C$_v$ Calculator Explanation

The C$_v$, or flow coefficient, is a multiplier used to quantify valve flow performance. It is used when the flow path is more complex than a simple orifice, providing a single quantity that takes into account all orifices and restrictions through the valve. System designers can use this C$_v$ value to predict pressure drops or flow rates when the valve is installed in a pneumatic system.

Because gas flow can become choked when its velocity reaches the speed of sound, two different formulas are utilized in C$_v$ flow calculations dependent on whether the flow is choked or not. A good rule of thumb for air or nitrogen is if the outlet pressure to an orifice or device is less than half the inlet pressure, the flow is choked.

First, the calculator determines if the flow is choked or unchoked by calculating the critical pressure ratio:

$$Critical\ Pressure\ Ratio = PR_{crit} = \left(\frac{2}{k+1}\right)^{\frac{k}{k-1}}$$

$$if\ PR_{crit} \geq \frac{P_o}{P_i}\ , flow\ is\ critical\ (choked)$$

$$if\ PR_{crit} < \frac{P_o}{P_i}\ , flow\ is\ subcritical\ (unchoked)$$

To calculate flow based on a C$_v$, the calculator uses the appropriate flow rate equation based on choked or unchoked flow:

For critical (choked) flow, the discharge capacity (Q_m) is calculated by:

$$Q_m = 13.61 * P_i * C_v * \sqrt{\frac{1}{S_g * T}}$$

For subcritical (unchoked) flow, the discharge capacity (Q_m) is calculated by:

$$Q_m = 16.05 * C_v * \sqrt{\frac{(P_i^2 - P_o^2)}{S_g * T}}$$

Both equations can be easily rearranged to solve for C$_v$ when provided pressures and flow.

Explanation of Variables:

$Q_m = Discharge\ Capacity\ (SCFM)$

$P_i = Valve\ Inlet\ Pressure\ (PSIA)$

$P_o = Valve\ Outlet\ Pressure\ (PSIA)$

$S_g = Specific\ Gravity\ of\ Gas$

$C_v = Flow\ Coefficient$

$T = Inlet\ Gas\ Temperature\ (°R)$

Note: Constants within equations are for solving with units given above.