Design Guide

FloCon
Watchman™

Designed for Ongoing Commissioning

SAV
SYSTEMS

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About SAV Systems

SAV has been operating in the UK since 1988.

SAV Systems is a leading provider of innovative building services solutions designed to boost energy efficiency and cut carbon emissions.

Products vary from sophisticated mini-CHP systems to simple water meters, but all are purpose-developed to serve a better internal environment and a greener world.

Used as individual products, or integrated into custom-designed systems, the SAV range makes a perfect partner for low energy technologies from renewables to central plant and even district heating systems.

It's a full family of choice sourced from some of the world's leading specialist companies - our Partners in Technology. Our product groups cover the full spectrum of modern building services.

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1.0 Introduction

This guide explains how to design heating and chilled water systems incorporating valve modules.

> A valve module is essentially a pre-insulated box within which all of the valves required for control, commissioning and pre-commission cleaning of terminal branches are located. An ultrasonic meter is integral to each module. Key benefits are derived from the centralisation of these components.

SAV were the first company to develop and promote valve modules. FloCon modular solutions have been available since 2003 and since then have been installed in over 100 buildings across the UK.

Valve modules enable highly flexible designs that facilitate the “change and churn” culture of modern buildings. They also help to maximise the energy saving benefits of modern variable flow systems.

The ultrasonic Watchman element facilitates commissioning, post commissioning and ongoing commissioning.

This guide explains:

- the benefits of modular design
- the components inside each module
- system design for modules
- commissioning and pre-commission cleaning functions
- ongoing commissioning (soft landings)
- change and churn

Figure 1: PICV module with Ultrasonic meter

2. Benefits of modular design

The benefits of valve modules derive from the simplified pipework arrangements they enable. Figures 2a and 2b show a typical rigid pipe layout relative to a flexible modular layout.

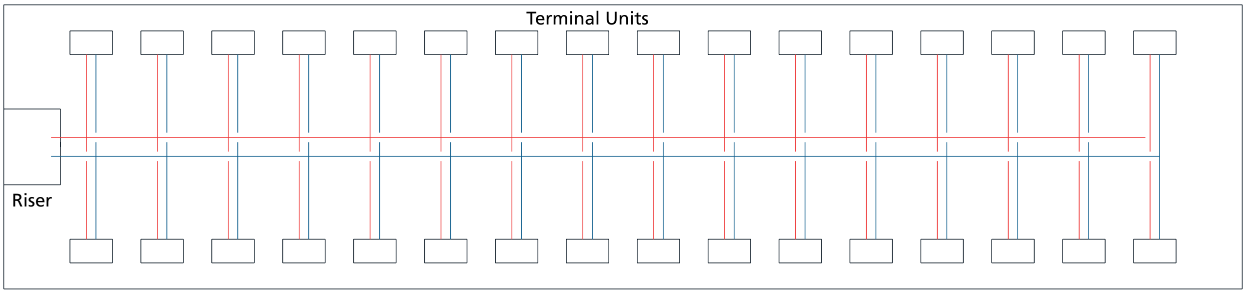


Figure 2a: Rigid pipework layouts serving terminal units

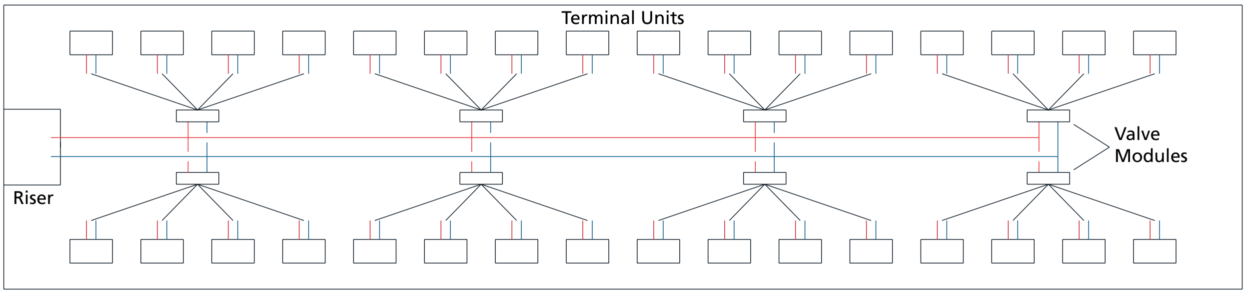


Figure 2b: Flexible modular layout

The relative benefits of the flexible modular approach compared to the rigid approach can be categorised as follows:

Design:

- All selections based on terminal unit flows and pressure losses. Hence:
  - Fewer pipes to size
  - No need to calculate individual valve pressure losses
  - No need to size control valves

Installation:

- Reduced on-site installation time compared to rigid systems
- No soldered joints and hence no hot work above ceilings
- Easier to vent
- Easier to insulate
- Ensured compliance with BSRIA Pre-Commission Cleaning Guide

Pre-commission cleaning:

- Flushing drains and isolating valves as required in BSRIA Guide BG29/2012
- Localised large bore strainer to prevent valve blockages
- Fewer flushing locations to access

Commissioning:

- No need for traditional proportional balancing
- Fewer valve locations to access
- Less chance of air/dirt blockages

On-going commissioning (Soft Landings):

- Automatic monitoring and targeting of energy consumption (and energy billing)
- Delta T monitoring
- Post occupancy recommissioning
- Trouble-shooting

Maintainability and flexibility:

- Fewer maintenance points
- Maintenance points can be away from occupied areas
- Change and churn - flexibility to add/move terminal units later

Energy savings:

- Lower pipe resistances and hence pressure losses
- Improved pump energy savings
- Better performance of central heating and cooling sources
- Less uncontrolled heat losses/gains (due to pre-insulated pipes and valve boxes)

2.1 Benefits backed by research

Some of the benefits identified above have been verified by independent research.

BSRIA Commissioning Module Study No. 19822/01 by Glenn Hawkins concluded that:

- A tradition rigid fan coil unit installation on an office floor takes 28% more man-hours to install than a fan coil unit system that has been designed to incorporate valve modules.
- The flushing of fan coil unit circuits in an office layout that incorporates valve modules can be undertaken in 23% of the time it would take to flush fan coil units in a tradition rigid pipework system.
- The commissioning of fan coil unit terminal circuits in an office layout that incorporates valve modules can be undertaken in 44% of the time it would take to balance fan coil terminal circuits in a traditionally configured pipework system.

BSRIA Guide BG 12/2011 *Energy efficient pumping systems* concluded that:

> *"Energy savings in variable flow systems are greatly improved by locating the DPCV as close as possible to the terminal unit control valves they serve. This is most easily achieved either by the use of PICVs which have their own integral DPCVs or DPCVs located on sub-branches serving small numbers of terminals such as in valve modules. Valve modules are effective because DPCVs are located close to terminal units and act to maintain a constant pressure differential across all terminal unit sub-branches."*

3 Module components

The various components that make up a valve module must be carefully selected to suit the building operating conditions and facilitate installation.

Figures 3a and 3b show schematic layouts for the two main types of valve module. The main components and their properties are described in the following sub-sections.

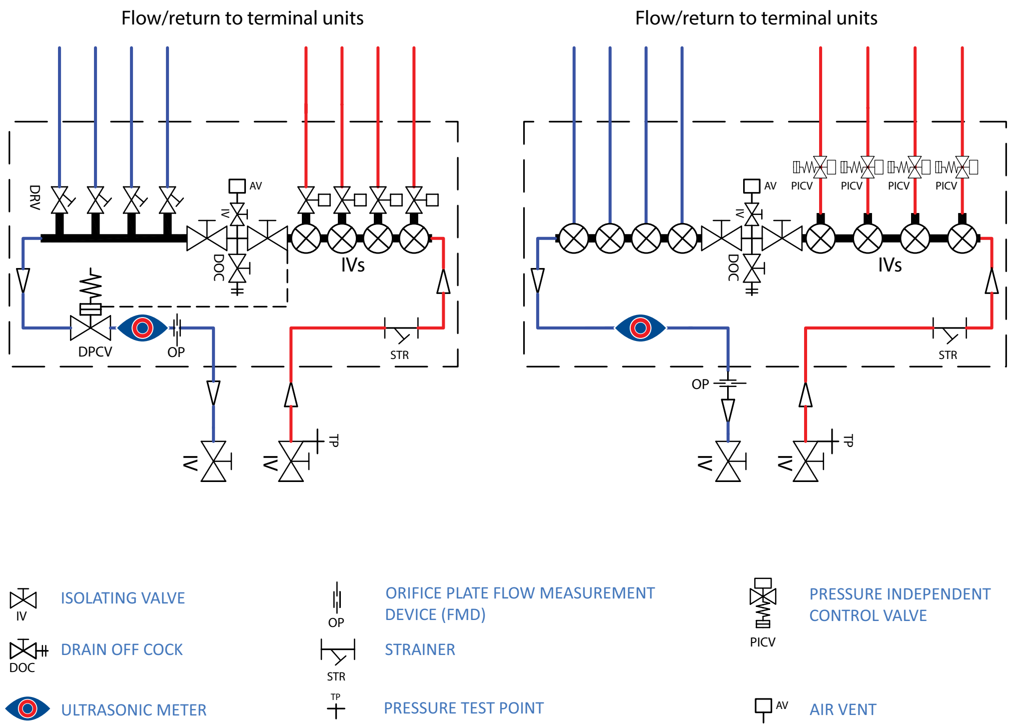


Figure 3a: DPCV valve module

Figure 3b: PICV valve module

3.1 Flexible pipe

Modular systems necessitate the use of a flexible pipe that can be laid in single lengths between the modules and terminal units. It is not recommended that rigid pipes are used to connect between modules and terminal units.

