IBC Valve Sizing Equations

July 25, 2007
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Symbol	Description	Units
P1	Absolute Upstream Pressure (Input)	psia
P2	Absolute Downstream Pressure (Input)	psia
Q	Volumetric Flow Rate (Input)	gpm
Pv	Vapour Pressure (Water)	psia
Pc	Critical Pressure (Water)	psia
SG	Specific Gravity (Water)	dimensionless
FF	Critical Pressure Ratio Factor	dimensionless
Cv	Flow Coefficient (Valve)	$\mathrm{gpm}\cdot\mathrm{psi}^{-0.5}$
FL	Pressure Recovery Coefficient (Valve)	dimensionless
σ	Cavitation Index	dimensionless

The vapour pressure of water is dependant on temperature. If the water temperature is known, the vapour pressure can be calculated using the Goff-Gratch equation. At 70°F (21°C) the vapour pressure of water is 0.36 psia. The critical pressure of water is constant 3200 psia (217.7 atm). Using these pressures we can calculate the critical pressure ratio factor.

$$FF = 0.96 - 0.28\cdot\sqrt{\frac{Pv}{Pc}}$$

1) Actual Pressure Drop

$$\Delta P_{act} = P1 - P2$$

2) Maximum Allowable Pressure Drop

$$\Delta P_{max} = FL^{2}\cdot(P1 - FF\cdot Pv)$$

For, $\Delta P_{act} \leq \Delta P_{max}$ the standard valve sizing equation is valid.

$$Cv = \frac{Q}{\sqrt{\frac{\Delta P}{SG}}}$$

Choked flow condition occurs when $\Delta P_{act} = \Delta P_{max}$

At this point the flow rate is maximum and can be calculated using the valve flow coefficient.

$$Q_{max} = Cv \cdot \sqrt{\frac{\Delta P_{max}}{SG}}$$

For, $\Delta P_{act} > \Delta P_{max}$

The standard valve sizing equation is no longer valid due to the presence of cavitation. Due to the presence of liquid water phase and unstable vapour phase, the fluid volume is no longer constant. The standard valve sizing equation as given here is only valid for single phase incompressible flow. Increasing the pressure drop will not increase flow rate, instead there will be increased cavitation and the flow rate will remain at Qmax. The cavitation index is calculated and compared to the IBC cavitation chart.

$$\sigma = \frac{P2 - Pv}{\Delta P_{act}}$$