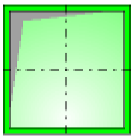
General Head Drop Formulations for Steady State and Incompressible Fluid Rectangular Cross-Section



Model description:

This component model brings together the main formulas relating to the calculation of pressure drops for incompressible fluids. These formulas apply to pipes of rectangular section and for stabilized flows.

Model formulation:

Cross-section area (m^2):

$$S = a \cdot b$$

Cross-section perimeter (m):

$$P = 2 \cdot (a + b)$$

Hydraulic diameter (m):

$$d_h = \frac{4 \cdot S}{P}$$

Mean velocity (m/s):

$$V = \frac{Qv}{S}$$

Mass flow rate (kg/s):

$$Qm = Qv \cdot \rho$$

Reynolds number:

$$Re = \frac{V \cdot d_h}{\nu}$$

Flow coefficient Av (m^2):

$$Av = Qv \cdot \sqrt{\frac{\rho}{\Delta P}}$$

or:

$$Av = S \cdot \sqrt{\frac{2}{\zeta}}$$

Flow coefficient Cv (gal/min US):

$$Cv = 41650 \cdot Av$$

or:

$$Cv = Qv_{[gpm\ \mathrm{US}]} \cdot \sqrt{\frac{G_{[-]}}{\Delta P_{[psi]}}}$$

where:

- Qv Volume flow rate (gal/min US)
- ΔP Pressure loss (psi)
- G Specific gravity of fluid (1 for water at 60°F)

Flow coefficient Kv (m^3/h):

$$Kv = 36023 \cdot Av$$

or:

$$Kv = Qv_{[m^3/h]} \cdot \sqrt{\frac{G_{[-]}}{\Delta P_{[bar]}}}$$

where:

- Qv Volume flow rate (m^3/h)
- ΔP Pressure loss (bar)
- G Specific gravity of fluid (1 for water at 15°C)

Pressure loss coefficient ():

$$\zeta = \lambda \cdot \frac{L}{d_h}$$

Pressure loss (Pa):

$$\Delta P = \zeta \cdot \frac{\rho \cdot V^2}{2}$$

Head loss of fluid (m):

$$\Delta h = \zeta \cdot \frac{V^2}{2 \cdot g}$$

Hydraulic power loss (W):

$$Wh = \Delta P \cdot Qv$$

Symbols, Definitions, SI Units:

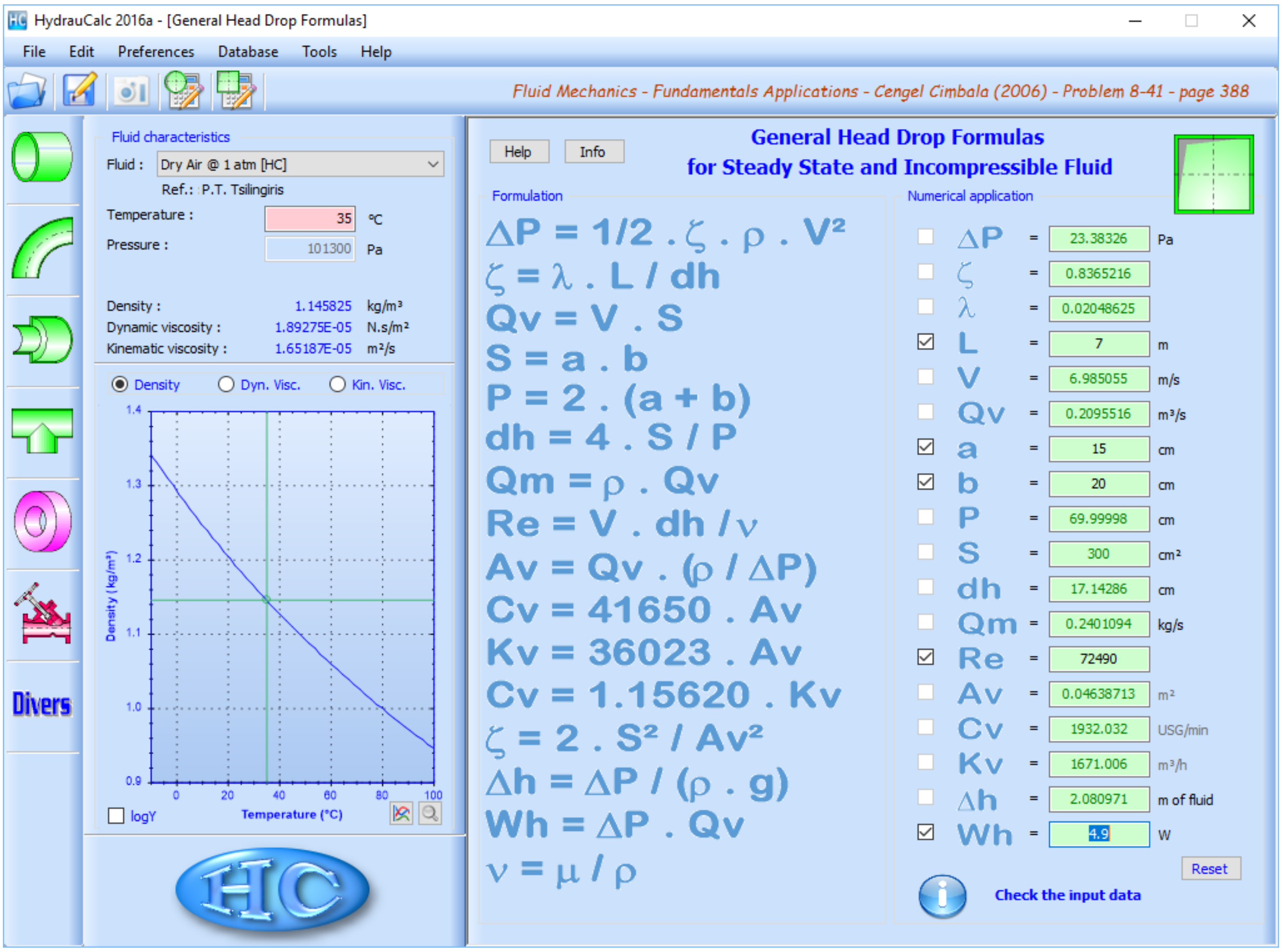
- a Rectangular cross-section width (m)
- b Rectangular cross-section height (m)

