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APPLICATION GUIDE

How to Improve Hydronic System Performance with Pressure Independent Control Valves

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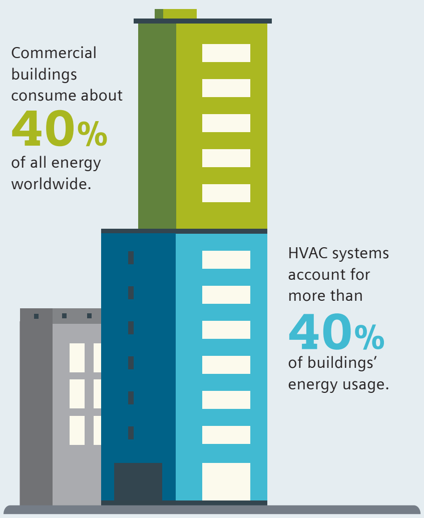
Achieve your design intent for hydronic flow optimization with Siemens Pressure Independent Control Valves (PICV).

This guide reviews hydronic systems and the value of Siemens Pressure Independent Control Valves (PICV) over traditional control valves for their ease of sizing and selection and dynamic balancing. Choosing the right devices in a hydronic system up front can lead to greater energy efficiency and significant savings in first costs and lifecycle costs.

Discover total system performance solutions to optimize delta-T through precise control. Make your building operations more efficient and bring balance to your bottom line.

According to the U.S. Energy Information Administration, commercial buildings consume about 40 percent of all energy worldwide, and HVAC systems account for more than 40 percent of buildings' energy usage.

Hydronic flow optimization is a prime way to reduce HVAC energy consumption, while increasing overall building efficiency and operational performance



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Hydronic system evolution

section 1

Evolving design

Constant Volume Systems

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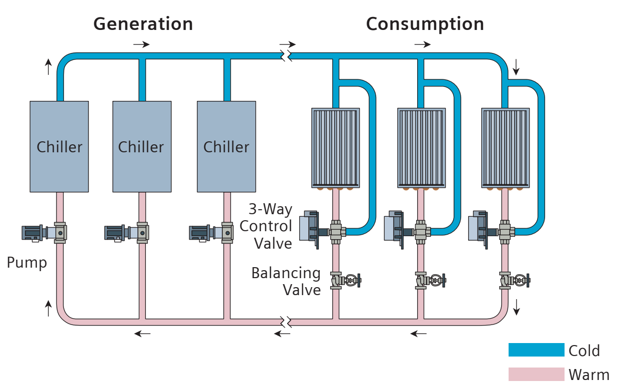
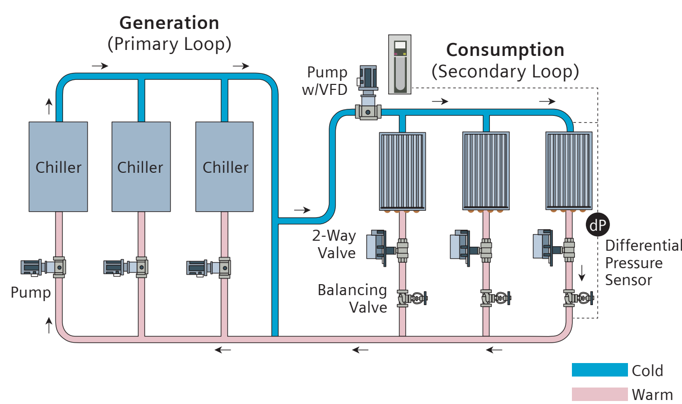
- 3-Way Control Valves
- Static balancing required
- Diverted flow of unused BTUs

Variable Volume Systems

- Reduced Pump Energy with VFDs
- Complicated Valve Selection
- Static balancing required
- Circuit Interactions





Constant volume systems have been the default building configuration for years. This design uses considerably more energy compared to modern methods because pumps see a relatively constant pressure having to continuously pump water throughout the entire piping network.

Generally, on/off pumps are used with 3-way valves to control the flow through the coils. Since the flow is constant, part of the flow will go through the coil and the remaining flow will bypass the coil. The constant volume system also requires balancing valves in order to balance the various loops throughout.

Hydronic systems have evolved from constant flow to variable flow. The primary loop is on the generation side with the chillers and pumps. On the consumption side, is the secondary loop that traditionally will have a pump with a variable frequency drive creating the variable flow. Static balancing is still required and there are circuit or loop interactions, meaning that changes in one loop based on load can affect the other loops.

