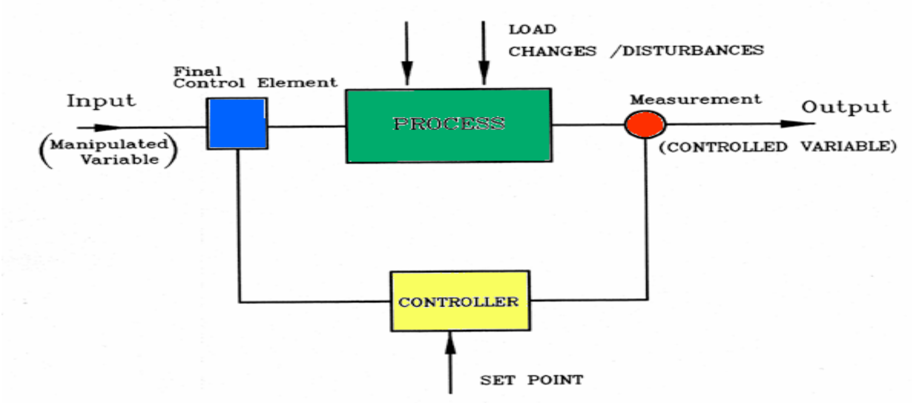
Selection Considerations for Control Valves versus Regulators

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.
All control is to a set point, and the control system can be diagrammatically illustrated as follows:

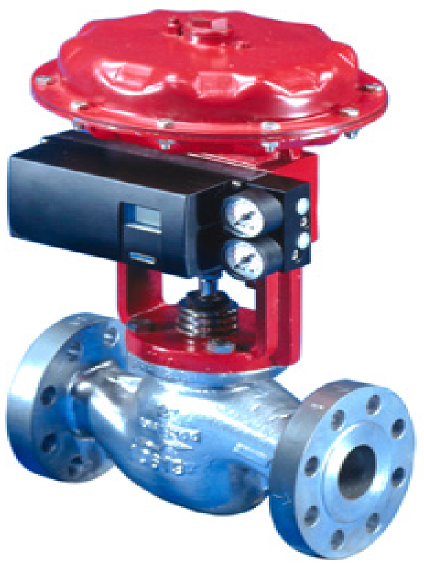


The essential feature of the controller (whether acting as a single loop controller or as a component within a PLC or within a DCS or Fieldbus device) is the incorporation of proportional and integral control modes capable of returning the measured variable to the set point following load changes or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

Rising stem control valves are typically globe valves commonly used to the 2 size. However, globe valves can extend to at least 24 inches in 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 2 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 approximately exponentially with the increase in travel.



The above figure shows a typical globe style control valve. Although a range of actuators can be used, pneumatic actuation predominates and the diaphragm actuator is generally the style of choice due to minimized resistance and hysteresis for small changes in travel associated with control to within 1 to 2 percent. For improved control and minimized deadband, positioners are generally specified. It is also common practice for the current 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.

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. Generalized cost estimates can only be considered representative, at best, and can vary significantly depending upon application, size, material, accuracy and commercial circumstances.

The following costs are considered to be illustrative of the potential difference between the installed costs of a control valve in a system and a standalone regulator.

<u>Transducers</u>	
Diff. Pressure	$1,400
Pressure	$1200
Low cost – non HART	$300

<u>Controllers</u>	
1 to 4 loops	$1,800 - $2,200
. Single loop PID	$700
DCS – computer card in component	$1,500
PLC- computer card	$500 - $1,000

<u>Final Control Element (2 ins size in carbon steel)</u>

Control Valve. w. Positioner vs. Regulator	+ $800
Control Valve. w. Positioner vs. Piloted Reg.	Approx even

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.

The advantages of selecting a Control Valve can therefore be summarized as:

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 can be summarized as:

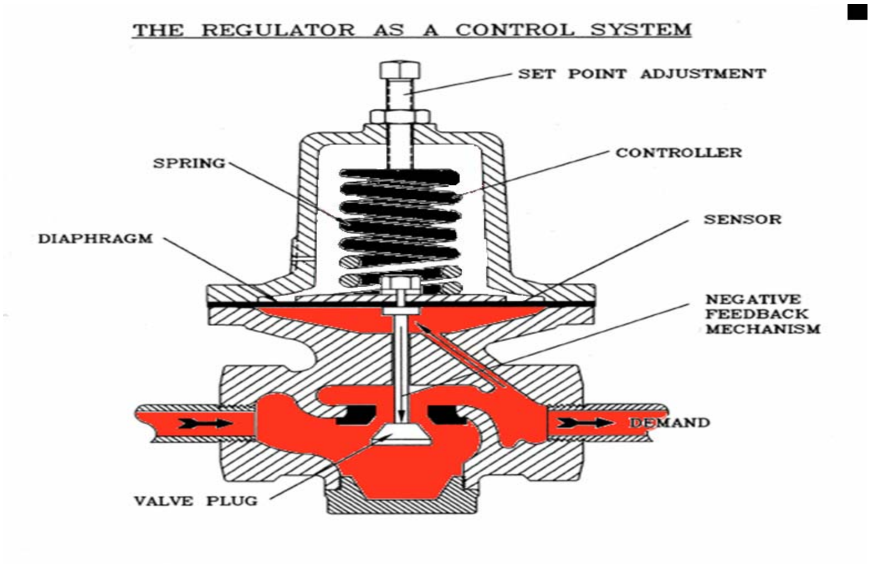
Cost and complexity
The requirement for auxiliary systems

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 deadbands 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.

