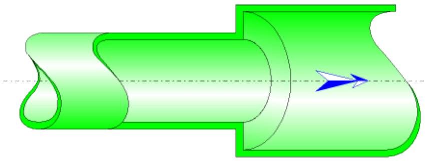
Sudden Expansion
Circular Cross-Section
(MILLER)



Model description:

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

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

Model formulation:

Minor cross-sectional area (m^2):

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

Major cross-sectional area (m^2):

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

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):

$$G = Q \cdot \rho$$

Reynolds number in minor diameter:

$$\mathrm{Re}_1 = \frac{U_1 \cdot D_1}{\nu}$$

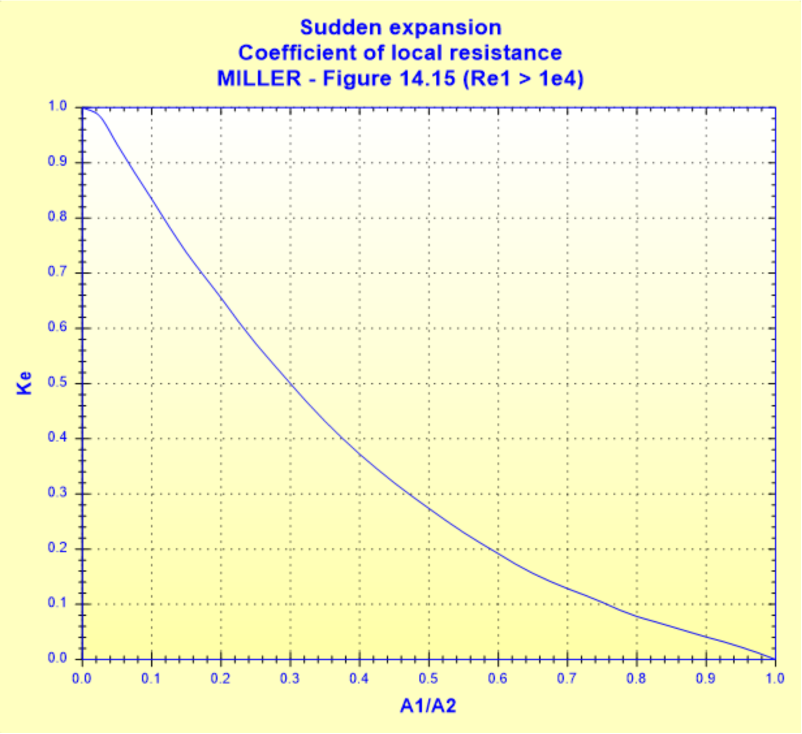
Reynolds number in major diameter:

$$\mathrm{Re}_2 = \frac{U_2 \cdot D_2}{\nu}$$

Local resistance coefficient:

- $\mathrm{Re}_1 \geq 10^4$

$$K_e = f(A_1 / A_2)$$ ([1] figure 14.15)

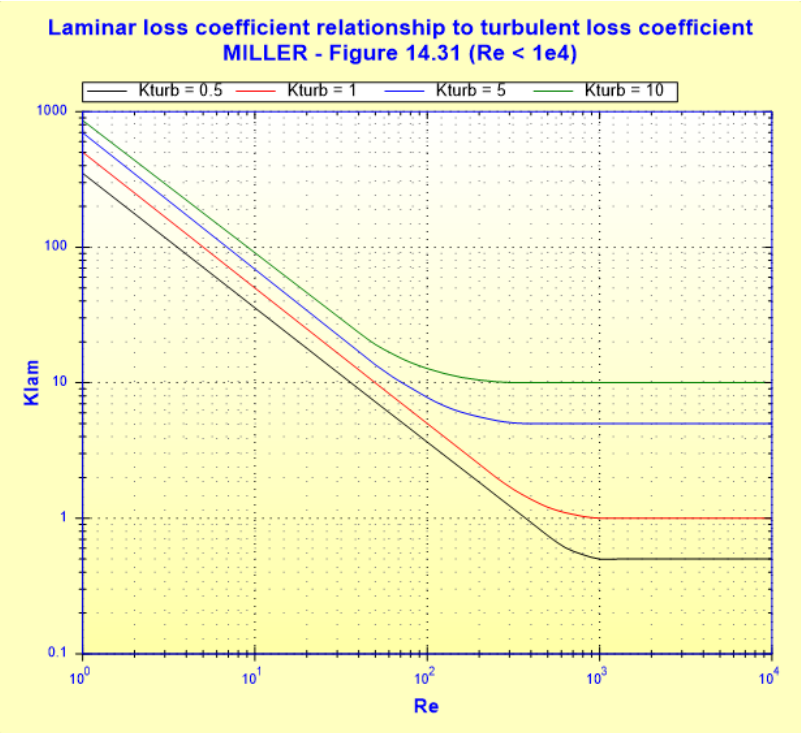


- $\mathrm{Re}_1 < 10^4$

$$K_{lam} = f(K_{turb}, \mathrm{Re}_1)$$ ([1] figure 14.31)

where:

K_{turb} is the local resistance coefficient in turbulent regime (K_e for $\mathrm{Re}_1 = 10^4$ - figure 14.15)



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 ($Re_1 \geq 10^4$):

$$K = K_e$$

- 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)
A_1	Minor cross-sectional area (m^2)

