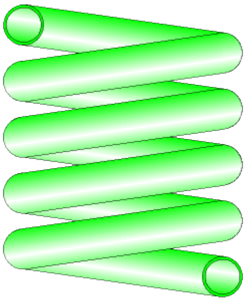
# Helical Tube (Coil)
# Circular Cross-Section
# (CRANE)



**Model description:**

This model of component calculates the head loss (pressure drop) of a helical tube whose cross-section is circular and constant. In addition, the flow is assumed fully developed and stabilized upstream of the helical tube.

**Model formulation:**

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Cross-section area ($m^2$):

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

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Mean velocity (m/s):

$$v = \frac{q}{A}$$

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Length measured along the axis (m):

$$L = 2 \cdot \pi \cdot r \cdot N_t$$

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Mass flow rate (kg/s):

$$w = q \cdot \rho$$

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Fluid volume ($m^3$):

$$V = A \cdot L$$

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Fluid mass (kg):

$$M = Vol \cdot \rho_m$$

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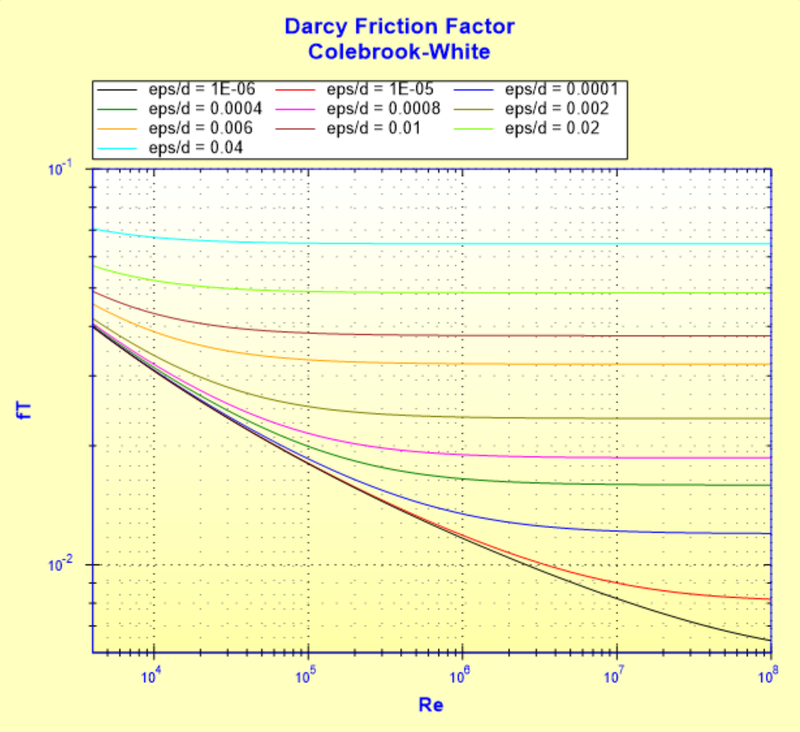
Reynolds number:

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

Darcy friction factor:

$$f_T = \frac{1}{\left[2 \cdot \log\left(\frac{\varepsilon}{3.7 \cdot d} + \frac{2.51}{\mathrm{Re} \cdot \sqrt{f_T}}\right)\right]^2}$$

Colebrook-White equation

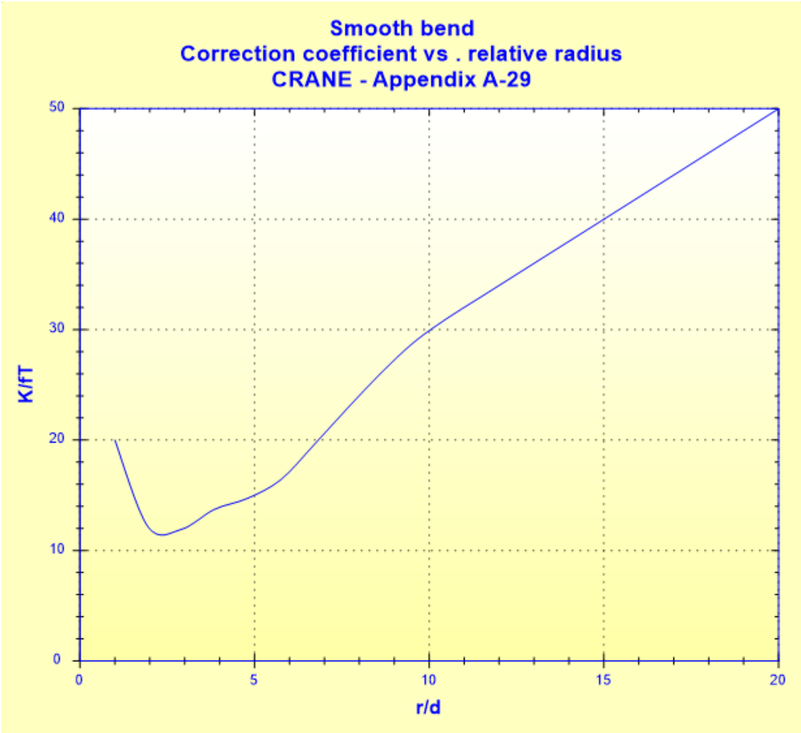



Resistance coefficient for one 90° smooth bend:

$$K = f\left(\frac{r}{d}, f_T\right)$$

([1] Appendix A-29)

| r/d | K | $K/f_T$ |
|---|---|---|
| 1 | 20 $f_T$ | 20 |
| 1.5 | 14 $f_T$ | 14 |
| 2 | 12 $f_T$ | 12 |
| 3 | 12 $f_T$ | 12 |
| 4 | 14 $f_T$ | 14 |
| 6 | 17 $f_T$ | 17 |
| 8 | 24 $f_T$ | 24 |
| 10 | 30 $f_T$ | 30 |
| 12 | 34 $f_T$ | 34 |
| 14 | 38 $f_T$ | 38 |
| 16 | 42 $f_T$ | 42 |
| 20 | 50 $f_T$ | 50 |




Total pressure loss coefficient (based on mean velocity in helical tube):

$$K_B = (n-1)\left(0.25 \cdot \pi \cdot f_T \cdot \frac{r}{d} + 0.5 \cdot K_1\right) + K_1$$

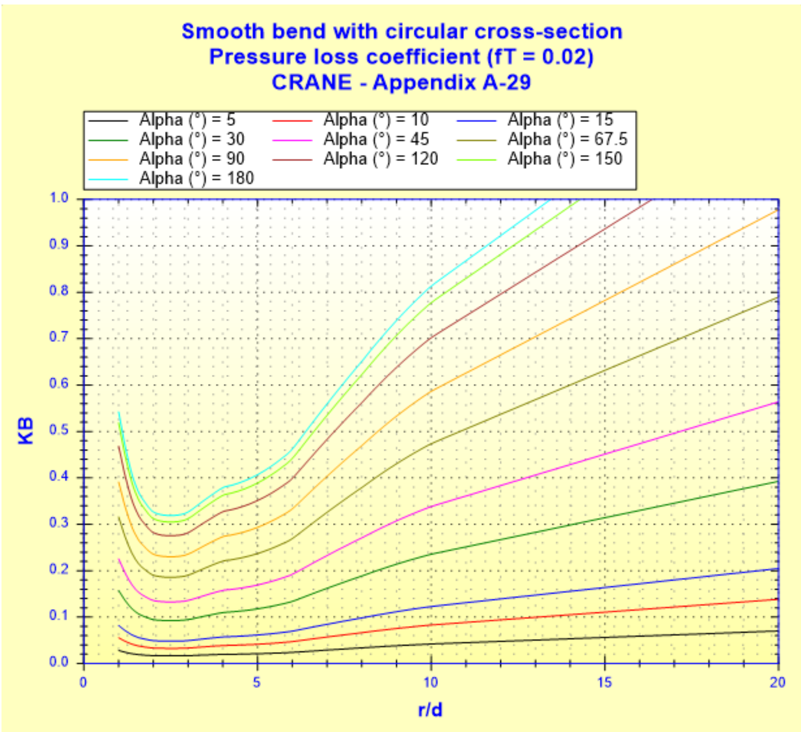
([1] Equation 2-20)

with:

$$n = 4 \cdot N_t$$

and:

$$K_1 = K \cdot F_t$$




(with $f_T$ = 0.02)

Total pressure loss (Pa):

$$\Delta P = K_B \cdot \frac{\rho \cdot v^2}{2}$$

Total head loss of fluid (m):

$$\Delta H = K_B \cdot \frac{v^2}{2 \cdot g}$$

Hydraulic power loss (W):

$$Wh = \Delta P \cdot q$$

Straight length of equivalent pressure loss (m):

$$L_{eq} = K_B \cdot \frac{d}{f_T}$$

**Symbols, Definitions, SI Units:**

| | |
|---|---|
| d | Internal diameter of the helical tube (m) |
| A | Cross-section area ($m^2$) |
| q | Volume flow rate ($m^3/s$) |
| v | Mean velocity (m/s) |
| $N_t$ | Number of turns constituting the helical tube () |
| r | Radius of curvature (m) |
| L | Length measured along the axis (m) |
| w | Mass flow rate (kg/s) |
| V | Fluid volume ($m^3$) |
| M | Fluid mass (kg) |
| Re | Reynolds number () |
| $\varepsilon$ | Absolute roughness of walls (m) |
| $f_T$ | Darcy friction factor |
| n | Number of 90 ° bends constituting the helical tube () |
| $K_1$ | Resistance coefficient for one 90° smooth bend () |
| $K_B$ | Total pressure loss coefficient (based on mean velocity in helical tube) () |
| $\Delta P$ | Total pressure loss (Pa) |
| $\Delta H$ | Total head loss of fluid (m) |
| Wh | Hydraulic power loss (W) |
| $L_{eq}$ | Straight length of equivalent pressure loss (m) |
| | |
| $\rho$ | Fluid density ($kg/m^3$) |
| $\nu$ | Fluid kinematic viscosity ($m^2/s$) |
| g | Gravitational acceleration ($m/s^2$) |

