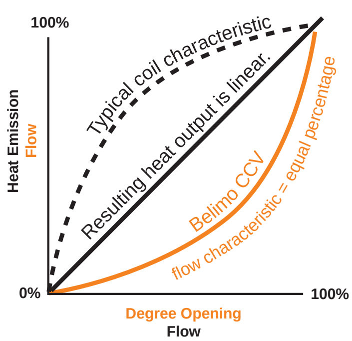
PICCV–Pressure Independent Characterized Control Valves Technology

PICCV versus conventional two-way control valves
A valve with an equal percentage characteristic has historically been used to counteract the nonlinear heat emission of the coils. The result is a linear heat emission versus the valve opening. This is a prerequisite for a stable control and a low proportional band of the control system. See Fig. 1, 2 and 3. Unfortunately this situation is only true when the pressure is held constant as the valve goes from closed to open. This is a condition that exists in a laboratory condition only.



The flow rate of a conventional two-way valve depends upon both the degree of opening and the pressure. For example: a valve that is 50% open and supplies 5 GPM at 4 PSI, will at 36 PSI, supply 15.0 GPM at the same opening.

When a conventional two-way control valve opens or closes, it causes pressure changes in the system. Often the pressure changes are quite large, and this causes a severe distortion of the valve's ability to control. When all the valves are open the differential pressure is very low, but as they close the pressure increases more and more. Eventually the full pump pressure exists over the valves. The differential pressure across the valves increases quickly as the flow is reduced. This is due to the quadratic nature of the losses in the pipe, coil and other system components. See Fig. 4, 5 and 6. These pressure changes cause a severe distortion of the valve characteristic and its ability to control in a stable manner.

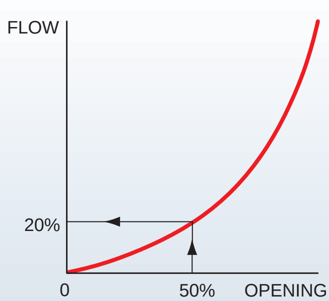


Figure 1

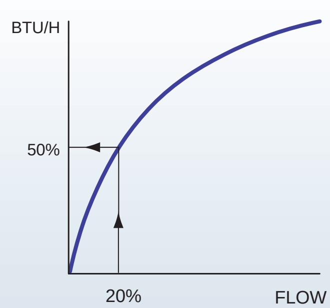


Figure 2

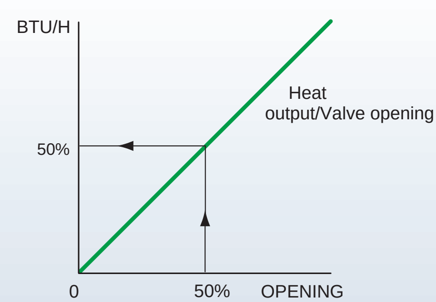


Figure 3

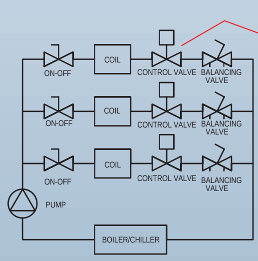


Figure 4

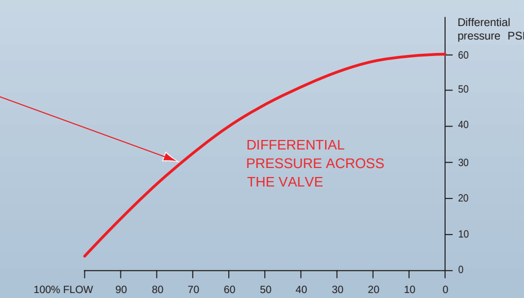


Figure 5

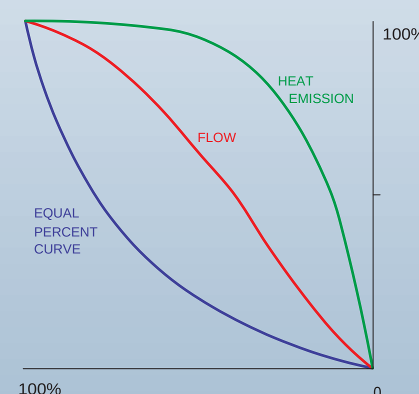


Figure 6

PICCV–Pressure Independent Characterized Control Valves Technology

The PICCV valves are used as a replacement for conventional two-way control valves, but offer a very important new feature. It will regulate the flow rate regardless of the differential pressure. In other words, it is a true flow controller.

