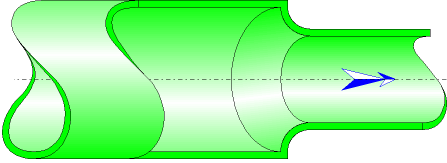




## Sudden Contraction Rounded Circular Cross-Section (Pipe Flow - Guide)



### Model description:

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

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 small to large diameter:

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

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

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

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

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

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Mean velocity in major diameter (m/s):

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

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Mean velocity in minor diameter (m/s):

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

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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:

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

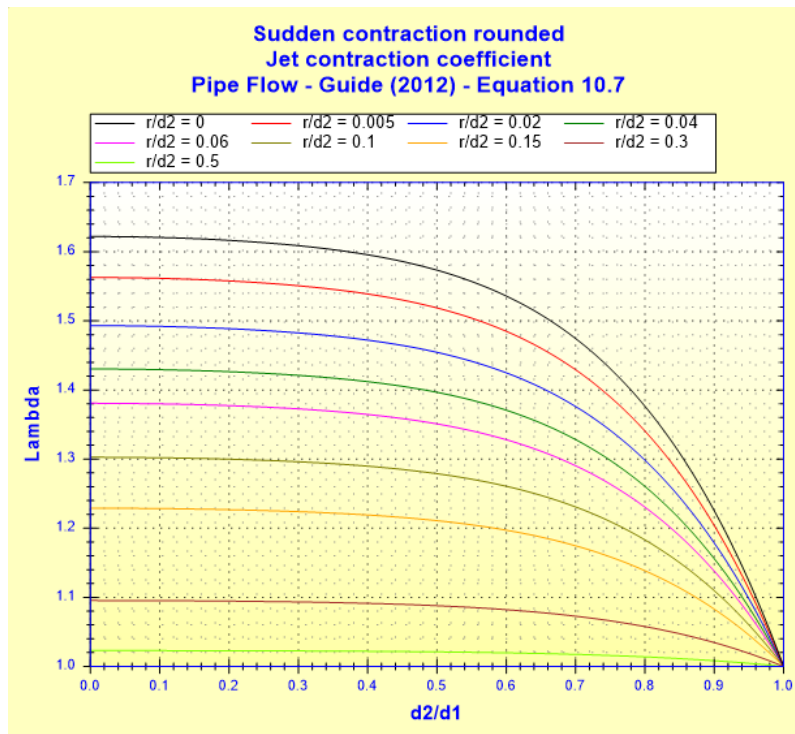
Jet contraction coefficient:

■  $0 \leq r/d_2 \leq 1$ :

$$\lambda = 1 + 0.622 \cdot \left( 1 - 0.30 \cdot \sqrt{\frac{r}{d_2}} - 0.70 \cdot \frac{r}{d_2} \right)^4 \cdot \left( 1 - 0.215 \cdot \beta^2 - 0.785 \cdot \beta^5 \right)$$

([1] equation

10.7)



■  $r/d_2 > 1$ :

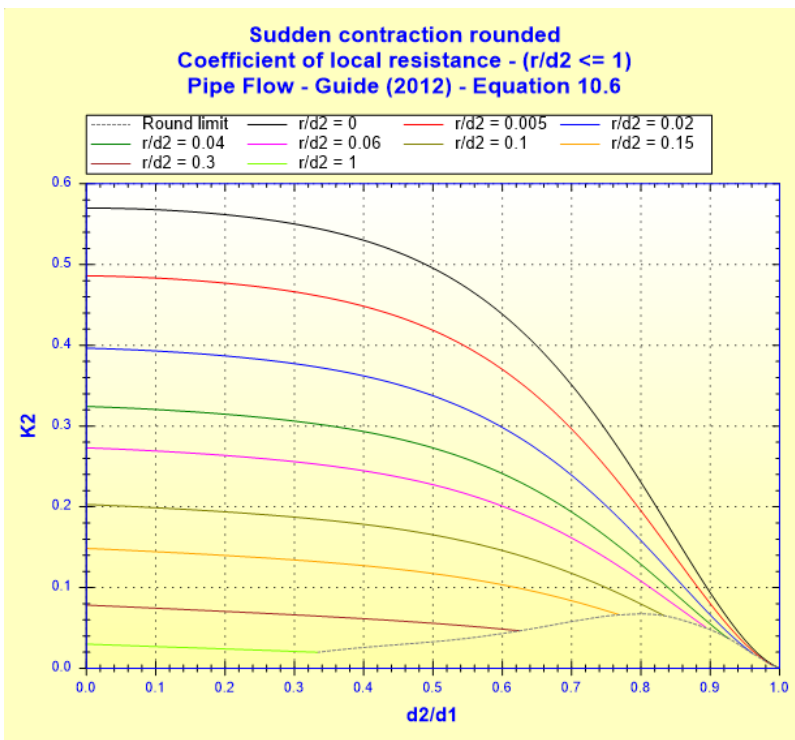
$$\lambda = 1$$

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

■  $0 \leq r/d_2 \leq 1$ :

