Introduction to PICVs and hydronic balancing

From Hattersley and MBS

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MODERN BUILDING SERVICES

Foreword

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The increasing focus on energy efficiency in buildings creates a greater requirement for building services engineers and installers to find cost-effective technologies that deliver efficient and effective heating and cooling systems.

The pressure independent control valve (PICV) is a piece of equipment that not only supports energy efficient heating and cooling; it also enables designers, installers and commissioning engineers to work in a timely and effective way – saving on installation costs and reducing errors in hydronic balancing.

Understanding PICVs is important for engineers and their clients, and this brief overview is a summary of a more detailed publication written and produced by valve experts Hattersley. In this guide, we introduce some of the basic concepts and highlight some important areas for consideration when discussing the selection and use of PICVs.

For those who would like further insights and more technical details, I recommend the Hattersley guide: 'Understanding the principles of DPCVs and PICVs in dynamic balancing".

This can be downloaded free from: https://www.hattersley.com/page/technical-guide

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Despite PICVs being in the market place for almost 20 years, it is only in the last 5 years that we have seen a significant uptake in their use within building services. As a result, there has been a relatively short period in which users have had to gain an understanding of their use and function. The purpose of this guide is to set out the foundations of this understanding to allow specifiers and users to appreciate how they work within a hydronic system.

Hattersley have a proud heritage of being at the forefront of valve technology and investing in quality products. In order to give the highest levels of confidence to our customers we put our PICVs through rigorous production testing in accordance to the latest industry standards and recommendations. This is not just limited to required pressure testing but also to performance testing, in accordance to BSRIA BTS-01. This all takes place within our UK manufacturing site in Hitchin, Hertfordshire.

1. System design – achieving balance

Systems which use water as the medium for transferring heat are known as 'hydronic'.
In order to deliver the correct heating or cooling flow rates around a building, designers and installers must ensure that the hydronic system is in balance. Imbalance results in overheating or over-cooling; causes discomfort for building occupants; and wastes energy.

A hydronic system is in balance when water flow rates in the building's primary, distribution and terminal circuits are stable and close to the design requirements. The aim of the designer therefore is to:

- Design systems with high operational efficiency
- Achieve occupant comfort at acceptable costs
- Conserve energy resources

It is challenging to achieve a balanced system through pipe sizing and configuration alone. Instead, balancing valves, both static and dynamic, can be used in a system to achieve hydronic balance.

2. Trends in systems and the role of valves

One of the most significant trends in building services design in the past ten years has been the shift towards variable volume systems. The constant volume system, which is seen less frequently these days, used a constant volume of water and 3- or 4-port control valves along with constant speed (low volume) pumps to control the heat output of the terminal.

The benefit of a constant volume approach is easy sizing of control valves. However, the constant volume means that water is being pumped around a heating system even when there is no demand – thereby wasting energy and creating areas of discomfort for occupants.

In our more energy-conscious times, variable volume systems are regarded as more efficient because they deliver heat only when it's needed. The disadvantage of this approach used to be that achieving and retaining balance in a variable volume system required the application of a differential pressure control valve (DPCV); a 2-port control valve; and a balancing valve – leading to complex design and adding to installation time.

However, in recent years, valve manufacturers developed a useful tool known as the pressure independent control valve (PICV) which combines these three functions into a single technology. This makes for easier design and more straightforward installation. PICVs have also been shown to greatly assist in the more efficient and effective operation of heating and cooling systems.

3. PICVs – a combined approach

Pressure independent control valves combine several important functions in achieving and retaining a balanced hydronic system (see diagram 1).