In variable volume systems there is no longer a coil, or three-way valves with a bypass, since the system is just providing the amount of flow needed in this loop for each coil with traditional valves. There is still a need for balancing valves to provide the proper amount of flow to each of the different coils.

The differential pressure sensor, at the critical coil or the one farthest from the pump, provides feedback to the Variable Frequency Drive (VFD) which ensures the system is getting the necessary differential pressure to control adequate flow to that critical circuit. The main benefit of variable volume systems is reducing pump energy.

Siemens PICV vs Traditional Control Valves

Drawbacks of traditional variable flow systems

Complications in valve selection

There are a number of steps that need to be taken when selecting traditional control valves.

Sizing and selecting traditional control valves is complex and requires several calculations.

To calculate the Cv and properly size a valve, the design flow of the coil and the design pressure drop are needed.

The calculated Cv will almost always be different than the actual Cv of the valves. Typically, the closest, but higher valve Cv is selected in order to not undersize the valve. Once the valve Cv is selected, plug that actual Cv back into the formula to derive the actual differential pressure. Calculate the valve authority next, which is traditionally as close to 0.5 as possible.

Steps to selecting traditional control valves

1	**Control Valve Size** 2.5”, 3”, 4” ?
2	**Control Valve Type** Globe, ball, zone?
3	**Cv** Exact Cv available?
4	**Valve Authority** Is it the recommended value?

In this example, valve authority is not that close. So, sizing becomes an issue.

Valve Authority Requirement

$$ß = \frac{10}{4.3 + 0.7 + 5 + 10} = 0.5$$

$$ß = \frac{10}{20} = 0.5$$

Control Valves Sizes

4 Cv	= 1/2”
6.3 Cv	= 3/4”
10 Cv	= 1”
16 Cv	= 1 1/4”
25 Cv	= 1 1/2”
40 Cv	= 2”
63 Cv	= 2 1/2”
100 Cv	= 3”

$$Cv = \frac{95\ gpm}{\sqrt{10\ psi}} = \frac{95}{3.16} = 30$$

$$\Delta p = \left(\frac{Q}{Cv}\right)^2$$

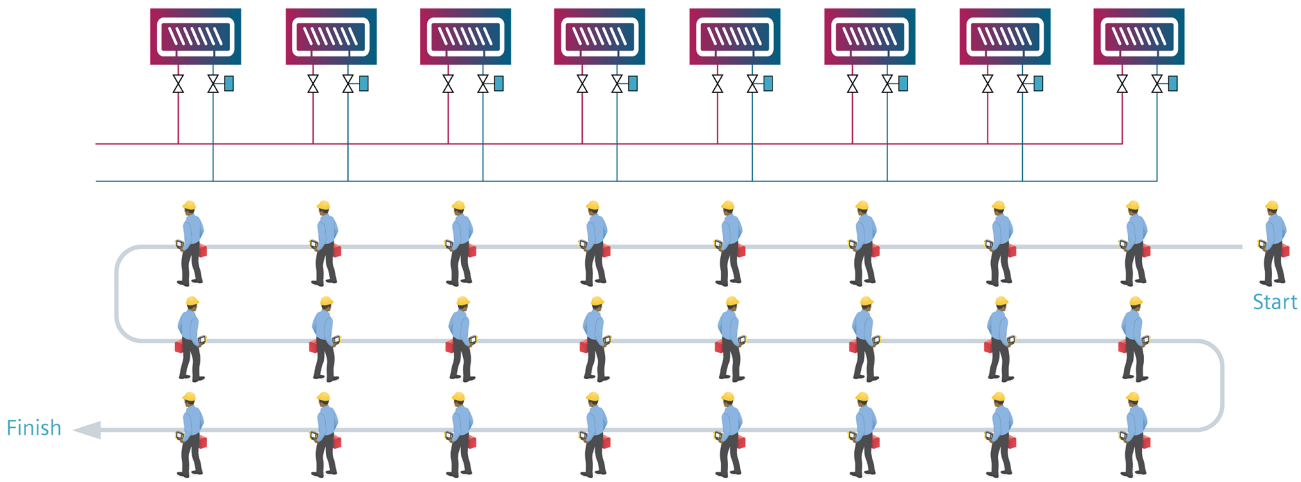
$$\Delta p = \left(\frac{95}{40}\right)^2 = 2.375^2 = 5.6$$

$$ß = \frac{5.6}{20} = 0.28$$

Authority not optimum
Recommended = 0.5

Pressure dependent valves require more commissioning time:

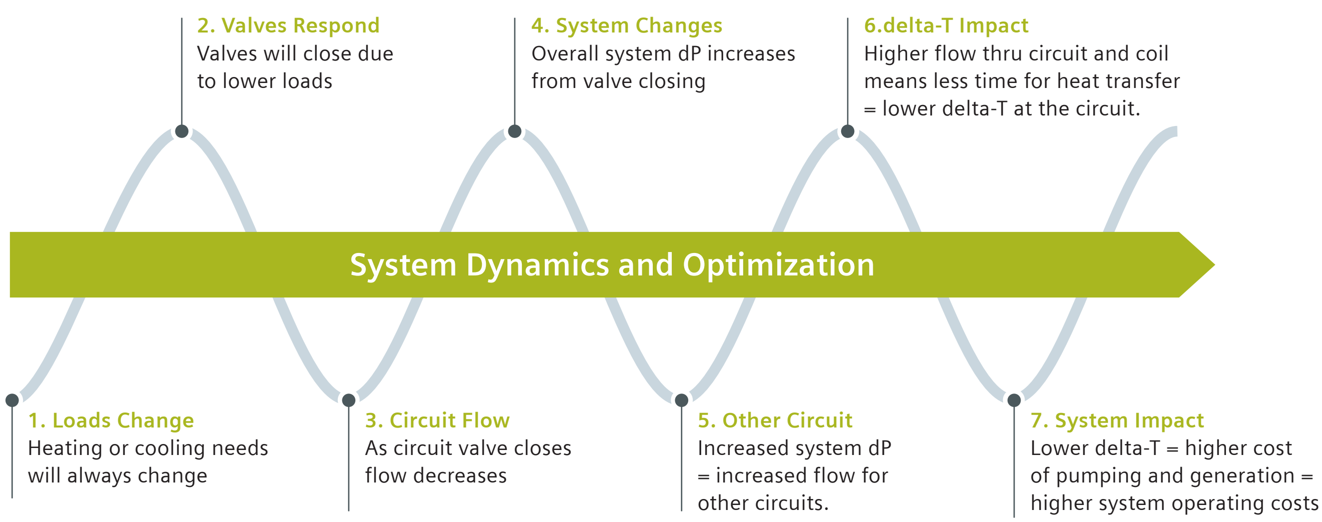
1. A change to a valve in a branch results in changes to the flow through the rest of your system.
2. It is common to do three passes for proper balance when using conventional control valves.



Pressure dependent valves don't stay balanced.

Why pressure dependent valves require more commissioning time:
Typically, a balancer would start with the first valve and control loop on the right. They will set the manual balancing valve so that the coil will get the flow it needs for design. Then the balancer moves on to the next one and sets it and so on, all throughout the system on all of the valves. Every time the balancer sets another balancing valve, it affects the previous ones that were already set. So traditionally they will repeat the process two or three times to reset those valves, which is very time-consuming and labor-intensive. When the balancer is done, the system is balanced to the design parameters, but a system rarely operates at design conditions. Therefore, the system is rarely balanced properly.

System operation overflow leads to higher system operating costs



Coil performance and effects of overflow

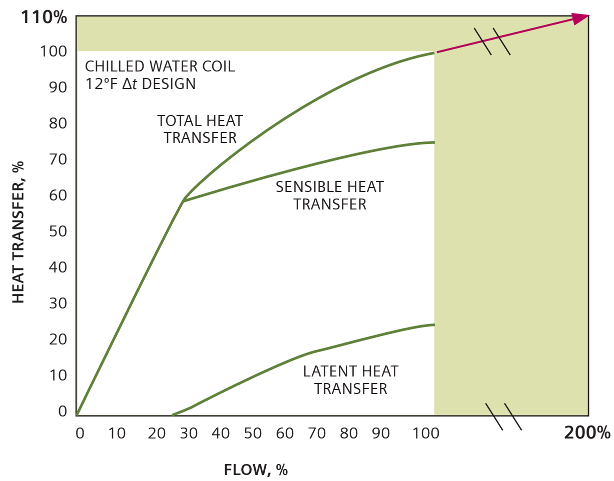
Overflows beyond design flow does not lead to more heat transfer efficiency.

