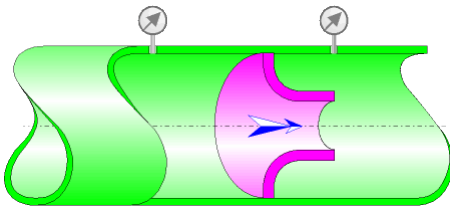




Long radius nozzle (ISO 5167-3:2003)



Model description:

This model of component determines the fluid flow through a long radius 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:

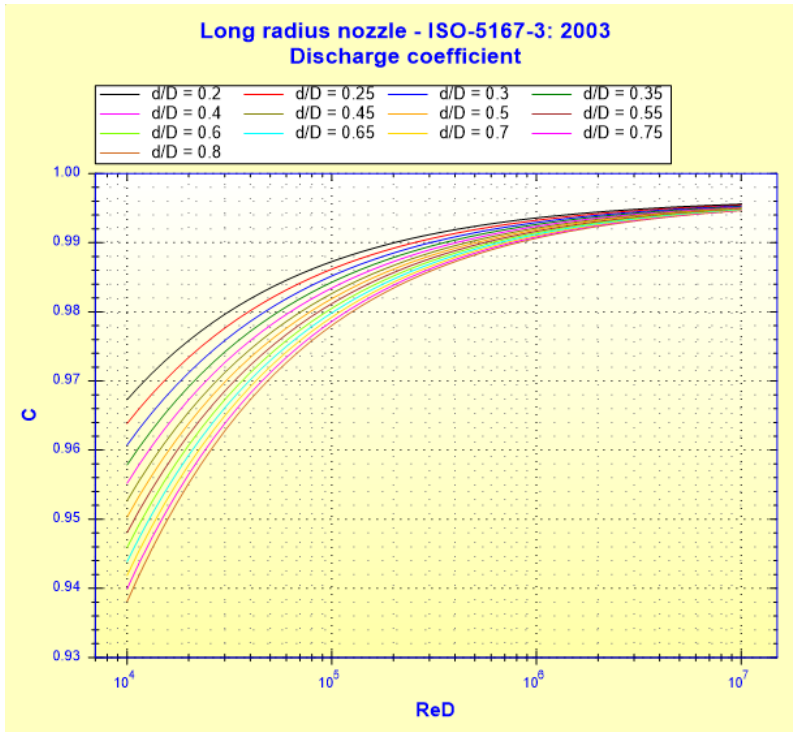
$$Re_d = \frac{v \cdot d}{\nu}$$

Reynolds number referred to internal pipe diameter:

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

Discharge coefficient:

$$C = 0.9965 - 0.00653 \cdot \sqrt{\frac{10^6 \cdot \beta}{\text{Re}_D}} \quad ([2] \text{ §5.2.6.2 eq. 8})$$



Expansibility factor:

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

Mass flow rate (kg/s):

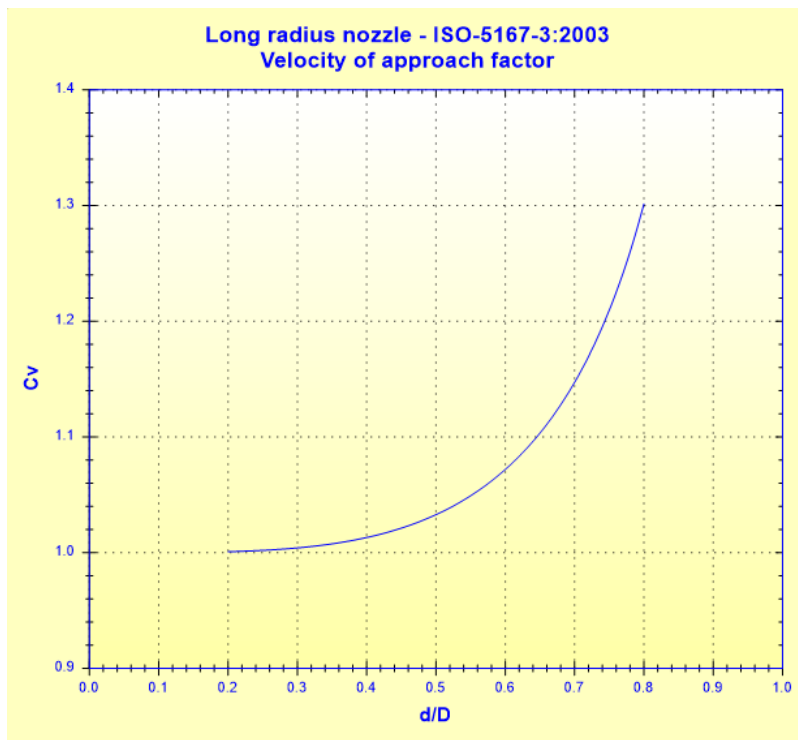
$$q_m = \frac{C}{\sqrt{1-\beta^4}} \cdot \varepsilon \cdot \frac{\pi}{4} \cdot d^2 \cdot \sqrt{2 \cdot \Delta p \cdot \rho} \quad ([1] \text{ §5.1 eq. 1 and [2] §4 eq. 1})$$

Volume flow rate (m³/s):

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

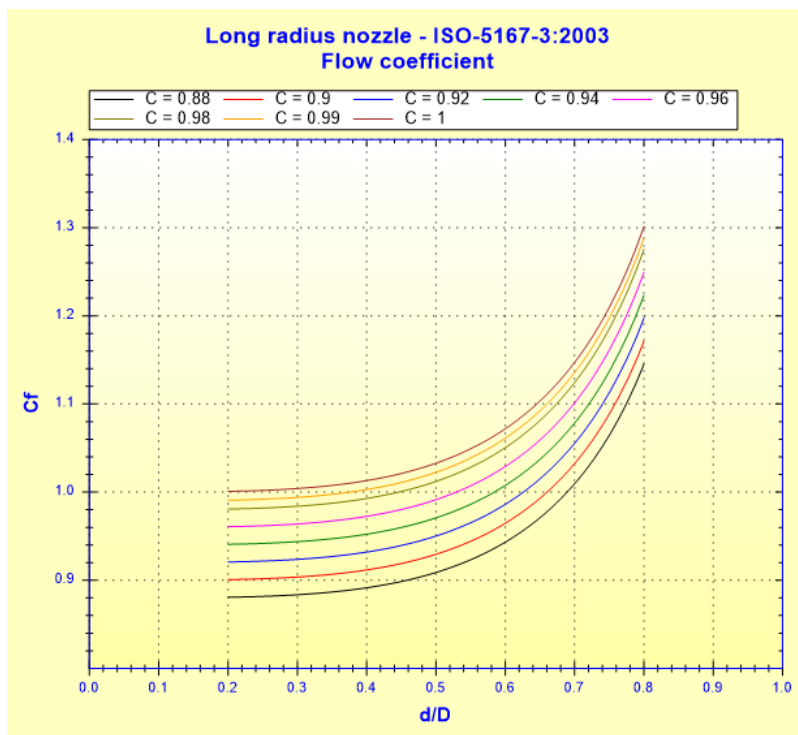
Velocity of approach factor:

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



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)

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] §5.2.6.1):

- 50 mm ≤ D ≤ 630 mm
- 0.2 ≤ β ≤ 0.8

- $10^4 \leq Re_D \leq 10^7$

Example of application:

HydrauCalc 2021a - [Long radius nozzle - ISO5167-3:2003]

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Fluid characteristics

Fluid : Water @ 1 atm [HC]
Ref.: IAPWS IF97

Temperature : T 20 °C
Pressure : P 1.013 bar

Density : ρ 998.2061 kg/m³
Dynamic Viscosity : μ 0.00100159 N.s/m²
Kinematic Viscosity : ν 1.00340E-06 m²/s

Density Dyn. Visc. Kn. Visc.

Geometrical characteristics

Measured differential pressure ΔP 0.5 bar
 Δh 5.1077 m of fluid

qm 9.7787 kg/s
qv 0.009796262 m³/s
V 2.524 m/s (Turbulent)

Net pressure loss Δp 0.3035336 bar
 Δh 3.1007 m of fluid

Complementary results

Designation	Symbol	Value	Unit
Pipe cross-section area	S	0.003881508	m ²
Orifice cross-section area	s	0.0009621127	m ²
Diameters ratio	β	0.4978663	
Cross-sections area ratio	s/S	0.2478708	
Pipe Reynolds number	ReD	176824.5	
Orifice Reynolds number	Red	355164.6	
Discharge coefficient	C	0.9855428	
Expansibility factor	ϵ	1	
Velocity of approach factor	Cv	1.032212	
Flow coefficient	Cf	1.017289	
Net pressure loss coefficient (based on mean pipe velocity)	K	9.547658	
Hydraulic power loss	Wh	297.3495	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