The key functions are:

- differential pressure control
- adjustable pre-set flow rate
- actuated flow control

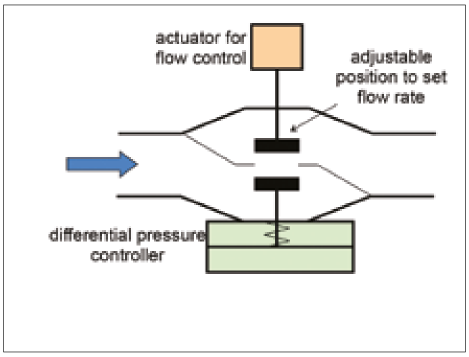

Diagram 1

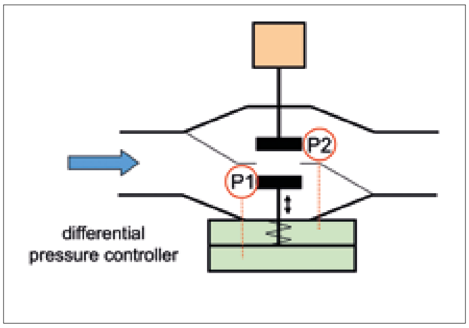

Diagram 2

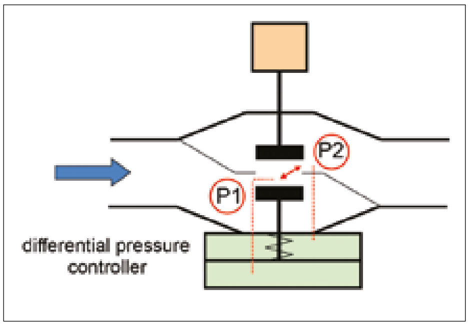

Diagram 3

In a hydronic system, flow rates in the distribution pipework fluctuate to match demand. This means that the available pressure at individual terminal units (such as the fan coil unit) varies, resulting in poor performance. Unless the different pressures are controlled, this variation across the pipework has the effect of changing the flow rate through the terminal sub-circuit. An increase in pressure accelerates the flow rate – leading to an unbalanced system.

To counter these fluctuations in distribution pressure, PICVs are fitted to individual terminal units. The PICV maintains a constant pressure drop across P1 and P2 (see diagram 2), ensuring a constant flow rate to the terminal.

Another benefit of the PICV is that designers and installers can apply a pre-set flow rate. This is done by changing the open area between P1 and P2 (see diagram 3) and creating what is effectively a constant flow regulator. As a result, the flow can be held at a steady rate, no matter what is happening in other areas of the hydronic system.

Manufacturers publish tables (as the one below shows) giving flow rates at the PICV set positions and these are useful for installers to ensure proper set-up of the valve.

As well as holding the flow rate in a steady state, the PICV can also be combined with an actuator for what is termed 'actuated flow control'. This allows the flow rate to be varied, which in turn controls the heat output of the terminal. For valves which have an equal percentage disk, there is a direct (linear) relationship between the valve open position and heat output. This means, for example, that if the valve is half open, the heat output is halved.

DN15 LF			DN15 SF			DN15 HF		
POS	Typical ΔP	FLOW	POS	Typical ΔP	FLOW	POS	Typical ΔP	FLOW
2	15	0.008	2	20	0.060	2	25	0.085
3	15	0.015	3	20	0.085	3	30	0.130
4	15	0.028	4	20	0.115	4	35	0.175
5	15	0.038	5	20	0.130	5	35	0.210
6	20	0.050	6	20	0.150	6	35	0.250
7	20	0.060	7	20	0.170	7	40	0.280
8	20	0.070	8	25	0.180	8	45	0.300
9	20	0.075	9	25	0.190	9	45	0.320
10	20	0.080	10	25	0.200	10	50	0.340

5. Selection and sizing

There are several characteristics to consider when selecting the right PICV for a project. These include:

- Flow control and flow rate – the accuracy of control is vital for a balanced hydronic system.
- Flow setting – ease of installation and commissioning are important for those working on-site. The valve should be easy to set by hand for commissioning purposes and the latest PICVs offer quick-fit actuator connection with no tools required.
- Pipework size – matching pipe size could be a consideration when selecting a PICV. Whilst selection of a smaller sized PICV could offer a saving, the additional costs of pipework changes may be greater.
- Pressure drop across PICV – the minimum pressure required to activate the PICV can vary between sizes, typically about 15 kPa for smaller sizes but increasing to 30 kPa for larger valves. This may be a consideration for some projects because an increased pressure drop in the least-favoured circuit could increase the whole-life operating costs of the system.
- Stem regulation – if the PICV uses stem travel to regulate the flow rate, then the recommended selection criteria is to select the valve that can achieve the required flow rate in the most fully-open position.

