E-training

"Welcome to the
K Controls e-training course designed to deliver useful "Pneumatic Valve Actuation" application information in small instalments."

To unsubscribe or to register a colleague to receive these documents Click here

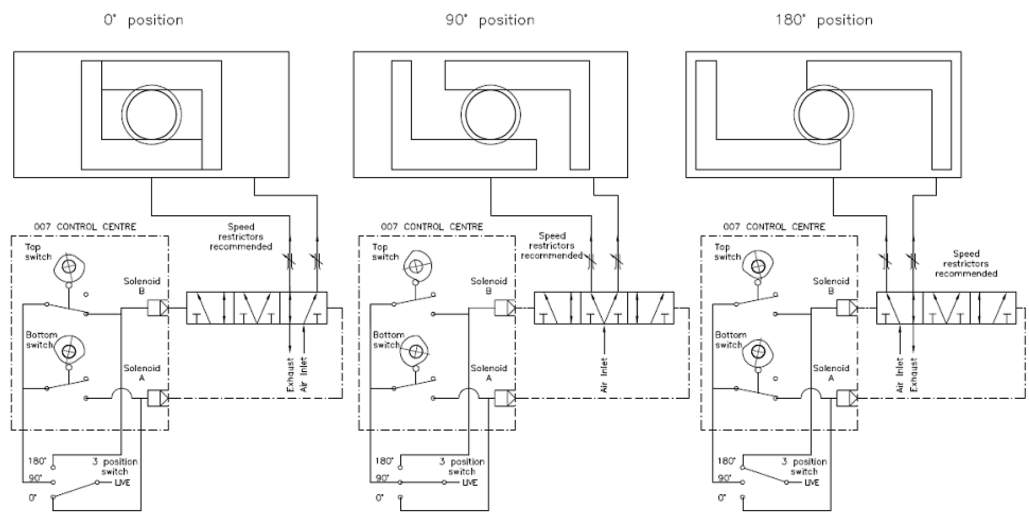
Positioners (Pneumatic, Electro pneumatic, I to P converters)

Pneumatically actuated valves can be positioned in a number of ways.

System 1) On /off actuated valve that operates through the full lift or rotation controlled by solenoid valve(s). This subject has been covered in the e-training document "Solenoid control of pneumatic actuators"

System 2) On /off actuated valve controlled as system 1 but lift or rotation can be restricted at one or both ends of travel via the use of adjustable mechanical stops in the actuator.

System 3) Three position control. This moves an actuated valve to one of three discrete positions. The most common applications are three-way valves operated by actuators that move through 180 degrees or valves that are being used to fill tanks. With three-way valves the actuator is required to stop at the 0, 90 and 180 degree positions. With the tank filling application the valve is required to move to a position near to closed for the final stages of filling. Three position control systems use solenoids, switches and speed controllers to move the actuators to each position in response to discrete signals to the solenoids. The diagram below shows a double acting system for 0, 90 and 180 degree control.



System 4) Three position control with fine adjustment available at the ends of travel. The mechanical stops used in System 2 can be combined with System 3 if fine adjustment of the open and or closed positions is required.

System 5) Modulating valve using spring return diaphragm actuator, **controlled directly via a pneumatic signal** (e.g. 0.2 to 1 bar, 3-15 psi). As this system relies on a low pressure signal and a spring in the actuator for operation, the line pressures that the valve can handle are limited. In addition differential pressures acting on the valve plug are referred to the actuator such that at say, 0.6 bar (9 psi), the valve ends up being more 50% open.

E-training

K Controls designs and manufactures valve networking monitoring and control products:

Switchboxes
Control Monitors
Position Transmitters
Corrosion resistant
ATEX certified – gas + dust
High and low temperatures
IP68 for submersion
Low powered solenoids
Remote I/O compatible
AS-interface®
DeviceNet™
PROFIBUS® PA
FOUNDATION™ FIELDBUS
4-20mA + HART®
Wireless solutions
Linear or rotary adaptation

