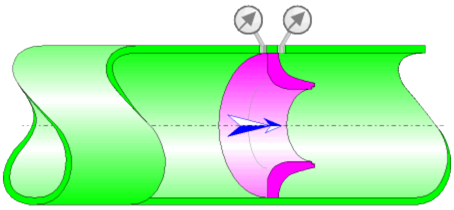
ISA 1932 nozzle
(ISO 5167-3:2003)



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 (m²):

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

Pipe cross-sectional area (m²):

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

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:

$$\mathrm{Re}_d = \frac{v \cdot d}{\nu}$$

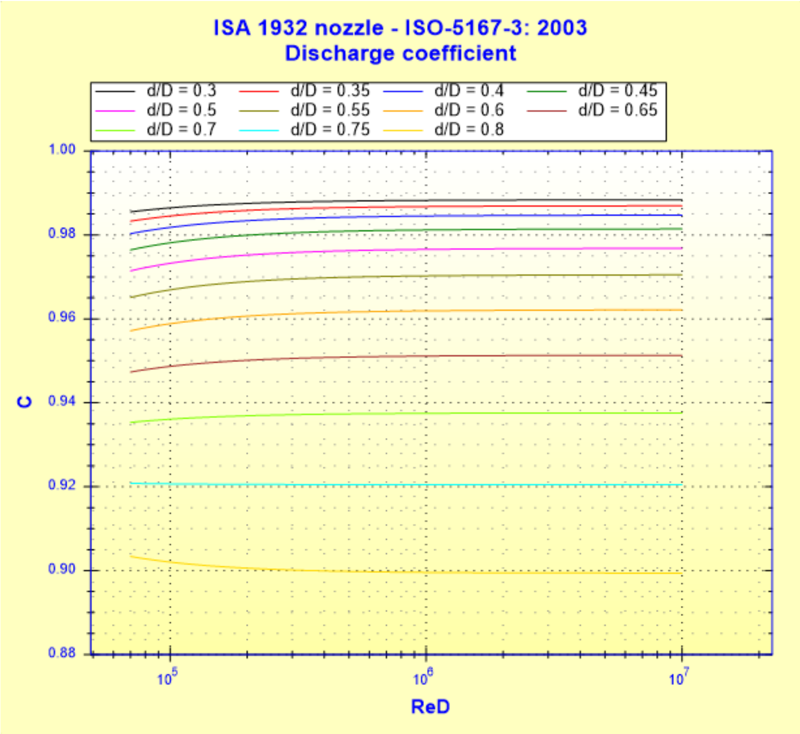
Reynolds number referred to internal pipe diameter:

$$Re_D = \frac{V \cdot D}{\nu}$$

Discharge coefficient:

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

([2] §5.1.6.2 eq. 3)



Expansibility factor:

$$\varepsilon = 1$$

([1] §3.3.6) for incompressible fluid (liquid)

Mass flow rate (kg/s):

$$q_m = \frac{C}{\sqrt{1-\beta^4}} \cdot \varepsilon \cdot \frac{\pi}{4} \cdot d^2 \cdot \sqrt{2 \cdot \Delta p \cdot \rho}$$

([1] §5.1 eq. 1 and [2] §4 eq. 1))

Volume flow rate (m^3/s):

