Valve Selection and Sizing Guide: How to Pick the Best Valve for Your Application
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INTRODUCTION

Control Consultants Inc. (CCI) has been in the control distribution business for over 27 years. We know choosing the right control valve for your projects is an important responsibility. In addition to keeping a project on budget, choosing the correct control valves ensures you will wind up with equipment that can efficiently perform their required tasks. We have compiled this guide to help you choose the correct control valves for all of your jobs.

WHY THE RIGHT VALVE MATTERS

While valves are by no means the flashiest aspect of a control project, they’re a very critical piece of the overall equation. If the correct valve is not selected or applied correctly it can very quickly spell disaster.

Because valves live in critical yet often time out-of-sight places, like mechanical rooms, boiler rooms, above ceilings, and other hard to reach spaces it’s essential that they do their jobs properly. Valves must be selected for their ability to meet temperature, pressure, flow characteristics, and piping connections of the hydronic systems they are installed into. Valve sizing is critical to ensure support for the heating and cooling loads with adequate valve capacity, yet be able to control system flow to provide stable building conditions efficiently. This means there should be no malfunctions or inefficiencies that can cause discomfort to the inhabitants or damage to the space around them or equipment they are connected to.

At the end of the day, valves are what allow HVAC systems to operate efficiently and seamlessly, so it’s critical that the valves chosen and installed are the right ones for the application.
CHOOSING THE RIGHT-SIZED VALVE

To perform well under pressure, the valve needs to be the smallest size it can be while still doing the job correctly. This works out nicely for everyone involved because smaller valves are often less expensive and are a better physical fit than their larger counterparts.

Instead of just purchasing the smallest valve possible, however, it’s critical to understand the application so that you know which size valve you actually need. This will help keep the valve functioning efficiently and prevents operating issues from cropping up. Here’s how to measure a pipe effectively:

**DETERMINE THE FLOW RATE.** To choose the right valve, you’ll need to identify the designed flow rate specified for the equipment you are working with. If the valve has a flow rate that is too low or too high, you’ll experience hunting, hammering, poor control and inefficiencies.

**SIZE THE PRESSURE DROP ACROSS THE VALVE.** Placing a valve in a pipe will inherently cause pressure loss in the pipe. Determine the maximum allowable amount of pressure differential upstream and downstream of the valve. Oftentimes this value is specified by an engineer.

**USE AN EQUATION TO FIND THE IDEAL SIZE.** To estimate the perfect size for your valve, use the following equation to calculate the Flow Coefficient (also known as CV): \( CV = \frac{\text{Flow (gpm)}}{\sqrt{\text{pressure differential (psi)}}} \). This is more easily explained latter in this document.

**PURCHASE THE VALVE.** Once you’ve completed this equation, it’s time to buy a valve. For the correct fit, you’ll want to buy one that is equal to or just slightly higher than the CV number you calculated. This ensures a well-fitting valve while also leaving room for boosted future flows.

While this is a somewhat extensive process, following these guidelines will help ensure that you get the right size valve for the job every time.
ADDITIONAL VALVE CONSIDERATIONS

In addition to understanding how to calculate the size of valve needed, it’s also important to understand what else influences the valve purchasing decision. Here are some of the most important factors:

OPERATING CONDITIONS. Operating conditions have an enormous impact on the type of valve purchased. For example, you’ll need to buy a different valve for handling liquids than you would for processing steam. When considering operating conditions, take the time to decide if anything in the operating environment is corrosive or explosive, which will influence the material of the valve.

APPLICATION. Is the valve going to be used IN AN On/Off application or does it have a more advanced use, such as modulating an advanced PID loop? While valves are very similar to one another, the purpose of the valve in question will go a long way toward determining the size, shape and material you need to purchase.

BUDGET. There are many types of valves on the market, and they come at varying price points. To purchase the correct valve for your upcoming job, it’s important to spend some time considering your budget and how much you can afford to devote to a valve. In many situations, the best valve on the market is not the best valve for your application and budget. That being said, keep in mind that “There is nothing so expensive as something cheap.”

