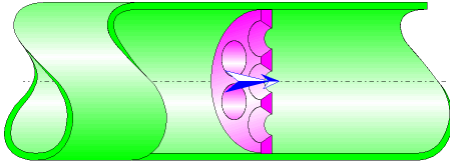




Bevelled-Edged Grid Circular Cross-Section (IDELCHIK)



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):

$$D_h = D_0$$

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:

$$Re_1 = \frac{w_1 \cdot D_1}{\nu}$$

Reynolds number in holes:

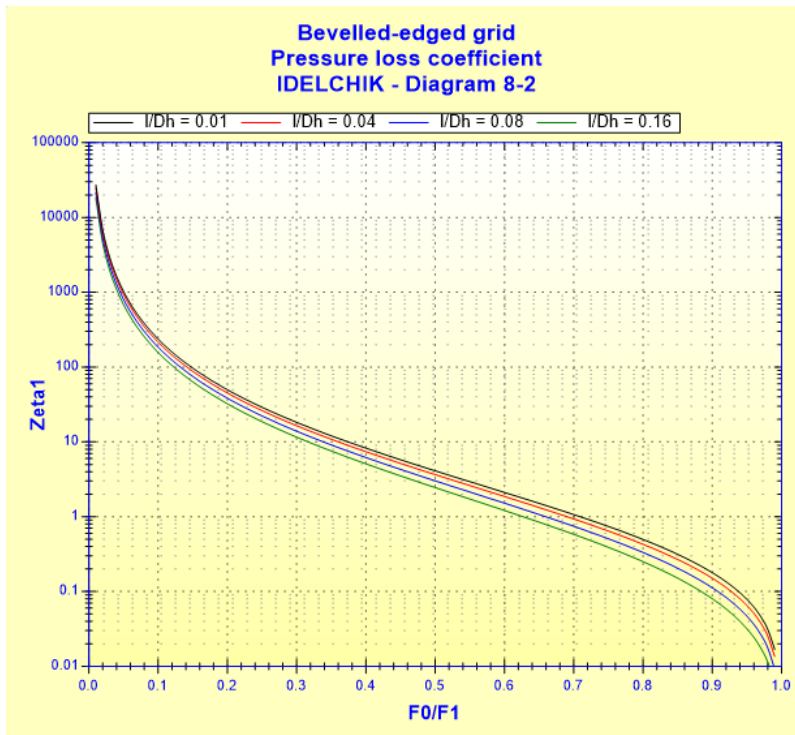
$$Re_0 = \frac{w_0 \cdot D_0}{\nu}$$

Local resistance coefficient:

■ $Re_0 \geq 10^5$

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

([1] diagram 8-2)

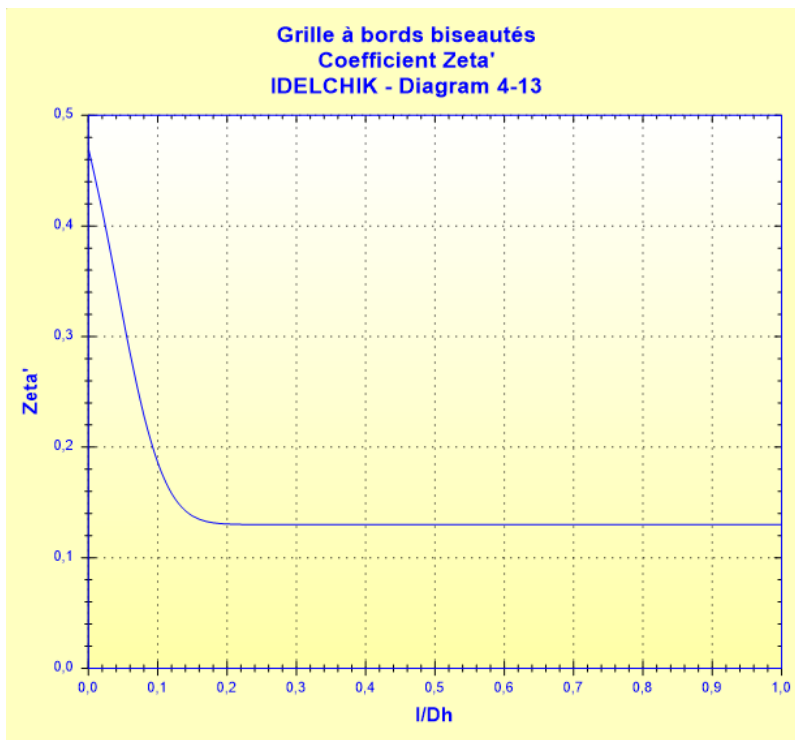


with :

Coefficient of effect of the orifice thickness:

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

([1] diagram 4-13)



■ $Re_0 \leq 10^5$

Quadratic local resistance coefficient:

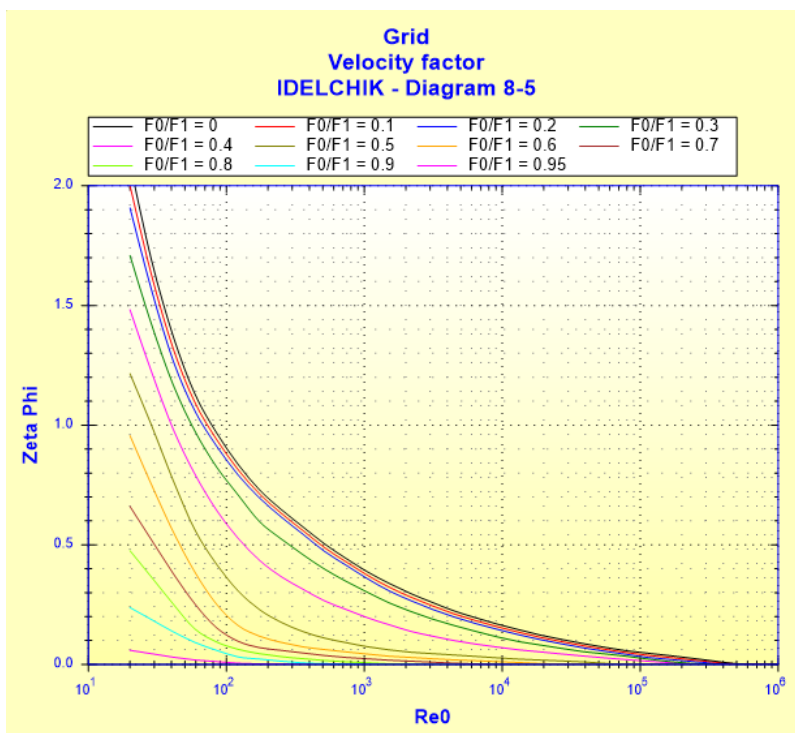
$$\zeta_{1quad} = \left[\sqrt{\zeta'} \cdot \left(1 - \frac{F_0}{F_1}\right)^{0.375} + \left(1 - \frac{F_0}{F_1}\right) \right]^2 \cdot \left(\frac{F_1}{F_0}\right)^2$$

([1] diagram 8-2)

Velocity factor:

$$\zeta_\varphi = f\left(Re_0, \frac{F_0}{F_1}\right)$$

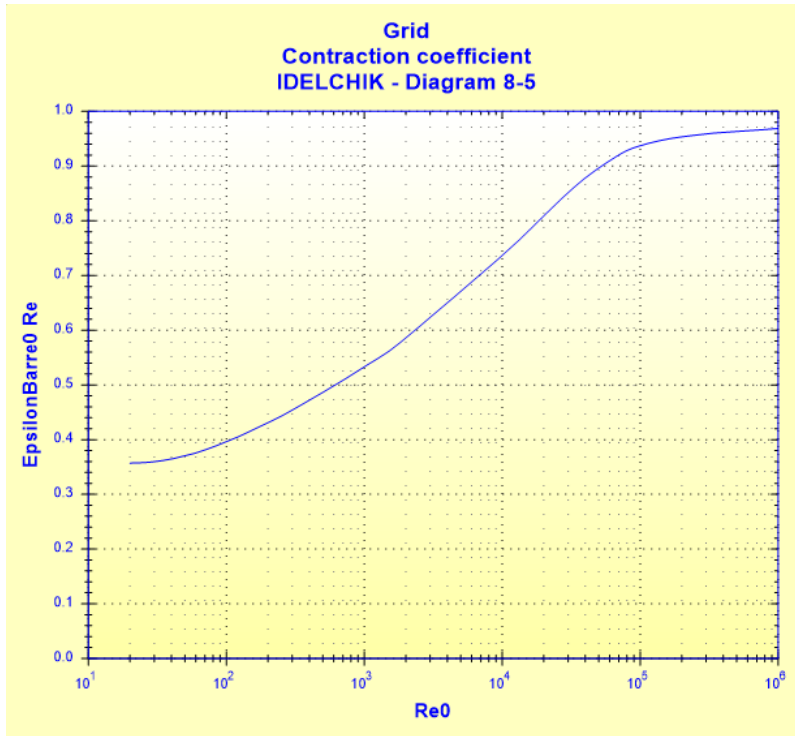
([1] diagram 8-5)



Contraction factor:

$$\bar{\varepsilon}_{0Re} = f(Re_0)$$

([1] diagram 8-5)



Coefficient of local resistance:

- $30 < Re_0 < 10^5$

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

([1] diagram 8-5)

