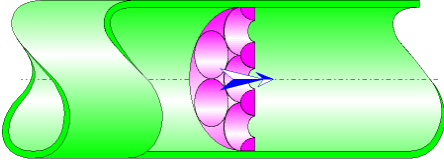




## Rounded-Edged Grid Circular Cross-Section (IDELCHIK)



### 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:

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Hydraulic diameter (m):

$$D_h = D_0$$

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Pipe cross-section area (m<sup>2</sup>):

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

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Cross-section area of one hole (m<sup>2</sup>):

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

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Clear cross-sectional area of the grid (m<sup>2</sup>):

$$F_0 = f_0 \cdot N$$

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Mean velocity in pipe (m/s):

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

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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:

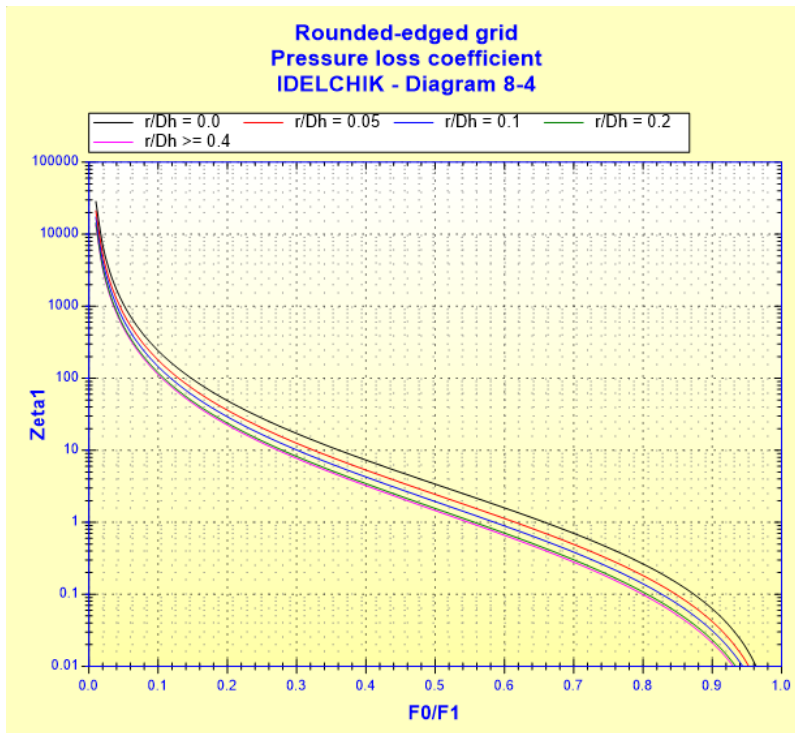
$$Re_0 = \frac{w_0 \cdot D_0}{\nu}$$

Local resistance coefficient:

■  $Re_0 \geq 10^5$

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

([1] diagram 8-4)

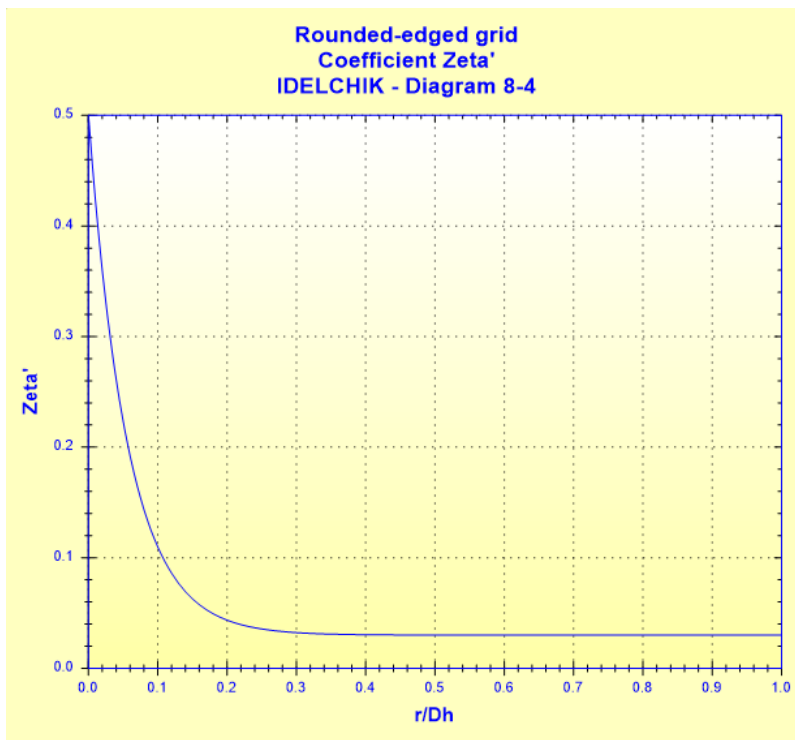


with :

Coefficient of effect of the round:

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

([1] diagram 8-4)



■  $Re_0 \leq 10^5$

Quadratic local resistance coefficient:

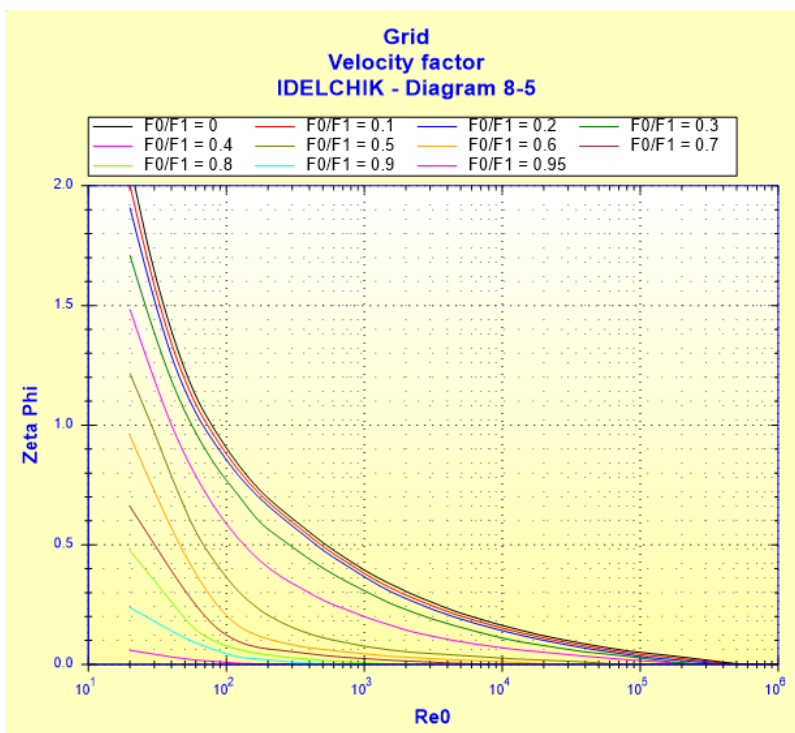
$$\zeta_{1quad} = \left[ \sqrt{\zeta'} \cdot \left(1 - \frac{F_0}{F_1}\right)^{0.75} + \left(1 - \frac{F_0}{F_1}\right) \right]^2 \cdot \left(\frac{F_1}{F_0}\right)^2$$

([1] diagram 8-4)

Velocity factor:

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

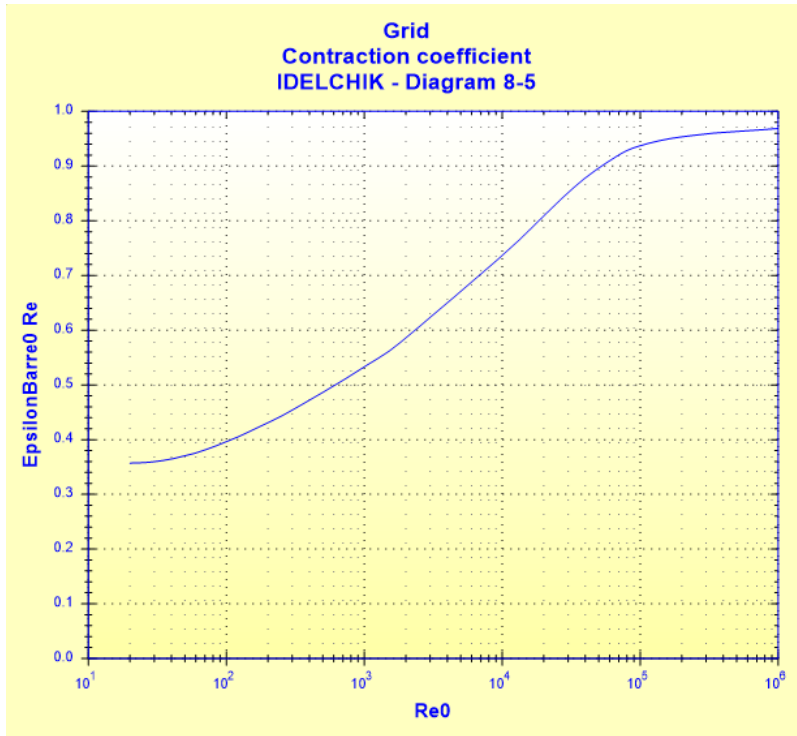
([1] diagram 8-5)



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)

