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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 C_v .

1.1 Summary of Equations

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

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

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

Note: density of water is given at 60 °F

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, °F
\bar{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, $t = 20$ °F, $S_g = 1.215$, 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:

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

where:

$$\varepsilon = 0.00015 \text{ (absolute roughness, commercial steel pipe)}$$

$$d = 2.00 \text{ inches}$$

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:

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

where:

$$\rho = 75.77 \text{ lb/ft}^3 \text{ (density of 22\% CaCl, } t=20 \text{ °F, } S_g=1.215)$$

$$v = 2.553 \text{ ft/sec}$$

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, $C_v = 67$, therefore:

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

where:

$$Q = 25 \text{ gallons per minute, gpm}$$

Answer: **$\Delta p = 0.17 \text{ psi}$**

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