- 200% flow only yields 10% more heat transfer
- Flow over 100% quickly erodes delta-T

If control valves are oversized, and there's a demand like on a start-up condition, the valve will open up all the way.

When there is coil overflow, there will be minimal heat transfer effect. Even with coil overflow of 200%, only 10% is gained in heat transfer. Therefore, if there is coil overflow, the delta-T will quickly erode, so ideally it is best to eliminate overflow to keep delta-T as high as possible to optimize heat transfer.

Chilled-water coil heat transfer characteristic

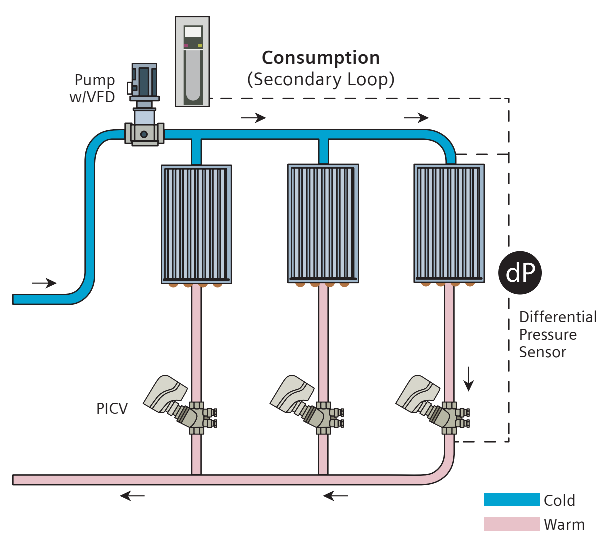


Summary of drawbacks with traditional variable flow systems

1. **Complicated selection of control valves.**
   Each application needs to be assessed for:
   - Cv, valve type, valve size, and proper control authority.
2. **Balancing is required for proper circuit flowrates.**
   - Static balance valve required with control valve in each circuit.
3. **More installation time, more installation risks.**
   - More components to install (increased footprint & weight): control valve, balance valve
   - 3X more labor for system balancing.
   - More leak paths increasing downtime risk.
4. **Improper design leads to potential energy waste.**
   - Balanced at design flow rates only.
   - Higher potential for circuit overflow.
   - Higher potential for increased pumping energy.

Dynamic balancing of hydronic systems using PICV

- Single circuit change leads to circuit interaction.
- PICV immediately responds to dP changes in circuit to prevent overflow or underflow.
- Flow rates maintained at desired levels for proper heat transfer.
- No wasted pumping energy from system reaction to circuit change.



The next evolution in variable flow systems is to add Pressure Independent Control Valves (PICVs). Under the coils in the diagram, the standard control valves and balancing valves have been replaced with PICVs.

Everything else stays the same. The loops are now balancing dynamically, meaning each loop is able to automatically and dynamically adjust for changes in the other loops since the PICV immediately responds to those differential pressure changes.

The PICV is also designed to prevent overflow and the flow rates are maintained for proper heat transfer, so there's better comfort in the system, and no wasted pump energy from the system changes.

Advantages of Siemens PICV

Here’s a comparison of some of the basic system requirements. From our research, 90% of the market requires these features. Siemens mechanical PICVs have all the features of conventional control valves and are easier to size and select. In addition, these PICVs perform dynamic balancing with minimal pressure drop and are field adjustable.

Basic Control Valve & Balance Valve Requirements

90% of the market requires these features

Requirements	Conventional Control Valve	Siemens Mechanical PICV
Easy Selection		•
Dynamic Balancing		•
High Close Off	•	•
Low Minimum Pressure Drop		•
Field Adjustable		•
Leakage Class	ANSI Class IV	≤ ANSI Class IV
Warranty	5	5
Full Stroke	•	•

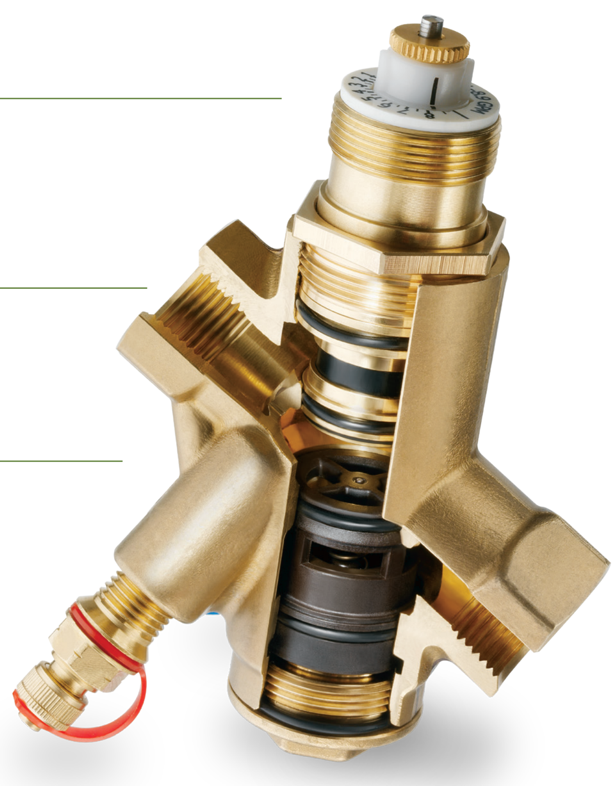
An easier ΔT solution 3-in-1 control valve

The Siemens pressure independent control valve is a three-in-one device. The main difference with Siemens compared to other competitors is that the field adjustable flow limiter is independent of the stroke. With other PICVs, flow is adjusted by adjusting the stroke. So, by reducing the flow, the stroke is reduced. Since the Siemens PICV is independent, you can maintain full stroke, full controllability, regardless of the maximum flow setting of the PICV.

Field Adjustable Flow Limiter
- Full stroke always maintained for higher control accuracy
- Easily adjust maximum flow at any time
- Presetting prevents oversupply to the coil

Control Valve
- Linear stroke control valve with 100% stroke regardless of flow limitation

Automatic Pressure Regulator
- Auto adjusts to pressure fluctuations
- Maintain consistent flow at all times



How do PICVs really work?

PICVs combine a control valve, automatic differential pressure regulator and a field adjustable flow limiter.

1. The control valve controls the flow through the coil to maintain the required room temperature
2. The automatic differential pressure regulator maintains consistent flow regardless of system pressure changes
3. The field adjustable flow limiter preset limits to maximum flow while maintaining full valve stroke

The control portion of the valve controls the flow through the coil to maintain the required room temperature based on the load. At any given setting or position of the control valve, the differential pressure regulator is constantly adjusting to any pressure changes in the system to maintain consistent flow.

The adjustable flow limiter is preset. Set it once at the beginning – set that equal to the design flow of the coil, – and you will never get overflow because that limits the maximum amount that can flow through the valve.

The presetting is very easy to set. The scale is in gallons per minute, so there is no calculation just straight gallons per minute on our threaded PICV. There is no need to know what the maximum possible flow is and to do a percentage.

Siemens PICV easier sizing & selection

Pressure independent control valves are easier to size and select.
The first step is to determine the design flow of your coil, then look at the flow ranges of the valves, and find the one that falls within your design flow range.

It is recommended to select a valve that's one size down from the pipe size. You can also select a valve the same size as the line size, either one has no effect because these are pressure independent and will control to that flow.

If there are multiple valves the design flow falls within, choose a valve where the design flow falls in the middle of the flow range.

If you choose a valve close to the upper or lower range of your design flow, you may be limited in any adjustments that are required. Select a valve for the middle of the range for the most flexibility.

1 Determine design flow of coil

2 Find PICVs with max flow range compatible with coil design flow

3 Typically select a PICV one size down or select on line size

4 It is possible to select a PICV with max flow buffer for post design adjustments

Siemens PICV: The easier solution

Smaller Footprint

Easy Installations

Fast Response Time

Fewest Leak Points

Longer Reliability

With Siemens PICVs, there's no need for additional flow regulating or balancing valves, which means there are less components and installation efforts, less piping and fewer leak points which leads to no callbacks.

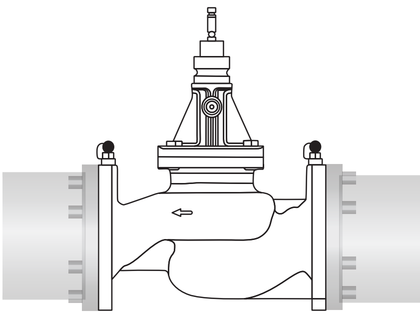
Smaller install footprint

No matter how complicated the pipe network, Siemens PICVs are the right fit.
Siemens PICVs combine a control valve and a balancing valve functionality into a single device. The traditional control valve and balancing valve require almost twice as much space.