It consists of a differential pressure regulator in series with a control valve. The differential pressure is held constant over the control valve. This is what gives a specific flow for each degree of opening, regardless of the differential pressure over the whole PICCV valve. The pressure changes before and after the PICCV valve are absorbed by the pressure regulator, so the differential pressure across the control valve remains constant.

See Fig.8 . . The flow rate of the PICCV valve depends only upon how much the actuator has opened the valve. The pressure has no importance. (Within the range of 6 – 50 PSI.)

The actuator modulates the PICCV to a required flow rate, independent of the pressure. This more stable flow means less work for the actuator, thus increasing actuator life.

Figure 7

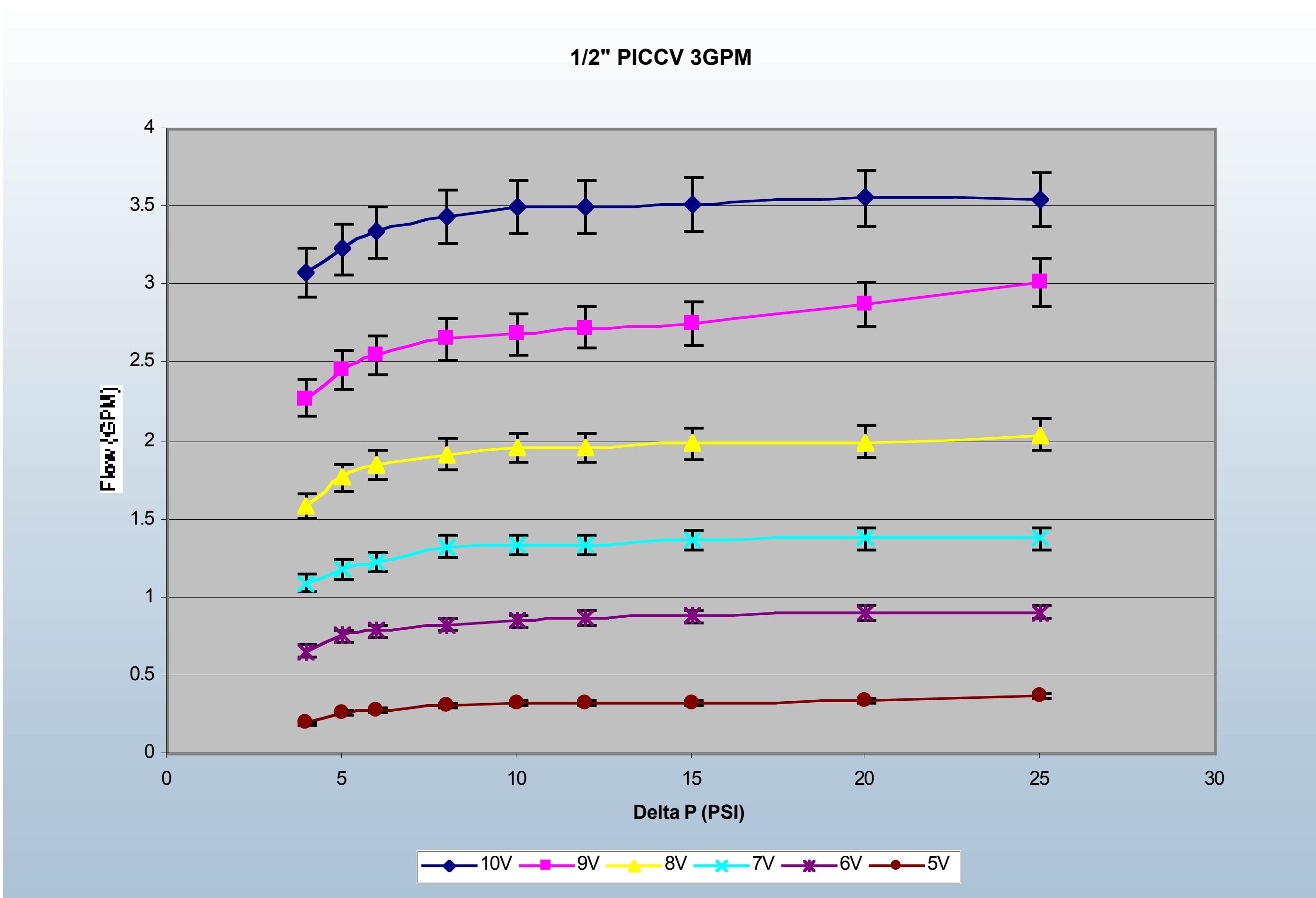


Figure 8

PICCV versus a "conventional pressure dependent" control valve

There are several factors that contribute to a conventional control valve not being able to control well in a system. They include:

Constant speed pumps

The pressure over a regular control valve can vary greatly. For example: from 4 psi at full flow, to 36 psi at 25% flow.

The pressure change a control valve is subject to when it is operated from open to closed is called "valve authority". A poor valve authority distorts the resulting flow characteristics so it is no longer equal percentage. The flow is no longer controlled gradually, but increases quite dramatically especially in the beginning.

