Tech Sheet #CVR 407

Selection Considerations for Control Valves vs. Regulators

In any control system, the option potentially exists to select either a control valve or a regulator and it is useful to compare the respective performance and economics of these approaches to arrive at some general selection guidelines.

Unlike regulators, control valves are not standalone products. A control valve is the final control element in a control system and needs to be evaluated in that context. A control valve is most frequently used in the control of the following parameters:

- Temperature
- Pressure
- Flow
- Level

However, in principle, any continuously varying system parameter that can be measured and compared to a set point can be controlled. Also, it is necessary to keep in mind, irrespective of the parameter being controlled (the controlled variable), that the control valve itself can only change the flow rate. Regardless of the control parameter (e.g. temperature, pressure, etc.) all control is to a specific measurable quantity, which is set point, and the control system can be diagrammatically illustrated in Figure 1.

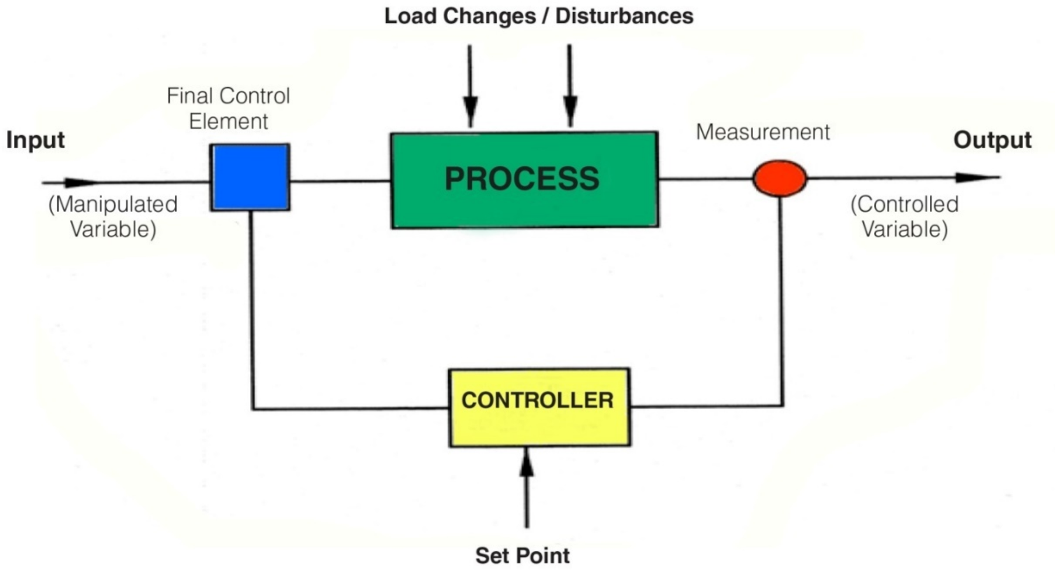

Figure 1

This Tech Sheet was developed by the members of the Fluid Controls Institute (FCI) Control Valve/Regulator/Solenoid Valve Section. FCI is a trade association comprising the leading manufacturers of fluid control and conditioning equipment. FCI Tech Sheets are information tools and should not be used as substitutes for instructions from individual manufacturers. Always consult with individual manufacturers for specific instructions regarding their equipment.

The essential feature of the controller (whether acting as a single loop controller or as a component within a PLC or within a DCS or Fieldbus device) is the incorporation of proportional and integral control modes capable of returning the measured variable to the set point following load changes or system disturbances. Control is generally within 5%, but often within 1% to 2%.

Rising stem control valves are typically globe valves commonly used up to the 2-inch connection size. However, globe valves can extend to at least 24 inches in connection size with special trims and cages for severe service and high noise applications.

For economic reasons, rotary control valves are generally applied as line sizes increase above two inches and a variety of ball valves, eccentric plug and segmented ball valves and butterfly valves exist in this segment of the market. The segmented ball valve is used in many applications and the largest size rotary control valves such as butterfly valves can extend to 72 inches in diameter.

Globe style valves offer advantages in that the plug and/or cage can be more readily characterized to optimize the installed flow characteristic. Most rotary valves have an inherent flow coefficient characteristic that increases exponentially with the increase in travel.

Figure 2

Figure 2 shows a typical globe style control valve. Although a range of actuators can be used, pneumatic actuators predominate and the diaphragm actuator is generally the style of choice due to minimized resistance and hysteresis[1] for small changes in travel associated with control to within 1% to 2%. See Figure 3. For improved control and minimized dead band,[2] positioners are generally specified. It is also common practice for the electric to pneumatic conversion to occur at the positioner. There is also a continuing increase in the use of intelligent or smart positioners thereby providing automatic commissioning, higher accuracy, tight shut off, customizable characteristics and diagnostic capabilities. Electric actuators provide some unique advantages and this is presented below.