To comfortably handle the temperatures and pressures in heating and chilled water systems in all buildings, flexible multi-layer pipe should be the main choice. Figure 4 shows the typical construction of a multi-layer pipe.

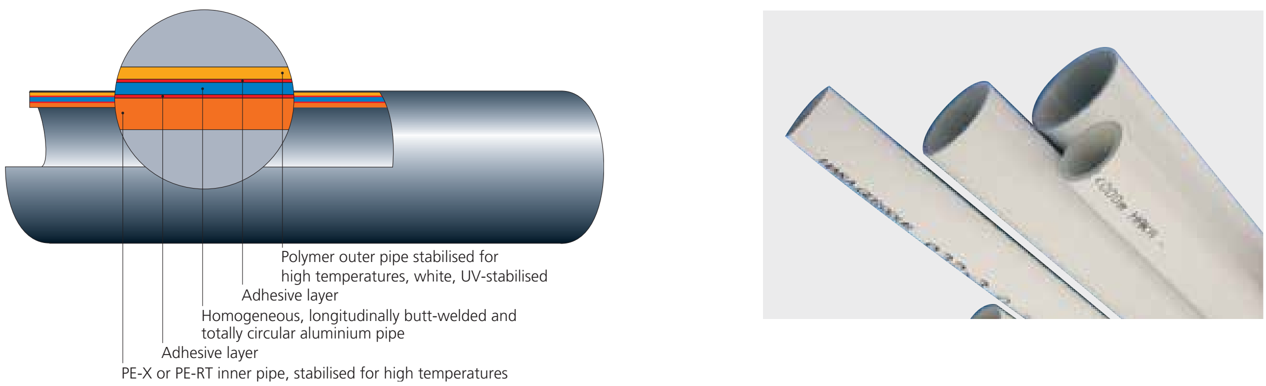


Figure 4: Multilayer pipe cross section

The pipe consists of 3 layers. An internal butt welded aluminium pipe is sandwiched between two layers of PE-RT (polyethylene of raised temperature resistance).

The aluminium layer brings many benefits relative to plastic pipes:

- **Higher strength:** The aluminium layer in multilayer pipe gives it a pressure rating of 10bar, equivalent to that of many metal pipe components making it suitable for multi-storey buildings with high static pressures. Plastics have less tensile strength than metals. Consequently, their pressure ratings are usually much lower.
- **More temperature resistant:** The aluminium layer in multilayer pipe enables it to withstand higher temperatures without degradation (up to 85°C). The pressure ratings and life expectancies of plastic pipes reduce significantly when operated at higher temperatures.
- **Less expansion:** Multilayer pipe will expand at about 22.2×10^{-6}m/mK. This value is close enough to the expansion coefficient of copper (16.6×10^{-6}m/mK) that the pipe can be supported at similar intervals. Plastic pipes have a larger coefficient of expansion (approx. 200×10^{-6}m/mK) meaning that some pipe distortion has to be accepted or special mounting provisions are required.
- **Zero oxygen diffusion:** The aluminium layer in multilayer pipe prevents oxygen diffusion completely. Pure plastic pipes, even those with anti-diffusion barriers, will permit gradual diffusion of oxygen into the water potentially causing corrosion of steel components.
- **No sagging:** Multilayer is flexible in that it can be bent by hand or with a bending tool. However, unlike flexible plastic pipes, it holds its shape after bending. This means that it will not sag between supports.

Pipe Insulation

For energy savings in heating circuits and protection from condensation in chilled water circuits, pipes and valves must be properly insulated. If insulation and a vapour seal aren't properly applied on chilled water pipes, condensate will form and water damage may occur.

Rigid pipes can be expensive to insulate due to the necessity to cut and fit multiple lengths of rigid insulation between elbows and tees. Valves and other pipeline components can also be difficult to insulate. Any solution adopted for valves has to be flexible enough to permit regular access during the pre-commission cleaning and commissioning activities.

Flexible modular solutions greatly simplify the process of pipe insulation. Flexible multilayer pipes can be supplied pre-insulated (to BS476 Class 0 fire rating) thereby avoiding the need for on-site application of insulation. The modules themselves are supplied pre-insulated i.e. in a box with an internal layer of insulating foam. The boxes are sealed to prevent vapour ingress.

Figure 5 shows insulation solutions for pipes and modules.

Figure 5: Insulation for flexible pipes and modules

3.2 Pipe fittings

On all projects it is essential that pipe fittings and their connections are 100% fool proof to avoid the risk of leaks when the system is pressurised.

SAV multilayer pipe can be supplied with a crimped jointing system. This system has the following safety features:

1. Two inspection holes ensure that the pipe has been fully inserted and is flat up against the fitting. If the pipe hasn't been fully inserted or the pipe hasn't been cut perpendicular, it will be visible through the inspection holes.
2. Two O-rings are used to seal against the pipe. Flat O-rings are used since they have less chance of catching on the edge of the pipe and dislodging or getting damaged.
3. It is obvious when the part has been crimped. Using the proper equipment, proper crimping will be achieved 100% of the time; if a part hasn't been crimped a simple visual inspection will reveal the mistake.

All fittings are tested during manufacture. Figure 6 shows typical crimped joint components.

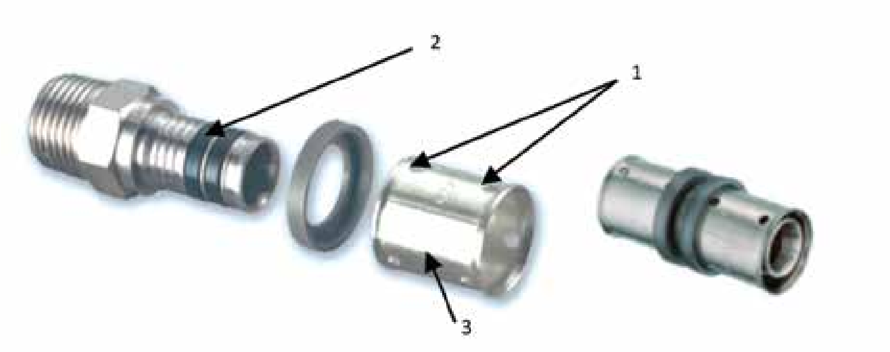


Figure 6: Exploded pipe fitting with o rings and inspection holes

3.3 Strainer

A large bodied strainer, as shown in Figure 7, is assembled into the module. The strainer has a mesh size of 0.7mm. This is sufficiently small to remove particles that might block control valves but without creating excessive resistance. Due to the size of the strainer body, a large amount of debris can be collected before any reduction in flow is experienced. Locating the strainer within the valve module allows for easy access and therefore, easier maintenance.

Figure 7: Strainer

3.4 Flushing bypass

The flushing bypass assembly, as seen in Figure 8, allows multiple functions to be performed. Using the processes outlined in section 6, the system can be fully vented, as well as forward and back flushed. Locating these valves all in one easy to reach location, decreases the time needed to fill, drain, vent and flush the system.

The assembly consists of two isolating valves, an air vent and drain port.

Figure 8: Flushing by-pass

3.5 Valves

The valve types incorporated in each module are described in the following sections.

Isolating valves (IVs)

An isolating valve is a simple valve that provides flow rate shut off but which is not suited to flow regulation.

In a typical rigid system, each terminal branch would require its own isolating valve, each of these add two additional pipe joints. In a modular design, isolating valves can be incorporated within manifolds. This significantly reduces the individual cost of the valves and also reduced the number of joints required.

Figure 9: Flow manifold with integral isolating valves

Double regulating valves (DRVs)

A double regulating valve is a regulating valve that can perform the double function of flow isolation and regulation. This double function is achieved by incorporating a locking mechanism in the handle of the regulating valve. This allows the valve to be regulated until the required flow rate is achieved and then locked in place. If the valve is subsequently closed for isolation purposes, on re-opening, the valve handle will only open as far as its locked position.

