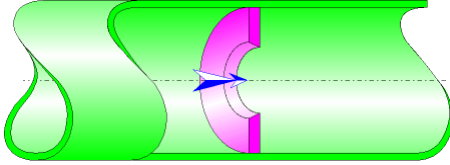




## Bevelled-Edged Orifice Circular Cross-Section (Pipe Flow - Guide)



### Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a bevelled-edged orifice 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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Ratio of orifice to pipe diameters:

$$\beta = \frac{d_o}{d}$$

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

$$A = \pi \cdot \frac{d^2}{4}$$

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Orifice cross-sectional area (m<sup>2</sup>):

$$A_o = \pi \cdot \frac{d_o^2}{4}$$

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Pipe velocity (m/s):

$$V = \frac{Q}{A}$$

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Orifice velocity (m/s):

$$V_o = \frac{Q}{A_o}$$

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Mass flow rate (kg/s):

$$G = Q \cdot \rho_m$$

Reynolds number in pipe:

$$N_{Re} = \frac{V \cdot d}{\nu}$$

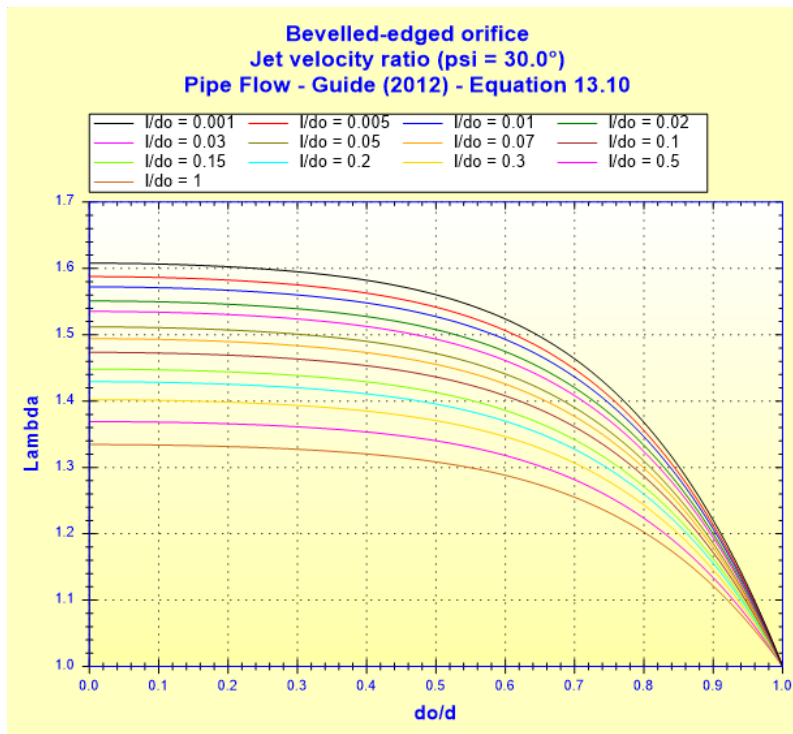
Reynolds number in orifice:

$$N_{Re_o} = \frac{V_o \cdot d_o}{\nu}$$

Jet velocity ratio:

$$\lambda = 1 + 0.622 \cdot \left[ 1 - C_b \cdot \left( \frac{l}{d_o} \right)^{\frac{1-4\sqrt{l/d_o}}{2}} \right] \cdot (1 - 0.215 \cdot \beta^2 - 0.785 \cdot \beta^5)$$

([1] equation 13.10)

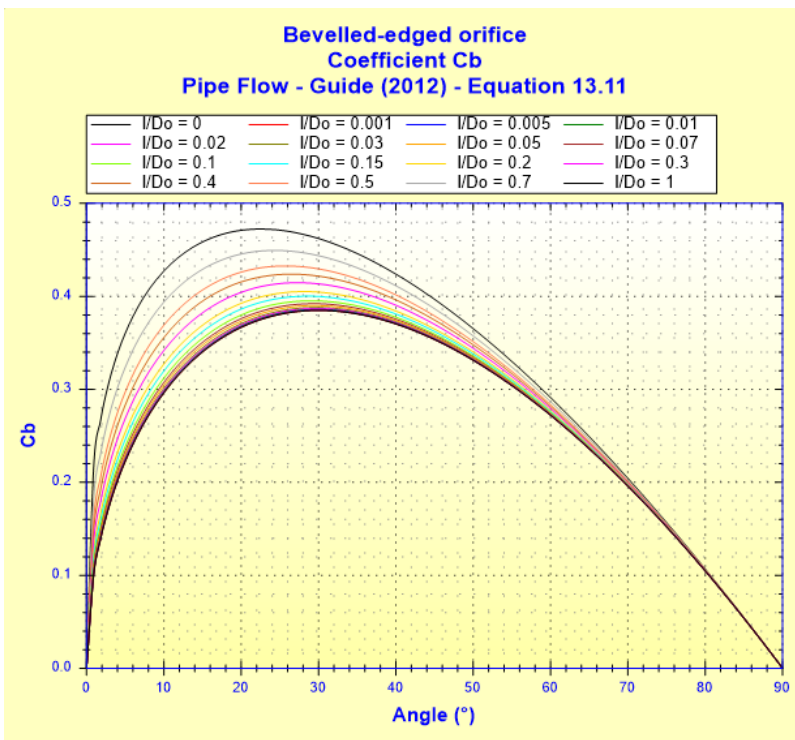


with:

Coefficient of effect of the bevel angle:

$$C_b = \left( 1 - \frac{\Psi}{90} \right) \cdot \left( \frac{\Psi}{90} \right)^{\frac{1}{2+l/d_o}}$$

([1] equation 13.11)



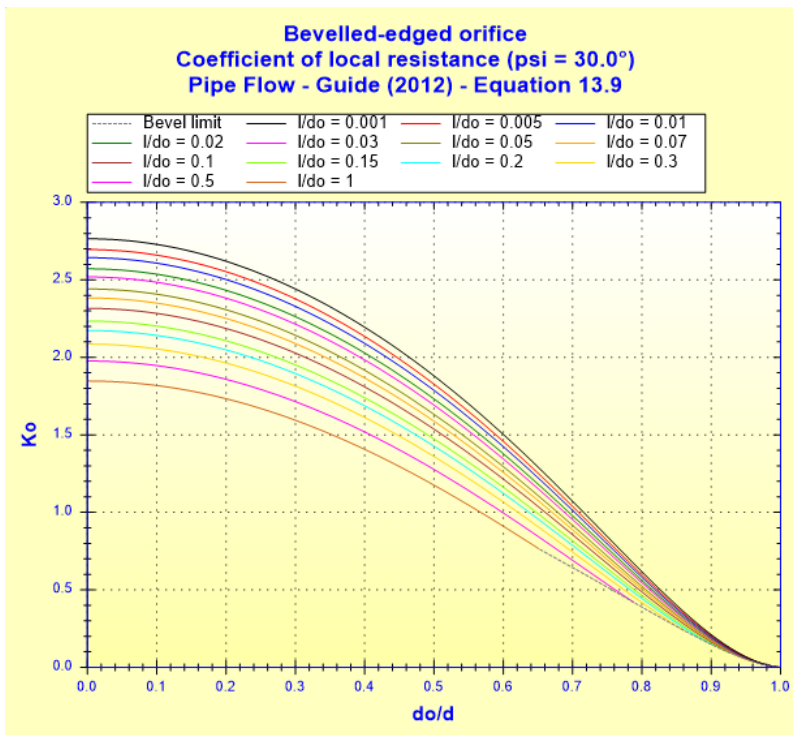
Velocity in vena contracta:

$$V_c = V_0 \cdot \lambda$$

Coefficient of local resistance ( $NRe_o \geq 10^4$ ):

$$K_o = 0.0696 \cdot \left(1 - C_b \cdot \frac{l}{d_o}\right) \cdot \left(1 - 0.42 \cdot \sqrt{\frac{l}{d_o}} \cdot \beta^2\right) \cdot (1 - \beta^5) \cdot \lambda^2 + (\lambda - \beta^2)^2$$

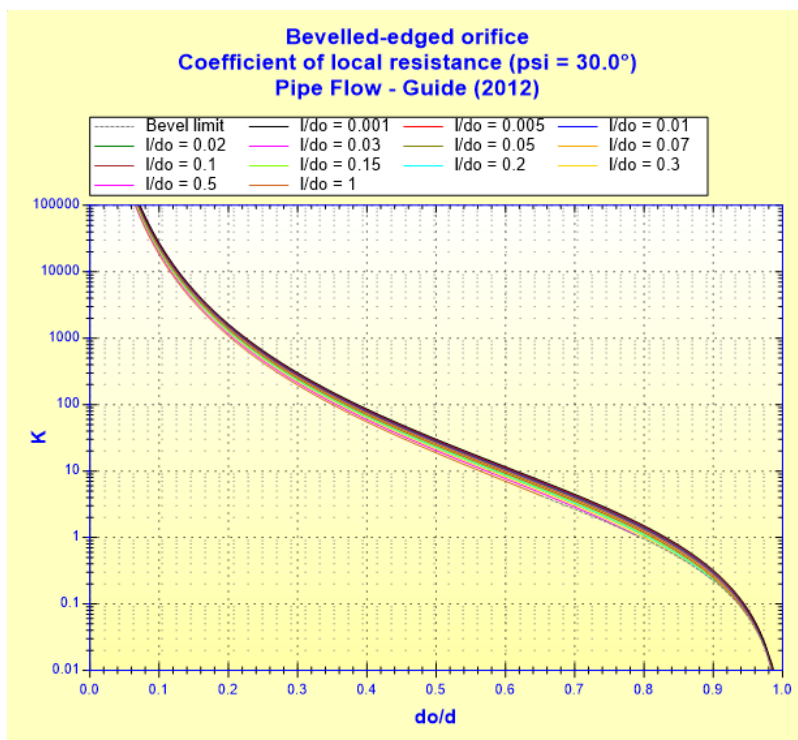
([1] equation 13.9)



