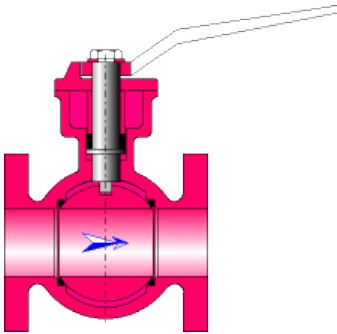




Ball valve (User defined by a flow coefficient)



Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a ball valve installed in a straight pipe.

The pressure drop of the valve is characterized by a flow coefficient "Kv", "Cv" or "Av" at full opening, and a law of flow coefficient evolution according the valve opening.

Model formulation:

Cross-sectional area (m²):

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

Mean velocity (m/s):

$$U = \frac{Q}{A}$$

Mass flow rate (kg/s):

$$G = Q \cdot \rho$$

Reynolds number:

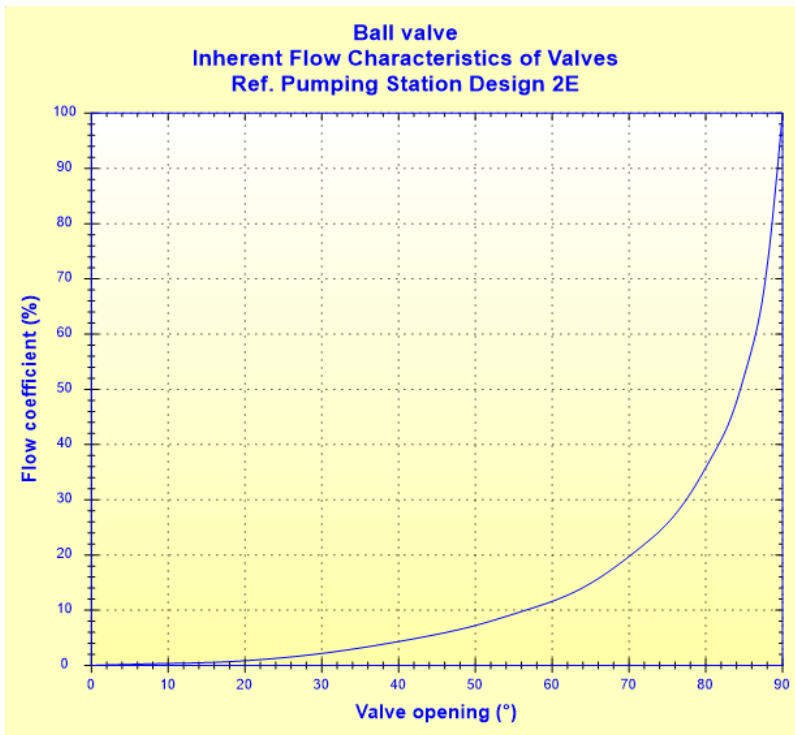
$$Re = \frac{U \cdot D}{\nu}$$

Evolution of the flow coefficients according to the valve opening:

$$Kv = Kvs \cdot F_{low} C_{oef} (V_{alve} O_{pening}) / 100$$

$$Cv = Cvs \cdot F_{low} C_{oef} (V_{alve} O_{pening}) / 100$$

$$A_v = A_{vs} \cdot F_{low} C_{oef} (V_{valve} O_{pening}) / 100$$



$$FlowC_{oef}(V_{valve}O_{pening}) \quad ([1])$$

Figure 5-2)

Local resistance coefficient (Pa):

- $Re \geq 10^4$ (turbulent flow)

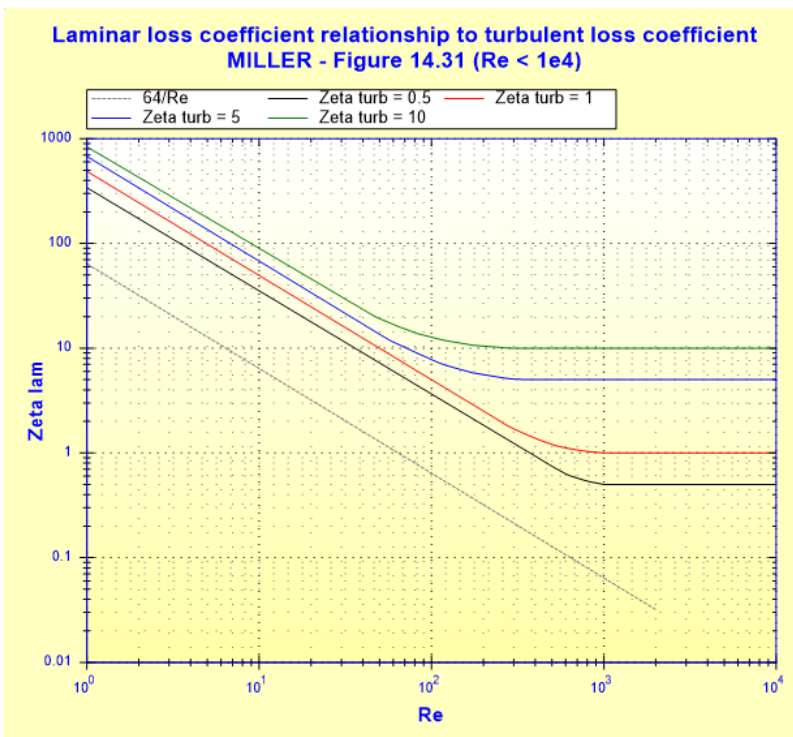
$$K_{turb} = \frac{2 \cdot A^2}{\left(\frac{K_v}{36023}\right)^2}$$