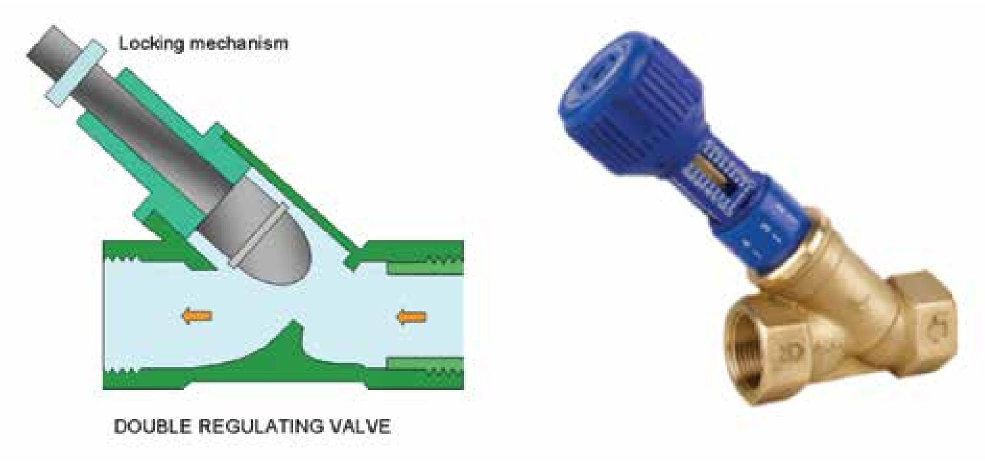


Figure 10: Double regulating valve

Orifice plate flow measurement devices (OP)

An orifice plate (or fixed orifice) flow measurement device uses the pressure differential across an orifice as an indicator of flow rate. An orifice plate is a plate with a circular opening at its centre of a diameter that is less than the internal bore of the adjoining pipe. Pressure tappings are fitted upstream and downstream of the orifice and are used to measure the pressure differential signal across the orifice.

Figure 11 shows a cross section through a flow measurement device.

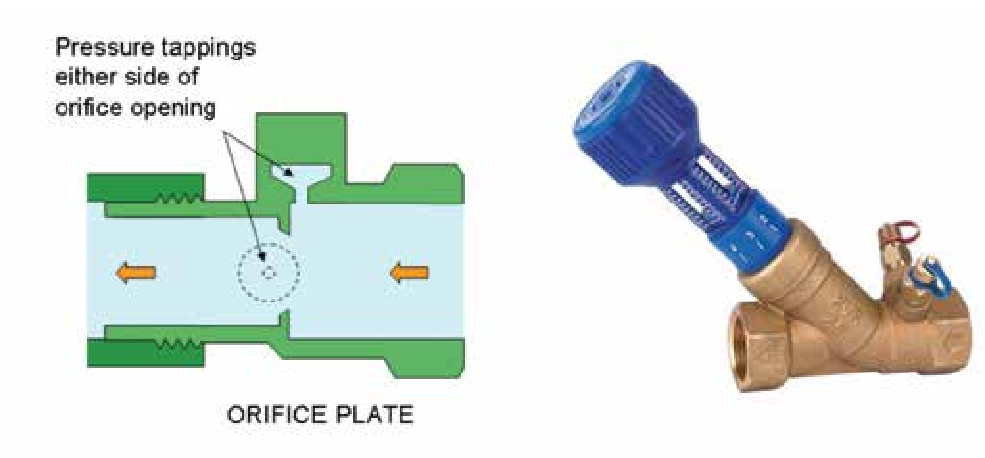


Figure 11: Orifice plate flow measurement device

Flow rate can be determined from the equation

$$Q = \frac{kv \sqrt{\Delta P}}{36}$$

Where;

Q = flow rate (l/s)

kv = device flow coefficient (provided by manufacturer)

ΔP = pressure differential signal across device

In rigid systems, it would be common to install a flow measurement device on every terminal branch. In valve modules a single flow measurement device can be provided that enables the measurement of flows in all sub-branches.

3.6 Ultrasonic meter

Installing an ultrasonic meter within the valve module creates multiple benefits. These benefits include;

- Accurate flow rate measurement
- Commissioning using the subtraction method (as explained in section 8 of this guide)
- Delta T measurement and monitoring (as explained in section 7 of this guide)
- Ongoing commissioning (as explained in section 8 of this guide)
- MID approval to allow for billing

There are various different types of energy meter that can be used. However, ultrasonic meters have many benefits including:

- High flow measurement accuracy across a range of different and varying flow rates
- Unaffected measurement accuracy when particles of debris are present
- Unlikely to be damaged when debris is flushed through the system (hence no need to remove it during flushing)
- No moving parts, so accuracy is maintained throughout the life of the meter

With the introduction of an energy meter, cost can be removed from the module to alleviate the additional cost of the energy meter. For example, individual metering stations and flow straighteners can be removed from each terminal unit line.

3.7 Control Valves

Differential pressure control valves (DPCVs)

The function of a DPCV is to maintain a constant differential pressure between two points in a pipework system that are either side of a variable resistance.

Figure 12 shows the basic design for a differential pressure control valve. The valve will automatically control a constant pressure differential between points A and B.

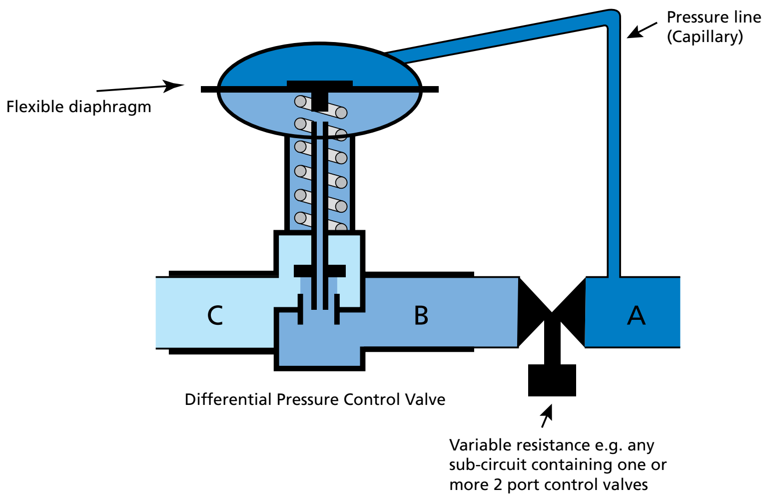


Figure 12: Differential pressure control valve

The disk shaped housing at the top of the valve contains a flexible diaphragm. A capillary tube from the flow pipe is connected to the upper side of the diaphragm whilst the lower side is exposed to pressure from the return pipe. Once the valve is set, any variation in pressure between the flow and return pipes will be sensed automatically causing the diaphragm to flex resulting in movement of the valve stem.

If the pressure available in the particular flow pipe should increase, then the differential pressure valve will close in order to take out the excess pressure. If the pressure available should reduce, then the differential pressure valve will open so that more pressure becomes available.

Similarly, if two port valves within the variable load served should begin to close, then the differential pressure valve will also begin to close in order to maintain the same overall pressure drop between flow and return pipes.

To provide accurate control of pressure, DPCVs must themselves establish some degree of authority over the circuits they control. They therefore, typically require a minimum differential pressure of 10-30kPa across them depending on the pressure loss around the circuit in which they are installed.

Pressure independent control valves (PICVs)

PICVs combine the 2 port valve and differential pressure control valve into a single body. Therefore, the valve is self-protected against excess pressures. Because the integral DPCV holds the pressure differential constant across the integral 2 port control valve, the result is that whenever the control valve is fully open, the flow rate through the valve always returns, approximately, to its set value (since a constant pressure differential across a fixed resistance results in a constant flow rate).

The opening through the 2 port control valve can be varied manually, and can therefore be used to regulate the flow rate through the valve to the required design value. A flow setting dial on the valve spindle can be used for this purpose. Once set, the valve should perform the function of a constant flow regulator (or “flow limiting valve”) whenever the 2 port control valve is fully open. Only when the control valve begins to close might the flow rate change from its set value.

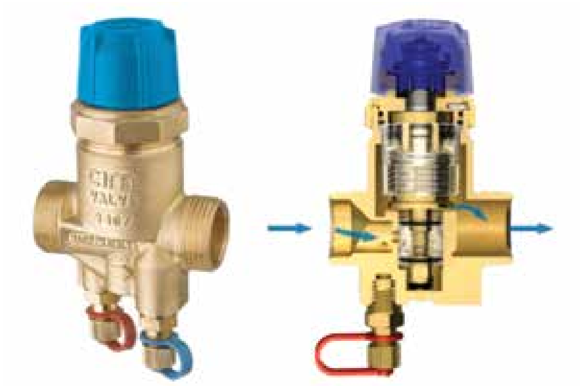


Figure 13: Pressure independent control valve

4. Module types

Valve modules can be adapted to suit all types of terminal device. For the commercial office sector serving mainly fan coil units and chilled beams, there are two main options; the DPCV module or PICV module.