**Validity range:**

- turbulent flow regime ($Re \geq 10^4$)
- stabilized flow upstream of the helical tube

- relative radius of curvature (r/d) range between 1 and 20
  for relative radii 'r/d' between 0.5 and 1 or those greater than 20, the coefficient 'K' is linearly extrapolated.

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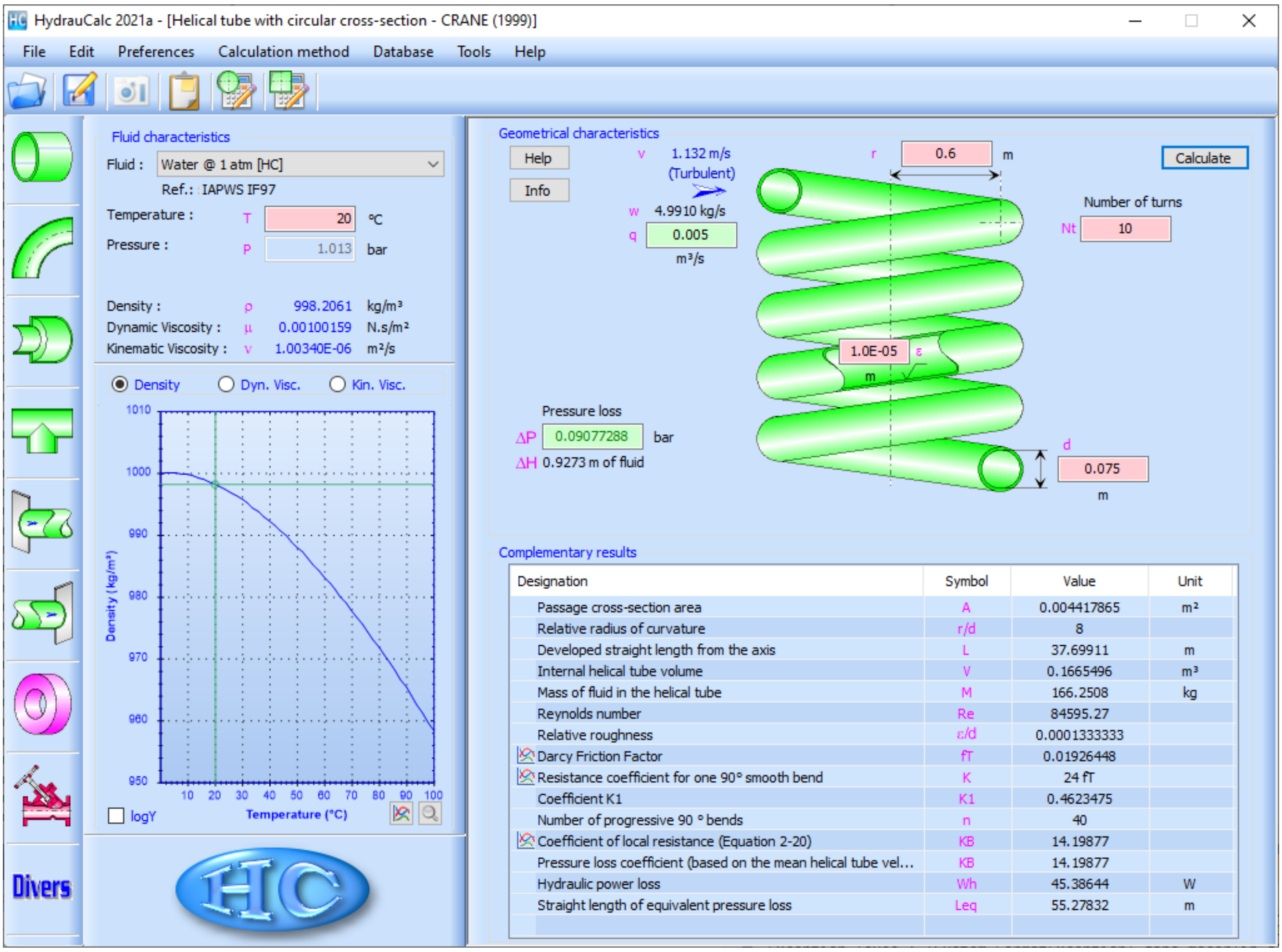
## Example of application:

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## References:

[1] CRANE - Flow of Fluids Through Valves, Fitting and Pipe - Technical Paper No. 410 - Edition 1999

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