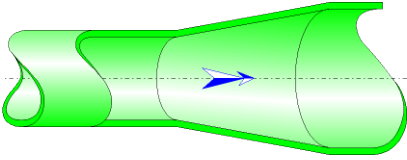




Gradual Expansion Circular Cross-Section (MILLER)



Model description:

This model of component calculates the head loss (pressure drop) generated by the flow in a gradual expansion.

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

Model formulation:

Half top angle of cone (°):

$$\theta = \tan^{-1}\left(\frac{D_2 - D_1}{2 \cdot N}\right)$$

Minor cross-sectional area (m²):

$$A_1 = \pi \cdot \frac{D_1^2}{4}$$

Major cross-sectional area (m²):

$$A_2 = \pi \cdot \frac{D_2^2}{4}$$

Mean velocity in minor diameter (m/s):

$$U_1 = \frac{Q}{A_1}$$

Mean velocity in major diameter (m/s):

$$U_2 = \frac{Q}{A_2}$$

Mass flow rate (kg/s):

$$G = Q \cdot \rho$$

Fluid volume in the truncated cone (m^3):

$$V = N \cdot \frac{\pi}{3} \cdot \left(\left(\frac{D_1}{2} \right)^2 + \left(\frac{D_2}{2} \right)^2 + \left(\frac{D_1}{2} \right) \cdot \left(\frac{D_2}{2} \right) \right)$$

Fluid mass in the truncated cone (kg):

$$M = V \cdot \rho$$

Reynolds number in minor diameter:

$$Re_1 = \frac{U_1 \cdot D_1}{\nu}$$

Reynolds number in major diameter:

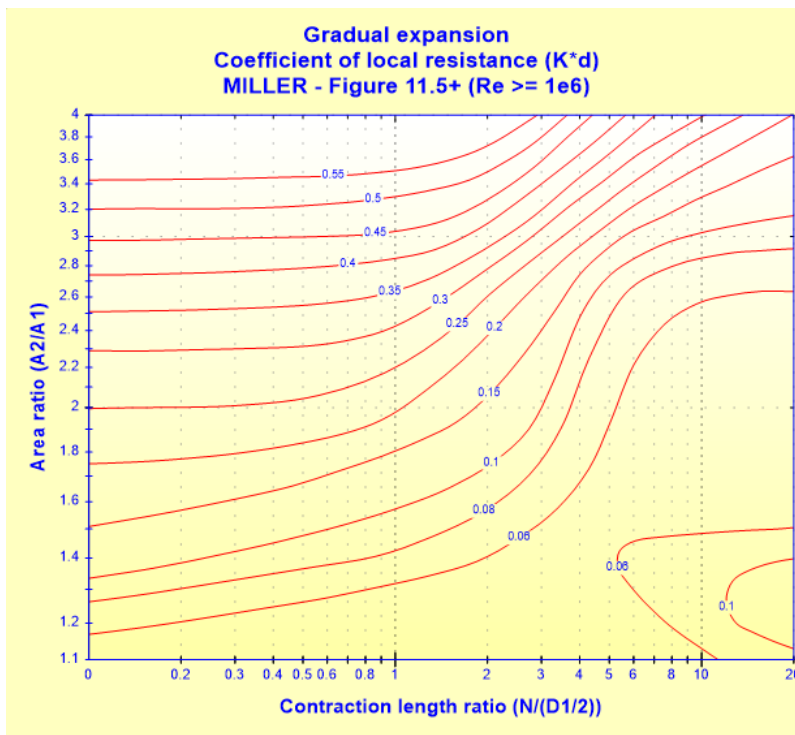
$$Re_2 = \frac{U_2 \cdot D_2}{\nu}$$

Local resistance coefficient:

■ $Re_1 \geq 10^4$

$$K_{*d} = f \left(\frac{N}{D_1/2}, \frac{A_2}{A_1} \right)$$

([1] figure 11.5+)



