

Liquid sizing

$$C_v \text{ (US units)} \quad C_v = Q \text{ (US gpm)} \times \sqrt{(SG \div \Delta P \text{ (psi)})}$$

$$K_v \text{ (metric)} \quad K_v = Q \text{ (m}^3/\text{h)} \times \sqrt{(SG \div \Delta P \text{ (bar)})}$$

$$\text{Conversion} \quad C_v = 1.156 \times K_v, K_v = 0.865 \times C_v$$

$$\text{Flow from } C_v \quad Q = C_v \times \sqrt{(\Delta P \div SG)}$$

Choked flow (IEC 60534)

$$\text{Maximum useful } \Delta P \quad \Delta P_{\max} = F_L^2 \times (P_1 - F_F \times P_v)$$

$$F_F \quad 0.96 - 0.28 \times \sqrt{(P_v \div P_c)}$$

$$\text{Cavitation index} \quad \sigma = (P_1 - P_v) \div (P_1 - P_2)$$

Flow does not increase once ΔP exceeds $\Delta P_{\max}$; expect cavitation or flashing.

Inherent characteristics

Type	Behaviour	Typical use
Linear	Flow $\propto$ travel	Level, constant ΔP
Equal %	Each step of travel changes flow by the same %	Pressure, flow, varying ΔP
Quick opening	Most flow in first travel	On/off, relief

Sizing rules of thumb

- Maximum flow at about 70 to 85 % open; minimum flow above about 10 %
- Valve authority: valve ΔP at least 25 to 50 % of system ΔP
- Body often one size smaller than the line; include reducer losses in sizing
- Check noise (85 dBA at 1 m is a common limit), cavitation and outlet velocity

Seat leakage (ANSI/FCI 70-2)

Class	Maximum leakage
II	0.5 % of rated capacity
III	0.1 % of rated capacity
IV	0.01 % of rated capacity
V	5×10^{-12} m ³ /s water per mm port diameter per bar ΔP
VI	Bubbles per minute by size, for example 1 at 1", 3 at 2", 11 at 4"

Fail action terms

Term	Meaning
ATO	Air to open = fail close (FC)
ATC	Air to close = fail open (FO)
FL / FAI	Fail last position / as is
Direct acting positioner	Increasing signal increases output pressure

Rangeability

$$\text{Definition} \quad R = C_{v_{\max, \text{controllable}}} \div C_{v_{\min, \text{controllable}}}$$

Typical **Globe 30:1 to 50:1, ball (V port) 100:1 or more**

Common problems

Symptom	Check
Hunting	Oversized valve, tight packing, tuning
Cannot reach set point	Undersized valve, low supply air
Noise, vibration	Cavitation or high gas velocity
Seat leakage	Damaged trim, wrong bench set