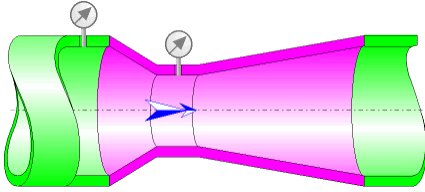




## Classical Venturi tube with an "as cast" convergent section (ISO 5167-1:1991)



### 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-5167-1:1991".

### 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:

$$C = 0.984 \quad ([1] \text{ § 10.1.5.2})$$

Expansibility factor:

$$\varepsilon = 1 \quad ([1] \text{ § 3.3.5}) \text{ for incompressible fluid (liquid)}$$

Mass flow rate (kg/s):

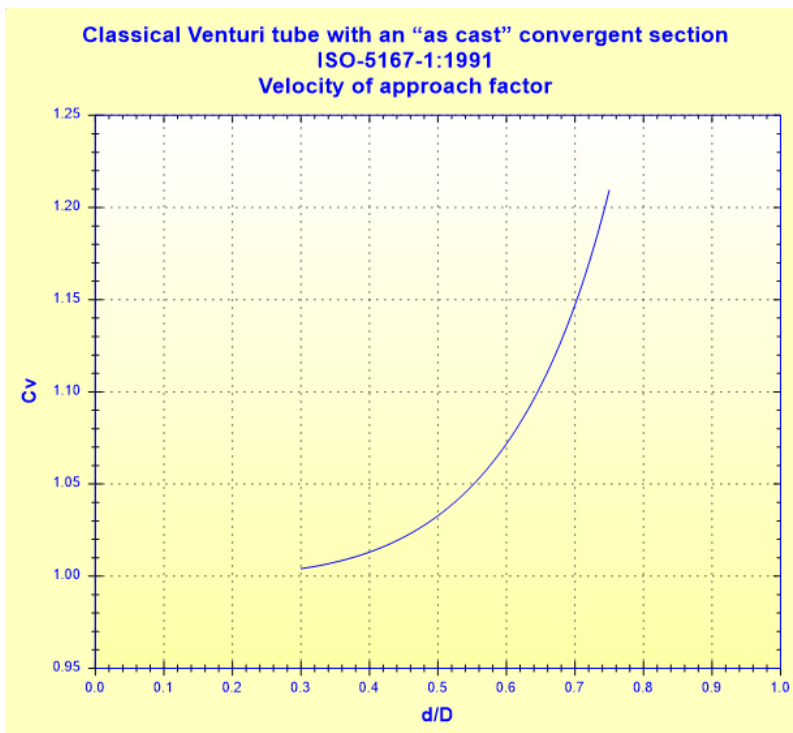
$$q_m = \frac{C}{\sqrt{1-\beta^4}} \cdot \varepsilon \cdot \frac{\pi}{4} \cdot d^2 \cdot \sqrt{2 \cdot \Delta p \cdot \rho} \quad ([1] \text{ § 5.1 eq. 1})$$

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

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

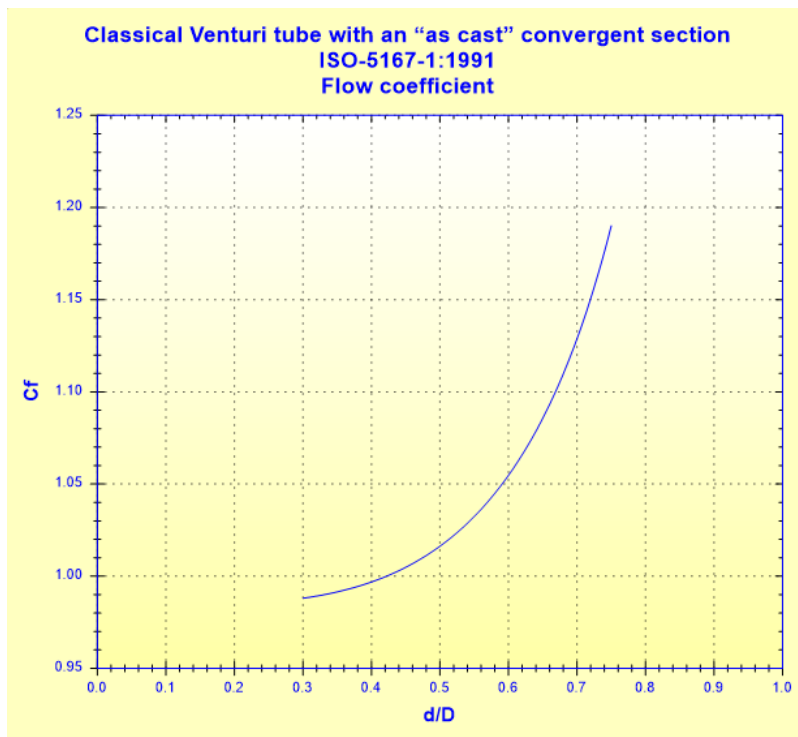
Velocity of approach factor:

$$C_v = \frac{1}{\sqrt{1-\beta^4}} \quad ([1] \text{ § 3.3.4})$$



Flow coefficient:

$$C_f = C \cdot \frac{1}{\sqrt{1-\beta^4}} \quad ([1] \text{ § 3.3.4})$$



Net pressure loss:

The net pressure loss is not formulated in the reference document [1]

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 ([1] §10.1.5.2):

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

## Example of application:

The screenshot displays the HydraulCalc 2021a software interface for a Venturi tube calculation. The window title is "HydraulCalc 2021a - [Classical Venturi tube with an 'as cast' convergent section - ISO5167-1:1991]".

**Fluid characteristics:**

- Fluid: Water @ 1 atm [HC]
- Ref.: IAPWS IF97
- Temperature: T = 20 °C
- Pressure: P = 1.013 bar
- Density:  $\rho = 998.2061 \text{ kg/m}^3$
- Dynamic Viscosity:  $\mu = 0.00100159 \text{ N.s/m}^2$
- Kinematic Viscosity:  $\nu = 1.00340E-06 \text{ m}^2/\text{s}$

**Geometrical characteristics:**

- Measured differential pressure:  $\Delta P = 0.5 \text{ bar}$
- Equivalent head:  $\Delta H = 5.1077 \text{ m of fluid}$
- Mass flow rate:  $q_m = 9.7634 \text{ kg/s}$
- Volume flow rate:  $q_v = 0.009780926 \text{ m}^3/\text{s}$
- Approach velocity:  $v = 2.52 \text{ m/s (Turbulent)}$
- Venturi throat velocity:  $v = 10.166 \text{ m/s}$
- Throat diameter:  $d = 0.035 \text{ m}$
- Pipe diameter:  $D = 0.0703 \text{ m}$

**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	Re <sub>d</sub>	354608.6	
Discharge coefficient	C	0.984	
Expansibility factor	$\epsilon$	1	
Velocity of approach factor	C <sub>v</sub>	1.032212	
Flow coefficient	C <sub>f</sub>	1.015697	
Net pressure loss coefficient (based on mean pipe velocity)	K	9.584956	
Hydraulic power loss	W <sub>h</sub>	297.1113	W

## References:

- [1] ISO 5167-1:1991 - Measurement of fluid flow by means of pressure differential devices