EnergyIdeas Clearinghouse
PTR #12.1
Revised May 2006

Product & Technology Review

DeltaPValve™

An industrial-grade, pressure-independent, two-way flow control valve for use in hydronic heating and cooling systems in buildings.

Product

DeltaPValve Pressure-Independent Modulating Two-Way Flow Control Valves. The series identifications FDP, HDP, EDP, IDP and JDP essentially indicate valve sizes, from smallest to largest. Sizes are available from 1/2" to 14", maximum flows from 1 to 4000 gpm, and maximum differential pressures up to 90 psid.

Manufacturer/Distribution Contact in the Northwest

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Product History

Flow Control Industries, Inc. first debuted a pressure-independent valve for use in the chemical industry in 1989. In 1991, they entered the HVAC market with the DeltaPValve.

Product Function and Application According to the Manufacturer

The following information was primarily provided by the manufacturer and is not evaluated in this section. Refer to "Additional Reviewer Comments" below for our assessment of this information and the energy saving claims in the next section.

Exterior of the DeltaPValve

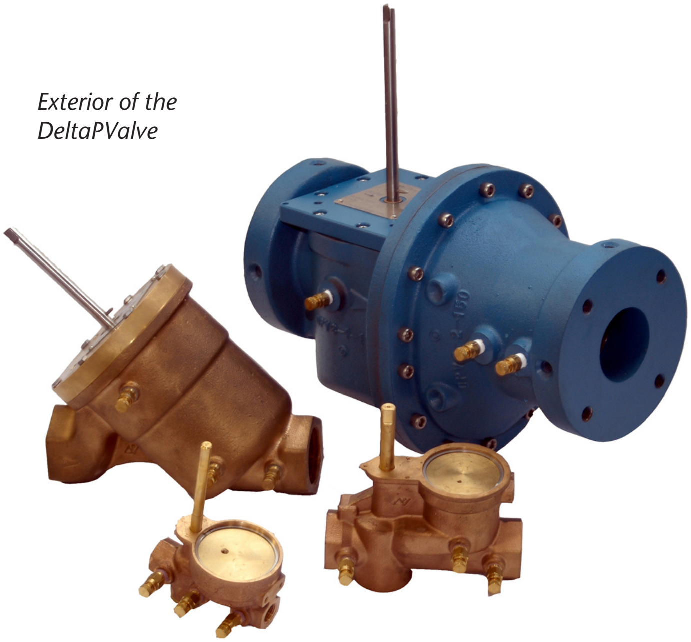

Image courtesy of Flow Control Industries

Two-way control valves are used in variable and constant volume HVAC hydronic systems to control the flow of water through coils depending on room temperature requirements. With a "pressure-independent" valve, flow is related only to valve opening, rather than to both the valve opening and the pressure difference across the valve. Many actions such as operation of valves or changes in pump speed affect the pressure in the distribution system. These actions in turn will affect flow through a conventional two-way valve even

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if the load does not change. There will be a time delay before this change in flow causes the temperature in the space to change. The thermostat will then respond and the valve will modulate to bring the flow back to what is required to meet the loads. Until the flow is corrected, the coil has been operating at an off-design point and will have over- or under-conditioned the space.

With a pressure-independent valve this off-design point operation will not happen. The valve will respond only to a signal from a thermostat indicating that the load has changed. A pressure-independent valve will not "feel" the operation of other equipment on the system. By responding only to the change in load, the pressure-independent valve is "self-balancing"; i.e., it will deliver the proper amount of flow to meet the requirements of that load regardless of the state of other components of the system.

How does it accomplish pressure-independent operation? The DeltaPValve has two sections, while standard valves have only one. The first section consists of the control "surface" or valve and control shaft, located at the inlet of the valve. Flow is modulated by rotating the shaft. The second section consists of a spring-actuated piston at the outlet, essentially a pressure regulator. The piston automatically adjusts such that the pressure drop across the control surface remains constant, even though the pressure difference across the entire valve assembly from inlet to outlet varies. This automatic adjustment enables the control surface to operate independently of system pressure.

Interior of the DeltaPValve

Another important consideration is a valve's rangeability, which is the ratio between a valve's maximum controllable flow and the minimum controllable flow. The DeltaPValve has a rangeability of 100 to 1, meaning that it has good control over a much wider range of flows than a standard globe-type HVAC control valve with a rangeability of 20 to 1.

