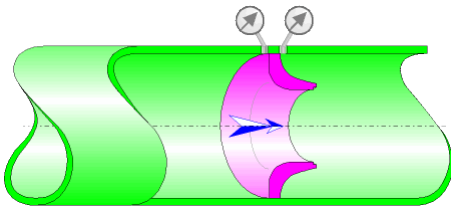




## ISA 1932 nozzle (ISO 5167-3:2003)



### Model description:

This model of component determines the fluid flow through a ISA 1932 nozzle flowmeter, according to the international standard "ISO-5167-3:2003".

### 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:

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

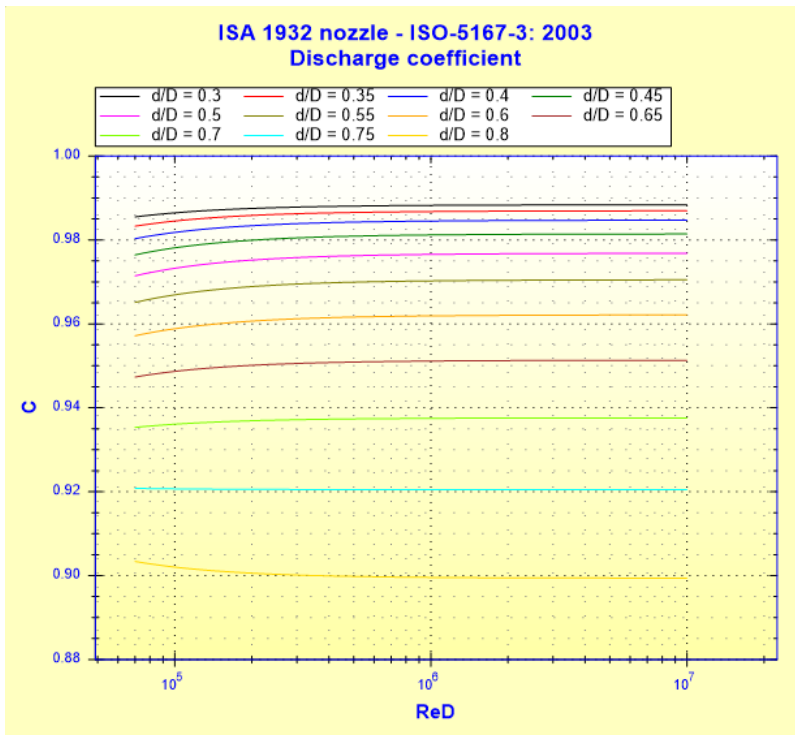
Reynolds number referred to internal pipe diameter:

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

Discharge coefficient:

$$C = 0.99 - 0.2262 \cdot \beta^{4.1} - (0.00175 \cdot \beta^2 - 0.0033 \cdot \beta^{4.15}) \cdot \left( \frac{10^6}{\text{Re}_D} \right)^{1.15}$$

([2] §5.1.6.2 eq. 3)



Expansibility factor:

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

Mass flow rate (kg/s):

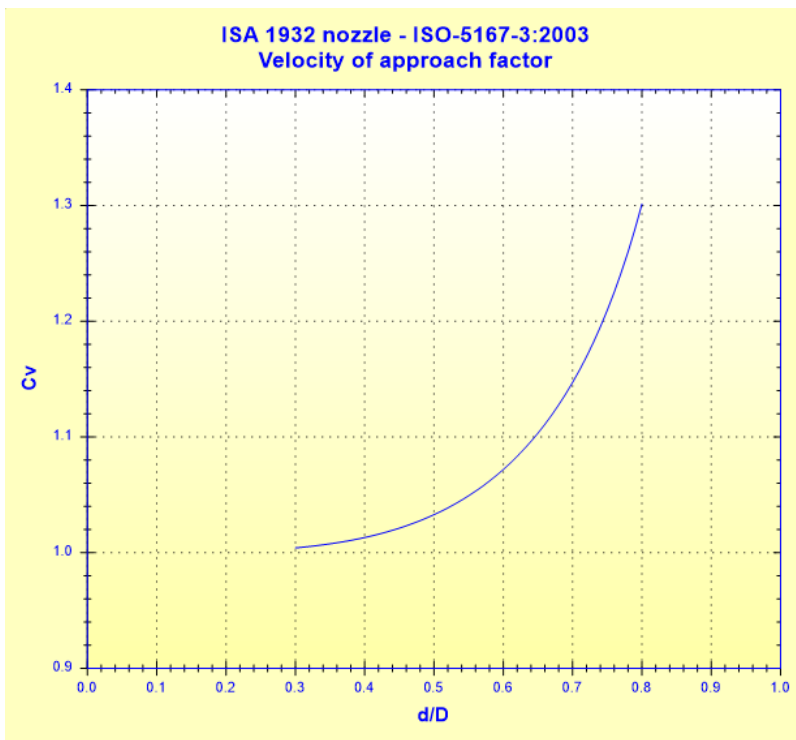
$$q_m = \frac{C}{\sqrt{1-\beta^4}} \cdot \varepsilon \cdot \frac{\pi}{4} \cdot d^2 \cdot \sqrt{2 \cdot \Delta p \cdot \rho} \quad ([1] \text{ §5.1 eq. 1 and [2] §4 eq. 1))$$