d_h	Pipe hydraulic diameter (m)
S	Cross-sectional perimeter (m)
S	Cross-sectional area (m^2)
Qv	Volume flow rate (m^3/s)
Qm	Mass flow rate (kg/s)
V	Mean velocity (m/s)
Re	Reynolds number ()
Av	Flow coefficient (m^2)
Cv	Flow coefficient (USG/min)
Kv	Flow coefficient (m^3/h)
ζ	Pressure loss coefficient ()
λ	Friction factor ()
L	Straight length (m)
ΔP	Pressure loss (Pa)
Δh	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:

- Equations for the flow coefficients Av, Cv and Kv are valid only for turbulent flows.

Example of input data and results:


HydrauCalc 2016a - [General Head Drop Formulas]
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Fluid Mechanics - Fundamentals Applications - Cengel Cimbala (2006) - Problem 8-41 - page 388
Fluid characteristics
Fluid : Dry Air @ 1 atm [HC]
Ref.: P.T. Tsilingiris
Temperature : 35 °C
Pressure : 101300 Pa
Density : 1.145825 kg/m³
Dynamic viscosity : 1.89275E-05 N.s/m²
Kinematic viscosity : 1.65187E-05 m²/s
Density Dyn. Visc. Kin. Visc.
Density (kg/m³)
Temperature (°C)
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General Head Drop Formulas
for Steady State and Incompressible Fluid
Formulation
ΔP = 1/2 . ζ . ρ . V²
ζ = λ . L / dh
Qv = V . S
S = a . b
P = 2 . (a + b)
dh = 4 . S / P
Qm = ρ . Qv
Re = V . dh / ν
Av = Qv . (ρ / ΔP)
Cv = 41650 . Av
Kv = 36023 . Av
Cv = 1.15620 . Kv
ζ = 2 . S² / Av²
Δh = ΔP / (ρ . g)
Wh = ΔP . Qv
ν = μ / ρ
Numerical application
ΔP = 23.38326 Pa
ζ = 0.8365216
λ = 0.02048625
L = 7 m
V = 6.985055 m/s
Qv = 0.2095516 m³/s
a = 15 cm
b = 20 cm
P = 69.99998 cm
S = 300 cm²
dh = 17.14286 cm
Qm = 0.2401094 kg/s
Re = 72490
Av = 0.04638713 m²
Cv = 1932.032 USG/min
Kv = 1671.006 m³/h
Δh = 2.080971 m of fluid
Wh = 4.9 W
Reset
Check the input data