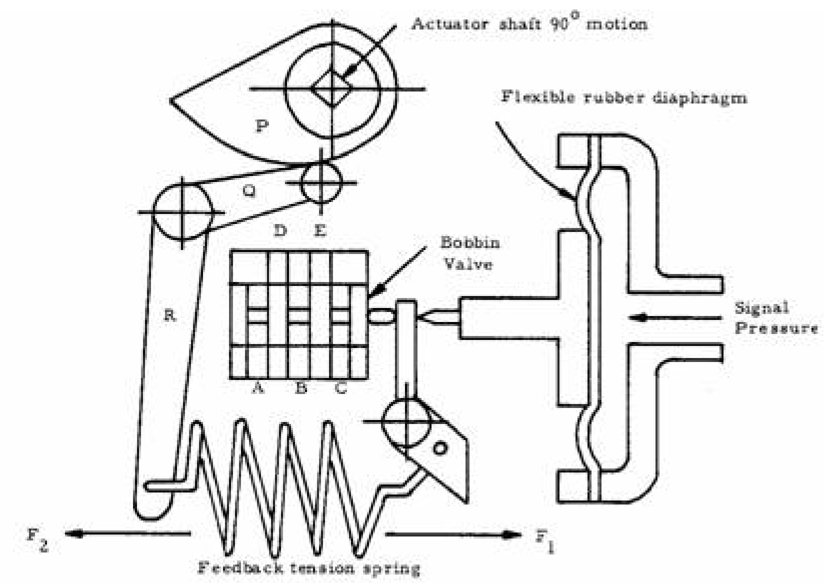
K Controls can also supply your positioner requirements

As valve stem position is not being compared with the incoming signal, positional accuracy will also be affected by friction and wear that may develop in the valve or actuator over time. Most of these problems can be overcome by fitting a positioner.

When a valve positioner is fitted for a given signal the valve will always attempt to maintain the same position regardless of changes in line pressure, friction or wear. A positioner will also allow higher pressures through to the actuator increasing both speed of operation and the pressures the valve can handle.

System 6) Modulating valve using diaphragm or piston actuator fitted with a **pneumatic positioner** receiving a pneumatic signal (e.g. 0.2 to 1 bar, 3-15 psi) usually from an "I to P" (current to pneumatic) converter.

A **pneumatic positioner** uses a "force balance" mechanism to compare an instrument signal with valve stem or shaft position. When the control signal differs from the actuator's position, the positioner supplies or vents air from the actuator until the desired position is reached. The positioner supplies air to the actuator at a higher pressure than that available from the instrument signal.



The diagram above attempts to explain how the "force balance" principle functions in a pneumatic positioner.

1) Signal air pressure (typically between 0.2 to 1 bar, 3 and 15 psi) is applied to the diaphragm, the valve in the positioner is moved to the left and the spring is tensioned F_1.

2) Supply air (typically at 5.5 bar g, 80 psi) is allowed to pass from port B to port D and enters the actuator. At the same time air is exhausted via ports E and C.

E-training

K Controls designs and manufactures valve networking monitoring and control products:

Switchboxes
Control Monitors
Position Transmitters
Corrosion resistant
ATEX certified – gas + dust
High and low temperatures
IP68 for submersion
Low powered solenoids
Remote I/O compatible
AS-interface®
DeviceNet™
PROFIBUS® PA
FOUNDATION™ FIELDBUS
4-20mA + HART®
Wireless solutions
Linear or rotary adaptation

K Controls can also supply your positioner requirements

3) This will cause the actuator and cam P to rotate anti-clockwise and the movement is transferred via levers Q and R to the spring that is tensioned in the opposite direction, F_2.

4) When the forces F_1 and F_2 are in balance the valve will return to the neutral position, air will no longer enter or exhaust from the actuator and movement will cease.

5) If the signal pressure is then reduced, F_2 will exceed F_1 and the valve will move to the right. Supply air will then pass via ports B and E into the actuator. At the same time air is exhausted via ports D and A.

6) This will cause the actuator and cam P to rotate clockwise and the movement is transferred via levers Q and R to the spring that is relaxed such that force F_2 is reduced until it balances F_1. Once again the valve will return to the neutral position, air will no longer enter or exhaust from the actuator and movement will cease.

The profile of the cam P can be changed to alter the characteristic of the valve.
E.g. **“Linear”** where a given percentage change in signal results in the same percentage change in valve movement or **“Equal Percentage”** where a given change in valve position results in the same percentage change to the resultant flow. A number of valves exhibit an equal percentage characteristic as a result of their design. The characteristic of a standard ball valve approximates to equal percentage so in this case it would be appropriate to select a positioner with a linear characteristic.

A **direct acting** positioner increases the output signal as the input signal increases.
A **reverse acting** positioner decreases the output signal as the input signal increases.
Some positioners allow the action to be changed in the field.

Spilt ranges can be used. For example: In order to use two valves installed in parallel in a control system the smaller valve will close at 3psi and be fully open at 9 psi. The larger valve will be closed at 9 psi but fully open at 15psi.

