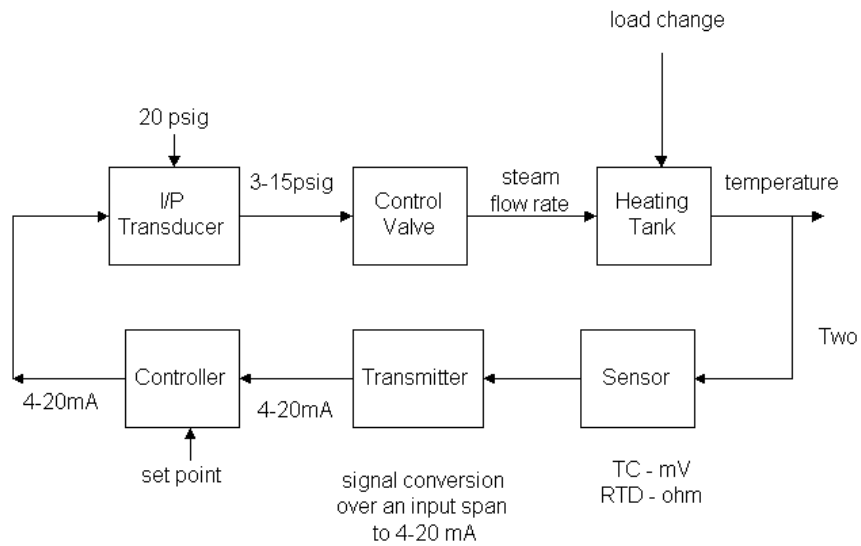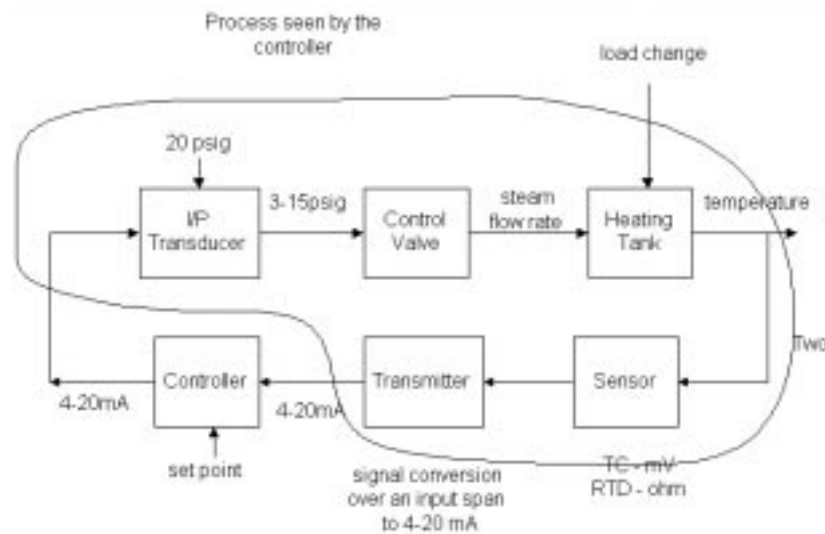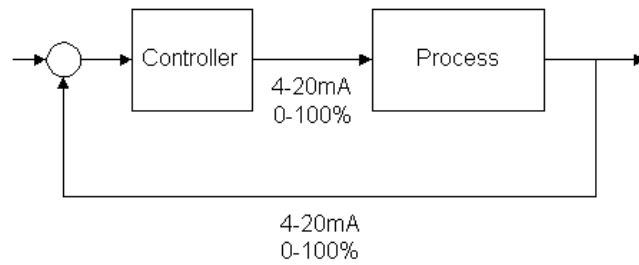# 1.3 ELEMENTS OF A FEEDBACK SYSTEM

Process seen by the Controller

Transmitter

- Conditioning the sensor signal

  - Ohm, mv, mA $\cdots$ to voltage

  - linearization

  - conversion of the voltage signal to 4-20 mA(0-100 %) standard signal.

- To transmit a signal over a long distance while minimizing corruption with electro-magnetic noise, the signal needs to be converted into a current form.

- 4 mA(0%) bias is for detection of a sensor failure.

I/P (Current to Pneumatic Pressure) Transducer

- Linearly convert 4-20 mA to 3-15 psig(0.2-1.0 Kgf/cm2) air pressure

- A separate device or embedded in a valve positioner.

Control Valve

- Mostly pneumatic for safety reason

- Composed of an actuator and a valve body

- Actuator

  - ATO(air to open) and ATC types. Sometimes called NC(normally close)/NO or FC(fail close)/FO

  - Selection is based on what the fail-safe position is.