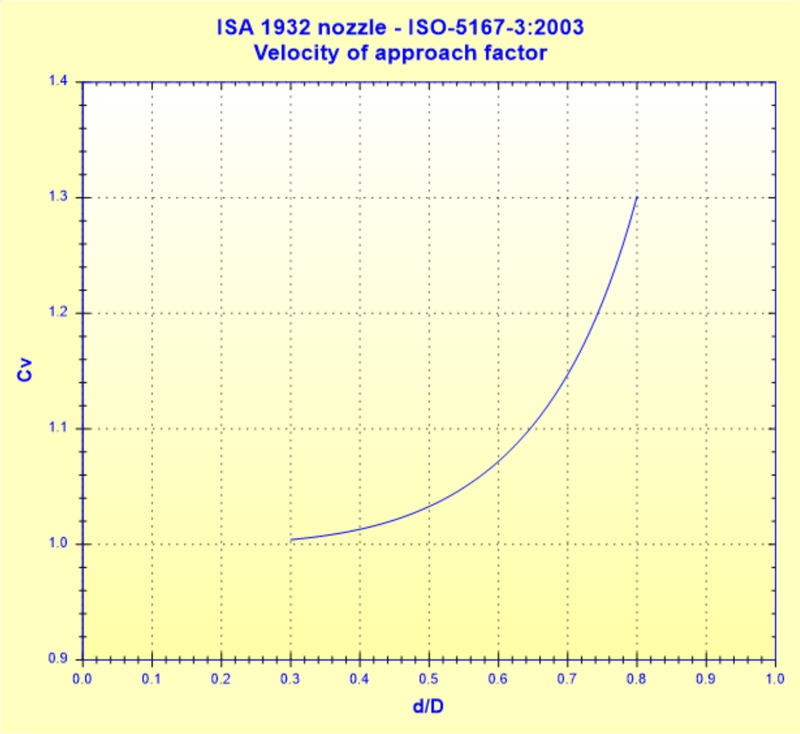
$$q_v = \frac{q_m}{\rho}$$

([1] §5.1 eq. 3 and [2] §4 eq. 2))

Velocity of approach factor:

$$C_v = \frac{1}{\sqrt{1-\beta^4}}$$

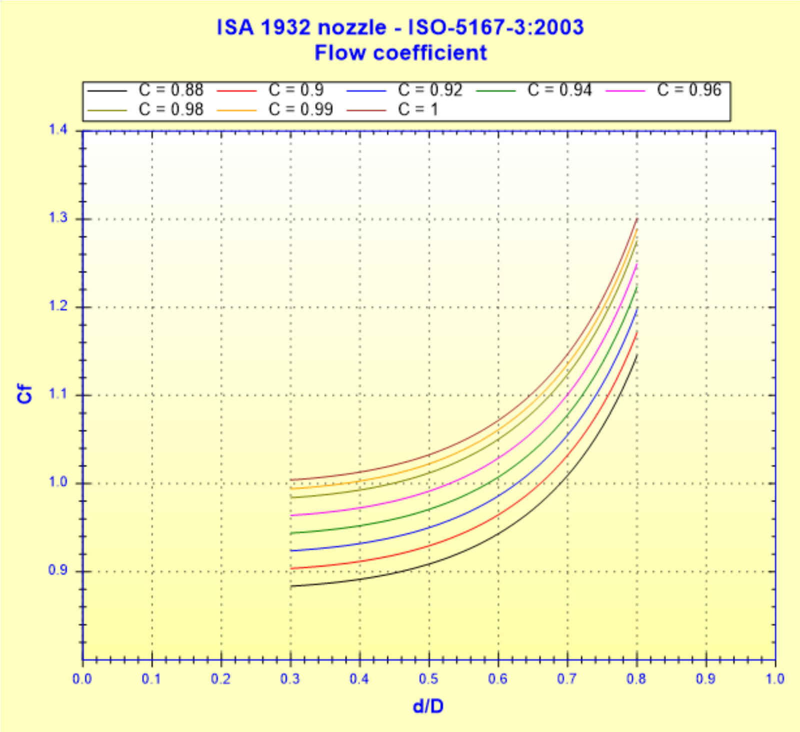
([1] §3.3.5)



Flow coefficient:

$$C_f = C \cdot \frac{1}{\sqrt{1-\beta^4}}$$

([1] §3.3.5)



Net pressure loss (Pa):

$$\Delta\varpi = \frac{\sqrt{1-\beta^4} - C \cdot \beta^2}{\sqrt{1-\beta^4} + C \cdot \beta^2} \cdot \Delta p$$

([1] § 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)

Net head loss (m):

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

Net hydraulic power loss (W):

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

Measured head loss (m):

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

Symbols, Definitions, SI Units:

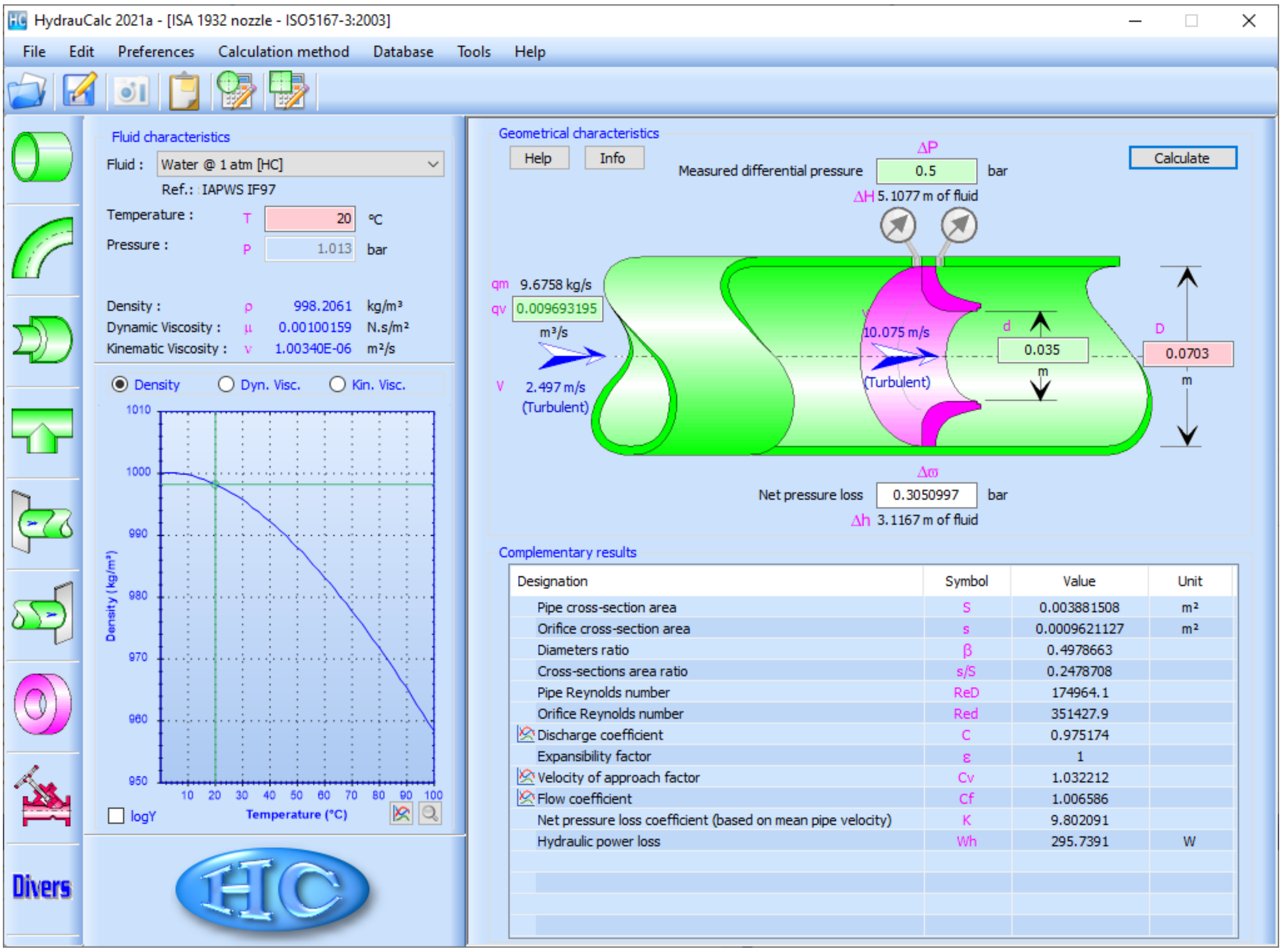
d	Orifice diameter (m)
D	Internal pipe diameter (m)
β	Diameter ratio ()
s	Orifice cross-sectional area (m^2)
S	Pipe cross-sectional area (m^2)
q_v	Volume flow rate (m^3/s)
v	Mean velocity in orifice (m/s)
V	Mean velocity in pipe (m/s)
Re_d	Reynolds number referred to orifice ()
Re_D	Reynolds number referred to pipe ()
C	Discharge coefficient ()
ε	Expansibility factor ()
q_m	Mass flow rate (kg/s)
C_v	Velocity of approach factor ()
C_f	Flow coefficient ()
$\Delta\varpi$	Net pressure loss (Pa)
ΔP	Measured pressure loss (Pa)
K	Net pressure loss coefficient (based on the mean pipe velocity) ()
Δh	Net head loss of fluid (m)
Wh	Net hydraulic power loss (W)
ΔH	Measured head loss of fluid (m)
ρ	Fluid density (kg/m^3)
ν	Fluid kinematic viscosity (m^2/s)
g	Gravitational acceleration (m/s^2)

Limit of use ([2] §5.1.6.1):

- $50 \text{ mm} \leq D \leq 500 \text{ mm}$

- $0.3 \leq \beta \leq 0.8$
  $0.3 \leq \beta < 0.44$ 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:



Designation	Symbol	Value	Unit
Pipe cross-section area	S	0.003881508	m²
Orifice cross-section area	s	0.0009621127	m²
Diameters ratio	β	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	ε	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