The performance of a positioner is sometimes defined as shown in the following example:

Sensitivity: 0.5% @ 4-20mA, 90° range
Linearity: <1.0%
Hysteresis <0.5%
Repeatability <0.5%

Sensitivity: This defines the reaction of the device to a change of signal. In this case a very small change in signal would result in a movement no greater than 0.45 degrees.

Linearity: As the signal is increased, the trace of changing valve position should be a straight line.In this case the plot of actual position deviates from the straight line by no more than plus or minus 1%.

E-training

K Controls designs and manufactures valve networking monitoring and control products:

Switchboxes
Control Monitors
Position Transmitters
Corrosion resistant
ATEX certified – gas + dust
High and low temperatures
IP68 for submersion
Low powered solenoids
Remote I/O compatible
AS-interface®
DeviceNet™
PROFIBUS® PA
FOUNDATION™ FIELDBUS
4-20mA + HART®
Wireless solutions
Linear or rotary adaptation

K Controls can also supply your positioner requirements

Hysteresis: This is the maximum difference in valve position for a given input signal during a full range of movement in each direction. In this case it is less than 0.5% of full travel.

Repeatability: If the same signal is selected on two consecutive occasions this is the difference between the two positions that are reached. In this it is case less than 0.5% of full travel.

Deadband: The range through which a signal can be varied without initiating an observable response.

As most control loops are now electronic, the 0.2 to 1 bar, 3-15 psi signal usually comes via an **"I to P" converter** (also known as a Current to Pneumatic or Electro-Pneumatic converter) which accepts either a 4–20 mA or 0-10 v DC signal.

The pneumatic control signal from the "I to P" converter is either fed directly into the actuator (see system 5 above) or to the pneumatic ("P to P") positioner (see system 6 above).

An "I to P" converter usually operates via a force balance principle. A coil is suspended in a magnetic field and mounted using a technique that will reduce the effects of vibration. At the lower end of the coil is a flapper valve that operates against a nozzle to create a back pressure on the servo diaphragm of a booster relay. When input current flows in the coil it produces a force between the coil and the flapper valve, which controls the servo pressure and the output pressure.

System 7) Modulating valve using diaphragm or piston actuator fitted with an **electro-pneumatic positioner** receiving an electronic signal (e.g. 4-20mA) directly from the control system. An electro-pneumatic positioner combines the functions of an "I to P" converter and a "P to P" positioner.

Some electro-pneumatic positioners simply mechanically combine a "P to P" positioner with an "I to P" converter. Others eliminate the mechanical "force balance" equipment described in system 6 above and replace it with electronic components.

Valve position is monitored via a precision potentiometer of alternatively by a non-contact optical transducer. These devices produce an electronic signal proportional to valve position that can be compared with the incoming control signal. The electronic circuitry that does this will then send a signal to a pneumatic system that is sometimes similar to that is found in an "I to P" converter.

The device that regulates the flow of air to and from the actuator will usually be driven by a coil, low powered solenoid or piezo valves that will use the limited power available directly from the control signal.

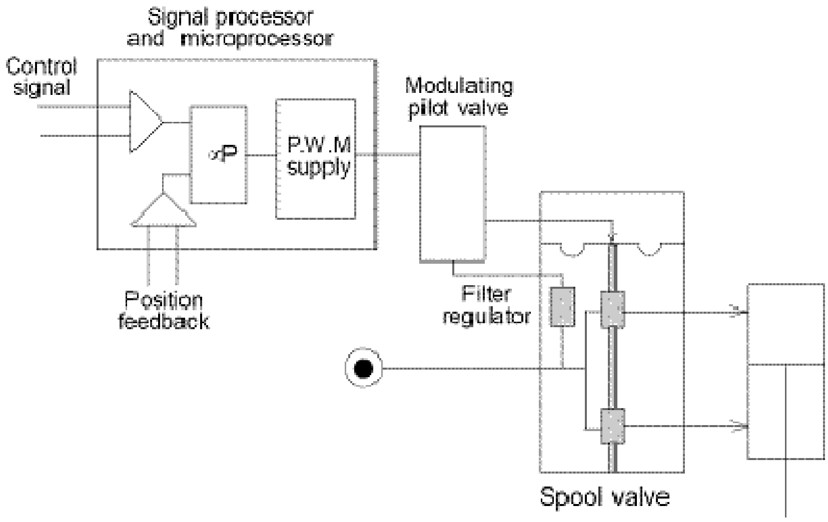
E-training

K Controls designs and manufactures valve networking monitoring and control products:

Switchboxes
Control Monitors
Position Transmitters
Corrosion resistant
ATEX certified – gas + dust
High and low temperatures
IP68 for submersion
Low powered solenoids
Remote I/O compatible
AS-interface®
DeviceNet™
PROFIBUS® PA
FOUNDATION™ FIELDBUS
4-20mA + HART®
Wireless solutions
Linear or rotary adaptation

K Controls can also supply your positioner requirements

(The abbreviations in the diagram of a typical unit below stand for "microprocessor" and "pulse width modulated power supply")



System 8) Modulating valve using diaphragm or piston actuator fitted with a **"smart" electro-pneumatic positioner** receiving an electronic signal (e.g. 4-20mA) directly from the controller. For the purposes of this document we define a "smart" electro-pneumatic positioner as an electro-pneumatic positioner with micro-processor that has a self-calibration capability and an ability to adjust on board pre-programmed control algorithms in service in order to optimise control. The algorithm selected will be a function of actuator size and the performance of the valve, actuator or positioner during initial auto-calibration. Should the performance of the valve, actuator or positioner alter in service the algorithm can be manually or automatically adjusted to optimise control. The positioner can only communicate with the control room using a conventional 4-20mA signal.

System 9) Modulating valve using diaphragm or piston actuator fitted with an **"intelligent" electro-pneumatic positioner** receiving an electronic signal (e.g. 4-20mA + HART® or Fieldbus) directly from the controller. For the purposes of this document we define an "intelligent" electro-pneumatic positioner as a "smart" electro-pneumatic positioner that can be remotely calibrated and interrogated via a HART®, PROFIBUS® or FOUNDATION™ fieldbus link. This can very useful if the positioner is located in a hazardous or inaccessible location.

System 10) Modulating valve using diaphragm or piston actuator fitted with a **"Digital Valve Controller (DVC)"** receiving an electronic signal via a HART®, PROFIBUS® or FOUNDATION™ fieldbus link with the controller. For the purposes of this document we define a Digital Valve Controller as an "intelligent" electro-pneumatic positioner with one or more additional functions.

E-training

K Controls designs and manufactures valve networking monitoring and control products:

Switchboxes
Control Monitors
Position Transmitters
Corrosion resistant
ATEX certified – gas + dust
High and low temperatures
IP68 for submersion
Low powered solenoids
Remote I/O compatible
AS-interface®
DeviceNet™
PROFIBUS® PA
FOUNDATION™ FIELDBUS
4-20mA + HART®
Wireless solutions
Linear or rotary adaptation

K Controls can also supply your positioner requirements

If you have any questions or comments, would like a colleague to receive this information or you would like the latest list of training documents, please use the contact details below:

K Controls Ltd
2 Crown Way
Crown Business Centre
Horton Road
West Drayton UB7 8HZ
United Kingdom

Phone:
+44 (0)1895 449601

Fax:
+44 (0)207 990 8111

E-mail:
sales@k-controls.co.uk

Web:
www.k-controls.co.uk

Blog:
www.k-controls.info

Visit us:
View a map

These functions could be valve condition reporting (usually more sophisticated if the valve and DVC are supplied by the same manufacturer), partial stroke testing for ESD valves, signal characterisation and field control. Information reported can include cumulative valve travel and valve cycles, equipment failure alarms, DVC or process shutdowns and initial and ongoing valve position signature tests. The position signature test usually involves measuring valve hysteresis, deadband, repeatability and linearity through the opening and closing cycles. Some Digital Valve Controllers can take measurements of actuator pressure. When the valve is new a test plots signal versus position and also compares this data to pressures within the actuator. This test can then be repeated during the life of the valve to identify problems such as pneumatic leaks, excessive stem friction, loose linkages and faulty actuator springs or spool valves. HART®, PROFIBUS® or FOUNDATION™ fieldbus can carry the higher volumes of information required for sophisticated condition monitoring. FOUNDATION™ fieldbus Digital Valve Controllers can also be specified with control block functionality so that control of the local loop takes place at the valve itself or with a signal characterisation function block which can change the valve characteristic without having to change the valve trim.

(Please note that vendors definitions could differ from those detailed above.
A product described as “intelligent” or “smart” could have some or all of the functionality detailed in systems 8, 9 and 10. It is important therefore, to review the specification in detail).