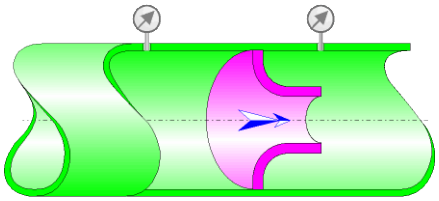
Long radius nozzle
D and D/2 pressure tapings
(CRANE)



Model description:

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

Model formulation:

Diameter ratio:

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

Orifice cross-sectional area (m^2):

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

Pipe cross-sectional area (m^2):

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

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:

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

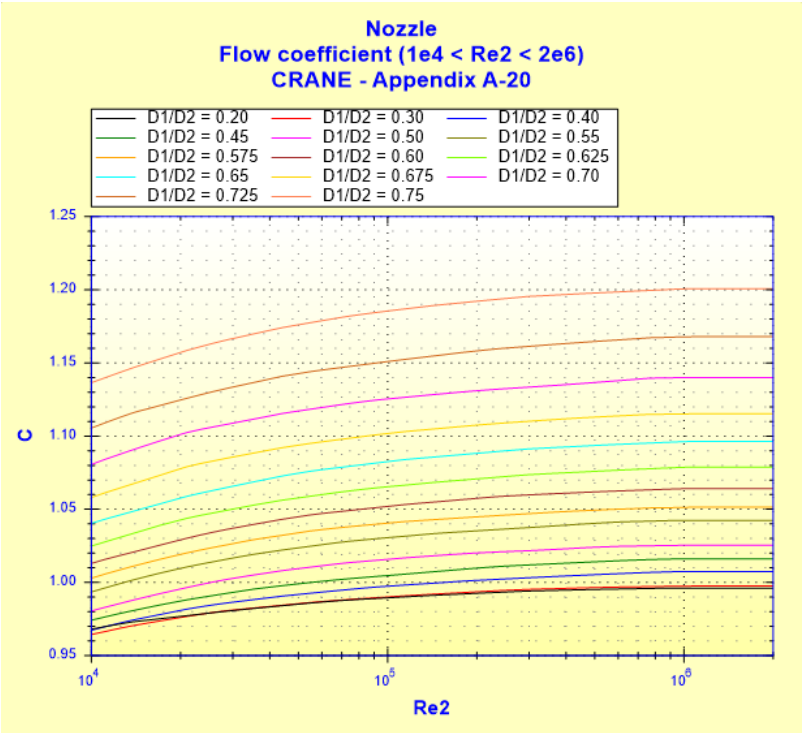
Reynolds number in pipe:

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

Flow coefficient:

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

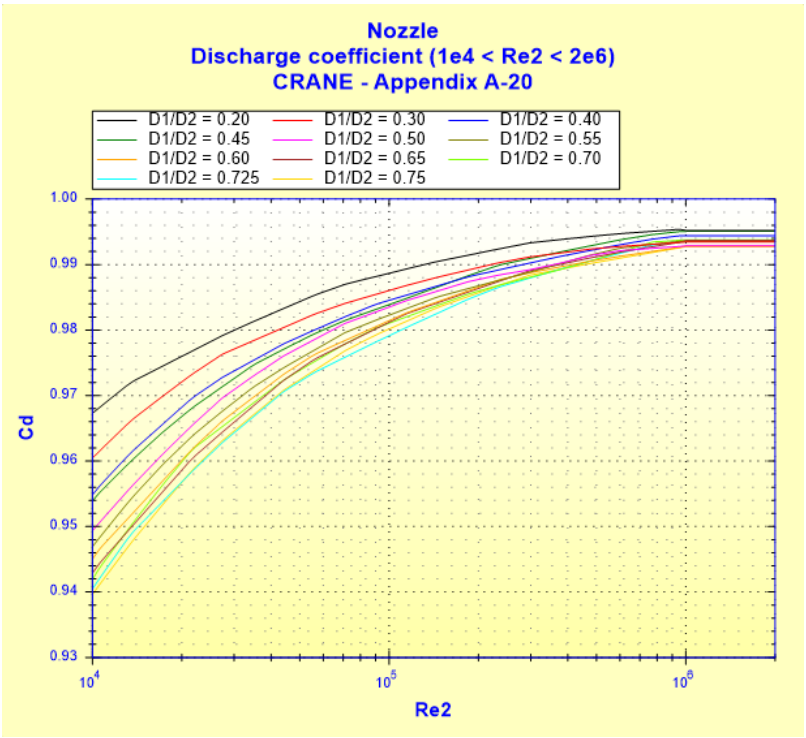
([1] appendix A-20)



