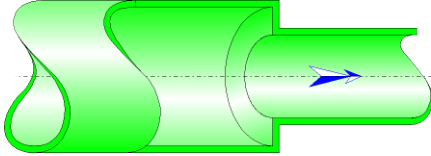




Sudden Contraction Sharp Circular Cross-Section (Pipe Flow - Guide)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a sudden contraction sharp.

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

Model formulation:

Ratio of small to large diameter:

$$\beta = \frac{d_2}{d_1}$$

Major cross-sectional area (m²):

$$A_1 = \pi \cdot \frac{d_1^2}{4}$$

Minor cross-sectional area (m²):

$$A_2 = \pi \cdot \frac{d_2^2}{4}$$

Mean velocity in major diameter (m/s):

$$V_1 = \frac{Q}{A_1}$$

Mean velocity in minor diameter (m/s):

$$V_2 = \frac{Q}{A_2}$$

Mass flow rate (kg/s):

$$G = Q \cdot \rho$$

Reynolds number in major diameter:

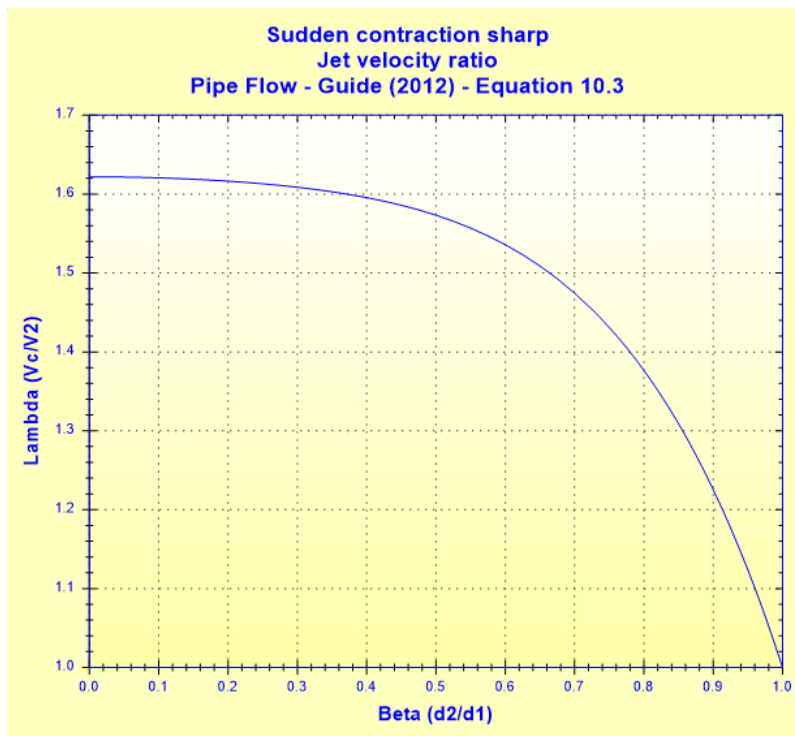
$$N_{Re_1} = \frac{V_1 \cdot d_1}{\nu}$$

Reynolds number in minor diameter:

$$N_{Re_2} = \frac{V_2 \cdot d_2}{\nu}$$

Jet velocity ratio:

$$\lambda = 1 + 0.622 \cdot (1 - 0.215\beta^2 - 0.785\beta^5) \quad ([1] \text{ equation 10.3})$$

