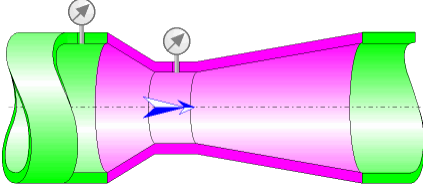




## Classical Venturi tube with an "as cast" convergent section (ISO 5167-4:2003)



### Model description:

This model of component determines the fluid flow through a classical Venturi tube with an "as cast" convergent section, according to the international standard "ISO-5167-4:2003".

### Model formulation:

Diameter ratio:

$$\beta = \frac{d}{D}$$

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

$$s = \pi \cdot \frac{d^2}{4}$$

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

$$S = \pi \cdot \frac{D^2}{4}$$

Mean velocity in orifice (m/s):

$$v = \frac{q_v}{s}$$

Mean velocity in pipe (m/s):

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

Reynolds number referred to orifice diameter:

$$Re_d = \frac{v \cdot d}{\nu}$$

Reynolds number referred to internal pipe diameter:

$$\text{Re}_D = \frac{V \cdot D}{\nu}$$

Discharge coefficient:

$$C = 0.984 \quad ([2] \text{ §5.5.2})$$

Expansibility factor:

$$\varepsilon = 1 \quad ([1] \text{ §3.3.6}) \text{ for incompressible fluid (liquid)}$$

Mass flow rate (kg/s):

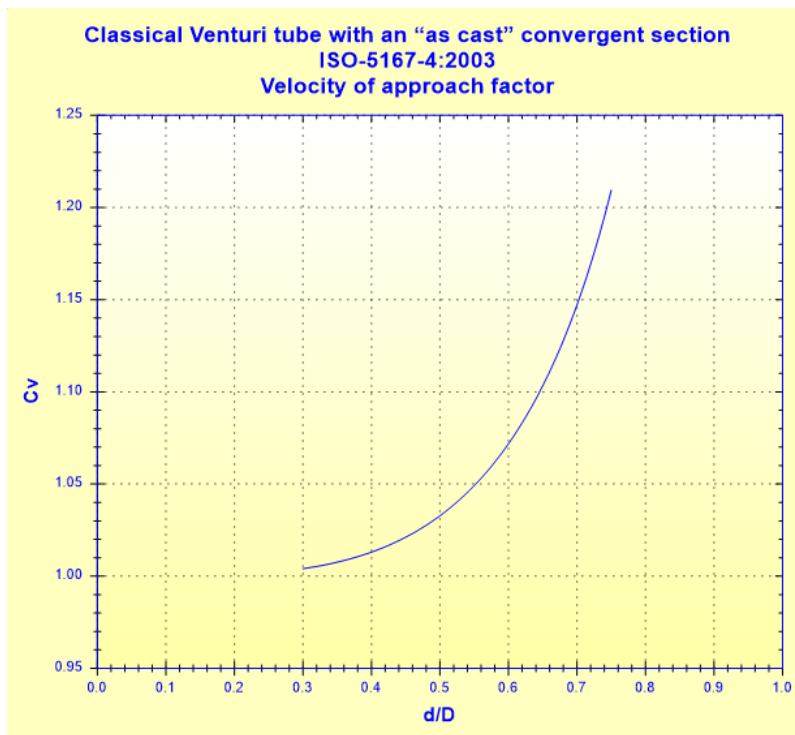
$$q_m = \frac{C}{\sqrt{1-\beta^4}} \cdot \varepsilon \cdot \frac{\pi}{4} \cdot d^2 \cdot \sqrt{2 \cdot \Delta p \cdot \rho} \quad ([1] \text{ §5.1 eq. 1 and [2] §4 eq. 1})$$

Volume flow rate (m<sup>3</sup>/s):

$$q_v = \frac{q_m}{\rho} \quad ([1] \text{ §5.1 eq. 3 and [2] §4 eq. 2})$$

Velocity of approach factor:

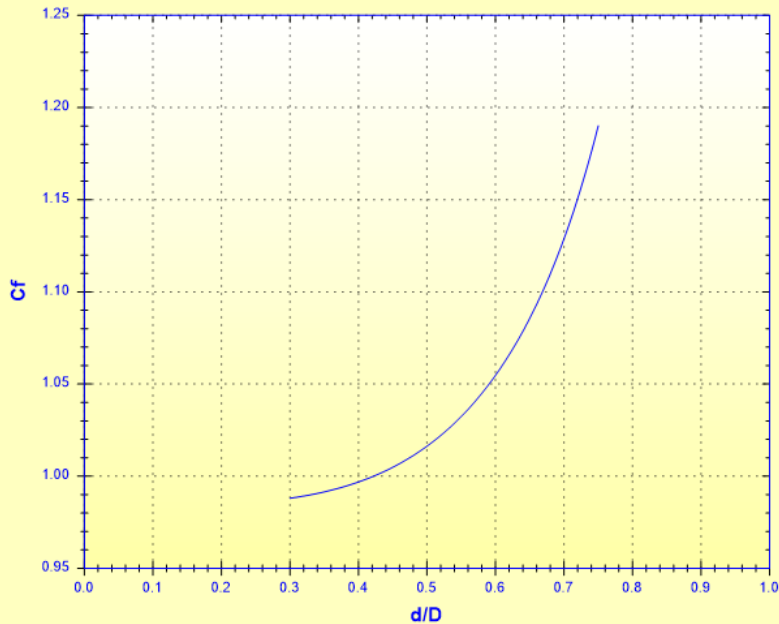
$$C_v = \frac{1}{\sqrt{1-\beta^4}} \quad ([1] \text{ §3.3.5})$$