To properly pipe this configuration, almost twice the amount of space is needed. Also, considering that a flanged control valve and the balancing valve each are about 200 pounds, there is double the weight which would require additional piping support.

The Siemens PICV helps achieve a smaller footprint, for an easier install. This solution allows for faster commissioning, less labor and less material costs as well as helping meet the goals of fewer leak points, no callbacks and longer reliability.

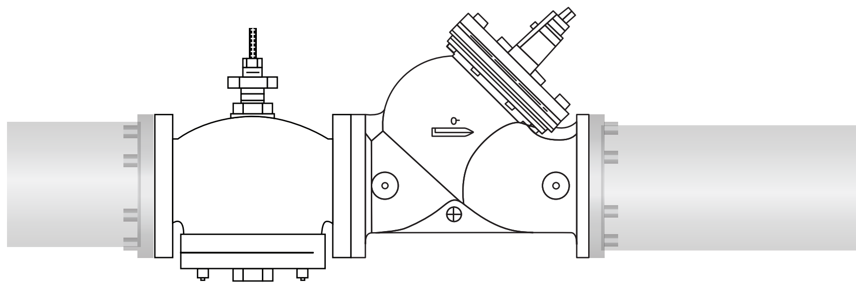
Siemens PICV
Combined control valve
& balance valve



18”

6-inch PICV

Traditional control valve + balance valve
Nearly twice as much space required



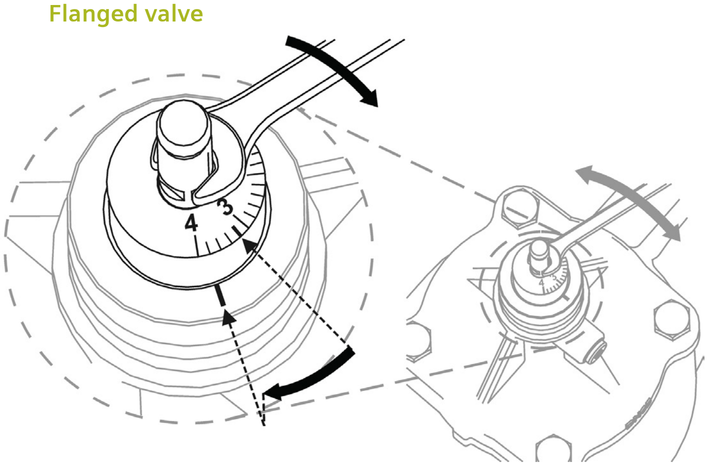
Min. 34.5”