4.1 DPCV module description

Figure 14 shows a DPCV module configuration.

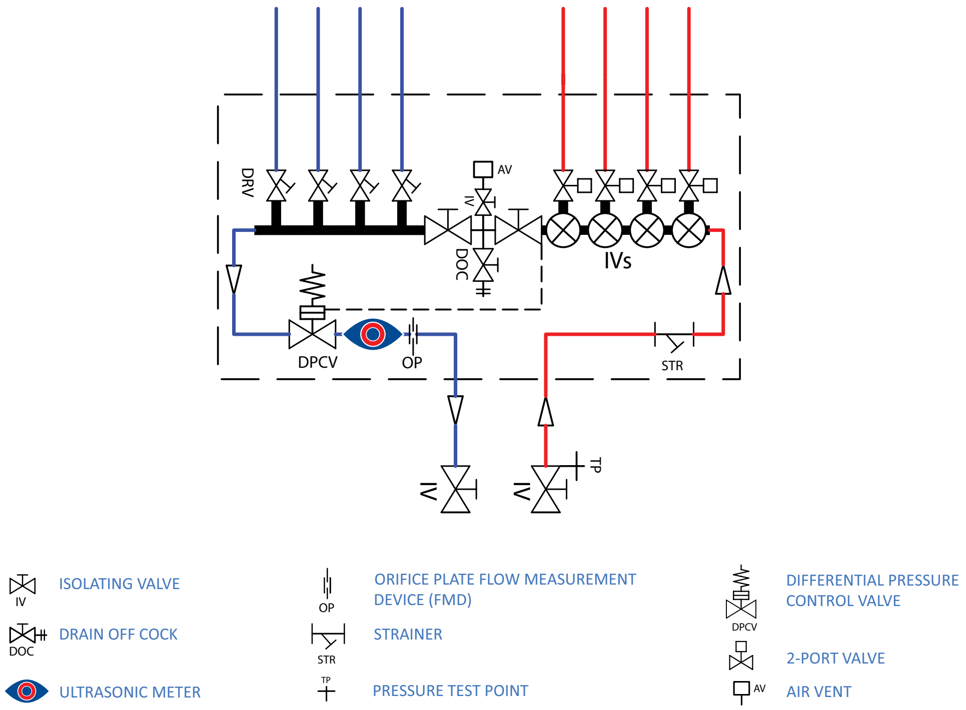


Figure 14: DPCV valve module

As the flow enters the module, a large bodied strainer removes all particles greater than 0.7mm in size. This ensures that valves with narrow clearances (such as 2 port valves and PICVs) will not become blocked during normal operation. The strainer is well placed since all of the pipes downstream of the strainer are made from non-corrosive materials i.e. brass or plastic. This means that, unlike rigid systems where steel pipes are located downstream of strainers, there is no risk of re-contaminating the water.

The flow manifold incorporates isolating valves so that individual branch circuits can be isolated. Each flow connection also incorporates a modulating 2 port control valve to provide accurate control of flow rates and hence heating or cooling outputs from terminal units.

Flow balancing is achieved by means of double regulating valves installed in the return pipes from the terminal units. Double regulating valves are installed next to each of the ports from a manifold. The regulating valves can be used for flow regulation and isolation.

The main return pipe from the module contains the DPCV. It can be seen that the capillary tube governing the DPCV is connected to the flow manifold. This means that in operation, the DPCV will maintain a constant pressure differential between the flow manifold and the DPCV inlet. Since the DPCV inlet pressure is effectively the same as the pressure in the return manifold, the result is that a constant pressure differential is maintained between the flow and return manifolds. As 2 port valves open and close or the pump varies its speed. The DPCV will respond and constantly maintain the pressure differential.

For flow measurement purposes, the main return pipe may incorporate either a standard fixed orifice type flow measurement device and/or an electronic energy meter that enables flow measurement. The energy meter option is more accurate and convenient. It also enables a number of important on-going commissioning functions as explained in section 8 of this guide.

Whichever flow measurement option is adopted, individual flows through the terminal branches can be measured using the "subtraction method" as explained in CIBSE Code W Water distribution systems. The flow through each terminal branch can be measured by closing the branch and registering the drop in flow rate through the flow measurement device.

In between the flow and return manifolds is a central arrangement designed specifically to enable the circuits to comply with the cleaning requirements recommended in BSRIA guide BG29/2012 Pre-commission cleaning of water systems. These valves would be closed under normal operation. Their use for system cleaning is explained in section 6 of this guide.

4.2 PICV module description

Figure 15 shows a PICV module configuration.

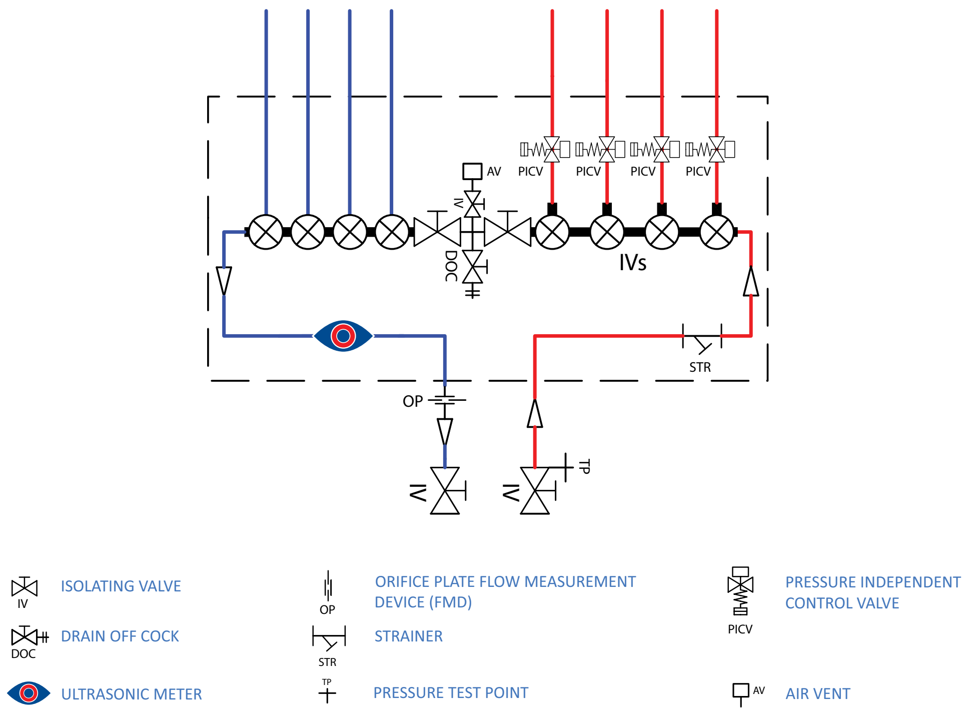


Figure 15: PICV valve module

PICV modules incorporate many of the same features as DPCV modules except that the separate DPCVs and 2 port control valves are replaced by PICVs on each terminal branch. Since PICVs incorporate 2 port control and differential pressure control, there is no need for separate valves.

5. System design

Valve modules and the terminal units they feed are effectively self-contained sub-systems. Hence, all of the components can be sized given the following information:

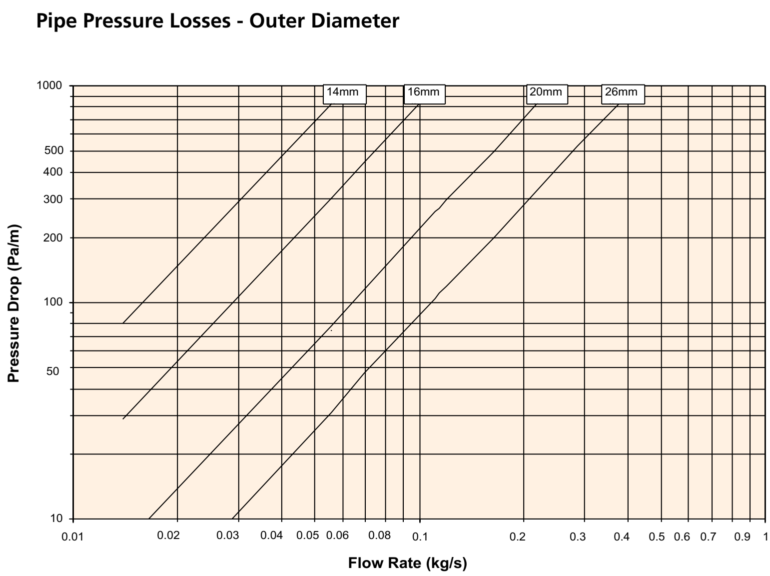
- Design flow rates for terminals served
- Design pressure losses for terminals served
- Pipe lengths between modules and terminals

The following sections explain the sizing methodology. A sizing service can be provided by SAV. Technical data can be found in Appendix A.

5.1 Pipe sizing

Figure 16 shows typical pressure loss values for multilayer pipe. It can be seen that four nominal pipe sizes are available to suit terminal branches. There are some significant differences to sizing multilayer pipe relative to copper pipe sizing.

- **Lower pressure losses:** PE-RT, the inside material, has a very smooth surface. In conjunction with replacing sharp elbow joints with smooth swept bends reduces the amount pressure drop through the pipework.
- **Higher velocities:** BSRIA and CIBSE guides recommend that to avoid erosion, small copper pipes should not be sized such that the design velocities exceed 1m/s. Multilayer pipe does not experience the same erosion issues and can therefore be sized to accommodate higher velocities (up to 3m/s).
- **Smaller pipe diameters:** Designers and installers are justifiably wary about using 8 or 10mm copper since, although flexible, it can be prone to kinking causing restrictions. Multilayer pipe with external/internal dimensions of 14/10mm and 16/12mm can be bent without kinking.
- **Less air and dirt settlement:** By select smaller multilayer pipes with larger velocities, the risks associated with air and dirt settlement in rigid 15mm copper pipes are greatly reduced.
- **Flexibility to match circuit resistances:** Circuits with significantly different design pressure losses can, to some extent, be balanced by selecting pipe lengths and diameters that equalise the pressure losses.



NB: Pressure losses are for straight pipe

Figure 16: Pressure losses through multilayer pipe

5.2 Sizing DRVs

Double regulating valves can be selected based on flow rate and/or pipe size. There is no need to calculate the design pressure differentials across the valves, as would be the case in a rigid system. The manifold arrangement inside valve modules ensures that the resistances of each circuit served are within the balancing limits of the regulating valves.

5.3 Sizing PICVs

Because PICVs incorporate their own differential pressure control, they can be selected based on flow rate regardless of the system in which they are installed. Hence, these are much easier to size than 2 port control valves.

However, their use may not always be appropriate. In systems with ultra-low design flow rates (i.e less than 0.012l/s) PICVs may struggle to give accurate control. Furthermore, some PICVs may not give very accurate equal percentage characteristic at such low flows. An equal percentage control characteristic is essential for accurate control over heating and cooling output from forced convection terminal devices.

These considerations will influence the decision whether to use DPCV modules or PICV modules. In general, DPCV modules can achieve better modulating control over flow through terminal units at low flow rates.

In order to control accurately, each PICV must be sized such that it can achieve some degree of control authority across the circuits it is controlling. Therefore, the valve itself typically requires a minimum pressure drop of 10-15kPa across its ports. Without this it would not be able to maintain accurate control of the pressure differential across its integral 2 port valve.

The PICVs used in the PICV valve module are designed to control against a maximum pressure differential of up to 4bar without noise. This means that even if pump pressure of up to 4 bar were imposed across the module, the valve would continue to function holding flows to terminal units at their required values.

5.4 Sizing DPCVs and 2 port control valves

In order for modulating 2 port control valves to achieve accurate control over the flow rate through terminal units, the valves must be sized to achieve a good authority - typically greater than 0.25. Valve authority can be defined as the ratio of the fully open control valve pressure loss to the pressure loss in the circuit through which flow is controlled.

In a rigid system, the controlled circuit is effectively all of the pipework back to the nearest DPCV controlled pressure differential. This means that the sizing of a 2 port valve is dependent on the location of the DPCV. Hence, some re-routing of pipework may be necessary to ensure that DPCVs and 2 port valve are correctly located. (NB BSRIA Guide 51/2014 *Selection of control valves in variable flow systems* explains the sizing of 2 port valves for rigid systems).

Valve modules simplify the selection of 2 port control valves by providing a DPCV within the module itself that controls the pressure differential across flow and return manifolds (and hence terminal branches) to a fixed pre-set value. Hence, 2 port valves can be sized relative to the pressure losses across pipes and terminal devices in the same branches.

The DPCVs used in the Valve Module are pre-set to control at fixed differential pressure settings. The pressure settings available are 20kPa, 30kPa, 50kPa and 70kPa. The setting of a particular valve can easily be changed between these values simply by changing the internal spring within the valve, although if sized correctly, this should not be necessary.

In order to control accurately, each DPCV must be sized such that it can achieve some degree of control authority across the circuits it is controlling. Therefore, the valve itself typically requires a minimum pressure drop of 10-15kPa across its ports. Without this it would not be able to maintain accurate control of the pressure differential between the manifolds.

Hence, if a valve is selected with a differential pressure setting of 20kPa, then the pressure drop required across the entire Valve Module is likely to be 30-35kPa. Similarly, if the valve is selected to control 30kPa, then the pressure drop across the entire Valve Module is likely to be 40-45kPa etc.

The DPCVs in the DPCV valve module are designed to control against a maximum pressure differential of up to 12bar without noise. This means that even if pump pressure of up to 12 bar were imposed across the module, the valve would continue to function holding flows to terminal units at their required values.

5.5 Pump speed control

BSRIA guide BG12/2011 *Energy efficient pumping systems* recommend that to minimise pump energy consumption, pump speed should be controlled such the pressure differential across the most remote differential pressure controlled sub-branch is maintained constant. (Multiple sensors might be required if the system load pattern suggest that the index branch could move.)

In a pipe system containing valve modules the most remote differential pressure controlled sub-branch will occur at the module located furthest from the pump. Hence, a differential pressure sensor should be located across the flow and return pipes feeding to the most remote module, and pump speed should be controlled to hold this value constant. The set-point value for the sensor should be the combined pressure losses of all module components plus pipes and terminal units.

5.6 DPCV or PICV module?

The decision to go with a DPCV or PICV module will depend on project circumstances.

The PICV module will generally be cheaper, easier to use and modify. However, DPCV modules can give better control especially at low flows and are better able to cope in systems with high pump pressures (up to 12bar).

Table 1 provides a summary of the relative merits of each option.

DPCV modules	PICV modules
Harder implementation of change and churn	Easier implementation of Change and Churn
Better control at low ultra -low flow rates	May not control well at low flows (<0.012l/s)
More likely to give flow repeatability	Flow repeatability may not be as good
Can cope with up to 12 bar differential pressure	Can cope with 4 bar differential pressure
Individual branch flows need regulating	Flows can simply be set at the valves
More measurement points for trouble-shooting	Fewer measurement points

Table 1: Relative merits of DPCV modules versus PICV modules

When changing a system layout (Change and churn) certain procedures are needed to ensure the correct parts and commissioning has taken place to give the correct flow to the new terminal unit. Comparing the two modules, with what is needed if a terminal unit is added to the module.

DPCV modules require a specific commissioning set related to the terminal unit demands, but also the DPCV differential pressure affects the type of commissioning set. Should the flow rate differ greatly from the other terminal units on the module then issues can occur when trying to maintain a greater than a 0.25 valve authority.

When change and churn is implemented within a PICV module, only a new PICV is installed and the desired flow rate selected. Re-commissioning will be easier and quicker.

The differing accuracy and repeatability of the two options becomes more noticeable at very low flow rates.

PICVs typically provide acceptable control of flow rates down to around 0.012l/s. In some highly insulated modern buildings, designed for large flow/return delta T values, specified design flow rates may fall below this value. In these cases, (and following the guidance in CIBSE Code W), the designer should design for these reduced values rather than increase them to the minimum that can be controlled by a PICV.

In such cases, DPCV modules usually provide more accurate control. High resistance (low kv) 2 port control valves can be selected to provide modulating control when closed against a pressure differential of 20kPa held constant by the DPCV.

Furthermore, the repeatability of flows controlled by DPCV modules are usually better than those controlled by PICV modules. Both devices utilise a rubber diaphragm pressing against a spring to control flow. The positioning of a spring at a given pressure condition is never perfectly repeatable since all springs experience some inertia and also hysteresis. The resulting variations in repeatability are more likely to be noticeable when using PICVs with smaller springs than DPCVs in which the springs are larger.

In order to monitor very low flows effectively as combination of a DPCV and ultrasonic meter is required. Due to the capability of the DPCV to give the lower flows, the ability to measure this flow is crucial. Using an orifice plate the lowest flow that can be measured is 0.015l/s. Therefore, the subtraction measure is needed (explained in section 7)

6. Pre-commission cleaning

Compared to rigid systems, valve modules can reduce the number of valve locations by up to 75% (assuming each module serves, on average 4 terminal units). This means the pre-commission cleaning specialists have significantly fewer locations to visit. This largely explains the finding reported in the BSRIA Commissioning Module Study:

> *"The flushing of fan coil unit circuits in an office layout that incorporates valve modules can be undertaken in 23% of the time it would take to flush fan coil units in a tradition rigid pipework system."*

6.1 Flushing through a DPCV valve module

BSRIA guide BG29/2012 requires that the main distribution pipes are flushed, cleaned and dosed before flushing through individual terminal branches with potentially sensitive control valves. Valve modules facilitate this process by the inclusion of centralised flushing by-passes and drains.