Energy Savings Claims

The first energy saving claim of the manufacturer has two components: (1) pressure-independent valves stabilize flow and (2) heat transfer is better with stable flows. The result of this enhanced heat transfer, according to the claim, is that the temperature difference across a coil can be increased by 2°F-4°F just by replacing a conventional two-way valve with a DeltaPValve. If true, the improvement in heat transfer would result in energy savings because less flow is required to achieve the same heat transfer. According to the manufacturer's catalog, HVAC hydronic systems with standard valves experience constantly varying pressures and "cascading system instabilities."

> "Without pressure-independent control, the flow rate varies through heating and cooling coils, with or without a load change… Pressure-independent control valves do not 'hunt'… Stabilizing the flow rate through heating and cooling coils leads to higher [temperature difference across the coil] and better energy performance. It has also been shown to reduce the load by stabilizing the air temperature leaving the coil and minimizing simultaneous heating and cooling in systems that employ reheat."

A second claim is that because DeltaPValves are self-balancing they always deliver the right amount of flow to meet the load, and so maximize the temperature difference across the coil or "delta T." In comparison, conventional two-way valves are often oversized. An oversized valve will tend to "overflow," i.e., pass more water than is necessary to meet the load, resulting in low delta T. More pumping energy will be required for the case of an oversized valve compared to a well-sized valve. Further, a DeltaPValve will remain well sized even if the facility expands. In contrast, conventional valves that once might have been well sized may no longer be if the distribution system is expanded.

A manufacturer's representative did say that at steady state, with no variation in flow, there will be no performance difference between a well-sized conventional valve and a pressure-independent valve. The manufacturer's catalog claims "25%-45% chilled water energy savings is very common." In personal communication with the manufacturer's representative, it was clarified that these savings included more than just changing out conventional two-way control valves with DeltaPValves. Savings were also obtained by measures such as removing bypasses or cross-over bridges, removing "knock-down valves" or automatic pressure-reducing valves, and tuning the controls, in addition to replacing the valves. The representative did not quantify savings attributable just to replacement of conventional two-way valves with DeltaPValves.

Non-Energy Benefits

Pressure-independent valves are much easier to size and select compared to standard valves, often resulting in lower design costs and more reliable installations. Balancing valves are not necessary with pressure-independent valves, resulting in equipment cost savings. Labor expenses are reduced by eliminating the need for system balancing and subsequent rebalancing.

Overall system performance can be improved in certain systems where valves close to the pump experience very high pressure differentials, while valves farther from the pump experience insufficient pressure. These improvements are due to the valve's pressure-independence, its good controllability at low strokes (i.e., small valve openings), and its "high close-off pressure" or ability to completely close against a high pressure.[1]

If instability is a problem in a particular system, stabilizing flow reduces wear on valves and pumps and thus will increase equipment life and reduce maintenance costs. Comfort may improve in some cases as more stable temperatures are achieved.

Independent Testing Results

A study funded by Southern California Edison is currently in progress, with final results expected by summer of 2006. While the project includes replacement of standard control valves with DeltaPValves, it also involves other changes to the distribution system. This study has not been set up to quantify savings due to the valve retrofit separately from other system changes.

Cost

The manufacturer's catalog reports that DeltaPValves are "larger and have more components to provide pressure-independent control" and so the first cost of the control valve "is initially higher" compared to standard control valves. Keep in mind that, depending on the application, the higher first cost of DeltaPValves may be offset by energy savings, avoided costs in design, elimination of balancing valves, and reduced balancing costs.

In July 2005, the manufacturer's retail cost data lists a ½-inch DeltaPValve at $265 and a 2-inch DeltaPValve at $1,275. These prices are provided for illustration purposes only. Actual prices may vary depending on factors such as the quantity purchased and dealer discounts. Please check with your local dealer for actual pricing.

Alternative Products and Strategies

Pressure-independent valves and valves with high rangeability resulting in good control from 0% to 100% of load are also available from at least two other manufacturers. For more information, contact the Energy Ideas Clearinghouse (*www.EnergyIdeas.org*) at 1-800-872-3568.

Case Studies

Princeton University recently completed an upgrade of their chilled water system, which included upgrading the distribution infrastructure, adding chilled water capacity, replacing air handler coils, and replacing conventional two-way control valves with DeltaPValves. Coils were replaced with new coils rated for higher delta T. The combined impact of the valve and coil replacements was an increase of 1°F in campus delta T. In personal communication, the project manager estimated approximately 80% of the improvement in delta T was due to DeltaPValves and 20% due to the coil replacements, although the effects of the two changes were not measured separately.