The result is very dramatic when the flow is applied to a coil. For example, a 10% degree of opening of the valve, equals to a 15% flow, which translates to a 50% BTU output from the coil. At low loads the system most certainly will hunt. The question is not if the control system will hunt, but how small loads the system can control in a stable manner.

See Fig. 9. The PICCV on the other hand, is unaffected by any pressure changes and gives an equal percent control of the flow in the beginning and there after an essentially linear characteristics. This characteristics looks the same at low and high pressures and is unaffected by the valve authority.

See Fig. 10. The "concave" flow control matches the "convex" coil characteristics and the result is an essentially proportional output change of the heat emission- regardless of any pressure changes.

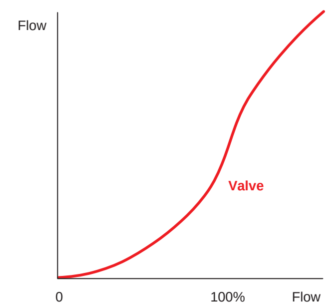


Figure 9

Equal percent valve characteristics.

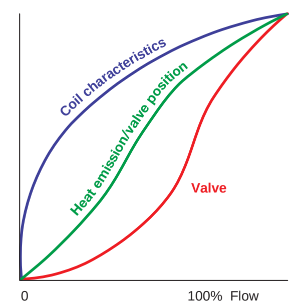


Figure 10

Combination coil and control valve characteristcs gives a linear heat/cooling output.

Variable speed pumps

Variable speed control is an improvement, but does not completely eliminate the pressure variations at the control valves.

See Fig. 11, 12 and 13. The conventional control valve located near the pressure sensor for the pump control has conditions that is favorable. The problem arises with the other valves, especially the valve as far away from the sensor as possible.

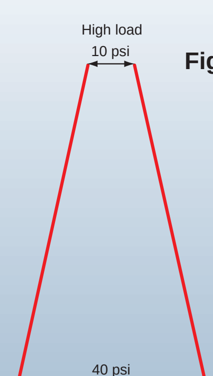


Figure 11

High load = Large pipe losses.