- $10 < Re_0 \leq 30$

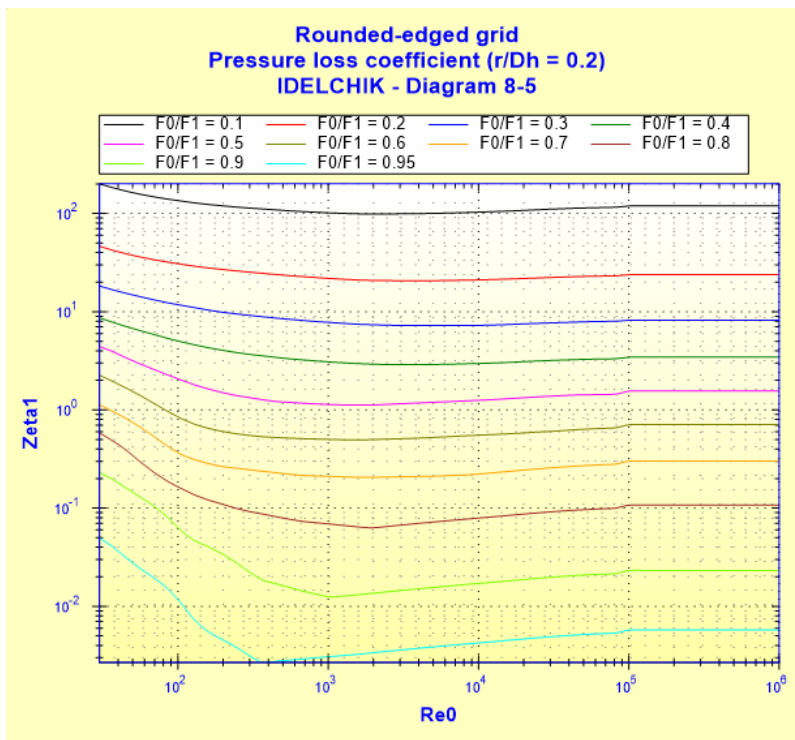
$$\zeta_1 = \frac{33}{Re_0} \cdot \left(\frac{F_1}{F_0}\right)^2 + \bar{\varepsilon}_{0Re} \cdot \zeta_{1quad}$$

([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

r/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 <sup>2</sup> )
$N$	Holes number ( )
$D_0$	Holes diameter (m)
$F_0$	Clear cross-sectional area of the grid (m <sup>2</sup> )
$f_0$	Cross-section area of one hole (m <sup>2</sup> )
$Q$	Volume flow rate (m <sup>3</sup> /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 ( )
$\zeta_{1quad}$	Quadratic pressure loss coefficient determined as $Re = 10^5$ ( )
$\zeta_p$	Velocity factor ( )
$\varepsilon_{0Re}$	Contraction factor ( )
$\zeta_l$	Coefficient of local resistance ( )
$\zeta$	Pressure loss coefficient (based on the mean pipe velocity) ( )
$\Delta P$	Total pressure loss (Pa)
$\Delta H$	Total head loss of fluid (m)
$Wh$	Hydraulic power loss (W)
$\rho$	Fluid density ( $kg/m^3$ )
$\nu$	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

### Example of application:

The screenshot shows the HydraulCalc 2020a software interface. The main window is titled "HydraulCalc 2020a - [Rounded-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/m<sup>3</sup>
  - Dynamic Viscosity: 0.00100159 N.s/m<sup>2</sup>
  - Kinematic Viscosity: 1.00340E-06 m<sup>2</sup>/s
  - Graph: Density (kg/m<sup>3</sup>) vs Temperature (°C) showing a decreasing trend from 1000 at 0°C to approximately 950 at 100°C.
- Geometrical characteristics:**
  - Flow rate (G): 4.9910 kg/s
  - Flow rate (Q): 0.005 m<sup>3</sup>/s
  - Velocity (w1): 1.288 m/s (Turbulent)
  - Velocity (w0): 4.042 m/s (Turbulent)
  - Grid spacing (D0): 0.015 m
  - Grid spacing (D1): 0.0703 m
  - Number of holes (N): 7
  - Pressure loss ( $\Delta P$ ): 0.05230587 bar
  - Head loss ( $\Delta H$ ): 0.5343 m of fluid
- Complementary results:**

Designation	Symbol	Value	Unit
Hydraulic diameter	Dh	0.015	m
Pipe cross-section area	F1	0.003881508	m <sup>2</sup>
One hole cross-section area	f0	0.0001767146	m <sup>2</sup>
Total holes cross-section area	F0	0.001237002	m <sup>2</sup>
Diameters ratio	D0/D1	0.2133713	
Cross-sections area ratio (Porosity)	F0/F1	0.3186911	
Relative radius of the round	r/Dh	0.3333333	
Pipe Reynolds number	Re1	90251	
Holes Reynolds number	Re0	60425.19	
Coefficient of effect of the round (Diagram 8-4)	$\zeta'$	0.03127477	
Quadratic pressure loss coefficient (Re0 = 1e5) (Diag. 8-4)	$\zeta_{1quad}$	6.522768	
Contraction coefficient (Diagram 8-5)	$\varepsilon_{0Re}$	0.910014	
Velocity factor (Diagram 8-5)	$\zeta_p$	0.03858278	
Pressure loss coefficient (Re0 < 1e5) (Diagram 8-5)	$\zeta_l$	6.315696	
Pressure loss coefficient (based on the mean pipe velocity)	$\zeta$	6.315696	
Hydraulic power loss	Wh	26.15293	W

### References:

