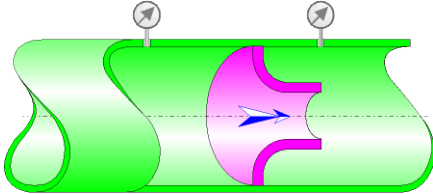




## Long radius nozzle D and D/2 pressure tapings (CRANE)



### Model description:

This model of component determines the fluid flow through a long radius nozzle flowmeter with D & D/2 pressure tapings, according to the reference document [1].

### Model formulation:

Diameter ratio:

$$\beta = \frac{D_1}{D_2}$$

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

$$A_1 = \pi \cdot \frac{D_1^2}{4}$$

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

$$A_2 = \pi \cdot \frac{D_2^2}{4}$$

Mean velocity in orifice (m/s):

$$v_1 = \frac{q}{A_1}$$

Mean velocity in pipe (m/s):

$$v_2 = \frac{q}{A_2}$$

Reynolds number in orifice:

$$Re_1 = \frac{v_1 \cdot D_1}{\nu}$$

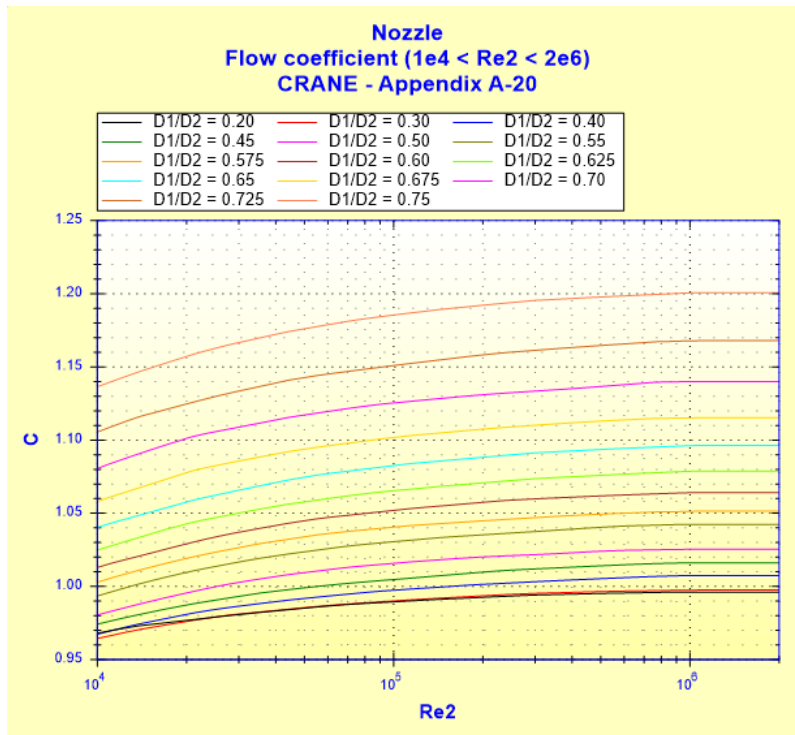
Reynolds number in pipe:

$$\text{Re}_2 = \frac{v_2 \cdot D_2}{\nu}$$

Flow coefficient:

$$C = f\left(\text{Re}_2, \frac{d_1}{d_2}\right)$$

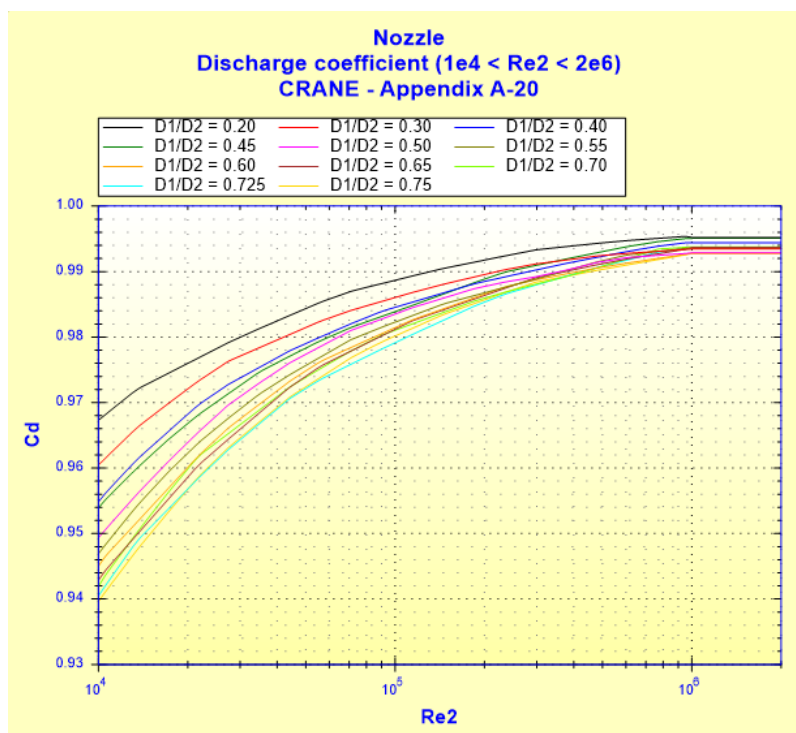
([1] appendix A-20)



Discharge coefficient:

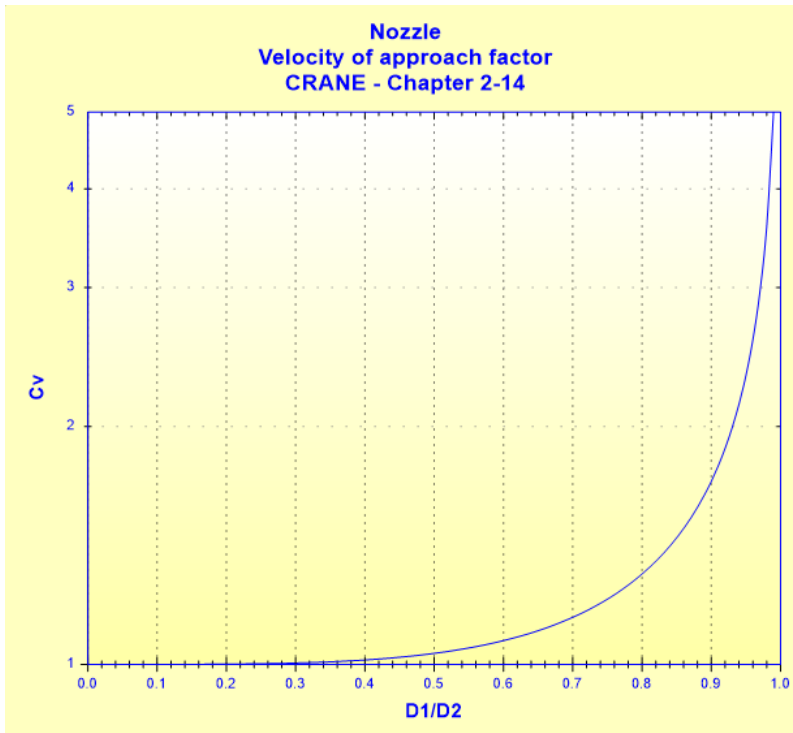
$$C_d = C \cdot \sqrt{1 - \beta^4}$$

([1] appendix A-20)



Velocity of approach factor:

$$C_v = \frac{1}{\sqrt{1-\beta^4}} \quad ([1] \text{ 2-14})$$



Volume flow rate ( $\text{m}^3/\text{s}$ ):

$$q = A_1 \cdot C \cdot \sqrt{\frac{2 \cdot \Delta p}{\rho}} \quad ([1] \text{ Equation 2-23})$$

Mass flow rate ( $\text{kg/s}$ ):

$$w = q \cdot \rho$$

Net pressure loss (Pa):

$$\Delta \varpi = \frac{\sqrt{1-\beta^4} - C \cdot \beta^2}{\sqrt{1-\beta^4} + C \cdot \beta^2} \cdot \Delta p \quad ([2] \text{ § 5.2.8})$$

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

$$K = \frac{\Delta \varpi}{0.5 \cdot \rho \cdot V^2} \quad ([2] \text{ § 5.2.8})$$

Net head loss (m):

$$\Delta h = K_o \cdot \frac{v_2^2}{2 \cdot g}$$

Net hydraulic power loss (W):

$$Wh = \Delta w \cdot q$$

---

Measured head loss (m):

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

---

**Symbols, Definitions, SI Units:**

$D_1$	Orifice diameter (m)
$D_2$	Internal pipe diameter (m)
$\beta$	Diameter ratio ( )
$A_1$	Orifice cross-sectional area (m <sup>2</sup> )
$A_2$	Pipe cross-sectional area (m <sup>2</sup> )
$q$	Volume flow rate (m <sup>3</sup> /s)
$v_1$	Mean velocity in orifice (m/s)
$v_2$	Mean velocity in pipe (m/s)
$Re_1$	Reynolds number in orifice ( )
$Re_2$	Reynolds number in pipe ( )
$C$	Flow coefficient ( )
$C_d$	Discharge coefficient ( )
$C_v$	Velocity of approach factor ( )
$\Delta P$	Measured pressure loss (Pa)
$w$	Mass flow rate (kg/s)
$\Delta \varpi$	Net pressure loss (Pa)
$K_o$	Resistance coefficient (based on the mean pipe velocity) ( )
$\Delta h$	Net head loss of fluid (m)
$Wh$	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> )

Notation of equations according to sources.

---

**Validity range:**

- turbulent flow regime ( $10^4 < Re_2 < 2 \cdot 10^6$ )
- stabilized flow upstream of the orifice

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**Example of application:**

HydrauCalc 2021a - [Nozzle - CRANE 1999]

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**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

Density  Dyn. Visc.  Kin. Visc.

**Geometrical characteristics**

Measured differential pressure  $\Delta P$  0.5 bar  
 $\Delta H$  5.1077 m of fluid

Net pressure loss  $\Delta p$  0.3760645 bar  
 $\Delta h$  3.8417 m of fluid

**Complementary results**

Designation	Symbol	Value	Unit
Pipe cross-section area	S2	0.003881508	m <sup>2</sup>
Orifice cross-section area	S1	0.0009621127	m <sup>2</sup>
Diameters ratio	$\beta$	0.4978663	
Cross-sections area ratio	S1/S2	0.2478708	
Pipe Reynolds number	Re2	177133.3	
Orifice Reynolds number	Re1	355784.9	
<input checked="" type="checkbox"/> Flow coefficient - Appendix A-20	C	1.019066	
<input checked="" type="checkbox"/> Velocity of approach factor	Cv	1.032212	
<input checked="" type="checkbox"/> Discharge coefficient	Cd	0.9872643	
Net pressure loss coefficient (based on mean pipe velocity)	Ko	11.78791	
Hydraulic power loss	Wh	369.0461	W

## References:

- [1] CRANE - Flow of Fluids Through Valves, Fitting and Pipe - Technical Paper No. 410 - Edition 1999
- [2] ISO 5167-2:2003 - Measurement of fluid flow by means of pressure differential devices inserted in circular-cross section conduits running full Part 3: Nozzles and Venturi nozzles