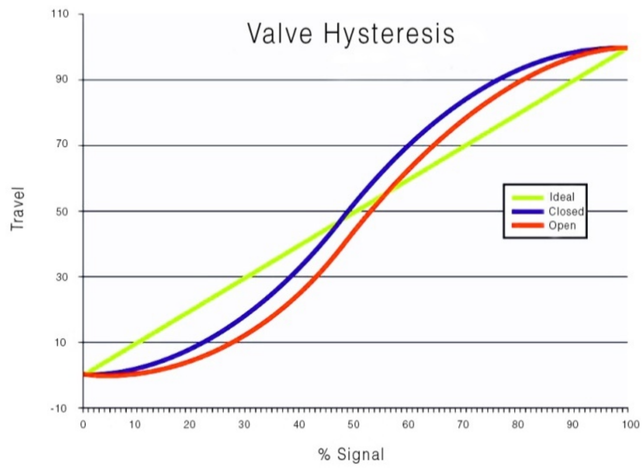

Figure 3

There are obvious economic considerations associated with the choice of a control valve, and as a minimum, require the incorporation of sensors and transmitters, controllers, positioners, instrument valves, tubing, wiring, calibration, tuning etc.

Additional costs will be associated with limit switches, position indicator/feedback, air sets, instrument valves, tubing, wiring, installation, calibration & tuning and may or may not factor directly into the selection decision. Beyond installation costs, all of this equipment must be maintained. Total installed costs for a control loop can be significant when compared to a self-operated regulator.

[1] Hysteresis - The maximum difference between increasing and decreasing output values for any single input during a calibration / operational cycle, excluding errors due to dead band
[2] Dead Band – The range through which an input can be varied without a measureable change in output.

Electrical Actuators

Some control valve applications can benefit from electrical actuators. For example, it is not uncommon for remote installations to rely upon natural gas to operate the pneumatic actuators which results in venting of product to atmosphere (waste and environmental considerations).

In recent years, there have been significant improvements in the reliability, technology, and applicability of electric actuators. Low power consumption permits use of batteries and/or solar for power. Fail safe operation can be obtained using capacitor storage. Normal operating/ positioning speed can be adjusted. In addition, recent electric actuator designs offer simplified set-up and commissioning with a variety of networking communication protocols.

The advantages of selecting a control valve is summarized as follows:

- Control within 5% and potentially within 1% to 2% for critical systems
- Availability of a wide range of sizes and valve types
- Severe service capabilities
- Selectable failure mode
- The controlled and measured variables can be in different loops

The limitations associated with control valves are summarized as follows:

- Cost and complexity
- The requirement for auxiliary components

In practice, the results due to the difficulty in matching the control valve characteristic to the system, dynamic instabilities and incompatibilities, over-sizing and larger than anticipated dead bands due to friction or backlash within the control valve, have not always justified the expense of selecting a control valve.

More importantly, the issue of the required accuracy of control should be critically assessed as a regulator may offer acceptable accuracy and high reliability with considerable savings.

A regulator is a standalone self-acting proportional controller. The essential characteristic of a proportional controller is that the controlling action is proportional to the deviation from the set point. Depending on the gain or sensitivity of the regulator, this controlling action minimizes the error or deviation on load change or system disturbance, but does not eliminate the “error” or offset.

A typical pressure regulator with its proportional control action is shown in Figure 4.

