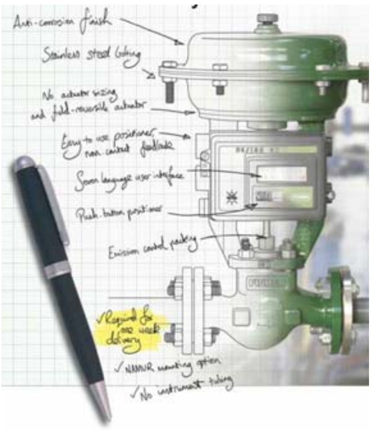
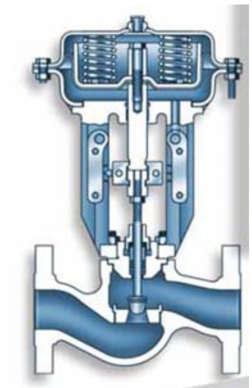
Control Valve

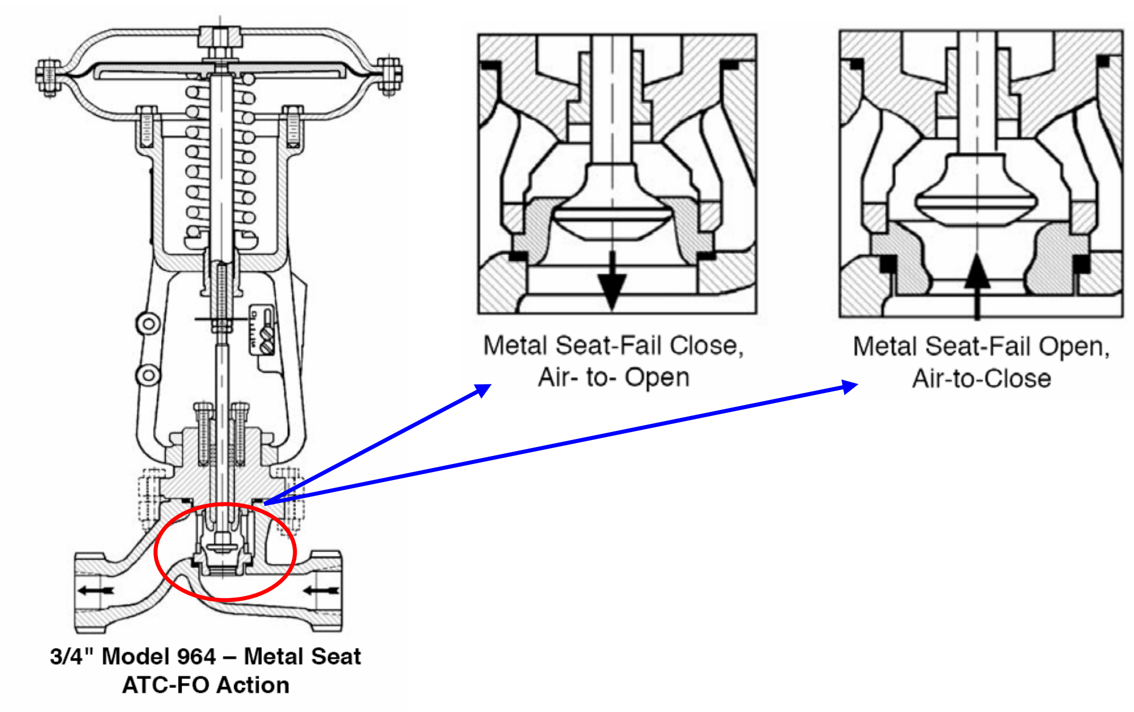
A mechanical-pneumatic device to regulate flow of liquid or gases (but not solid).





