Valve Mechanics

Opening Pressure under operating conditions

Valve is closed and ready to open \[ F_c = F_o \]

\[
F_c = p_{bT} A_b + S_i (A_b - A_v)
\]

\[
F_o = p_o (A_b - A_v) + p_s A_v
\]

combine

\[
p_0 = \frac{p_{bT}}{1 - A_v / A_b} + S_i - p_s \left( \frac{A_v / A_b}{1 - A_v / A_b} \right)
\]

Closing Pressure under operating conditions

\[
F_c = p_{bT} A_b + S_i (A_b - A_v)
\]

\[
F_o = p_{vc} A_b
\]

\[
p_{vc} = p_{bT} + S_i (1 - A_v / A_b)
\]

\[
p_{vc} = p_{vo} (1 - A_v / A_b)
\]

Valve Spread, the difference between the opening and closing pressures

\[
\Delta p = \left[ \frac{A_v / A_b}{1 - A_v / A_b} \right] \left( p_{bT} + S_i \left\{ 1 - \frac{A_v}{A_b} \right\} - p_s \right)
\]

\[ p_b = \text{pressure in bellows @ 60°} \]

\[ p_{bt} = \text{pressure in bellows @ operating temp} \]

\[ A_b = \text{bellows area} \]

\[ A_v = \text{valve area} \]

\[ p_o = \text{opening pressure} \]

\[ p_{vo} = \text{opening pressure} \]

\[ p_s = \text{pressure in tubing @ valve} \]

\[ S_i = \text{spring tension} \]
Remember static gas column

\[ p_v = p_{wh} \exp\left(\frac{0.1875 \gamma D}{z_a T_a}\right) \]

Flowing gas column

\[ p_v^2 = B(p_s^2 - A) + A \]
\[ A = 1.51E - 5 \times \left(\frac{q T_a z_a}{d^{3.23}}\right)^2 \]
\[ B = \exp\left(\frac{0.0376 \gamma D}{z_a T_a}\right) \]
\[ q = \text{mscfpd} \]
\[ d = \sqrt{\frac{0.5 \text{Annular area}}{7854}} \]

Valve Spacing

Top valve

\[ D_1 = \frac{p_o - p_{sp}}{G_s} \]

Next valve

\[ D_2 = \frac{p_{v2} - G_f D_1 - p_{sp}}{G_s} \]
\[ D_3 = \frac{p_{v3} - G_f (D_1 + D_2) - p_{sp}}{G_s} \]

\[ D = \text{depth valve} \]
\[ G_f = \text{unloading gradient} \]
\[ p_{sp} = \text{pressure of the separator} \]
\[ G_s = \text{static gradient} \]