(with  $\psi = 30^\circ$ )

Total pressure loss coefficient (based on the mean pipe velocity):

$$K = K_o \cdot \left(\frac{A}{A_o}\right)^2$$



Total pressure loss (Pa):

$$\Delta P = K \cdot \frac{\rho_m \cdot V^2}{2}$$

Total head loss of fluid (m):

$$\Delta H = K \cdot \frac{V^2}{2 \cdot g}$$

Hydraulic power loss (W):

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

**Symbols, Definitions, SI Units:**

$d_o$	Orifice diameter (m)
$d$	Internal pipe diameter (m)
$\beta$	Ratio of orifice to pipe diameters ( )
$A_o$	Orifice cross-sectional area (m <sup>2</sup> )
$A$	Pipe cross-sectional area (m <sup>2</sup> )
$Q$	Volume flow rate (m <sup>3</sup> /s)
$G$	Mass flow rate (kg/s)
$V_o$	Mean velocity in orifice (m/s)
$V$	Mean velocity in pipe (m/s)
$NRe_o$	Reynolds number in orifice ( )
$NRe$	Reynolds number in pipe ( )
$l$	Thickness orifice (m)
$\psi$	Bevel angle (°)
$\lambda$	Jet velocity ratio ( )
$V_c$	Mean velocity in vena contracta (m/s)

$C_b$	Coefficient of effect of the bevel angle ( )
$K_o$	Coefficient of local resistance ( )
$K$	Total pressure loss coefficient (based on the mean pipe velocity) ( )
$\Delta P$	Total pressure loss (Pa)
$\Delta H$	Total head loss of fluid (m)
$W_h$	Hydraulic power loss (W)

$\rho_m$	Fluid density ( $\text{kg/m}^3$ )
$\nu$	Fluid kinematic viscosity ( $\text{m}^2/\text{s}$ )
$g$	Gravitational acceleration ( $\text{m/s}^2$ )

### Validity range:

- turbulent flow regime in orifice ( $NRe_o \geq 10^4$ )
- stabilized flow upstream of the orifice
- bevel angle less than or equal to:  $\psi \leq \text{tg}^{-1}((d - d_o) / (2 l))$

### Example of application:

The screenshot shows the HydraulCalc 2020b software interface. The main window is titled "HydrauCalc 2020b - [Bevelled-edged orifice - Pipe Flow - Guide (2012)]". The interface is divided into several sections:

- Fluid characteristics:**
  - Fluid: Water @ 1 atm [HC]
  - Ref.: IAPWS IF97
  - Temperature:  $T = 20$  °C
  - Pressure:  $P = 1.013$  bar
  - Density:  $\rho = 998.2061$   $\text{kg/m}^3$
  - Dynamic Viscosity:  $\mu = 0.00100159$   $\text{N.s/m}^2$
  - Kinematic Viscosity:  $\nu = 1.00340E-06$   $\text{m}^2/\text{s}$
  - Graph: Density ( $\text{kg/m}^3$ ) vs Temperature ( $^{\circ}\text{C}$ )
- Geometrical characteristics:**
  - Help, Info, Orifice plot, Calculate buttons
  - Diagram of a pipe with a bevelled-edged orifice. Parameters shown:
    - Mass flow rate  $G = 4.9910$   $\text{kg/s}$
    - Volume flow rate  $Q = 0.005$   $\text{m}^3/\text{s}$
    - Mean pipe velocity  $V = 1.288$   $\text{m/s}$  (Turbulent)
    - Orifice velocity  $V_o = 5.197$   $\text{m/s}$  (Turbulent)
    - Orifice diameter  $d_o = 0.035$  m
    - Orifice thickness  $l = 0.007$  m
    - Orifice diameter  $d = 0.0703$  m
    - Pressure loss  $\Delta P = 0.1992118$  bar
    - Head loss  $\Delta H = 2.0350$  m of fluid
- Complementary results:**

Designation	Symbol	Value	Unit
Pipe cross-section area	$A$	0.003881508	$\text{m}^2$
Orifice cross-section area	$A_o$	0.0009621127	$\text{m}^2$
Diameters ratio ( $d_o/d$ )	$\beta$	0.4978663	
Cross-sections area ratio	$A_o/A$	0.2478708	
Thickness to orifice diameter ratio	$l/D_h$	0.2	
Pipe Reynolds number	$NRe$	90251	
Orifice Reynolds number	$NRe_o$	181275.6	
Jet section	$A_c$	0.000680654	$\text{m}^2$
Velocity in vena contracta	$V_c$	7.345876	$\text{m/s}$
Coefficient of effect of the angle (Equation 13.11)	$C_b$	0.36487	
Jet velocity ratio (Equation 13.10)	$\lambda$	1.413512	
Coefficient of local resistance (Equation 13.9)	$K_o$	1.477872	
Pressure loss coefficient (based on the mean pipe velocity)	$K$	24.05392	
Hydraulic power loss	$W_h$	99.6059	W

### References:

[1] Pipe Flow: A Practical and Comprehensive Guide. Donald C. Rennels and Hobart M. Hudson. (2012)

