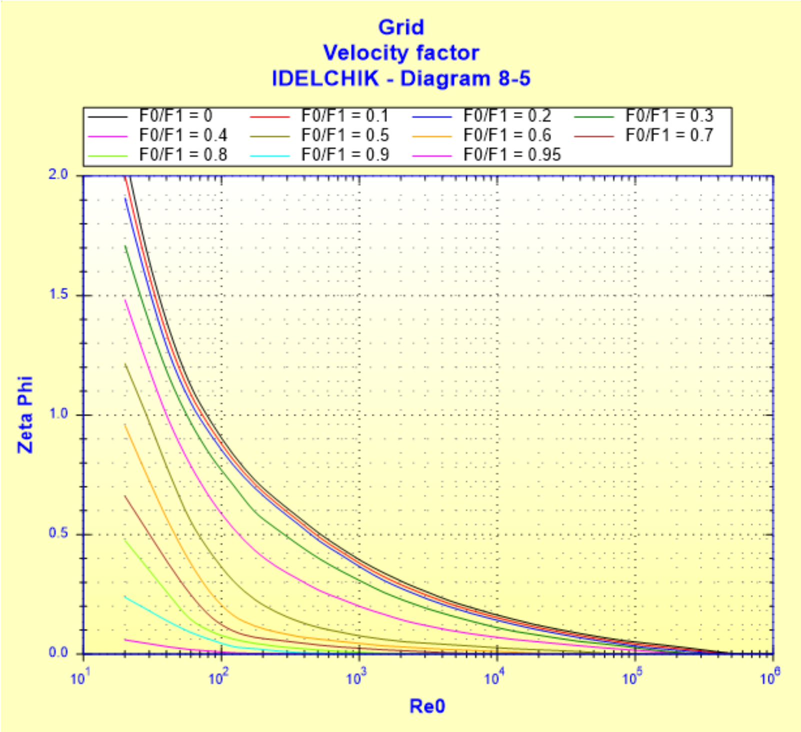
$$\zeta_{1quad} = \frac{0.5 \cdot \left(1 - \frac{F_0}{F_1}\right)^{0.75} + \tau \cdot \left(1 - \frac{F_0}{F_1}\right)^{1.375} + \left(1 - \frac{F_0}{F_1}\right)^2 + \lambda \cdot \frac{l}{D_h}}{\left(\frac{F_0}{F_1}\right)^2}$$

([1] diagram 8-3)

Velocity factor:

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

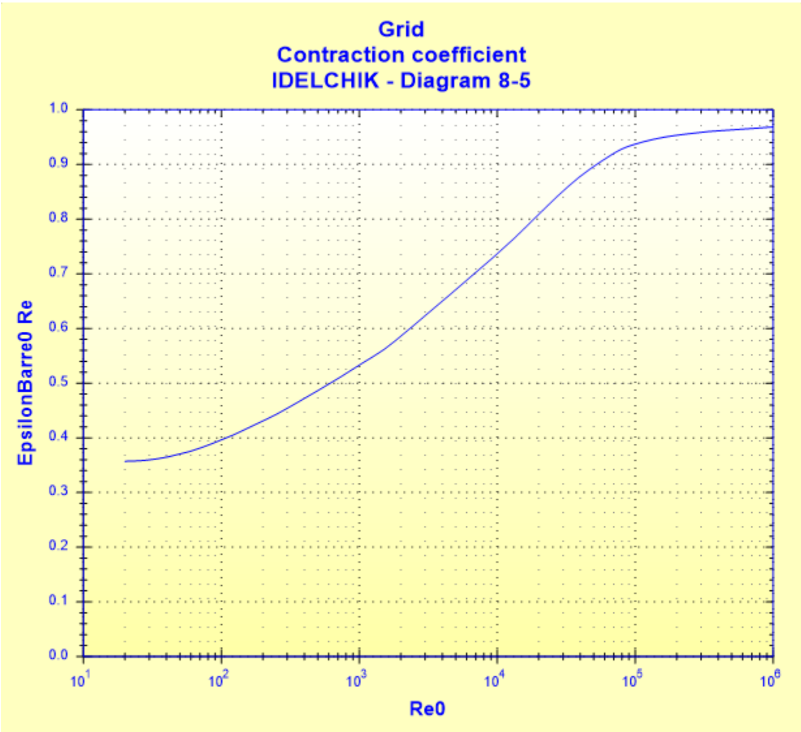
([1] diagram 8-5)



Contraction factor:

$$\bar{\varepsilon}_{0\mathrm{Re}} = f(\mathrm{Re}_0)$$

([1] diagram 8-5)



Coefficient of local resistance:

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

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

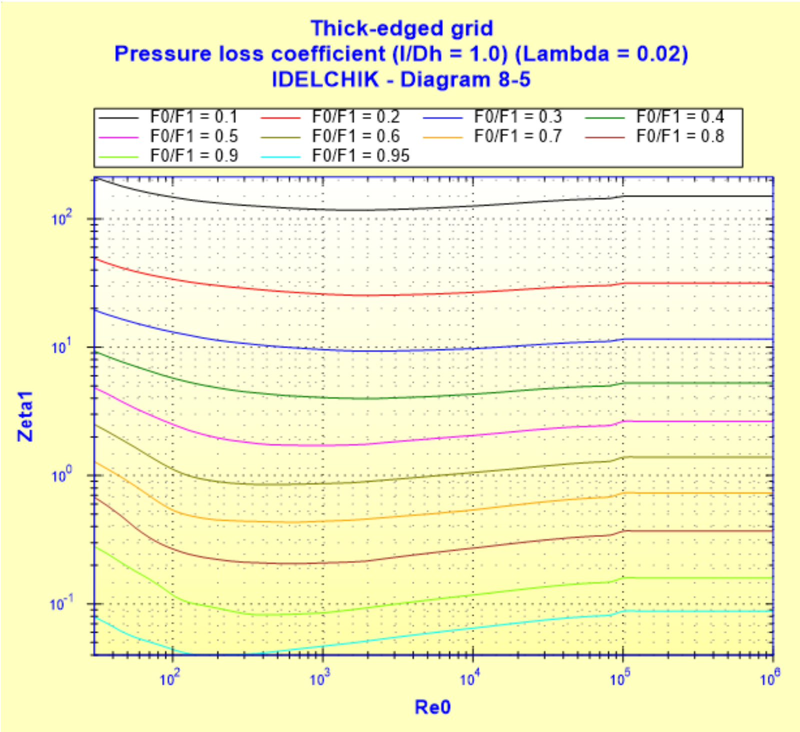
([1] diagram 8-5)

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

$$\zeta_1 = \frac{33}{Re_0} \cdot \left(\frac{F_1}{F_0}\right)^2 + \bar{\varepsilon}_{0Re} \cdot \zeta_{1quad}$$ ([1] diagram 8-5)

- $Re_0 \le 10$

$$\zeta_1 = \frac{33}{Re_0} \cdot \left(\frac{F_1}{F_0}\right)^2$$ ([1] diagram 8-5)



([1] diagram 8-5 with l/Dh = 1 and λ = 0.02)

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

$$\zeta = \zeta_1$$

Total pressure loss (Pa):

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

Total head loss of fluid (m):

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

Hydraulic power loss (W):

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

Symbols, Definitions, SI Units:

D_h	Hydraulic diameter (m)
D_1	Pipe internal diameter (m)
F_1	Pipe cross-sectional area (m²)

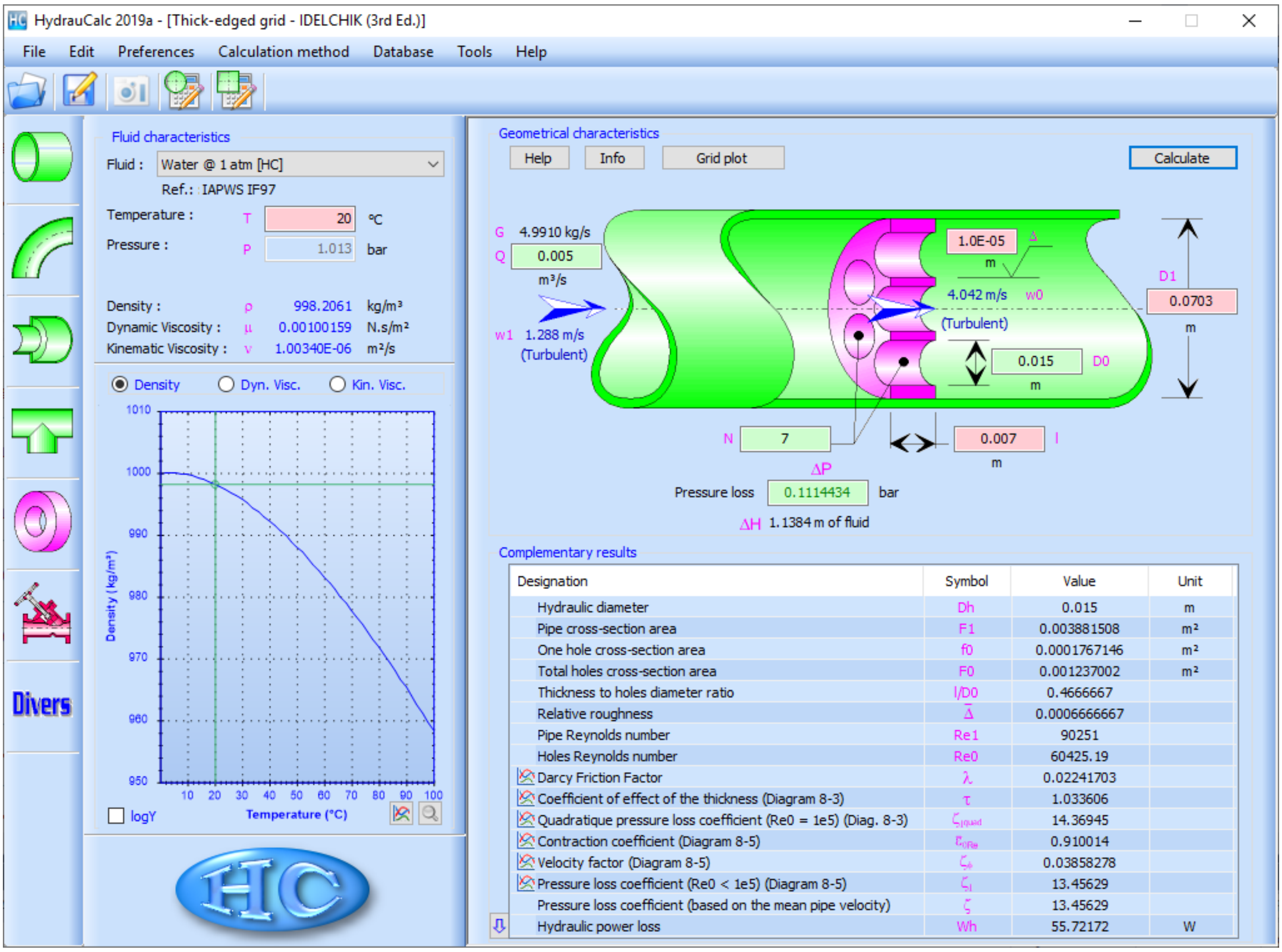
N Holes number ()
D_0 Holes diameter (m)
F_0 Clear cross-sectional area of the grid (m^2)
f_0 Cross-section area of one hole (m^2)
Q Volume flow rate (m^3/s)
w_1 Mean velocity in pipe (m/s)
w_0 Mean velocity in holes (m/s)
G Mass flow rate (kg/s)
Re_1 Reynolds number in pipe ()
Re_0 Reynolds number in holes ()
Δ Absolute roughness of holes walls (m)
$\bar{\Delta}$ Relative roughness of holes walls ()
l Grid thickness (m)
τ Coefficient of effect of the grid thickness ()
λ Darcy friction factor 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

Example of application:



References:

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

[2] Идельчик.И.Е.Справочник по гидравлическим сопротивлениям.1992 (original document in Russian language)

Note: The formulation used for the calculation of the coefficient $\varphi\left(\frac{l}{D_h}\right)$ is that of the original reference document [2] which differs from that of the translated document [1]