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

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

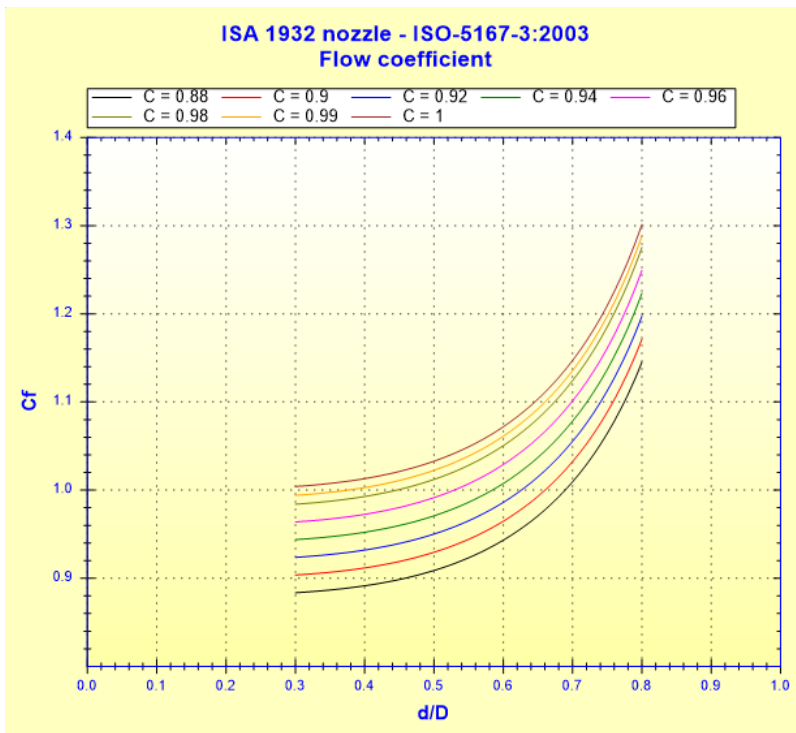
Velocity of approach factor:

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



Flow coefficient:

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



Net pressure loss (Pa):

$$\Delta \varpi = \frac{\sqrt{1 - \beta^4} - C \cdot \beta^2}{\sqrt{1 - \beta^4} + C \cdot \beta^2} \cdot \Delta p \quad ([1] \text{ § 5.1.8 eq. 5})$$

Net pressure loss coefficient (based on the mean pipe velocity):

$$K = \frac{\Delta \varpi}{0.5 \cdot \rho \cdot V^2}$$

([1] § 5.1.8 eq. 7)

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Net head loss (m):

$$\Delta h = \frac{\Delta \varpi}{\rho \cdot g}$$

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Net hydraulic power loss (W):

$$Wh = \Delta \varpi \cdot q$$

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Measured head loss (m):

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

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**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 ( )
$\Delta \varpi$	Net pressure loss (Pa)
$\Delta P$	Measured pressure loss (Pa)
K	Net pressure loss coefficient (based on the mean pipe velocity) ( )
$\Delta h$	Net head loss of fluid (m)
Wh	Net hydraulic power loss (W)
$\Delta H$	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> )

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**Limit of use** ([2] §5.1.6.1):

- 50 mm ≤ D ≤ 500 mm

- $0.3 \leq \beta \leq 0.8$   
 $0.3 \leq \beta < 0.44$  for  $7 \cdot 10^4 \leq Re_D \leq 10^7$   
 $0.44 \leq \beta \leq 0.8$  for  $2 \cdot 10^4 \leq Re_D \leq 10^7$

### Example of application:

The screenshot shows the HydraulCalc 2021a software interface. The main window is titled "HydrauCalc 2021a - [ISA 1932 nozzle - ISO5167-3:2003]". The interface is divided into several sections:

- Fluid characteristics:**
  - Fluid: Water @ 1 atm [HC]
  - Ref.: IAPWS IF97
  - Temperature: T = 20 °C
  - Pressure: P = 1.013 bar
  - Density:  $\rho = 998.2061$  kg/m<sup>3</sup>
  - Dynamic Viscosity:  $\mu = 0.00100159$  N.s/m<sup>2</sup>
  - Kinematic Viscosity:  $\nu = 1.00340E-06$  m<sup>2</sup>/s
  - Graph: Density (kg/m<sup>3</sup>) vs Temperature (°C) showing a decreasing trend from 1000 at 10°C to approximately 950 at 100°C.
- Geometrical characteristics:**
  - Measured differential pressure:  $\Delta P = 0.5$  bar
  - $\Delta H = 5.1077$  m of fluid
  - Flow rate:  $q_m = 9.6758$  kg/s,  $q_v = 0.009693195$  m<sup>3</sup>/s
  - Velocity:  $v = 2.497$  m/s (Turbulent)
  - Orifice velocity:  $10.075$  m/s (Turbulent)
  - Orifice diameter:  $d = 0.035$  m
  - Pipe diameter:  $D = 0.0703$  m
  - Net pressure loss:  $\Delta p = 0.3050997$  bar
  - $\Delta h = 3.1167$  m of fluid
- 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	174964.1	
Orifice Reynolds number	Red	351427.9	
Discharge coefficient	C	0.975174	
Expansibility factor	$\epsilon$	1	
Velocity of approach factor	Cv	1.032212	
Flow coefficient	Cf	1.006586	
Net pressure loss coefficient (based on mean pipe velocity)	K	9.802091	
Hydraulic power loss	Wh	295.7391	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 5167-3:2003 - Measurement of fluid flow by means of pressure differential devices inserted in circular-cross section conduits running full  
Part 3: Nozzles and Venturi nozzles