Selection of control valve

a) **Action** - Construction determine type of action. Two types. Air-to-open (ATO) or Fail closed (FC). Use to prevent flow when no pneumatic air supply. This action may prevent hazardous chemical or flammable fluid from endangering lives. Air-to-closed (ATC) or Fail open (FO). Use to allow flow of fluid during loss of pneumatic air supply. This action may save overheating of temperature related processes such as catalyst heating or heating of polimerization process.



b) **Size**. Significantly affecting the flowrate.The flowrate through a control valve depends on the size of the valve, the pressure drop across the valve, the stem position, and the fluid properties as shown in the following equation (nonflashing liquid):

$$Flowrate = C_v \; f(x)\sqrt{\frac{\Delta P_v}{sp.gr.}}$$

c) **Characteristics –** Shape of plug and seat determines flow's characteristic through the valve. Linear – Flowrate changes linearly with stem travel.

$$f(x) = x$$

Equal percentage – Flowrate changes proportionally based on equation below

$$f(x) = \alpha^{x-1}$$

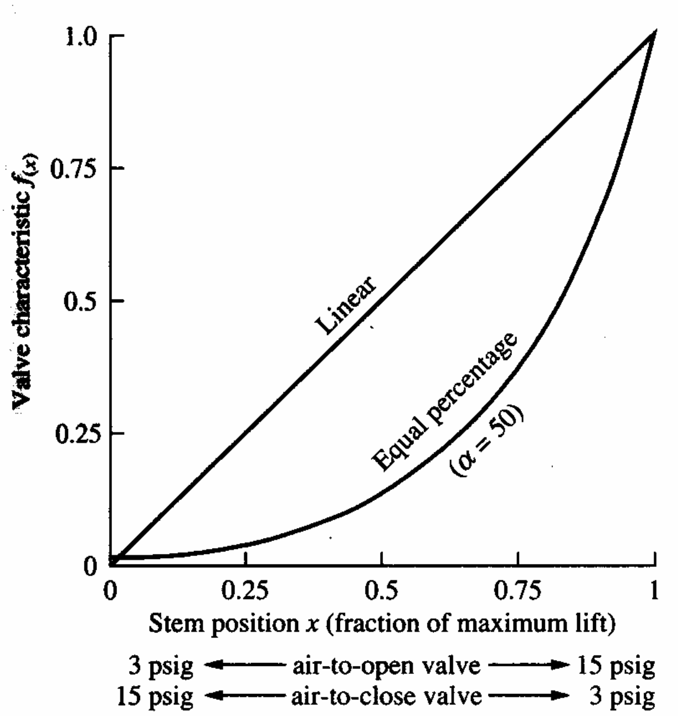


Figure 1: Control valve characteristics

Calculation and selection of control valve for a given set of process condition.

Sizing is based on

$$Flowrate, gpm = C_v \sqrt{\frac{\Delta P}{S.G.}} \quad , \; where\, \Delta P\, is\, in\, psi$$

(Note: Always Refer to control valve manufacturer for sizing equation. C_v depends on units of flowrate and ΔP).

Example

Select an equal percentage control valve for the following condition.

Flow condition	Flowrate, gpm	Pressure drop, psi	Valve lift, %
Maximum	120	10	80
Normal	42	15	50
Minimum	13	20	20

Calculation procedure

1 Calculate Cv at each condition.
2 Get a control valve's characteristic table.
3 Look in the table at lift = 80%, 50% and 20% for values that closer to calculated values.
4 Obtain the Cv's values at each valve's lift and the control valve's size.
5 Check for valve rangeability whether the selected valve is suitable to use.

Valve rangeability is given by

$$R_{installed} = \frac{Q_{\max}}{Q_{\min}}\sqrt{\frac{\Delta P_{\min rate}}{\Delta P_{\max rate}}}$$

$$R_{shelf} = \frac{C_{v,\ \max}}{C_{v,\ \min}}$$

Flow condition	Flowrate, gpm	Pressure drop, psi	Valve lift, %	❶ C_V calculated	❹ C_V actual
Maximum	120	10	80	37.9	37.3
Normal	42	15	50	10.8	10.8
Maximum	13	20	20	2.9	2.93

- (2) Get a control valve's characteristic table.
- (3) Look in the table at lift = 80%, 50% and 20% for values that closer to calculated values. → Found at size = 2"
- (4) Compare with actual C_v.