EFFICIENCY. Efficiency is a critical part of the valve purchasing decision. Valves that offer quality materials, interchangeable design and high capacity construction are often more efficient. This helps keep the entire operation running smoothly and helps minimize the likelihood of running into operating problems down the road.
VALVE TYPES AND APPLICATIONS

BALL VALVES

CHARACTERISTICS
- 2-Way or 3-Way Configuration
- Hot or Chilled Water Only
- Equal Percentage
- High Close-Off Ratings
- Higher Range Ability
- Replaceable Packing
- Self Cleaning as Ball Drives to Closed Position
- Modulating, Floating or 2-Position
- Less Expensive, 30 to 40% Less Than Globe Valves

APPLICATIONS
- VAV Box Reheat Coils
- Fan Coils
- Radiation
- High Close-Off Ratings
- Higher Range Ability

ZONE VALVES

CHARACTERISTICS
- 2-Way or 3-way configuration
- Steam, hot water or chilled water
- Typically just 2-Position
- Normally sized at ½”-1 ¼”

APPLICATIONS
- Baseboard Radiation
- Fan Coils
- Radiant Floor Heat
- Unit Heaters
VALVE TYPES AND APPLICATIONS

GLOBE VALVES

CHARACTERISTICS
- 2-way or 3-way configuration
- Steam, hot water or chilled water
- Mixing or diverting flow patterns
- Linear for steam
- Equal percentage for hot or chilled water
- Modulating, Floating or 2-Position

APPLICATIONS
- Air Handling Units
- Steam Coils
- Steam Heat Exchangers
- Steam Humidifiers
- 3-Way Outdoor Air Reset
- Differential Pressure

BUTTERFLY VALVES

CHARACTERISTICS
- 2-Way or 3-way configuration
- Hot water or chilled water only
- Mixing or diverting flow patterns
- 2” to 24”
- Modulating, Floating or 2-Position

APPLICATIONS
- Cooling Tower Bypass
- Chiller Isolation
- Boiler Isolation
- 3-Way Outdoor Air Reset
PRESSURE INDEPENDENT
CONTROL BALL VALVES

CHARACTERISTICS
• 2-way configuration only
• Hot water or chilled water only
• Maintain proper flow despite changes in system pressure
• Modulating, Floating, or 2-Position
• No balancing needed
• Higher temperature differentials across coils & branches producing more efficient systems
• Replaceable stems & packing
• Serviceable regulator cartridges

APPLICATIONS
• Fan Coils
• Chilled Beam
• Air Handling Units
ACTUATOR TYPES AND APPLICATIONS

2-POSITION

CHARACTERISTICS
- 24V or 120V Power
- Spring Return, Fail Safe or Fail in Place
- Fully open or fully closed

APPLICATIONS
- Baseboard Radiation
- Fan Coils
- Radiant Floor Heat
- Unit Heaters
- Mechanical Plants

FLOATING

CHARACTERISTICS
- Typically 24V Power
- Typically Fail in Place
- Drive Open/Drive Closed
- Uses 2 timed digital outputs for open & close signal
- Infinite number of possible valve positions
- Actuator resyncs its self once every 24 hours

APPLICATIONS
- VAV Box Reheat Coils
- Fan Coils
- Baseboard Radiation
- Unit ventilators

MODULATING

CHARACTERISTICS
- Typically 24V Power
- Spring Return/ Fail Safe or Fail in Place
- Typical signal 4-20mA, 0-10Vdc, 2-10Vdc
- Linier Signal
- Infinite number of possible valve positions
- Very accurate control

APPLICATIONS
- VAV Box Reheat Coils
- Fan Coils
- Baseboard Radiation
- Unit ventilators
- Air Handlers
- Differential Pressure
A "**SPRING RETURN**" actuator has a mechanical spring which is wound up when power is applied to the actuator. Upon the loss of electrical power the spring will unwind and return the actuator to its “Normal Position”. The “Normal Position” is the position that the valve will be in when there is no power at the actuator. A valve with a spring return actuator will either be classified as Normally Open or Normally Closed and the selection as to which will be used is determined by the application. The spring return feature can be found on 2-position, modulating, and floating control actuators.