The flushing procedure for DPCV modules is as follows:

1. With all terminal branches isolated, open the central flushing valves in the module and back-flush through the DPCV (Figure 17a).
2. For each terminal branch forward flush through the branch and out through the central drain (Figure 17b).
3. Repeat the flush through each terminal branch this time in a backward direction (Figure 17c).

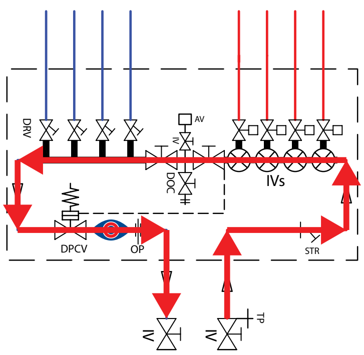


Figure 17a: Flushing through the main bypass (DPCV module)

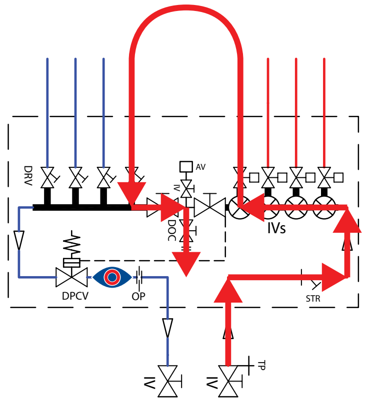


Figure 17b: Forward flush through terminals (DPCV module)

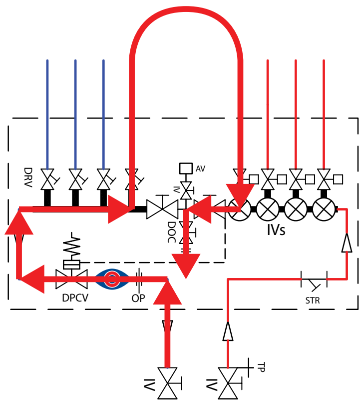


Figure 17c: Back flush through terminals (DPCV module)

6.2 Flushing through a PICV valve module

The same flushing principles apply to PICV modules as for DPCV modules. However, care is required not to contaminate the PICV with installation debris. An additional flushing drain is provided for this purpose.

The flushing procedure for PICV modules is as follows:

1. With all terminal branches isolated, open the central flushing valves in the module and back-flush through the main branch pipes (Figure 18a).
2. For each terminal branch forward flush through the branch and out through the central drain (Figure 18b).
3. Repeat the flush through each terminal branch this time in a backward direction but flushing to drain through installed drain cocks either next to the terminal unit or next to the module. (Figure 18c).

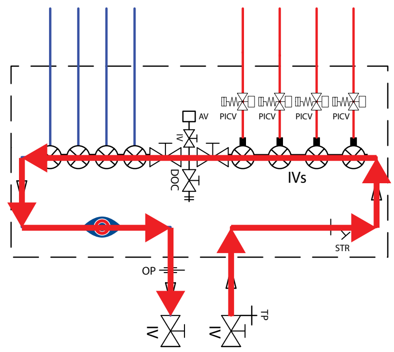


Figure 18a: Flushing through the main bypass (PICV module)

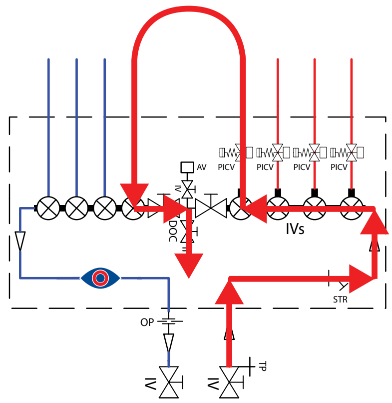


Figure 18b: Forward flush through terminals (PICV module)

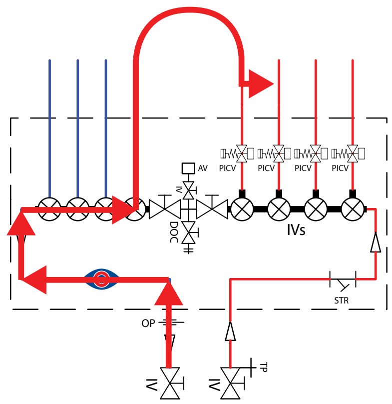


Figure 18c: Back flush through terminals (PICV module)

7. Commissioning

Compared to rigid systems, valve modules can reduce the number of valve locations by up to 75% (assuming each module serves, on average 4 terminals). This means the commissioning specialist has significantly fewer locations to visit. This largely explains the finding reported in the BSRIA Commissioning Module Study:

"The commissioning of fan coil unit terminal circuits in an office layout that incorporates valve modules can be undertaken in 44% of the time it would take to balance fan coil terminal circuits in a traditionally configured pipework system."

A further benefit of modular solutions is that there is no need for proportional balancing of individual flow rates through terminals, as would be required in a rigid layout incorporating double regulating valves.

7.1 Commissioning procedure for DPCV modules

The recommended commissioning procedure for DPCV modules is as follows:

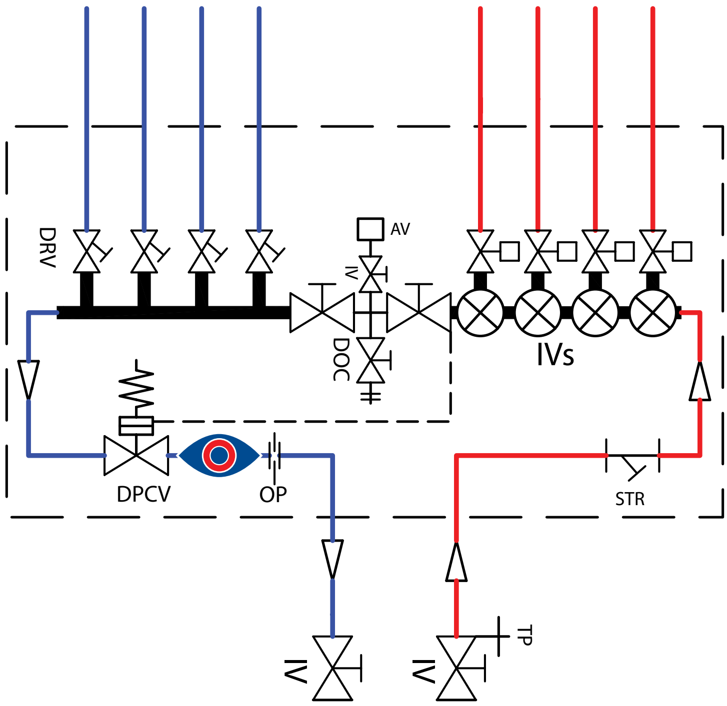


Figure 19: DPCV module (refer to section 4 for description)

1. Open all isolating valves and double regulating valves fully.
2. Manually set automatic control valves to full circuit flow. This usually involves removing the valve actuators.
3. Determine the control pressure for the DPCV (marked on the valve or module label). The value will be 20, 30, 50, or 70 kPa.
4. Measure the total pressure loss across the module flow and return pipes i.e. between the flow pipe test points (TP) and the low pressure test point in the orifice device in the return pipe. Confirm that the pressure available is greater than the DPCV control pressure plus 20kPa. Hence, for a module with a 20kPa DPCV the available pressure must be greater than 40kPa, for a module with a 30kPa DPCV the pressure must be greater than 50kPa etc. If the required pressure is not available, this may be due to insufficient pump pressure or a blockage somewhere in the connecting pipes.
6. With all valves open, measure the flow at the energy meter (or flow measurement device depending which is fitted). Close the regulating valve in the first port from the return manifold and measure the flow again. Re-open the regulating valve but only as far as is necessary for the measured flow to increase by an amount equal to the intended design flow rate for the port. (NB this is effectively the CIBSE "subtraction" method of flow measurement.)
7. Lock the regulating valve in this set position.
8. Repeat stage 6. For each of the regulating valves connected to the other ports. Note: The closure of commissioning valves should have minimal impact on already set valves since the DPCV will act to maintain a constant pressure differential across the manifolds.
11. For record purposes carry out a final scan of all ports and record the values.