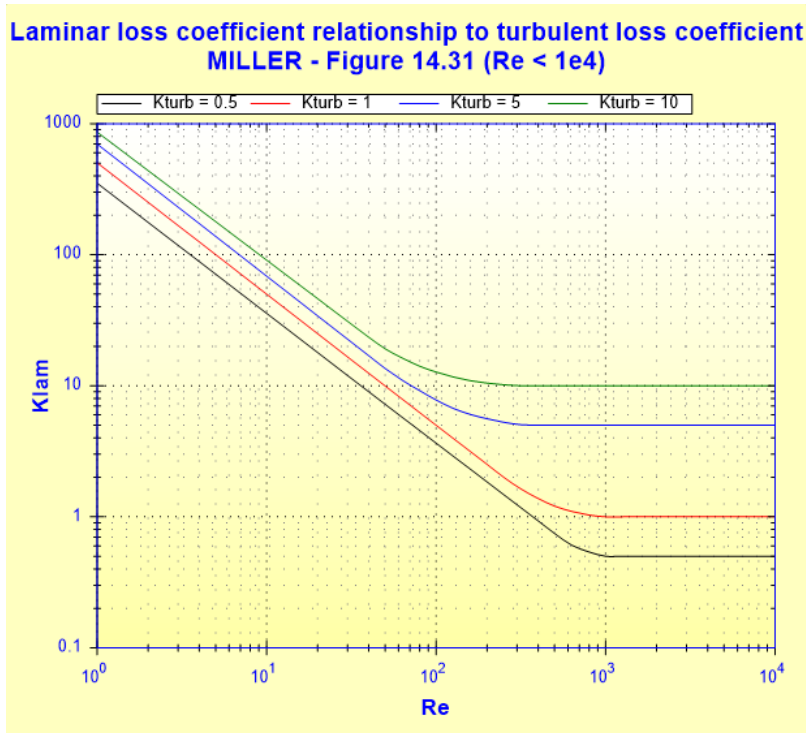
■ $Re_1 < 10^4$

$$K_{lam} = f(K_{turb}, Re_1)$$

([1] figure 14.31)

where:

K_{turb} is the local resistance coefficient in turbulent regime (K_{*d} for $Re_1 = 10^4$ - figure 11.5+)



Reynolds Number Correction ($Re_1 < 10^4$):

$$C_{Re} = \frac{K_{lam}}{K_{turb}}$$

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

- turbulent flow ($Re_1 \geq 10^4$):

$$K = K_{*d}$$

- laminar flow ($Re_1 < 10^4$):

$$K = K_{lam}$$

Total pressure loss (Pa):

$$\Delta P = K \cdot \frac{\rho \cdot U_1^2}{2}$$

Total head loss of fluid (m):

$$\Delta H = K \cdot \frac{U_1^2}{2 \cdot g}$$

Hydraulic power loss (W):

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

Symbols, Definitions, SI Units:

D_1 Minor diameter (m)

D_2	Major diameter (m)
N	Truncated cone length (m)
θ	Half top angle of cone ($^\circ$)
A_1	Minor cross-sectional area (m^2)
A_2	Major cross-sectional area (m^2)
Q	Volume flow rate (m^3/s)
U_1	Mean velocity in minor diameter (m/s)
U_2	Mean velocity in major diameter (m/s)
G	Mass flow rate (kg/s)
V	Fluid volume in the truncated cone (m^3)
M	Fluid mass in the truncated cone (kg)
Re_1	Reynolds number in minor diameter ($\text{}$)
Re_2	Reynolds number in major diameter ($\text{}$)
K^*_d	Local resistance coefficient for $Re_1 \geq 10^4$ ($\text{}$)
K_{turb}	Local resistance coefficient for $Re_1 = 10^4$ ($\text{}$)
K_{lam}	Local resistance coefficient for $Re_1 < 10^4$ ($\text{}$)
C_{Re}	Reynolds number correction ($\text{}$)
K	Total pressure loss coefficient (based on mean velocity in minor diameter) ($\text{}$)
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
- area ratio (A_2/A_1) between 1.1 and 4
- contraction length ratio ($N/(D_1/2)$) less than 20

note: for Reynolds number " Re_1 " lower than 10^4 , and coefficients " K_{turb} " lower than 0.5 or greater than 10, the laminar pressure loss coefficient " K_{lam} " is extrapolated

Example of application:

HydrauCalc 2018b - [Gradual expansion - MILLER (2nd Ed.)]

File Edit Preferences Calculation method Database Tools Help

Fluid characteristics

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

Temperature : T 20 °C
Pressure : P 1.013 bar

Density : ρ 998.2061 kg/m³
Dynamic Viscosity : μ 0.00100159 N.s/m²
Kinematic Viscosity : ν 1.00340E-06 m²/s

Density Dyn. Visc. Kn. Visc.

Geometrical characteristics

Help Info Calculate

Pressure loss ΔP 0.02199837 bar
 ΔH 0.2247 m of fluid

Complementary results

Designation	Symbol	Value	Unit
Diameters ratio	D2/D1	1.631091	
Minor cross-section area	A1	0.001458963	m ²
Major cross-section area	A2	0.003881508	m ²
Cross-sections area ratio	A2/A1	2.660456	
Internal truncated cone volume	V	2.573391E-05	m ³
Mass of fluid in the truncated cone	M	0.02568774	kg
Minor diameter Reynolds number	Re1	147207.5	
Major diameter Reynolds number	Re2	90251	
Top angle of cone	2- θ	107.3464	°
Contraction length ratio	N/(D1/2)	0.4640371	
<input checked="" type="checkbox"/> Coefficient of local resistance (Fig. 11.5+)	Kd*	0.3752746	
Pressure loss coefficient (based on velocity in minor diameter)	K	0.3752746	
Hydraulic power loss	Wh	10.99918	W

References:

[1] Internal Flow System, Second Edition, D.S. Miller