A "**FAIL SAFE**" actuator is an electronic actuator with a capacitor return. Capacitors are electronic devices that store an electric charge and require very little current to remain continuously charged when power is applied to the actuator. Upon the loss of electrical power, the charge in the capacitor is used to drive the actuator back to its “Normal Position. The “Normal Position” is the position that the valve will be in when there is no power at the actuator. A valve with a capacitor return actuator will either be classified as Normally Open or Normally Closed and the selection as to which will be used is determined by the application. The capacitor return feature can be found on 2-position, modulating, and floating control actuators.
ADVANTAGES OF CAPACITOR-DRIVEN OVER SPRING-RETURN FAIL-SAFE

Early on capacitor-driven actuators had a high failure rate and were looked down upon by most people in the control industry. Old timers knew that they could always rely on an electric spring return actuator just like that had for so many years with pneumatic actuators. Over time just like most electronics the capacitor driven actuators became very reliable and are now often times the preferred actuator.

Capacitor-driven fail-safe models provide multiple advantages over spring-driven actuators:

Capacitor-driven actuators usually have SMALLER cases, WEIGH LESS, and can ATTACH TO SHORTER SHAFTS than bulkier spring-return models. Capacitor-driven actuators also allow for greater torque because it does not have to overcome the force of the spring.

Capacitor-driven actuators provide SWITCH-SELECTABLE FAIL-SAFE AND POWERED DIRECTIONS, so that one model can easily be used for both Normally Open and Normally Closed fail-safe applications without flipping over the actuator and changing the shaft clamping mechanism. Not only can a capacitor-driven fail-safe easily change directions, it might also be turned off if desired (such as for testing purposes).

The easier installation of capacitor-driven actuators is further enhanced by a quick-release button or lever that allows EASY MANUAL POSITIONING of the shaft. Spring-returns, on the other hand, usually require a wrench to manually “wind” the shaft into position (if manual positioning is available at all).

Spring returns typically drive much faster and with excessive torque during fail-safe mode, potentially damaging equipment, but capacitor-driven actuators provide CONSISTENT TORQUE during fail-safe as well as powered modes.

Although they have higher peak initialization currents, capacitor-driven actuators provide overall HIGHER ENERGY EFFICIENCY. Spring-return actuators require extra motor torque to overcome spring resistance on every cycle, and they consume much more power just to maintain a stationary position.
There have been substantial advances in actuators over the years. Capacitor-driven fail-safe actuators are the most advanced in the terms of efficiency, size, and use. However, spring return actuators are still very relevant to the building automation industry. Building specs sometimes still state that spring-return actuators be used.

APPLICATIONS FOR SPRING RETURN/FAIL SAFE VALVE ACTUATORS

The decision as to when to use Non Spring Return/Fail in Place actuators is fairly simple; if the position of the valve upon loss of power has the no potential to cause damage or harm then you would want to choose Non Spring Return/Fail in Place actuation. Typical applications might be any water coil is not exposed to outdoor air such as a VAV reheat coil, reheat coils, interior fan coil units, and differential pressure valve control.

NON SPRING RETURN/FAIL IN PLACE

A “NON SPRING RETURN” or “FAIL IN PLACE” actuator does not have a spring or capacitor. Upon the loss of electrical power the actuator will remain in its current position. A Non Spring Return or Fail in Place valve can be classified as either open or closed, however this references the position of the valve when the control signal is at its lowest output and does not reference the position on loss of power. The Non Spring Return or Fail in Place feature can be found on drive open/drive closed, modulating or floating control actuators.

APPLICATIONS FOR NON SPRING RETURN/FAIL IN PLACE VALVE ACTUATORS

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VALVE SELECTION
PARAMETERS

INFORMATION REQUIRED FOR MAKING THE CORRECT VALVE SELECTION

APPLICATION: What is the valve being used for?