Flow coefficient:

$$C_f = C \cdot \frac{1}{\sqrt{1-\beta^4}} \quad ([1] \text{ §3.3.5})$$

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 ISO-5167-4:2003  
 Flow coefficient



Net pressure loss:

The net pressure loss is not formulated in the reference document [2]

Measured head loss (m):

$$\Delta H = \frac{\Delta P}{\rho \cdot g}$$

**Symbols, Definitions, SI Units:**

d	Orifice diameter (m)
D	Internal pipe diameter (m)
$\beta$	Diameter ratio ( )
s	Orifice cross-sectional area (m <sup>2</sup> )
S	Pipe cross-sectional area (m <sup>2</sup> )
q <sub>v</sub>	Volume flow rate (m <sup>3</sup> /s)
v	Mean velocity in orifice (m/s)
V	Mean velocity in pipe (m/s)
Re <sub>d</sub>	Reynolds number referred to orifice ( )
Re <sub>D</sub>	Reynolds number referred to pipe ( )
C	Discharge coefficient ( )
$\varepsilon$	Expansibility factor ( )
q <sub>m</sub>	Mass flow rate (kg/s)
C <sub>v</sub>	Velocity of approach factor ( )
C <sub>f</sub>	Flow coefficient ( )
$\Delta P$	Measured pressure loss (Pa)
$\Delta H$	Measured head loss of fluid (m)
$\rho$	Fluid density (kg/m <sup>3</sup> )
$\nu$	Fluid kinematic viscosity (m <sup>2</sup> /s)
g	Gravitational acceleration (m/s <sup>2</sup> )

## Limit of use ([2] §5.5.2):

- $100 \text{ mm} \leq D \leq 800 \text{ mm}$
- $0,3 \leq \beta \leq 0,75$
- $2 \cdot 10^5 \leq Re_D \leq 2 \cdot 10^6$

## Example of application:

The screenshot displays the HydraulCalc 2021a software interface. The window title is "HydrauCalc 2021a - [Classical Venturi tube with an 'as cast' convergent section - ISO5167-4:2003]". The interface is divided into several panels:

- Fluid characteristics:** Fluid: Water @ 1 atm [HC], Ref.: IAPWS IF97. Temperature: 20 °C, Pressure: 1.013 bar. Density: 998.2061 kg/m<sup>3</sup>, Dynamic Viscosity: 0.00100159 N.s/m<sup>2</sup>, Kinematic Viscosity: 1.00340E-06 m<sup>2</sup>/s. A graph shows Density (kg/m<sup>3</sup>) vs Temperature (°C).
- Geometrical characteristics:** Measured differential pressure: 0.5 bar,  $\Delta H$ : 5.1077 m of fluid. Mass flow rate (qm): 9.7634 kg/s, Volumetric flow rate (qv): 0.009780926 m<sup>3</sup>/s. Approach velocity (v): 2.52 m/s (Turbulent), Venturi throat velocity (v): 10.166 m/s (Turbulent). Pipe diameter (D): 0.0703 m, Orifice diameter (d): 0.035 m.
- Complementary results:**

Designation	Symbol	Value	Unit
Pipe cross-section area	S	0.003881508	m <sup>2</sup>
Orifice cross-section area	s	0.0009621127	m <sup>2</sup>
Diameters ratio	$\beta$	0.4978663	
Cross-sections area ratio	s/S	0.2478708	
Pipe Reynolds number	ReD	176547.7	
Orifice Reynolds number	Red	354608.6	
Discharge coefficient	C	0.984	
Expansibility factor	$\epsilon$	1	
Velocity of approach factor	Cv	1.032212	
Flow coefficient	Cf	1.015697	
Net pressure loss coefficient (based on mean pipe velocity)	K	9.584956	
Hydraulic power loss	Wh	297.1113	W

## References:

- [1] ISO 5167-1:2003 - Measurement of fluid flow by means of pressure differential devices inserted in circular-cross section conduits running full  
Part 1: General principles and requirements
- [2] ISO 5167-4:2003 - Measurement of fluid flow by means of pressure differential devices inserted in circular-cross section conduits running full  
Part 4: Venturi tubes