6-inch Globe Valve + 6-inch Circuit Setter

Easy installation

- No special tools
- No programming tools
- Field adjustable by hand

Flanged valve

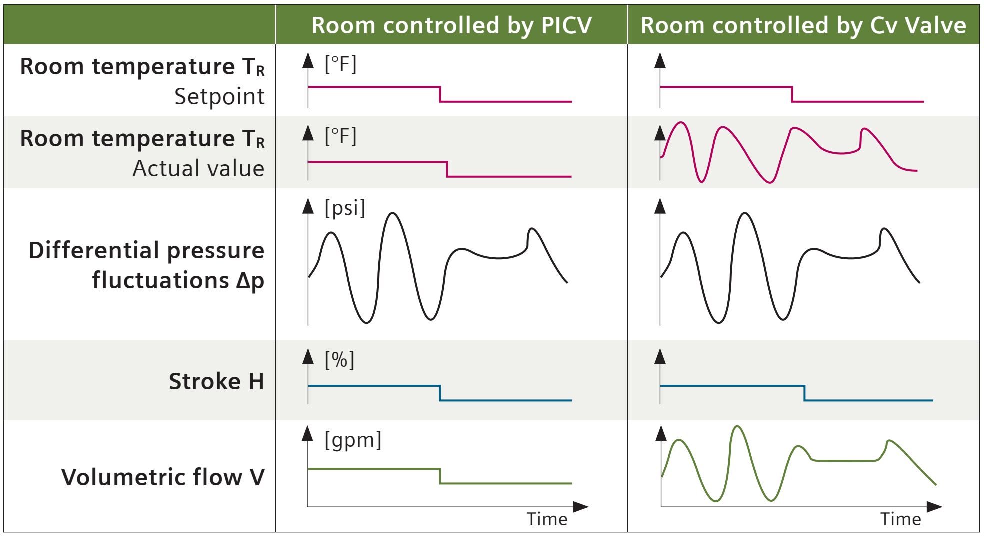


Threaded valve

Fast response time to system changes

Control Sequence

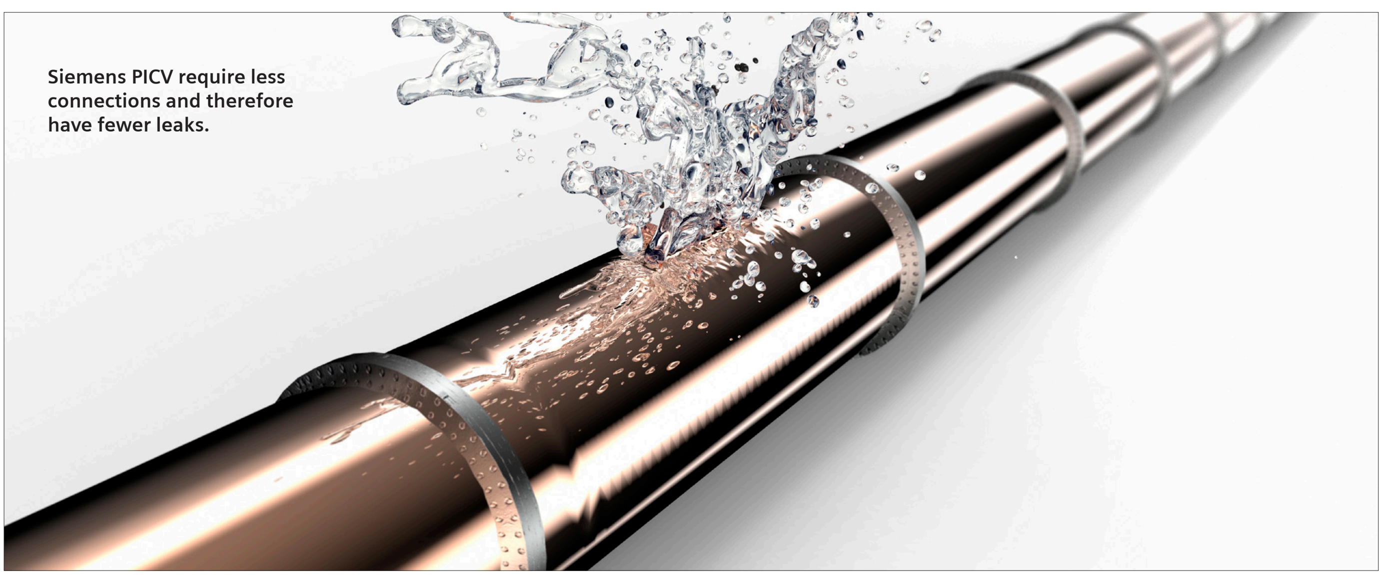
- Occupant changes room temperature setpoint
- Valve repositions (strokes)
- Pressure fluctuations are managed within the PICV
- Flow is stabilized
- Results in room temperature stabilizing at setpoint (vs hunting)



When temperature set points change due to a load change, the resulting action from the valve is a stroke change. This will lead to fluctuations with pressure in the system. In the case of a traditional Cv or pressure dependent control valve, the system pressure will experience changes that lead to flow changes at the coils causing temperature changes in the space whether there is a set point change or not.

Fewest leak points

With a PICV solution, there are fewer devices that need to be piped into the coil hookup, which leads to fewer potential leak paths. With fewer connections and leak paths, there are lower risks for callbacks and repairs, which is another advantage that is possible with PICVs.



Siemens PICV require less connections and therefore have fewer leaks.

Longer reliability

There are fewer PICV actuator repositions compared to traditional control valves and electronic pressure independent valves. With PICVs, the actuator only repositions due to load changes and not to flow changes due to pressure fluctuations in the system.

Another important point to call out on Siemens reliability is the rigorous testing our valves and actuators are put through. Every Siemens valve and actuator is tested right from the factory line to assure longer performance. Siemens goes above and beyond with rigorous lifecycle testing of up to 100K full strokes and up to 1 million repositions for higher reliability .

