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Predicting Valve Pressure Drop

This paper discusses an example illustrating the resistance coefficient K for predicting valve pressure drop. An example problem is also given in terms of the flow coefficient Cv.

1.1 Summary of Equations

(1) $\frac{1}{\sqrt{f}} = -2.0\log\left(\frac{12\frac{\varepsilon}{d}}{3.7}\right)$ fully-rough friction factor

(2) $\Delta p = K \cdot \frac{\rho}{144} \cdot \frac{v^2}{2g}$ pressure drop from resistance coefficient, psi

(3) $\Delta p = \left(\frac{Q}{Cv}\right)^2 \frac{\rho}{62.36}$ valve pressure drop using flow coefficient, psi

Note: density of water is given at 60 ºF

Nomenclature

d	diameter, inches (in)
f	friction factor, $h_L = f\,L\,v^2/D\,2\,g$
g	gravitational constant, 32.2 ft/sec^2
K	resistance coefficient, $h_L = K\,v^2/2\,g$
L	length of pipe, feet (ft)
L_e	equivalent length of pipe, feet (ft; TEL in text)
L/D	equivalent length of resistance to flow, pipe diameters
P	pressure, pounds per square inch, gauge (psig)
p	pressure, pounds per square inch, absolute (psia)
Q	rate of flow, gallons per minute (gpm)

t temperature, ºF

$\overline{V}$ specific volume, cubic feet per pound (also $1/\rho$), (ft^3/lb)

v fluid velocity, feet per second (fps)

Δp differential pressure, pounds per square inch (psi)

ε absolute roughness, feet (ft)

ε/D relative roughness, feet per foot (ft/ft)

μ absolute viscosity, centipoise

ρ weight density of fluid, pounds per cubic foot (lb/ft^3)

1.2 Example Problem Using Resistance Coefficient, K

Problem: You are designing a brine piping system using calcium chloride, 22% mass ratio, t = 20 ºF, Sg = 1.215, flowing at the rate of 25 gallons per minute through a 2" sch 40 (commercial steel) branch line to a silo plate heat exchanger. Your client has requested use of a particular manufacturer's globe valve for isolating the HX; it is now up to you to predict the fluid pressure drop through this valve. The information you are given is that it has a resistance coefficient, K = 340 f_T for a 2" port globe valve.

1.2.1 *Solution*: Step 1 – Find Fully-Rough Friction Factor (f_T)

The "T" in the sub position under *f* denotes that flow takes place in a turbulent regime, therefore the fully-rough friction factor may be found from:

$$\frac{1}{\sqrt{f}} = -2.0\log\left(\frac{12\frac{\varepsilon}{d}}{3.7}\right) \qquad (1)$$

where:

ε = 0.00015 (absolute roughness, commercial steel pipe)

d = 2.00 inches

Answer: ***f* = 0.01914**

1.2.2 Step 2 – Solve for K

Since the value of K was given in terms of *n* fully-rough friction factors (340 of those little buggers),

$\therefore K = 0.01914 \cdot 340$ **= 6.5076**

1.2.3 Step 3 – Predict Valve Pressure Drop Using D/W Equation

Knowing that $K = f\frac{L_e}{D}$, we can write:

$$\Delta p = K \cdot \frac{\rho}{144} \cdot \frac{v^2}{2g} \qquad (2)$$

where:

ρ = 75.77 lb/ft^3 (density of 22% CaCl, t=20 ºF, Sg=1.215)

v = 2.553 ft/sec

Answer: **0.347 psi**

1.3 Example Problem Using Flow Coefficient, Cv

Consider the prior problem, again at the same temperature, CaCl concentration and 25 gpm flow rate. A different 2" globe valve has a flow coefficient, Cv = 67, therefore:

$$\Delta p = \left(\frac{Q}{Cv}\right)^2 \frac{\rho}{62.36} \tag{3}$$

where:

Q = 25 gallons per minute, gpm

Answer: **Δp = 0.17 psi**

end of text

References:

1. ASHRAE, 2005, *Handbook of Fundamentals*, Chapter 2, American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.
2. Crane, 1976, Technical Paper 410, *Flow of Fluids Through Valves, Fittings and Pipe*, Crane Company