Discharge coefficient:

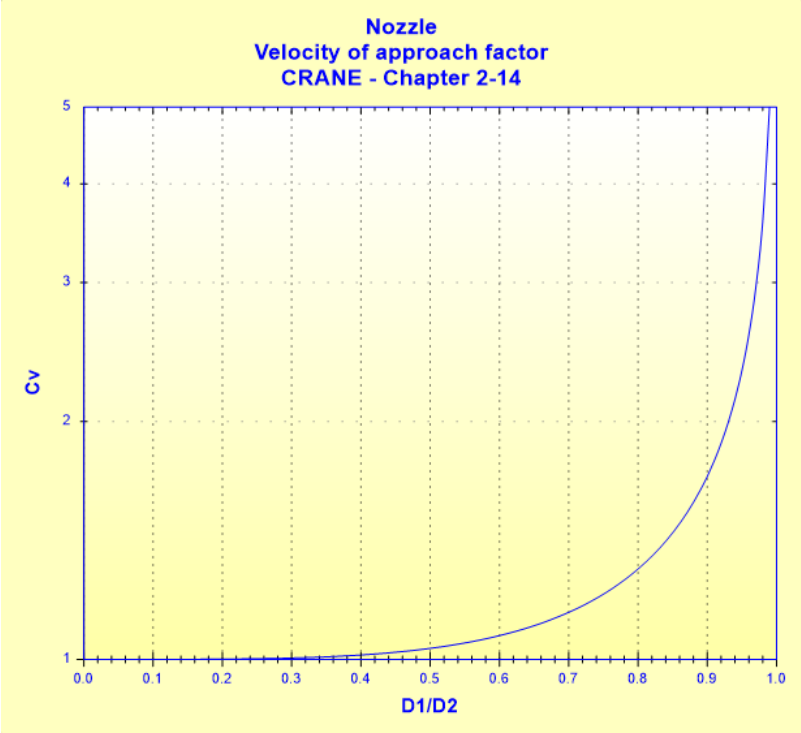
$$C_d = C \cdot \sqrt{1 - \beta^4}$$

([1] appendix A-20)



Velocity of approach factor:

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



Volume flow rate (m^3/s):

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

Mass flow rate (kg/s):

$$w = q \cdot \rho$$

Net pressure loss (Pa):

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

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

$$K = \frac{\Delta \varpi}{0.5 \cdot \rho \cdot V^2}$$ ([2] § 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:

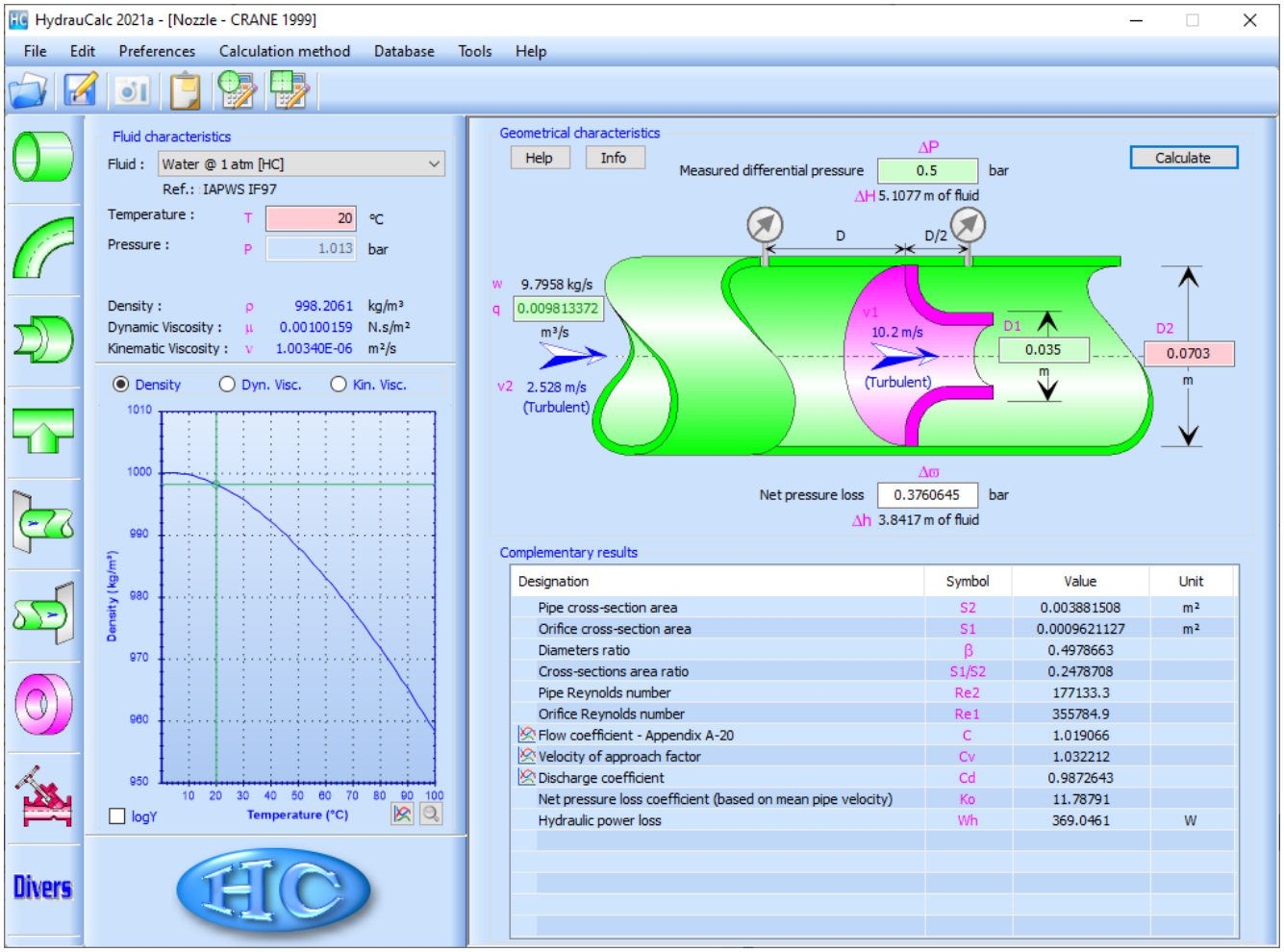
D_1	Orifice diameter (m)
D_2	Internal pipe diameter (m)
β	Diameter ratio ()
A_1	Orifice cross-sectional area (m^2)
A_2	Pipe cross-sectional area (m^2)
q	Volume flow rate (m^3/s)
v_1	Mean velocity in orifice (m/s)
v_2	Mean velocity in pipe (m/s)
Re_1	Reynolds number in orifice ()
Re_2	Reynolds number in pipe ()
C	Flow coefficient ()
C_d	Discharge coefficient ()
C_v	Velocity of approach factor ()
ΔP	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) ()
Δh	Net head loss of fluid (m)
Wh	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)

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

Example of application:



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