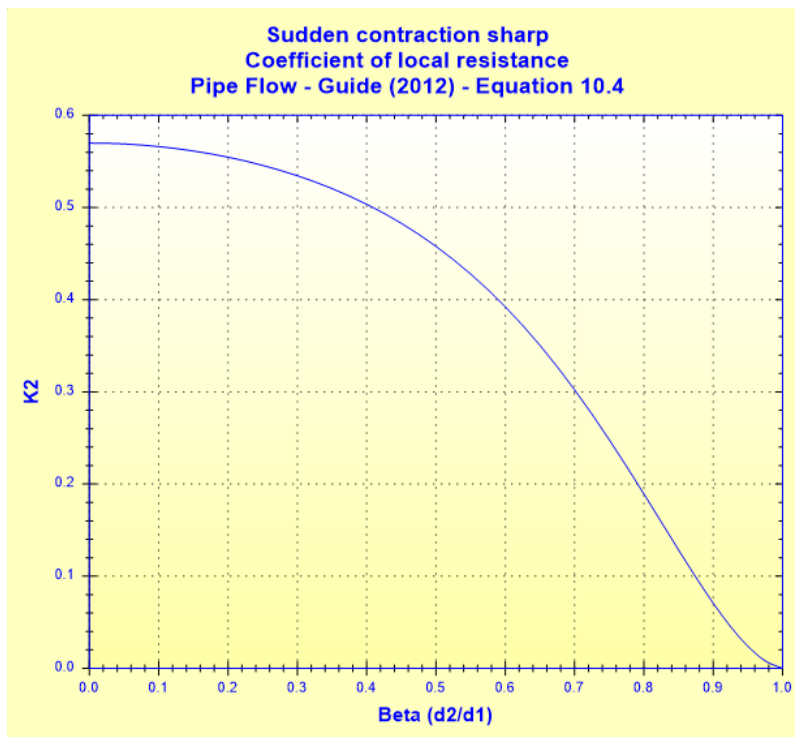


Velocity in vena contracta:

$$V_c = V_2 \cdot \lambda$$

Local resistance coefficient ($NRe_2 \geq 10^4$):

$$K_2 = 0.0696 \cdot (1 - \beta^5) \cdot \lambda^2 + (\lambda - 1)^2 \quad ([1] \text{ equation 10.4})$$



Total pressure loss coefficient (based on mean velocity in minor diameter):

$$K = K_2$$

Total pressure loss (Pa):

$$\Delta P = K \cdot \frac{\rho_m \cdot V_2^2}{2}$$

Total head loss of fluid (m):

$$\Delta H = K \cdot \frac{V_2^2}{2 \cdot g}$$

Hydraulic power loss (W):

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

Symbols, Definitions, SI Units:

d_1	Major diameter (m)
d_2	Minor diameter (m)
β	Ratio of small to large diameter ()
A_1	Major cross-sectional area (m ²)
A_2	Minor cross-sectional area (m ²)
Q	Volume flow rate (m ³ /s)
G	Mass flow rate (kg/s)
V_1	Mean velocity in major diameter (m/s)
V_2	Mean velocity in minor diameter (m/s)
NRe_1	Reynolds number in major diameter ()
NRe_2	Reynolds number in minor diameter ()
V_c	Mean velocity in vena contracta (m/s)

λ	Jet velocity ratio ()
K_2	Local resistance coefficient ()
K	Total pressure loss coefficient (based on mean velocity in minor diameter) ()
ΔP	Total pressure loss (Pa)
ΔH	Total head loss of fluid (m)
Wh	Hydraulic power loss (W)
ρ_m	Fluid density (kg/m ³)
ν	Fluid kinematic viscosity (m ² /s)
g	Gravitational acceleration (m/s ²)

Validity range:

- turbulent flow regime in minor diameter ($NRe_2 \geq 10^4$)

Example of application:

The screenshot shows the HydraulCalc 2018a software interface for a sudden contraction problem. The fluid is Water @ 1 atm [HC] with a temperature of 20 °C and a pressure of 1.013 bar. The major diameter is 0.0703 m and the minor diameter is 0.0431 m. The flow rate is 0.005 m³/s, resulting in a velocity of 1.288 m/s in the major diameter and 3.427 m/s in the minor diameter. The pressure loss is 0.02238793 bar, and the head loss is 0.2287 m of fluid.

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

Geometrical characteristics:

- Major diameter (d1): 0.0703 m
- Minor diameter (d2): 0.0431 m
- Flow rate (Q): 0.005 m³/s
- Velocity in major diameter (V1): 1.288 m/s (Turbulent)
- Velocity in minor diameter (V2): 3.427 m/s (Turbulent)
- Pressure loss (ΔP): 0.02238793 bar
- Head loss (ΔH): 0.2287 m of fluid

Complementary results:

Designation	Symbol	Value	Unit
Diameters ratio (d1/d2)	β	0.6130868	
Major diameter cross-section area	A_1	0.003881508	m ²
Minor diameter cross-section area	A_2	0.001458963	m ²
Cross-sections area ratio	A_2/A_1	0.3758754	
Major diameter Reynolds number	NRe_1	90251	
Minor diameter Reynolds number	NRe_2	147207.5	
Jet velocity ratio (Equation 10.3)	λ	1.529441	
Velocity in vena contracta	V_c	5.241533	m/s
Coefficient of local resistance (Equation 10.4)	K_2	0.3819202	
Pressure loss coefficient (based on velocity in minor diameter)	K	0.3819202	
Hydraulic power loss	Wh	11.19396	W

References:

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