Siemens PICV advantages

Project Phase	Control valve	Siemens PICV
Main Characteristic	• Cv value, pressure dependent	• Maximum flow setting in GPM, Pressure Independent.
Design	• Accurate calculation of the network differential pressure drops and required flow.	• Small effort for specification of components using only design flow. • Multi phase projects can be implemented independently.
Selection	• Calculation of valve authority is important. • Recalculation required each time changes are made during the planning phase.	• No need to calculate valve authority.
Sizing	• Required: Pressure drop across the heat exchanger and design flow, optionally temperature differential.	• Simply select a valve that delivers the required design flow.
Installation	• Control valve and balancing valves required.	• No balancing valves required. • Reduced leak risks in installation.
Commissioning	• Hydronic balancing. Verification of functioning under different operating conditions required.	• No hydronic balancing and no line balancing required.
Operation	• As load changes system becomes unbalanced, overflow occurs, and energy efficiency decreases.	• As load changes, circuits flow and heat transfer maintained, energy usage optimized.

Cost Overview: Traditional Control Valve vs Siemens PICV

The true costs of long term energy savings

Conventional Solution						
Equipment	**Valve Size (in)**	**Globe Valve List**	**Balance Valve List**	**Total Eqpt List**	**Install/Setup Cost**	**Balance Cost**
AHU-1 CW Coil	1.5	$ 8,391	$2,095	$ 10,486	$ 1,500	$2,250
AHU-2 CW Coil	1.25					
AHU-3 CW Coil	1.25					
AHU-4 CW Coil	1.25					
AHU-5 CW Coil	1					
AHU-6 CW Coil	1					
AHU-7 CW Coil	1					
AHU-8 CW Coil	1					
AHU-9 CW Coil	1					
AHU-10 CW Coil	0.5					

In this conventional solution, some assumptions were made for example purposes. Valves are at list price. Install and set up costs in terms of time and labor rates will vary by area.

Globe and balancing valves were used and this particular system has ten coils. Total equipment list is just over $10,000, and the install and balancing costs are $3,750.

Siemens PICV Proposal						
Equipment	**Valve Size (in)**	**PICV Valve List**	**Balance Valve List**	**Total Eqpt List**	**Install/Setup Cost**	**Balance Cost**
AHU-1 CW Coil	2	$ 14,042	$0	$ 14,042	$ 750	$0
AHU-2 CW Coil	1.5					
AHU-3 CW Coil	1.5					
AHU-4 CW Coil	1.5					
AHU-5 CW Coil	1.5					
AHU-6 CW Coil	1.5					
AHU-7 CW Coil	1.5					
AHU-8 CW Coil	1.25					
AHU-9 CW Coil	1.25					
AHU-10 CW Coil	0.75					

Making the same assumptions with Siemens PICVs, valves cost went up but the installation, set up and balancing costs went down.

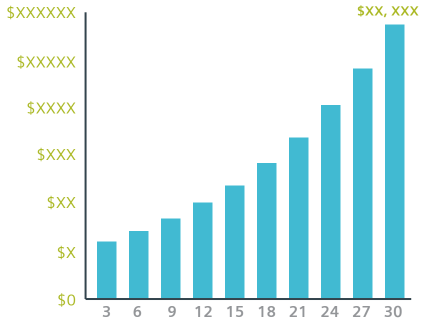
With Siemens PICVs, there’s no need for additional flow regulating or balancing valves, which means there are less components and installation efforts, less piping and fewer leak points which leads to no callbacks. Although first costs may be about the same with PICV vs traditional valves, over the long term, energy savings of over 30% and lifecycle costs savings build a strong case to switch over to PICVs.

Pay for it now? Or pay for it later? The true costs of a balanced system utilizing Siemens PICV.

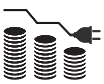
The right devices in a hydronic system can lead to greater energy efficiency and significant savings in first costs and lifecycle costs, with no sacrifice in comfort.

With Traditional Valves:
- First costs same
- Lifecycle costs higher
- Energy savings lower

With PICVs:
- **First costs same**
- **Lifecycle costs lower**
- **Energy savings higher (30%)**



How much could YOU save over 30 years in energy savings and lifecycle costs?



Energy Savings
Up to 30%

Maximize Comfort
Hydronic flow optimization leads to higher comfort

Discover total system performance solutions to optimize delta-T through precise control.
Make building operations more efficient and bring balance to your bottom line.

Rely on Siemens for the best possible system performance.
The right HVAC device matters to make your perfect place a reality.

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