As reported in the February 2004 issue of the *ASHRAE Journal*, the University of California, Riverside has undergone rapid expansion of its campus, while modification and expansion of its chilled water system has not always kept up (Hyman and Little 2004). Previously, many three-way valves with bypasses had been replaced with conventional two-way valves. System temperature differential (delta T) was increased for a time, but poor valve control resulted. For a variety of reasons, valves near the central plant experienced very high pressures while valves far from the plant experienced insufficient or even negative pressure. Two-way control valves in some buildings near the plant could be forced open by such high differential pressures. In a subsequent overhaul of the system, in addition to improving pump control strategies, conventional two-way valves were replaced with pressure-independent valves in eight critical locations. Pressure-independent valves were selected for their ability to withstand high differential pressures and provide good control regardless of system differential pressure. After these modifications, system pressure was stabilized and thermal comfort in buildings was achieved, while at the same time system efficiency was increased.

As reported in the November 2004 issue of *HPAC Engineering*, the Shell Point Retirement Community in Fort Myers, Florida, is a 425-acre multi-building complex, served by a 12,000 gpm central plant with 6,000 tons of cooling (HPAC 2004). As part of an expansion of the facility, problems with low delta T were corrected by replacing three-way valves and bypasses with pressure-independent valves. According to the project development engineer for Shell Point, pressure-independent valves were selected because the task of balancing conventional valves would have been "costly, burdensome, and questionable in terms of accuracy." Additionally, the pressure-independent valves "circumvented the issues we had, and we now have a self-balancing system for the med center. Because proper chilled-water balancing is in force for the med center, we are assured that the delta T across the coils is at design conditions, working optimally, and any additional pumping energy required for the med center is minimized." The Shell Point plant manager reported that there were "no increases in flow, chilled-water demand, or pump power," and noted that since start-up, no manual balancing has been required at the medical center.

Note that these case studies indicate the benefits of pressure-independent valves in general. In the second case study, the valve manufacturer was not identified and in the third, the pressure-independent valve was that of a Flow Control Industries' competitor.

Suggestions for Further Research and Testing

Further studies should carefully split out effects due to incorrect sizing and tuning of standard two-way valves, as well as improvements due to removing three-way valves and bypasses. Case studies have been performed resulting in testimonials by project personnel of dramatic improvements in system performance. We do not doubt such testimonials. However, in executing these case studies, more than one change to the system was made at the same time, such as the removal of bypasses, tuning of controls and replacing coils, in addition to replacement of conventional valves with pressure-independent valves. What is lacking is a comparison of conventional two-way valves with pressure-independent two-way valves in an independent and controlled study that carefully isolates the effect of the valve replacement from other modifications.

In addition, the extent of the problem of flow instability in existing HVAC systems is not well quantified and may be worth studying. While it is clear that large variations in pressure differentials across conventional two-way control valves can result in system instability, there are many strategies in common practice that are used to reduce this instability (Gut and Spethman 1990). There is conflicting anecdotal evidence in the literature and among professionals on the prevalence of this problem, with reports of instability as well as reports of generally stable operation with conventional valves.

The validity of the claim that stabilizing flow enhances heat transfer in typical heating and cooling coils has not been substantiated with independent tests. In fact, the *enhancement* of heat exchanger performance by unsteady, oscillating or chaotic flows has been documented for low flows through heat exchangers (Kearney et al. 2001, Saidi and Sudén 2001, Perrotin and Clodic 2003). It may be that HVAC coil performance is either enhanced or reduced by unsteady flows depending on many factors, some of which may be site specific such as average flow rate, the period of the oscillation, and heat exchanger geometry. Independent testing on a variety of applications and conditions is suggested.

Further study is also suggested of how the pressure drop across pressure independent valves, as well as total system head, compares to that for conventional control valves under similar conditions of flow, temperatures, and system pressure. The spring mechanism of the DeltaPValve operates such that the pressure drop across the control surface remains constant at approximately 2-3 psi. The rest of the pressure drop occurs across the spring mechanism and may vary, and can be as much as approximately 70 psi, depending on many factors such as plumbing arrangement and pump operation.