  - Depending the actuator type, sign of the process gain is reversed.
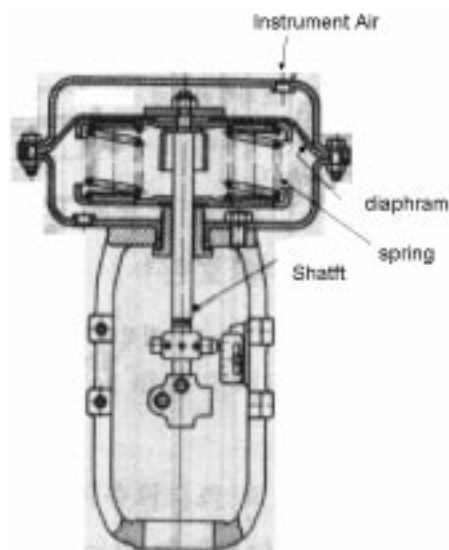
Mult-Spring Type Air-To-Close Actuator


Air-to-Close Type   Air-to-Open Type
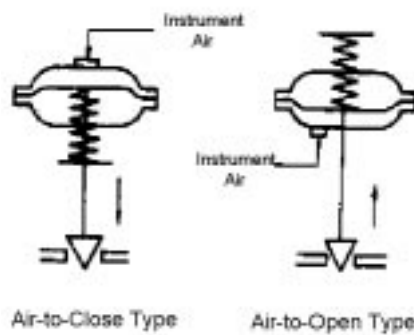
- Valve Body

  - According to intrinsic flow characteristics (Linear/Equal Percentage), leakage(single seated/double seated), critical flow characteristics, noise, etc, many different types of valves are designed.
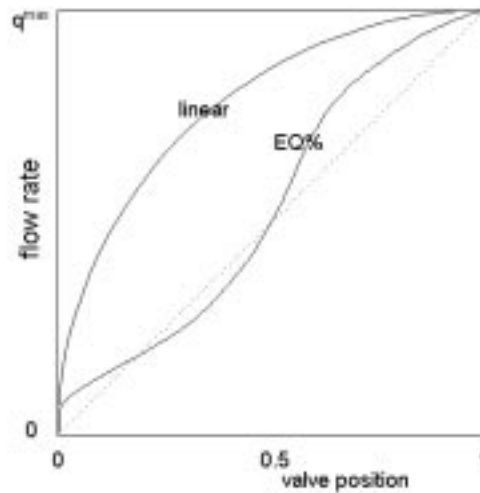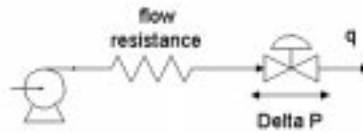 - Flow characteristics

$$q(\text{gal/min}) = C_v \times f(vp) \times \sqrt{\frac{\Delta P_v(\text{psig})}{\text{sp.gr}}}$$

$$f(vp) = \begin{cases} vp & \Rightarrow \text{ linear} \\ \sqrt{vp} & \Rightarrow \text{ quick opening} \\ R^{vp-1} & \Rightarrow \text{ equal percentage} \end{cases}$$

Intrinsic flow characteristic
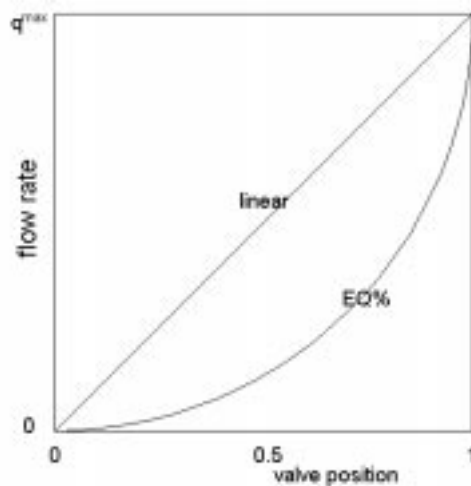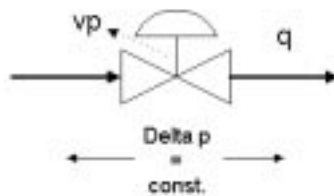
Installed flow characteristic

As q increases, Δp decreases.

A properly sized EQ-valve can show approximately linearized flow characteristics.

– Valve Size: $C_v = $ [gallon water]/[min][psig]

Choose it to cover the needed flow range (with some additional room). A larger valve covers a larger range and reduces pumping cost, but tends to be more nonlinear and sensitive to pressure drop changes.

Controller

- Appearance
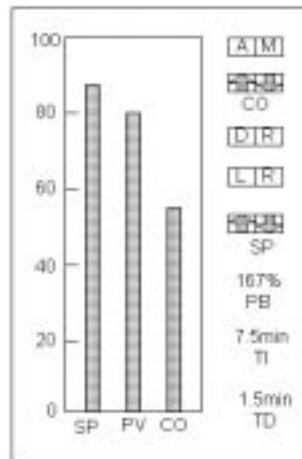
- A/M : Auto/Manual mode selection for CO adjustment

- D/R : Direct/Reverse mode selection
  Direct (Reverse) - CO increases(decreases) when PV increases. Negative (Positive) gain control.
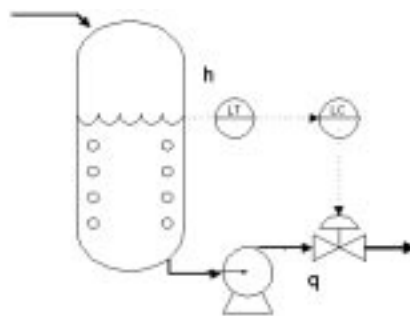
ATO valve, select DIRECT.
ATC valve, select REVERSE.

- L/R : Local SP/Remote SP selection

- PB, TI, TD : PID parameters

- In computer control, engineering units can be used for SP and PV instead of 0-100%.