6. Control characteristic

The control characteristics is the term used to describe how the PICV controls the flow rate when operated by the actuator.   The control characteristic is either the result of the design of the valve itself (the distance between the seat and the disk within the valve, or the characteristic is created by the actuator. There are three types of control characteristic:

On/off: Denotes that water flows when the valve is fully open; there is no flow when the valve is closed

Linear: When the PICV is installed, it creates a linear relationship between the valve 'open' position and the terminal unit heat output. In other words, the offsets of the heat output curve and the valve 'open' position curve counteract each other.

Equal percentage: When the valve movement and water flow change at the same rate, this is known as equal percentage.

7. Installation

Best practice is that pipework components that have a relatively high-pressure drop should be installed in the return pipework. This ensures that the other circuit components such as terminal coils are kept at the highest possible pressure available, reducing the risk of cavitation – the formation of bubbles in the liquid.

Hattersley recommends the installation of pressure test points (TP) at various positions to facilitate maintenance; verification of system operation; and trouble shooting. We have found their inclusion in systems to be invaluable when the installed system does not appear to be working as expected.

As PICVs incorporate differential pressure control, flow regulation and flow control, technically, the only other valves needed are strainers and isolation valves. Because of the inherent flow regulation and control issues associated with PICVs, flow measurement devices (FMDs) are often fitted in each terminal sub-circuit.

A compromise position could be to install an FMD where it is considered that better control over heat output is required. This could include equipment such as boilers and chillers as well as larger terminal units such as AHUs.

8. System balancing

As the PICV is set to give a specific flow rate, there is no actual commissioning of the PICV, other than flow rate verification. However, part of the function of the commissioning engineer is to set the circulation pump speed.

Having identified the least favoured (index) PICV, the commissioning engineer will set the pump speed to ensure that this PICV has sufficient pressure available to ensure it is within its working range. If the least favoured PICV has sufficient pressure available then all other PICVs must have a greater pressure available, and therefore be within working range.

On larger systems, the least-favoured circuit may change position as demand changes, and as a consequence the PICV control position changes. It would therefore be necessary to set up a system of pressure sensors to ensure that the pump always delivers enough head (pressure) to satisfy the 'new least favoured PICV'. It would be considered good practice to 'spot check' a selection of PICVs throughout the installation to confirm they are within working pressure range and hence the flow rate is correct.

Case study: Newcastle University

Hattersley Hook-Up Elite Prime manifold assemblies have been selected by M&E contractor Integral UK Ltd for the heating and air conditioning system of the Newcastle University Learning and Teaching Centre.

The Hattersley Hook-Up Elite Prime is a compact and modular valve system that includes the Elite Prime Pressure Independent Control Valve for accurate flow, temperature and pressure control. The lightweight units have an integral Venturi metering station for an improved flow range, a small footprint with equal length pipework and the ability to orientate the valve on-site for an easier and faster install on any fan coil or chilled beam.

Designed by architects Sheppard Robson, the £34m project will house a 750-seat auditorium, 200-seat lecture theatre, an exhibition space, plus several seminar rooms, offices and cafés. The Learning and Teaching Centre is part of Newcastle's £350m Helix project, formerly known as Science Central, which aims to bring together science, technology, business, living and leisure in one landmark location in the heart of the city.

Desco M&E consultants designed the HVAC system and specified Hattersley valves, which allowed for a seamless technical submittal and approval process for Integral.
By utilising the Hattersley gap detection actuator, the system is able to achieve excellent valve authority at all settings. This allows for maximum efficiency gains against required pump settings to achieve the required flow rates.

The Hook-Up Elite Prime has been designed to deliver and maintain a system that enables energy and cost reduction over its lifetime. Every valve is subject to both a pressure test, in accordance with BS EN 12266-1, as well as a flow limitation test, in accordance to BSRIA BTS1.

Free Training Available

Hattersley offers a range of Chartered Institution of Building Services Engineers approved CPD training modules, and free onsite practical training using a custom training rig.

Please go online to www.hattersley.com/training-mbs to enquire about the training and CPD modules we can offer to support your business

CIBSE CPD

You Tube

To visit our Video Library go to:
www.youtube.com/user/CraneHattersley

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