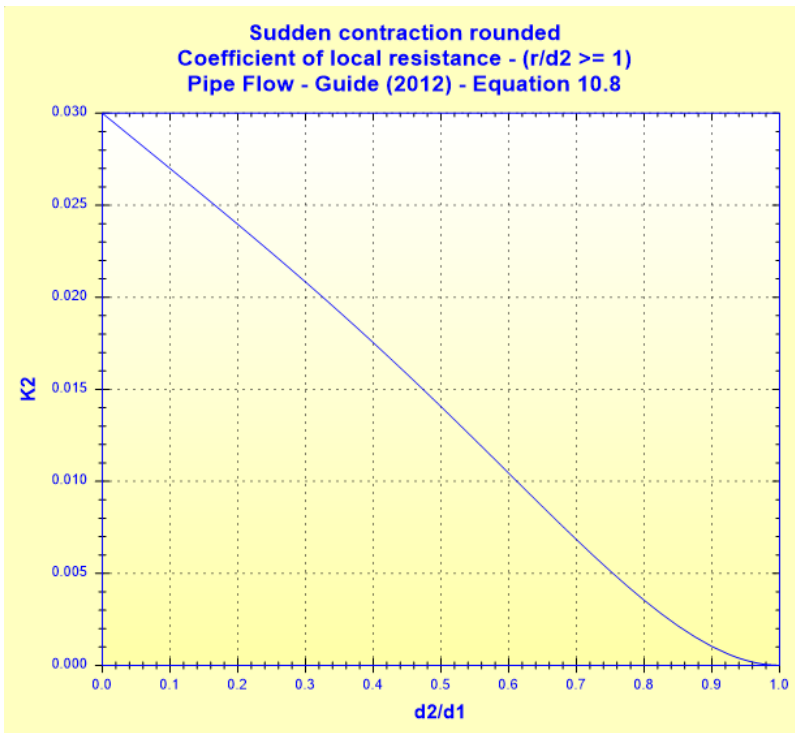
$$K_2 = 0.0696 \cdot \left( 1 - 0.569 \cdot \frac{r}{d_2} \right) \cdot \left( 1 - \sqrt{\frac{r}{d_2}} \cdot \beta \right) \cdot \left( 1 - \beta^5 \right) \cdot \lambda^2 + (\lambda - 1)^2$$

([1] equation 10.6)



■  $r/d_2 > 1$ :

$$K_2 = 0.030 \cdot (1 - \beta) \cdot (1 - \beta^4) \quad ([1] \text{ equation } 10.8)$$



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):

$$\Delta H = K \cdot \frac{v_2^2}{2 \cdot g}$$

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Hydraulic power loss (W):

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

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**Symbols, Definitions, SI Units:**

$d_1$	Major diameter (m)
$d_2$	Minor diameter (m)
$\beta$	Ratio of small to large diameter ( )
$A_1$	Major cross-sectional area (m <sup>2</sup> )
$A_2$	Minor cross-sectional area (m <sup>2</sup> )
$Q$	Volume flow rate (m <sup>3</sup> /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 ( )
$r$	Radius of the round (m)
$\lambda$	Jet contraction coefficient ( )
$K_2$	Local resistance coefficient ( )
$K$	Total pressure loss coefficient (based on mean velocity in minor diameter) ( )
$\Delta P$	Total pressure loss (Pa)
$\Delta H$	Total head loss of fluid (m)
$Wh$	Hydraulic power loss (W)
$\rho_m$	Fluid density (kg/m <sup>3</sup> )
$\nu$	Fluid kinematic viscosity (m <sup>2</sup> /s)
$g$	Gravitational acceleration (m/s <sup>2</sup> )

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**Validity range:**

- turbulent flow regime in minor diameter ( $NRe_2 \geq 10^4$ )
- round radius less than the radius difference ( $r < (d_1/2 - d_2/2)$ )

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**Example of application:**

HydrauCalc 2020a - [Sudden contraction rounded - Pipe Flow - Guide (2012)]

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Fluid characteristics

Fluid : Water @ 1 atm [HC]  
Ref.: IAPWS IF97

Temperature : T 20 °C  
Pressure : P 1.013 bar

Density :  $\rho$  998.2061 kg/m<sup>3</sup>  
Dynamic Viscosity :  $\mu$  0.00100159 N.s/m<sup>2</sup>  
Kinematic Viscosity :  $\nu$  1.00340E-06 m<sup>2</sup>/s

Density  Dyn. Visc.  Kin. Visc.

Geometrical characteristics

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Pressure loss  $\Delta P$  0.007452494 bar  
 $\Delta H$  0.0761 m of fluid

Complementary results

Designation	Symbol	Value	Unit
Diameters ratio (d2/d1)	$\beta$	0.6130868	
Major cross-section area	A1	0.003881508	m <sup>2</sup>
Minor cross-section area	A2	0.001458963	m <sup>2</sup>
Cross-sections area ratio	A2/A1	0.3758754	
Ratio 'Radius of the round / small diameter'	r/d2	0.1160093	
Major diameter Reynolds number	NRe1	90251	
Minor diameter Reynolds number	NRe2	147207.5	
Jet velocity ratio (Equation 10.7)	$\lambda$	1.235441	
Coefficient of local resistance (Equation 10.6)	K2	0.1271336	
Pressure loss coefficient (based on velocity in minor diameter)	K	0.1271336	
Hydraulic power loss	Wh	3.726247	W

## References:

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