Additional Reviewer Comments

Significant savings in pumping energy can, of course, be achieved by replacing existing three-way valves and bypasses – the most common configuration until the last decade – with two-way modulating valves. But here we are interested in comparing savings due to replacing conventional two-way valves with DeltaPValves. To the extent that a DeltaPValve reduces overflows by its automatic balancing feature, it will save pumping energy compared to an oversized conventional valve. The manufacturer's other energy savings claim – that use of standard two-way valves causes unstable flows and that instability reduces heat transfer in coils – is less clear. Regardless, installing pressure-independent valves to replace existing well-sized and tuned standard two-way valves in a stable system will likely have little benefits in energy savings, comfort, maintenance, or equipment life. Therefore, in an existing system, low delta T, flow instability, or other performance problems such as those discussed in the case study by Hyman and Little (2004), should first be confirmed before considering replacement with pressure-independent valves.

There are at least two causes of instability in a hydronic system. First, with conventional pressure-dependent valves, adjusting one valve in the system changes pressure in the header; this adjustment may cause another valve to move, even though its load has not changed. This action can result in instability, especially if controls are tuned such that they respond too quickly and the valve alternately overshoots and undershoots its target in response to a change.[2] This problem may be improved by reducing or setting to zero the derivative setting in proportional-integral-derivative (PID) controls, such that the valve responds more slowly. If tuning does not solve the problem, pressure-independent valves should be considered.

A second cause of instability is the low rangeability of standard valves. A typical globe valve with a 20-to-1 rangeability generally will not have good control at strokes less than 10% to 20%. If such a valve is oversized such that it frequently operates at low strokes, it may alternately jump open beyond its target and then close to compensate. This behavior may result in higher average flow, or overflows, compared to well-sized valves. A common strategy to correct this problem in systems with conventional valves is to adjust controls such that valves are more fully open, either by increasing chilled water temperature or reducing the pump speed via gain or reset settings.[3] This second type of instability also can be improved by valves having a high rangeability, such as the DeltaPValve.

It is worth noting that Flow Control Industries has a reputation for doing more than just selling valves to their customers. In the course of marketing, they provide design and consulting specific to their customer's facilities on the elimination of bypasses, removal of balancing and pressure regulating valves, differential sensor placement, fan energy optimization, and other system improvements. By all reports, they often help their customers achieve significant energy savings using a variety of strategies.

Conclusion

In summary, the most important advantages of DeltaPValve pressure-independent valves over standard two-way globe valves appear to be the following:

- Greater rangeability may improve flow control both at part-loads and at high differential pressures.
- Ease in sizing and selection may reduce design costs and result in more reliable installations.
- DeltaPValves eliminate the need for manual balancing valves, reducing installation costs and labor required for balancing.
- The DeltaPValve's automatic balancing characteristic may reduce overflows compared to oversized valves, saving pumping energy.

Non-energy benefits of DeltaPValves can be significant. Regarding energy benefits, case studies and independent tests of DeltaPValves have thus far not quantified energy savings due to replacement of standard valves separately from savings due to other modifications that were implemented at the same time. The case study of Princeton University's chilled water system improvements indicates pressure independent valves can have a positive impact on campus delta T. How much of this improvement was due to the valve replacements versus coil replacements made at the same time is not known for sure.

In any case, the decision to replace existing valves with DeltaPValves should be made carefully because they have a higher cost and because they may not have significant energy or non-energy benefits in all applications. In particular, in existing systems with standard two-way control valves, problems such as low temperature differentials or flow instability should be confirmed before considering replacement with pressure-independent valves.

Additional Information

Northwest businesses and utilities can contact the EnergyIdeas Clearinghouse for additional information on this or other energy technologies or products. Contact:

Phone: 1-800-872-3568
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Reviewer

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Note: Product & Technology Reviews are peer reviewed by objective industry professionals prior to publishing.

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End Notes

1 *A common strategy to correct this problem in systems with conventional valves is to install pressure-reducing valves on lines experiencing high pressures. While this practice will result in performance improvements, most pressure-reducing valves are globe valves that do not have good control characteristics at low loads, which may negatively impact system performance.*

2 *With variable speed pump control, the pump typically responds faster than another valve change, which reduces this type of instability.*

3 *If chilled water temperature is increased, this strategy may result in higher flows and lower delta T than with pressure-independent valves, increasing pumping energy use. Total chiller energy will decrease, however, and often chiller savings will outweigh the increase in pumping energy. Advanced control systems will consider both pumping and chiller energy use to optimize chiller reset.*