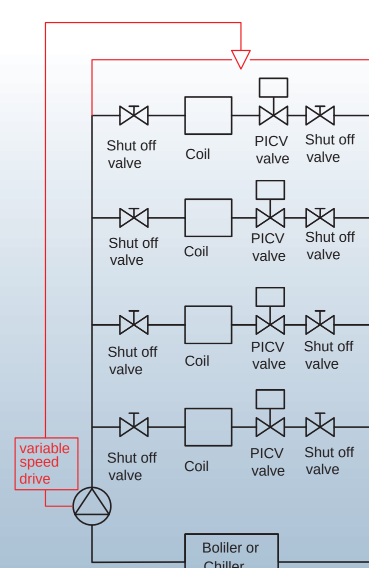


Figure 12

Figure 13

Low load = Very small pipe losses.

PICCV–Pressure Independent Characterized Control Valves Technology

Example: set point for pressure control = 10 psi. Pressure drop at full load is 30 psi between supply and return. This means that the pressure at the first valve is 30+10 = 40 psi at full load. At low loads on the other hand, the pressure approaches 10 psi, as the pipe losses goes down by the square. At full load (40 psi) we will have problem with a poor valve authority for the first valves, and at low loads (10 psi) we can not supply the full flow.

The use of the PICCV eliminates all difficulties associated with these systems.

Control Valve in Combination with a Flow Limiting Valve. Several manufacturers have a control valve built together with an automatic flow limiting valve. This must not be compared with a PICCV valve! This combination valve behaves exactly as a conventional control valve. Only when the maximum flow rate is reached, will the valve limit the flow.

See Fig. 14. It shows an example of the normal behavior of the control valve when the pressure is low.

See Fig. 15. It shows the behavior when the pressure is high and there is a call for full flow.

With conventional control valve it is next to impossible to size the control valves correctly. A high differential pressure should be used to size the valves, so that a good valve authority can be achieved. However, the caveat is that it requires a much larger pump.

The valves are typically sized for a low pressure drop at maximum load. The issue is that they normally work at a much lower load, where the pressure is much higher.

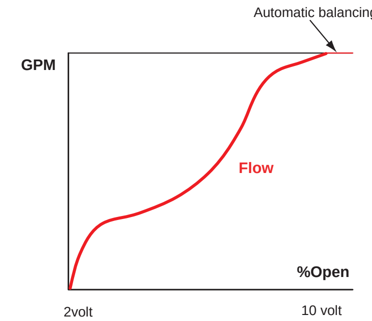


Figure 14

Varying pressure.

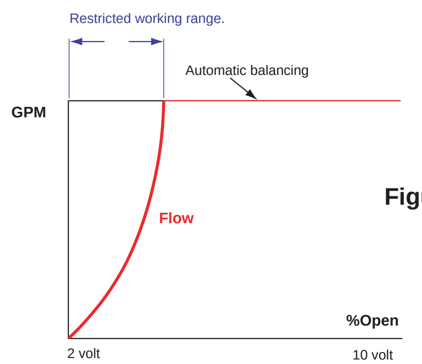


Figure 15

High pressure. The valve reaches the flow linit early so a large portion of the operating range becomes uneffective.

Figure XXX shows the operation of a combination valve as well as the PICCV. As you can see, the limiting valve acts as a conventional control valve (within its differential pressure limit of2-14 PSI) and then resumes the action of a conventional control valve with higher differential pressures.