The Regulator as a Control System

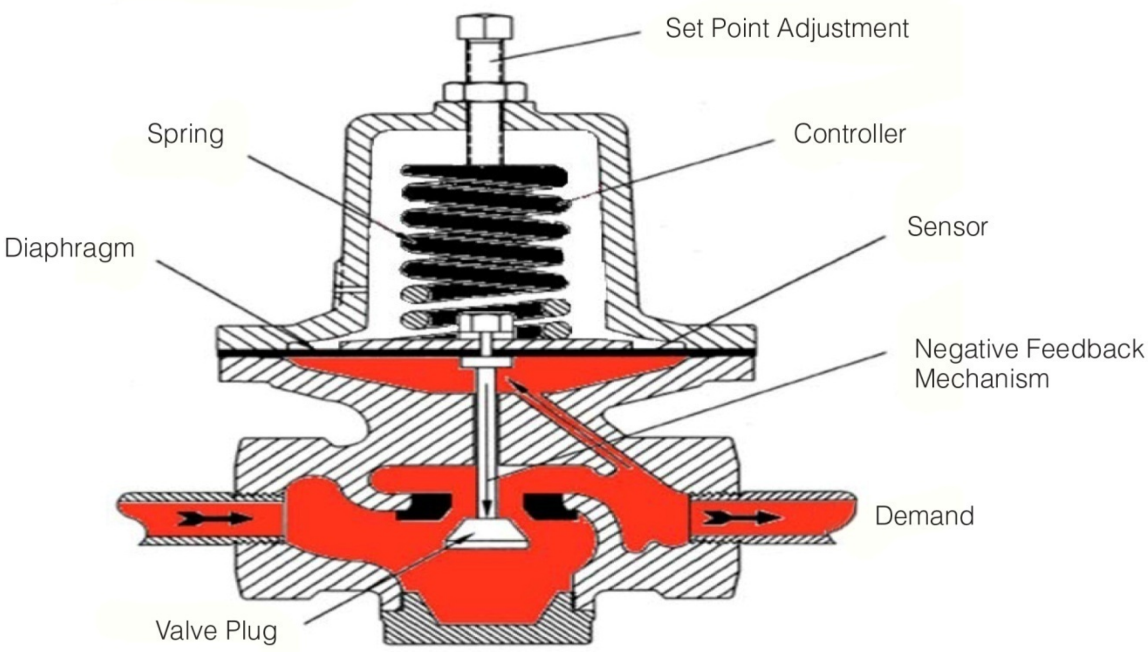

Figure 4

A Pressure Regulator is a Proportional Mode Controller

The principle characteristics of a regulator are proportional control and a rapid response in the order of milliseconds. Regulators are highly adaptable to a range of functional control modes including downstream pressure, backpressure, differential pressure, flow and temperature.

Regulator accuracy is expressed in terms of the offset (commonly referred to as "droop") as a function of flow. Flow rates for self-operated regulators are normally published at 10%, 20% or 30% droop or offset for various media such as steam, air and water. See Figure 5 and FCI Standard, FCI 99-2, Pressure Reducing Regulator Capacity for additional details.

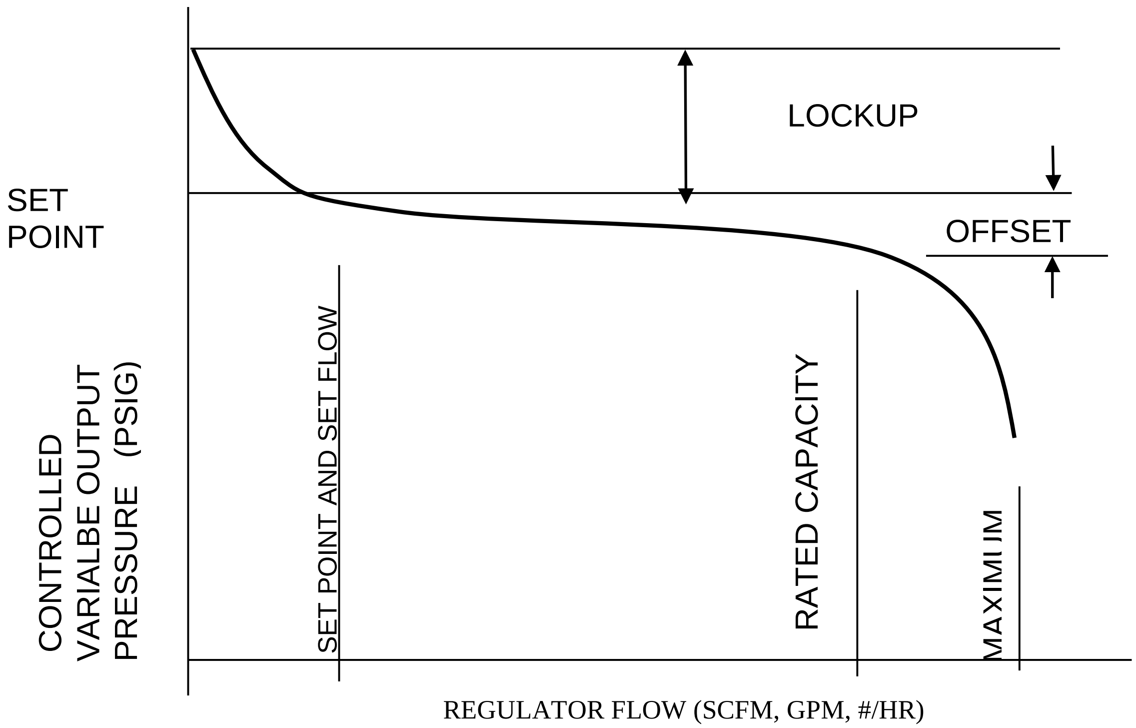

Figure 5

An effective method of increasing regulator accuracy involves using a pilot regulator to maintain a near constant pressure on the regulator diaphragm to improve the droop or offset performance to within 5% over the operating range.

Typical regulator applications can include any application requiring control within 1% to 30%. These applications include a myriad of "set and forget" functions:

- Pump bypass
- Steam heating and/or pressure control
- Gas cylinder pressure control
- Air sets
- Tank blanketing etc.
- Various backpressure relief functions

However, regulators also incorporate a unique capability to react within milliseconds and may offer superior control in fast systems such as liquid pressure control and in systems with positive feedback to disturbances such that rapid corrective action is required.

In addition, regulators may offer advantages in economic control in heating, drying and evaporator applications using saturated steam.

As shown in Figure 6, a conventional control valve controlling steam flow based on the measured outlet temperature of the heated process fluid would be a slow-acting system dependent on the process time of the fluid through the heat exchanger and the thermal capacitance of the system. Alternatively, changes in the steam pressure would not be sensed by the valve until recognized by a change in the outlet temperature of the process fluid. This system can be improved with increased expense by using cascade control and a second flow controller in the steam line. However, the use of a regulator can be a more effective, rapid and cost-effective option. Changes in steam inlet pressure are automatically accommodated and controlled by the regulator. If the flow rate or temperature of the process fluid changes, more or less heat will be absorbed from the steam, changing its pressure. This change in pressure will be directly sensed by the pressure regulator with a corresponding change in flow to compensate for the pressure change. Using a pilot operated regulator with an air supply to the pilot controlled by a temperature controller can further facilitate improved accuracy and control.

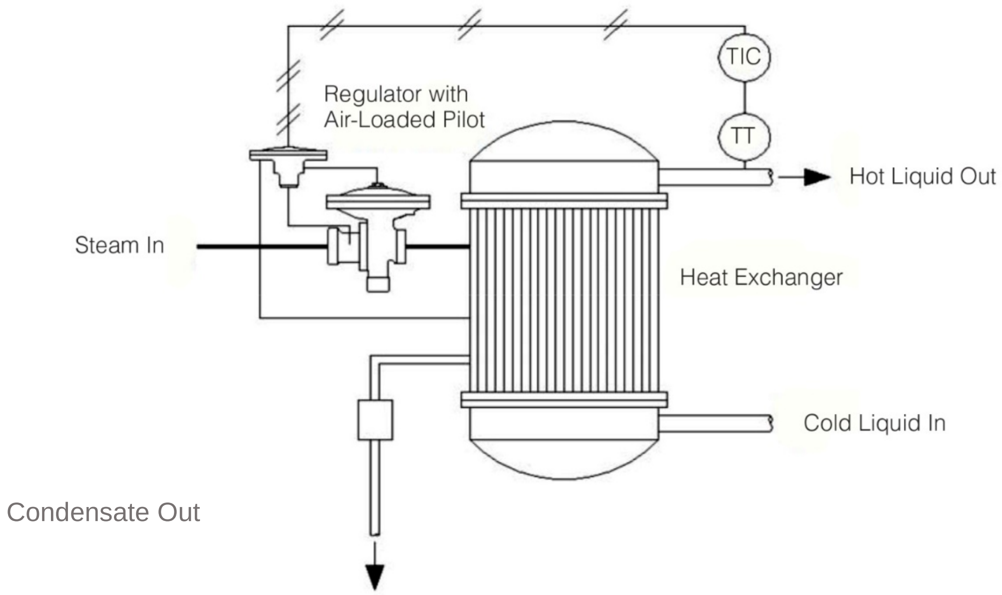

Figure 6

The basic advantages and features of a regulator are summarized as follows:

- Low Cost
- High reliability/ease of maintenance
- No requirement for auxiliary systems
- No stem sealing/low friction
- Fast acting with unique advantages in certain applications
- Concerns with potentially explosive environments are eliminated with a hermetically sealed, self-actuated regulator

The limitations associated with regulators are summarized as follows:

- Maximum available size is typically 6 inches
- Failure modes are fixed
- Regulators are generally not applicable for severe service

Summary

In making a choice, the essential questions that should be addressed are:

- What accuracy of control is required?
- What are the installation cost parameters?
- Is power/pneumatics available for actuation?
- Is rapid response a consideration?
- What line sizes and materials are required?
- Are noise and cavitation considerations?
- Is a predetermined failure mode required?
- Is the environment potentially hazardous or explosive?

General Considerations for Selection

Regulator	Control Valve
• Moderate accuracy – self-operated	• High accuracy
• High accuracy – pilot-operated	• External sensing required
• Lower cost	• Higher cost
• Self-powered	• Power/pneumatics for actuation required
• Rapid response	• Noise and cavitation control
• Most common under 4"	• More common over 4"
• Fixed failure mode	• Variable failure mode
	• Special precautions for hazardous or explosive locations

To view the current list of FCI members, visit the FCI website: fluidcontrolsinstitute.org.