7.2 Commissioning procedure for PICV modules

The recommended commissioning procedure for PICV modules is as follows:

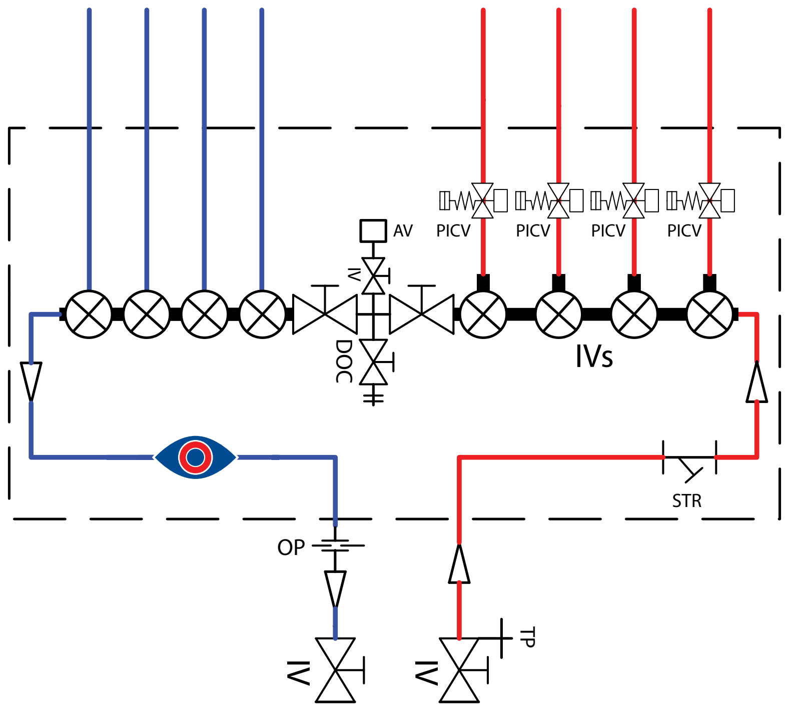


Figure 20: PICV module (refer to section 4 for description)

1. Open all isolating valves fully.
2. Remove the actuators from the PICVs to ensure that the valves are not under automatic control.
3. Using the flow setting devices inside each PICV, set the valves (in any order) to their specified design flow rates.
6. Measure the overall flow rate at the energy meter (or flow measurement device, depending on which is fitted) and check that its value is equal to the summated design flow rates through the PICVs.
7. If the measured total flow is less than the summated PICV flow rates, measure the pressure differential across the module flow and return pipes i.e. between the flow pipe test points (TP) and the low pressure test point in the orifice device in the return pipe. Check that this value is greater than the specified pressure differential for the module.
8. Confirm individual PICV flows by isolating each terminal circuit in turn and checking that the measured total flow drops by the amount set at the PICV in the isolated circuit.
9. or record purposes carry out a final scan of all ports and record the values.

8. On-going commissioning

Post occupancy ultrasonic meters can be used to enable a number of on-going commissioning functions that might form part of a “Soft Landings” framework.

These meters measure the flow rate through the module and the temperature differential across the main flow and return pipes. Values can be obtained manually at individual modules, or can be logged automatically by a BMS.

The measured data can be used for the following purposes:

- Energy monitoring and targeting: The energy consumptions for each part of the building can be monitored and logged. Any unexplained increases in energy consumption can be quickly identified and investigated.
- Occupant billing: Occupants can be billed accurately for the energy used by the terminals located in the areas they occupy.
- Temperature differential measurement (delta T): Evidence of low delta T values is often indicative of excessive (uncontrolled) flows through terminal devices resulting in poor occupant comfort and inefficient plant operation. By measuring and monitoring delta T values over prolonged periods, problems can be identified and investigated. Where necessary, set-point flow rates can be adjusted to give more efficient performance.
- Trouble-shooting: Operating problems such as fan failures or pipe circuit blockages can be easily identified from measurements of flows and operating temperatures

Figure 21 shows how the localised monitoring of temperature differential would work. It can be seen that due to the localised nature of valve modules, operating problems can be traced to the precise location within the system. This would be impossible in rigid systems.

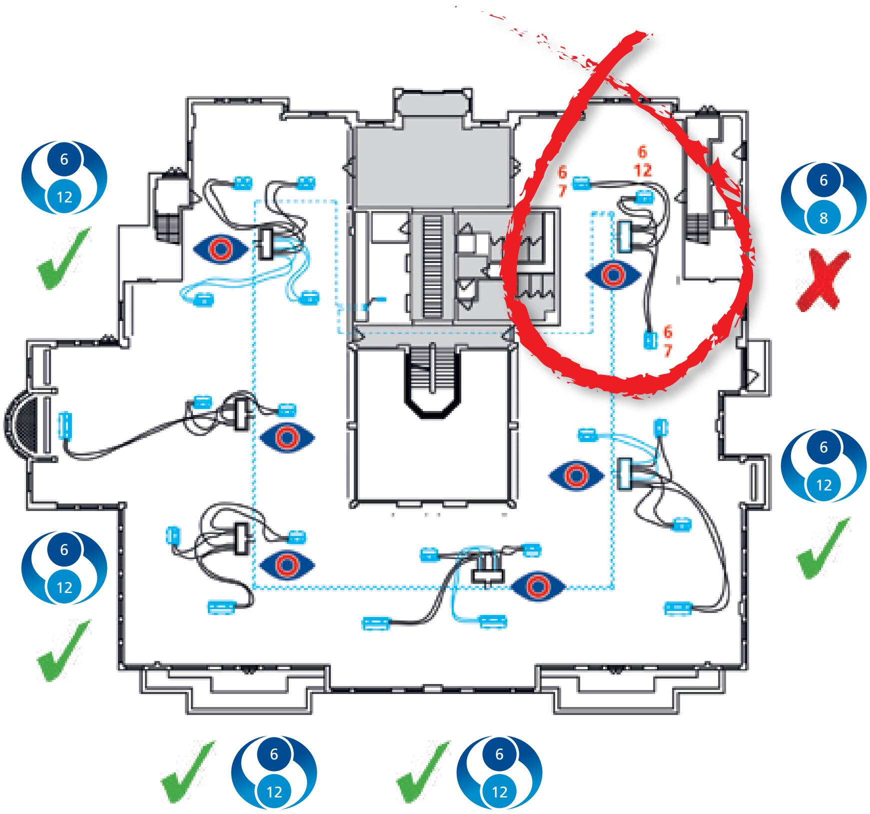


Figure 21: Delta T monitoring

Figure 22 shows a typical delta T calculation based on energy meter readings.

Reading 1
870 m^3

Reading 2
01340 m^3

Reading 1
00101 MWh

Reading 2
00120 MWh

Cubic Meter Consumption in period: 1340 – 780 = 560 m^3

Energy Consumption in period: 120 – 101 = 19 MWh

'Delta T' calculated as follows:

$$\frac{\text{MWh}}{\text{m}^3} \times 860 = \text{heating in °C}$$

The 860 is a constant, and is defined as the quantity of m^3 of water that will be heated by 1°C by 1 MWh

So in this example the 'delta T' calculation is as follows:

$$\frac{19}{560} \times 860 = 29°C$$

The average 'delta T' in this example is therefore 29°C

Figure 22: Calculation of average delta T

Where heating and chilled valve modules are located side by side, the modules can share a single junction box to enable automatic monitoring via a BMS. Each module can have its own control set points and monitoring targets. This arrangement is shown in Figure 23.