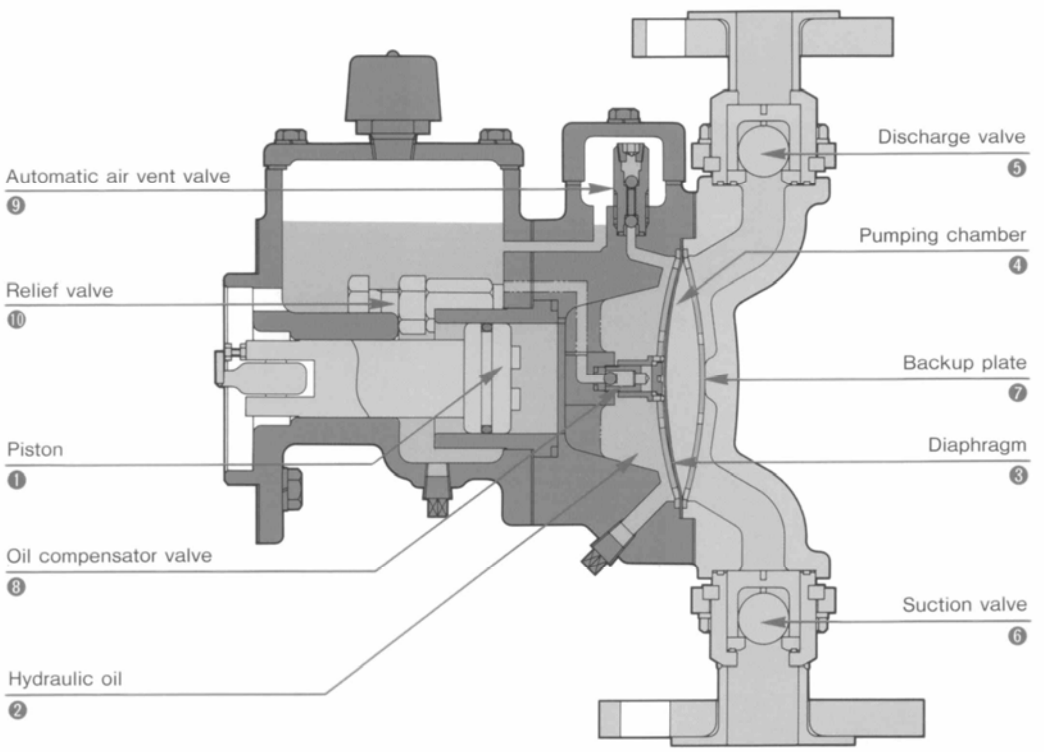
❺ Check for valve rangeability

$$R_{installed} = \frac{Q_{max}}{Q_{min}}\sqrt{\frac{\Delta P_{min\ rate}}{\Delta P_{max\ rate}}} = 13.0$$

$$R_{shelf} = \frac{C_{v,\ max}}{C_{v,\ min}} = \frac{37.9}{2.9} = 13.06$$

Small difference. Selection 2" okay to use.

Metering Pump



Hydraulic diaphragm-type metering pump

Working principle

When piston ❶ advances, it moves diaphragm ❸ through hydraulic oil ❷ and pushes out the process liquid in pumping chamber ❹, which in turn opens discharge valve ❺ and is discharged through the valve (discharge stroke).
Conversely, when the piston retracts, the diaphragm is sucked back, and liquid opens suction valve ❻ to enter the pump chamber (suction stroke). As a result, the diaphragm serves only as a membrane to separate hydraulic oil from liquid and suffers no stress concentration.
Additionally, the diaphragm is protected by backup plate ❼.