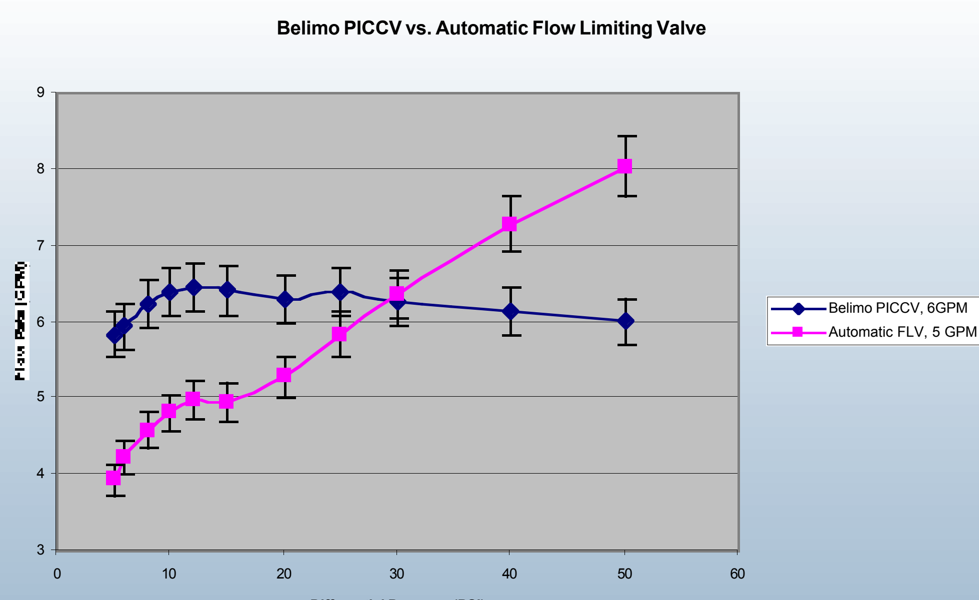


Figure XXX

Balancing Valve
The PICCV valve performs balancing of the system because the maximum flow is limited. Typically, the actuators for the PICCV will go to the maximum position during start-up. The rated maximum flow for each PICCV will be provided. When sizing the PICCV, a valve with a rated maximum flow that is equal to or just higher than the desired flow is selected. There are several ways of limiting the flow and this creates a broad range of available flow rates. Therefore, no significant overflow will result in the system during morning start up.

The average overflow will be very small. For _" valves and higher, the average overflow will be less than 15%. For _" valves, the percentage is higher, but the flow rate is so low that little effect will be seen. The overflow is estimated at less than 10% for the total installation, depending upon the mixture of valves. This overflow situation will last only for a short time during start-up.

Manual balancing valves publish an accuracy of +/-3%, but that is under special conditions, where the valves are adjusted near full open. Small balancing valves (1/2" and _") tend to be oversized versus the desired maximum flow so these balancing valves need to be turned down much, where their accuracy is lowered.
This situation compiled with a conventional valve will give more than a 10% overflow during morning start-up.

A note on Balancing Valves: Balancing valves are not needed with the PICCV and can be replaced by shut-off valves or a strainer/shut-off valve combination.

However, if manual balancing valves already are installed in the system, they can remain. Balancing valves will only limit the maximum flow when the PICCV valve is fully open, for example during morning start-up. At any time, they will not effect operation. Balancing valves, if present, should be sized after the maximum flow rate so they do not need to be turned down very much.

If desired, a main balancing valve can be installed after the pump, to regulate the maximum flow in the system, but this is optional.

Flow Measurement /Energy Management
If a proportional actuator or three-point actuator with a 2 – 10 VDC feedback is used, the signal can be used for flow measurement, which can be displayed for each terminal.

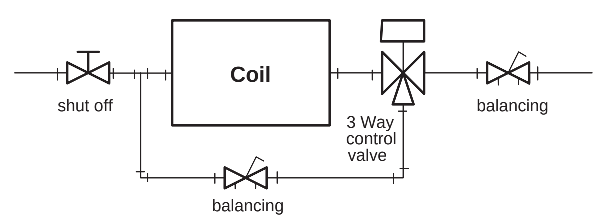
Every volt of control or feed back signal corresponds to a specific flow when a PICCV valve is used. A table in the DDC system translates volt to flow. The flow information is displayed for each terminal. The accuracy is about +/-10%.

The accuracy PICCV valve compares favorably with turbine, paddle wheel, venturi and orifice type flow meters. These could have better accuracy at full flow, but at reduced flow their accuracy is decreased. PICCV valves maintain their accuracy at reduced flows. In addition, no extra cost is involved when using the PICCV as a flow meter.