MEDIA: Is the valve controlling Hot Water, Chilled Water, or Steam?

BODY PATTERN: Is the valve a 2-Way Valve or 3-Way Valve?
   If it is a 3-Way valve is it a Mixing or Diverting valve?

TIP: A Mixing Valve has 2 inlets and 1 outlet, a Diverting Valve has 1 inlet and 2 outlets

PIPE SIZE: Pipe size is good to know, however it is not critical in sizing a valve.

TIP: As a rule you would never want to size a valve that is larger than the pipe that it is being connected to, and at the same time you would not want to supply a valve that is more one size smaller than the pipe that it is being connected to.
WATER VALVES

FLOW RATE (GPM): You need to know the gallons per minute of flow that is required for the equipment that the water will be flowing through.

TIP: When only BTU's are provided use the following formulas: 10,000 BTU’s = 1.0 GPM, and when only tonnage is known use the following formula, 1 Ton = 2.5 GPM

PRESSURE DROP: \( \Delta P \) = the difference in pressure from inlet of the valve to the outlet of the valve. The pressure drop through the valve should be equal to or no more than 25% greater or 25% less than the pressure drop through the coil.

TIP: As a rule you would be safe in using a pressure drop between 3 and 5 Psi on a modulating valve and between 0 and 1 on a 2-position valve. When sizing a modulating valve for differential pressure control take the pump GPM and use a pressure drop of 12 PSI, or take the pump GPM and multiply by .285

CV: Is the calculation between the flow rate and the pressure drop and is what you use to select the proper valve for the application. \( CV = \) Rated flow coefficient of the valve (Defined as the GPM that will flow through the full open valve with a \( \Delta P \) of 1 PSI.)

TIP: If the exact design CV is not available, select a smaller CV valve on heating coils and larger CV valve on cooling coils.

CLOSE OFF PRESSURE: Close off pressure is the maximum pressure that a valve can withstand without having leak-by in the fully closed position. You must know the system pressure so that you select the proper valve and actuator.

TIP: To convert pump head pressure into psi use:

\[ \text{PSI} = \text{Feet of Head} / 2.31 \text{ or } \text{PSI} = \text{Feet of Head} \times 0.433 \]
STEAM VALVES

STEAM PRESSURE: (PSI): You need to know operating system steam pressure.

FLOW RATE: (Lbs. /Hr. or BTU): You need to know the pounds per hour or the BTUs of the equipment that the valve will be controlling. If given the BTUs you can divide the BTUs by 1000 to obtain the Lbs. / Hr. Note: MBH is the same as Lbs. /Hr.

TIP: If you are provided the BTUs you can divide the BTUs by 1000 to obtain the Lbs. /Hr. NOTE: MBH is BTUs X 1000 so if you are provided with MBH it is the same as Lbs. /Hr.

PRESSURE DROP: $\Delta P =$ the difference in pressure from inlet of the valve to the outlet of the valve.

TIP: Use a pressure drop of 80% on a modulating valve and 10% on a 2-position valve.

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ACTUATOR REQUIREMENTS

**VOLTAGE:** What voltage do you want the actuator to be supplied with? 24V, 120V, 230V?

**CONTROL TYPE:** What type of control signal will the actuator receive? 2 Position-On-Off, Floating, or Modulating 4-20mA, Modulating 0-10Vdc?

**SPRING RETURN/FAIL SAFE OR FAIL IN PLACE:** Does the valve have to fail in a certain position, or can it fail in place?

**FAIL POSITION:** If it has to fail in a certain position will it fail open or fail closed?

**TIP:** Hot water and steam valves normally fail open, and chilled water valves normally fail closed. Steam valves used on heat exchanges should fail closed. Any valve feeding a coil exposed to outdoor air should fail open.

For more information, visit [www.controlconsultantsinc.com](http://www.controlconsultantsinc.com) to view valves and actuators from esteemed manufacturers such as Honeywell, Siemens, Belimo and others.