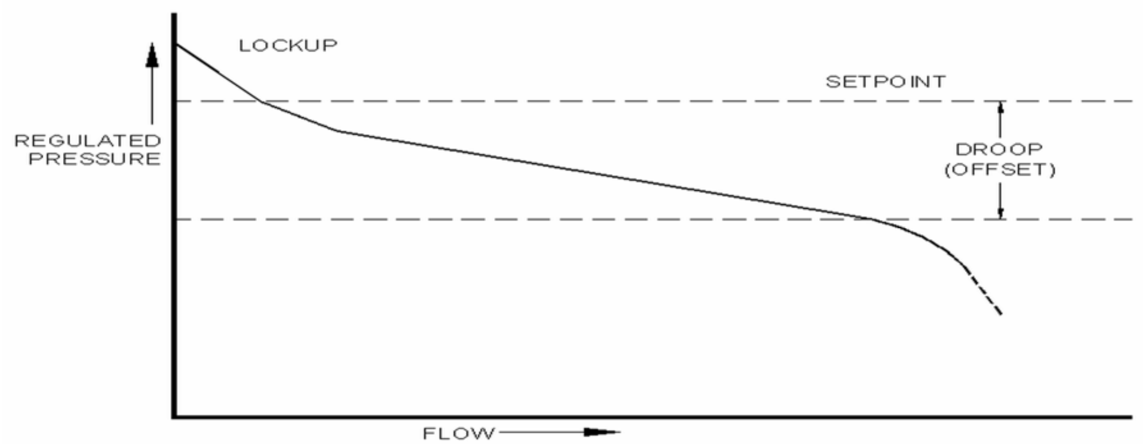
A typical pressure regulator with its proportional control action is shown is the following figure.



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 regulators are typically published at 10, 20 and 30 percent droop or offset for various media such as steam, air and water..



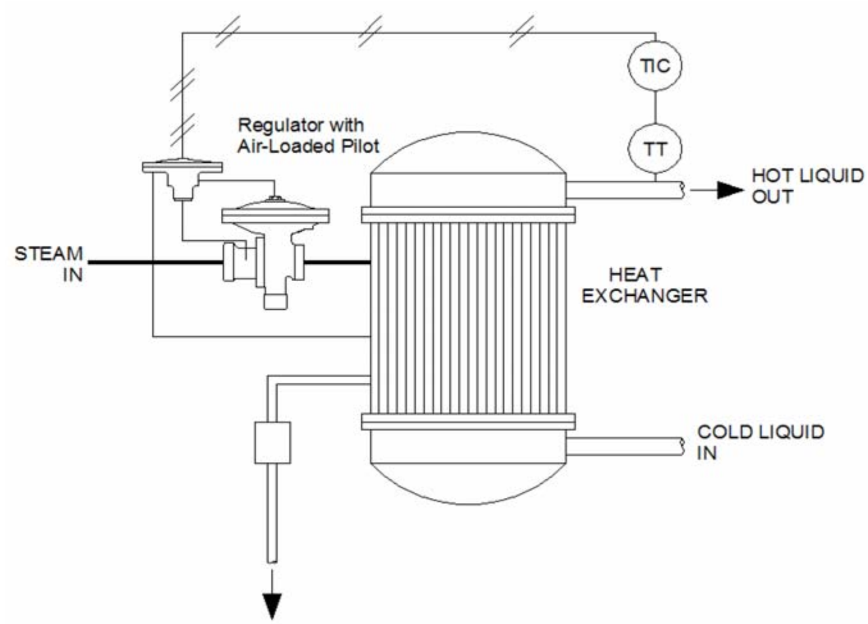
An effective method of increasing regulator accuracy involves using a pilot regulator to maintain a near constant pressure on the regulator diaphragm to improve the droop or offset performance to within about 5 percent over the operating range.

Typical regulator applications can include any application requiring control within 5 to 30 percent. These application 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 etc

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 the next figure, 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 hear 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 piloted regulator with a air supply to the pilot controlled by a temperature controller will further facilitate improved accuracy and control..



The basic advantages and features of a regulator can be 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:

Best accuracy about 5%
Maximum available size is typically 6 inches
Failure modes are fixed
Regulators are generally not applicable for severe service

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 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?

Tony George 3/8/2006