When the flow is known, it is a simple matter of measuring the temperature after each coil and one temperature in the supply. Using this differential temperature, the energy consumption can be calculated and displayed by the EMS system. By measuring the energy consumption, the cost for running each terminal or a group of terminals can be established. Therefore, the energy cost for each tenant can be established. This gives the ability to have a true energy management system, as you can measure the energy and see where and when it is consumed. This will prove to be an important feature as the cost for energy is likely to rise in the future.

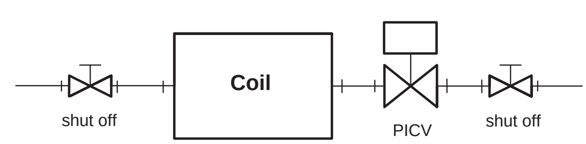
Less Complex Piping Systems
The PICCV makes it possible to use simpler and less expensive piping solutions. It eliminates bypass lines that contribute to a poor differential temperature "delta T" in the system. Instead, all the flow that leaves the chiller or boiler will pass through a coil, which will allow for a large differential temperature "delta T".

Elimination of Three-Way Valves
See Fig. 18 and 19. Instead of using three way valves, PICCV should be used, changing the system from constant flow, to a variable flow system.
All the bypasses are eliminated, improving the differential temperature "delta T" considerably. In addition, the installation cost is reduced.



Terminal with three way valve.

Figure 18



Terminal with PICV valve.

Figure 19

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Example of savings in material and installation is as follows:

To install a 3-way valve, it requires:

Item	Pieces
Shut off valve	1
Balancing valve	2
Three way valve	1
Couplings	14
Lengths of pipe	8

To install a PICCV, it requires:

Item	Pieces
Shut off valve	2 (1 piece could be shutoff valve/strainer combination)
Balancing valve	0
PICCV	1
Couplings	8
Lengths of pipe	3

As one can see, the installation costs can be reduced significantly.

Smaller Pipes
Smaller pipes can sometimes be used, because the effect of increased pipe losses can be accepted, because PICCV valves are unaffected by pressure changes.

Reset of the Supply Temperature.
Reset of the supply water temperature with respect to the outdoor temperature can be eliminated, or the reset schedule can be less aggressive. This makes it possible to mix terminals for outside zones with terminals for interior zones on the same supply line. This can result in substantial savings in the piping.

Pump Control
See Fig.16 and 17. Instead of using two large pumps, it is possible to use one large pump and one smaller pump. The large pump is used for start up situations and when the system operates under maximum load. The system switches automatically as soon as the load has gone down so much that the small pump can be used. The PICCV valves are unaffected by the sudden change in pressure. NOTE: If this is attempted with conventional control valves, you introduce a very large disturbance to the system at a time when the load is fairly large. This is not advised.

The large pump is constant speed. The small pump may have optional variable speed drives.

Example: Large pump, 50 HP @ 40 psi. Smaller pump, 5 HP @ 15 psi.

Primary/Secondary Pumping
See Fig. 20 and 21. Instead of using one main pump for the header, and then one for each riser, only one central pump is used.

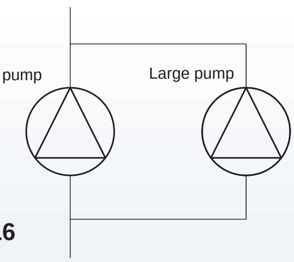


Figure 16

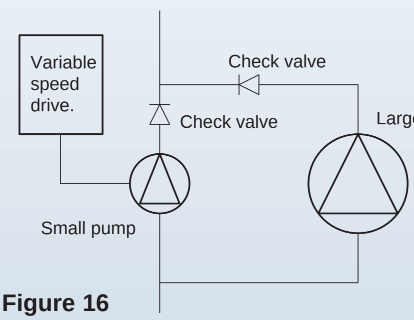
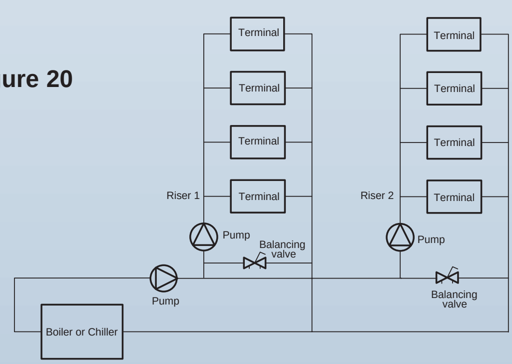