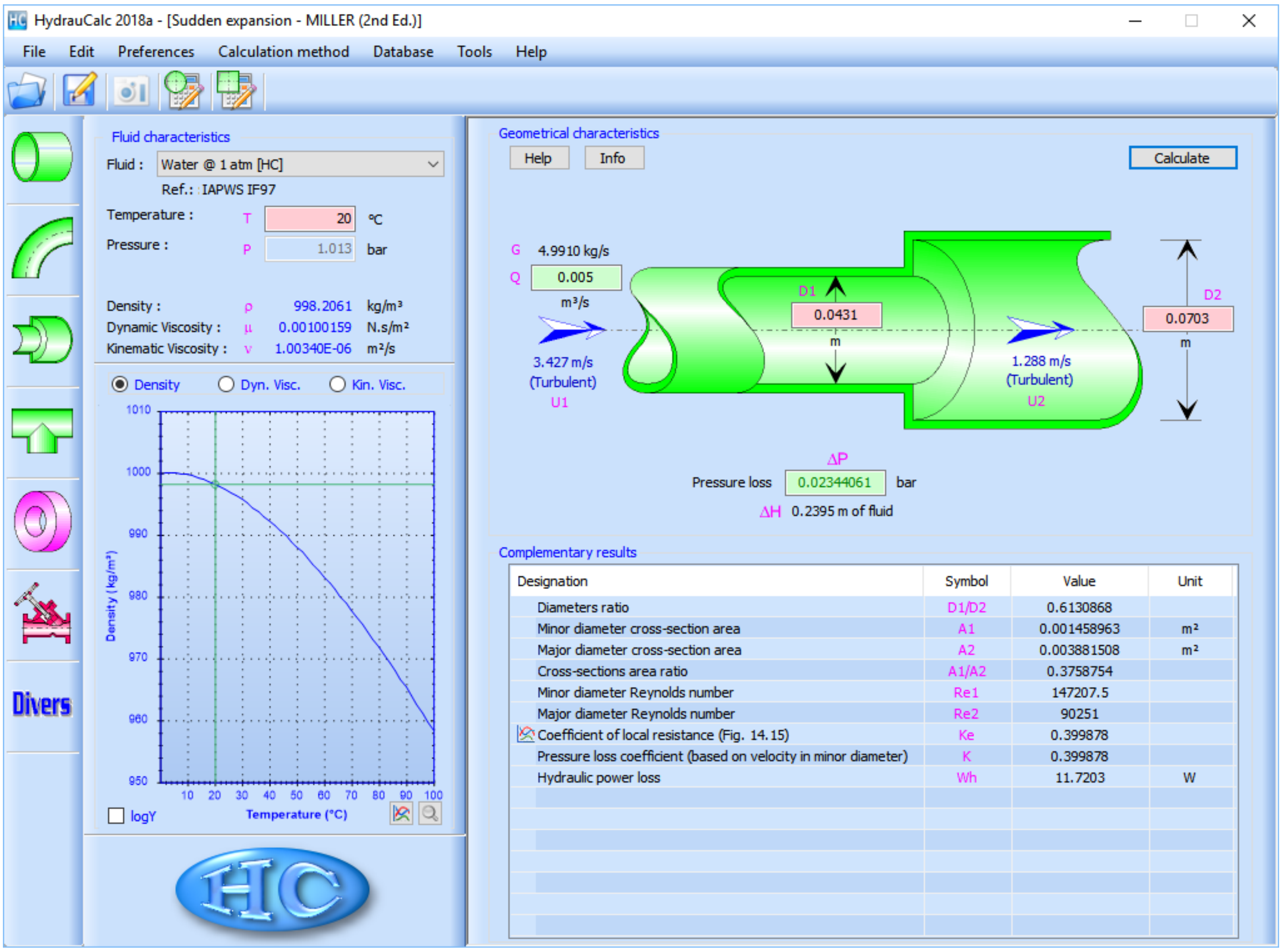
A_2	Major cross-sectional area (m^2)
Q	Volume flow rate (m^3/s)
G	Mass flow rate (kg/s)
U_1	Mean velocity in minor diameter (m/s)
U_2	Mean velocity in major diameter (m/s)
Re_1	Reynolds number in minor diameter ()
Re_2	Reynolds number in major diameter ()
K_e	Local resistance coefficient for $Re_1 \geq 10^4$ ()
K_{turb}	Local resistance coefficient for $Re_1 = 10^4$ ()
K_{lam}	Local resistance coefficient for $Re_1 < 10^4$ ()
C_{Re}	Reynolds number correction for $Re_1 < 10^4$ ()
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	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

  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:



Designation	Symbol	Value	Unit
Diameters ratio	D1/D2	0.6130868	
Minor diameter cross-section area	A1	0.001458963	m²
Major diameter cross-section area	A2	0.003881508	m²
Cross-sections area ratio	A1/A2	0.3758754	
Minor diameter Reynolds number	Re1	147207.5	
Major diameter Reynolds number	Re2	90251	
Coefficient of local resistance (Fig. 14.15)	Ke	0.399878	
Pressure loss coefficient (based on velocity in minor diameter)	K	0.399878	
Hydraulic power loss	Wh	11.7203	W

References:

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