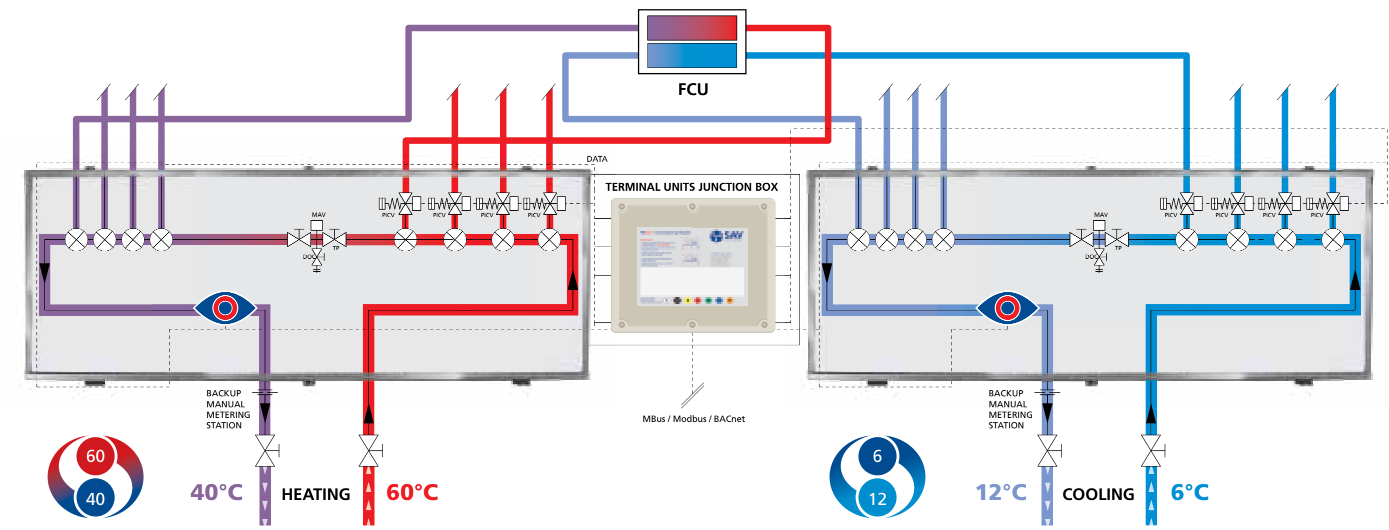


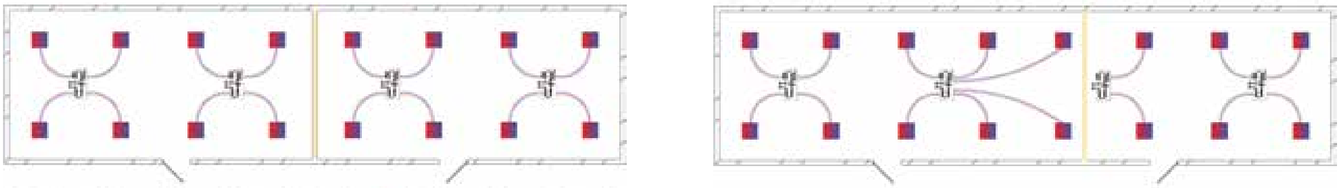
Figure 23: Typical metering and control at paired heating and chilled water modules

9. Change and Churn

The term “change and churn” is a key phrase of the soft landing approach to modern buildings. It is a recognition of the fact that modern buildings seldom retain a fixed usage pattern throughout their lives. In most cases buildings will experience change as different occupants move in with different requirements and expectations. Hence, building services systems need to be as flexible as possible to facilitate these changes.

Modular systems provide far more flexibility than rigid layouts. For example, Figure 24 shows a typical office plan incorporating two adjacent rooms with two valve modules in each and split down the middle. If the occupiers wish to move the split partition, and have the energy billing re-allocated accordingly, then valve modules greatly simplify this process.

Individual terminal units can be disconnected from their valve modules and re-piped to other nearby modules. Alternatively, modules can be provided with spare ports so that additional terminal devices can be easily connected. This represents a sigificant benefit compared to rigid systems where, to achieve the same result, would need expensive and time consuming system draining and disruptive pipework alterations.



Initial terminal unit groupings

Potential future groupings to reflect change in office zone partitioning

Figure 24: Illustration of change and churn

Appendix 1: Technical Data

Flow Capacities - Max. Working Temperature: 95°C Max. Working Pressure: 10bar

Note: Manifold ports can be adapted to receive different pipe sizes. Hence a mixture of sub-circuit sizes from the same manifold is possible.

Inlet Pipe Size mm (OD)	Maximum Flow (l/s)
20	0.29
26	0.54
32	1.12

Terminal Pipe Sizes		Maximum Flow (l/s)
mm (Outer Diameter)	mm (Internal Diameter)	
14	10	0.04
16	12	0.08
20	16	0.16
26	20	0.28

Terminal Unit Flow Equation: Q=kW/(4.2*Δt) where Q = flow in l/s, kW = Term. Unit duty in kW, Δt = difference between Flow & Return temperatures in °C

Commissioning Sets

Nom. Size	Flow Range (l/s)	Maximum balancing pressure (kPa)	kvs
15 LL	0.014 – 0.028	54200 Q^2	0.473
15 ML	0.028 – 0.055	54200 Q^2	0.976
15 SL	0.055 – 0.095	54200 Q^2	1.799
15 SS	0.095 – 0.12	2366 Q^2	1.799
20	0.12 – 0.29	1250 Q^2	4.057
25	0.21 – 0.54	1203 Q^2	7.452
32	0.46 – 1.12	284 Q^2	16.628

$\Delta P(kPa) = (Qx36/kvs)^2$ Where Q = flow kg/s,

$$Q = \frac{kvs\sqrt{\Delta P}}{36}$$

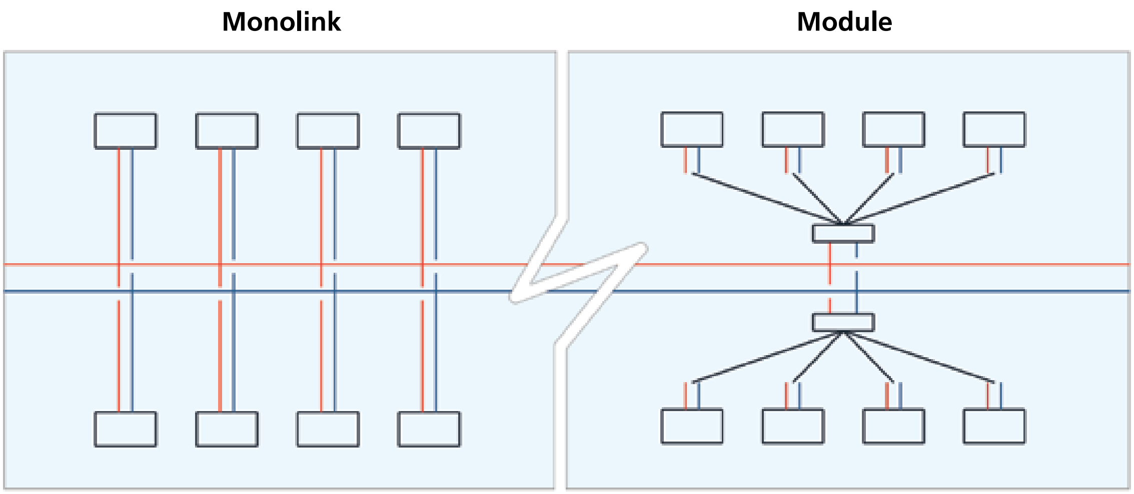
FloCon PICV Low Flow

Pressure independent control valve - PN 25 - "CR" Brass - Low Flow			
DN mm	Flow rate range		
	(l/s)	(l/h)	(GPM)
10	0.0119 - 0.0416	43 - 150	0.189 - 0.659
15	0.0240 - 0.0965	86 - 347	0.380 - 1.530

FloCon PICV High Flow

Pressure independent control valve - PN 25 - "CR" Brass - High Flow			
DN mm	Flow rate range		
	(l/s)	(l/h)	(GPM)
10	0.0240 - 0.0965	86 - 347	0.380 - 1.530
15	0.0266 - 0.1341	96 - 483	0.422 - 2.125
20	0.0500 - 0.2500	180 - 900	0.792 - 3.960
25	0.094 - 0.4720	340 - 1700	1.496 - 7.480

Appendix 2: Example Price Comparison of Monolink vs Module



Costings

Monolink

- PICVs + actuators
- 1 Energy meter
- Malleable iron Primary
- Copper pipe secondary
- T's and bends
- Drip tray
- Insulating the pipework
- Labour time

Module

- Aluflex pre-insulated pipework
- Aluflex fittings
- Insulate fittings and joints
- Malleable iron primary + T's
- Insulating malleable iron pipework
- Labour time

DN25 4 Port

Monolink

	Total	£/FCU
Materials	£3,410.09	£852.52
Labour	£515.20	£128.80
Total	£3,925.29	£981.32

Module

	Total	£/FCU
Materials	£3,097.35	£774.34
Labour	£204.00	£51.00
DPCV Total	£3,301.35	£825.34

	Total	£/FCU
Materials	£2,967.44	£741.86
Labour	£204.00	£51.00
PICV Total	£3,171.44	£792.86

DN25 7 Port

Monolink

	Total	£/FCU
Materials	£5,428.96	£775.57
Labour	£901.60	£128.80
Total	£6,330.56	£904.37

Module

	Total	£/FCU
Materials	£4,367.92	£623.99
Labour	£357.00	£51.00
DPCV Total	£4,724.92	£674.99

	Total	£/FCU
Materials	£4,195.55	£599.36
Labour	£357.00	£51.00
PICV Total	£4,552.55	£650.36

Notes

Notes

Notes

~~Combined~~ Optimised Heat and Power...

...for maximised CHP % share

EC POWER LoadTracker CHP

Lean Heat Networks

FlatStations™ - *Performance guaranteed!*

Danfoss

Designed for

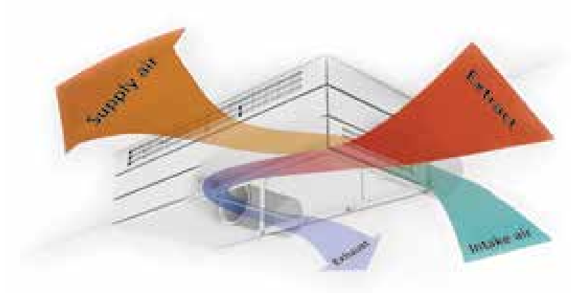
ongoing commissioning

FloCon Watchman™

Tempered Fresh Air...

...with the windows wide shut!

AIRMASTER



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