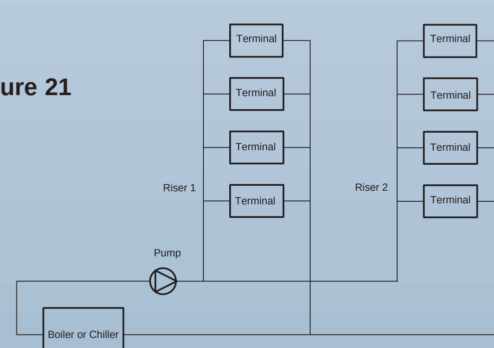
Figure 16

Figure 20



Conventional pipig arrangement.

Figure 21



Piping arrangement using only one pump.

PICCV–Pressure Independent Characterized Control Valves Technology

The bypass lines in the risers and all other bypass lines should be eliminated. This translates to improved differential temperature "delta T".

Chiller Control.
See Fig. 22 and 23. In a chiller we must maintain a certain minimum flow. Traditionally, this is done by a simple bypass line, but it results in a poor differential temperature "delta T" for the chiller, especially at light loads.

The following set up eliminates or reduces the bypass flow to a minimum, over the whole operating range of the chillers.

Suppose that three chillers are used, and the chillers can accept a flow that is reduced by a maximum of 25% (to 75% flow).

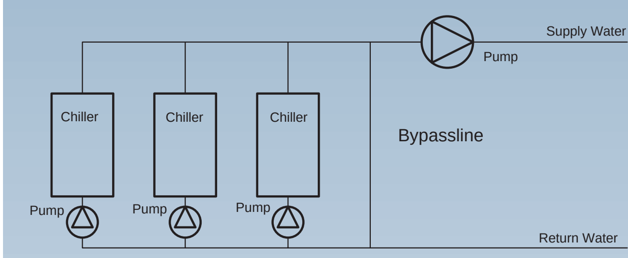
Install one flow sensor in the supply line. It sequences the chillers so the chillers are started a 1/3, 2/3 and 1/1 load.

Install a bypass line with a control valve. Install a second flow sensor between the bypass line and the chillers.

The control valve is closed between 100% - 75% flow. Between 75% - 66.7% the second flow sensor control the flow trough the control valve, and in doing so maintains a constant flow trough the three chillers.

The third chiller is switched off at 66.6%. The control valve is closed between 66.6% - 46.6%. Between 46.6% - 33.3% the control valve control the flow through the valve, and in doing so maintains a constant flow trough the two chillers.
The second (and third) chiller is switched off at 33.3%. The control valve is closed between 33.3% - 23.3%. Between 23.3% - 0% the control valve controls the flow through the valve, and in doing so maintains a constant flow through the chiller.

Certain boilers may also benefit from a similar installation.



Traditional solution results in low delta T.

Figure 22

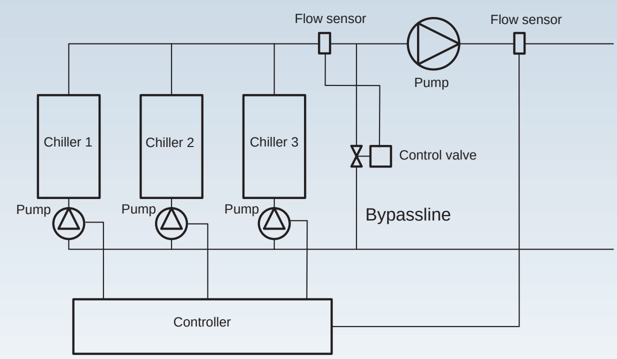


Figure 23