$$K_{turb} = \frac{2 \cdot A^2}{\left(\frac{C_v}{41650}\right)^2}$$

$$K_{turb} = \frac{2 \cdot A^2}{A_v^2}$$

- $Re < 10^4$ (laminar flow)

$$K_{lam} = f(K_{turb}, Re) \quad ([2] \text{ figure 14.31})$$



Reynolds Number Correction (Re < 10⁴):

$$C_{Re} = \frac{K_{lam}}{K_{turb}}$$

Corrected flow coefficient in laminar flow (Re < 10⁴):

$$K_{V_c} = \frac{K_V}{\sqrt{C_{Re}}}$$

$$C_{V_c} = \frac{C_V}{\sqrt{C_{Re}}}$$

$$A_{V_c} = \frac{A_V}{\sqrt{C_{Re}}}$$

Total pressure loss coefficient (based on mean velocity):

- turbulent flow (Re ≥ 10⁴):

$$K = K_{turb}$$

- laminar flow (Re < 10⁴):

$$K = K_{lam}$$

Total pressure loss (Pa):

$$\Delta P = K \cdot \frac{\rho \cdot U^2}{2}$$

Total head loss of fluid (m):

$$\Delta H = K \cdot \frac{U^2}{2 \cdot g}$$

Hydraulic power loss (W):

$$Wh = \Delta P \cdot Q$$

Symbols, Definitions, SI Units:

D	Internal diameter (m)
A	Cross-sectional area (m ²)
Q	Volume flow rate (m ³ /s)
G	Mass flow rate (kg/s)
U	Mean velocity (m/s)
Re	Reynolds number ()
α	Opening angle (°)
Kvs	Full opening flow coefficient (m ³ /h)
Cvs	Full opening flow coefficient (USG/min)
Avs	Full opening flow coefficient (m ²)
Kv	Partial opening flow coefficient (m ³ /h)
Cv	Partial opening flow coefficient (USG/min)
Av	Partial opening flow coefficient (m ²)
K _{turb}	Local resistance coefficient for Re ≥ 10 ⁴ ()
K _{lam}	Local resistance coefficient for Re < 10 ⁴ ()
C _{Re}	Reynolds number correction for Re < 10 ⁴ ()
K _v c	Corrected flow coefficient in laminar flow (m ³ /h)
C _v c	Corrected flow coefficient in laminar flow (USG/min)
A _v c	Corrected flow coefficient in laminar flow (m ²)
K	Total pressure loss coefficient (based on mean velocity) ()
ΔP	Total pressure loss (Pa)
ΔH	Total head loss of fluid (m)
Wh	Hydraulic power loss (W)
ρ	Fluid density (kg/m ³)
ν	Fluid kinematic viscosity (m ² /s)
g	Gravitational acceleration (m/s ²)

Validity range:

- any flow regime: laminar and turbulent
note: for laminar flow regime (Re < 10⁴), the pressure loss coefficient "K_{lam}" is estimated

Example of application:

HydrauCalc 2020b - [Ball valve - User]

File Edit Preferences Calculation method Database Tools Help

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. Kin. Visc.

Geometrical characteristics

Kv Cv Av

Flow coefficient at full opening: 100

Pressure loss: ΔP 0.04329062 bar
 ΔH 0.4422 m of fluid

Opening angle: 90 °

G 4.9910 kg/s
Q 0.005 m³/s
U 157.882 m/s (Turbulent)

D 0.00635 m

Calculate Help Info

Complementary results

Designation	Symbol	Value	Unit
Pipe cross-section area	A	3.166922E-05	m ²
Reynolds number	Re	999156.7	
Fully open flow coefficient 'Cvs'	Cvs	100	
Flow coefficient 'Cv' (at 90°)	Cv	100	
Coefficient of local resistance	K _{turb}	0.0003479671	
Pressure loss coefficient (based on the mean valve velocity)	K	0.0003479671	
Hydraulic power loss	Wh	21.64531	W

References:

- [1] Pumping Station Design, Second Edition, Garr M. Jones
[2] Internal Flow System, Second Edition, D.S. Miller