- $10 < Re_0 \leq 30$

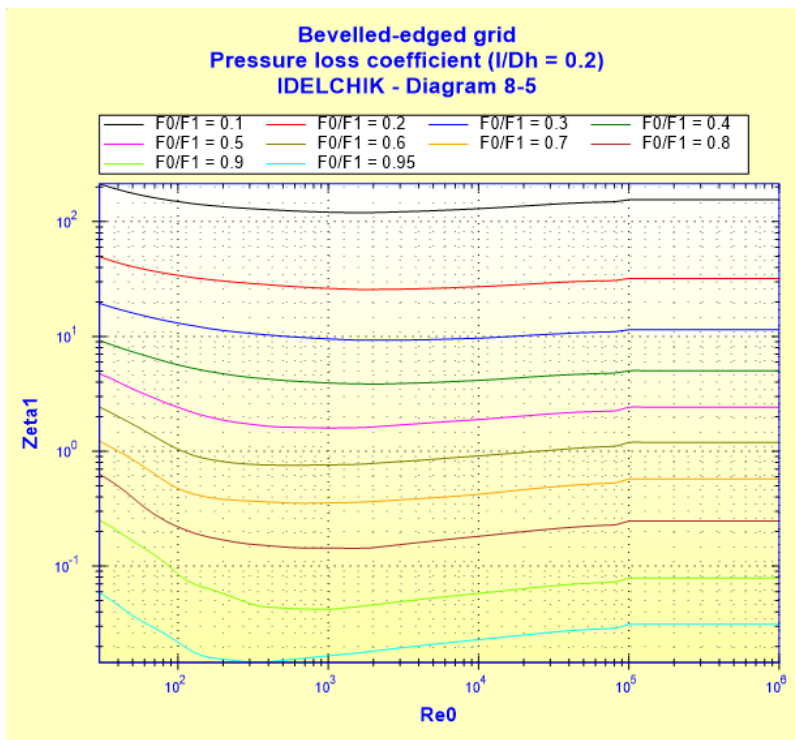
$$\zeta_1 = \frac{33}{Re_0} \cdot \left(\frac{F_1}{F_0} \right)^2 + \bar{\varepsilon}_{0Re} \cdot \zeta_{1quad}$$

([1] diagram 8-5)

- $Re_0 \leq 10$

$$\zeta_1 = \frac{33}{Re_0} \cdot \left(\frac{F_1}{F_0} \right)^2$$

([1] diagram 8-5)



([1] diagram 8-5 with

l/Dh = 0.2)

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 (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)

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_p	Velocity factor ()
ε_{0Re}	Contraction factor ()
ζ_l	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:

The screenshot shows the HydraulCalc 2020a software interface. The main window is titled "HydrauCalc 2020a - [Bevelled-edged grid - IDELCHIK (3rd Ed.)]". The interface is divided into several sections:

- Fluid characteristics:**
 - Fluid: Water @ 1 atm [HC]
 - Temperature: 20 °C
 - Pressure: 1.013 bar
 - Density: 998.2061 kg/m³
 - Dynamic Viscosity: 0.00100159 N.s/m²
 - Kinematic Viscosity: 1.00340E-06 m²/s
 - Graph: Density (kg/m³) vs Temperature (°C)
- Geometrical characteristics:**
 - Mass flow rate (G): 4.9910 kg/s
 - Volume flow rate (Q): 0.005 m³/s
 - Velocity (w1): 1.288 m/s (Turbulent)
 - Velocity (w0): 4.042 m/s (Turbulent)
 - Hole diameter (D0): 0.015 m
 - Grid thickness (l): 0.007 m
 - Number of holes (N): 7
 - Pressure loss (ΔP): 0.07639622 bar
 - Head loss (ΔH): 0.7804 m of fluid
- Complementary results:**

Designation	Symbol	Value	Unit
Hydraulic diameter	Dh	0.015	m
Pipe cross-section area	F1	0.003881508	m ²
One hole cross-section area	f0	0.0001767146	m ²
Total holes cross-section area	F0	0.001237002	m ²
Diameters ratio	D0/D1	0.2133713	
Cross-sections area ratio	F0/F1	0.3186911	
Thickness to orifice diameter ratio	l/Dh	0.4666667	
Pipe Reynolds number	Re1	90251	
Holes Reynolds number	Re0	60425.19	
Coefficient of effect of the thickness (Diagram 8-2)	ζ'	0.13	
Quadratic pressure loss coefficient (Re0 = 1e5) (Diag. 8-2)	ζ _{1quad}	9.719203	
Contraction coefficient (Diagram 8-5)	ε _{0Re}	0.910014	
Velocity factor (Diagram 8-5)	ζ _p	0.03858278	
Pressure loss coefficient (Re0 < 1e5) (Diagram 8-5)	ζ _l	9.224497	
Pressure loss coefficient (based on the mean pipe velocity)	ζ	9.224497	
Hydraulic power loss	Wh	38.19811	W

References:

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

HydrauCalc
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