Low Flow
Pump Protection Strategies

In our recent article "Minimum Flow Circulation in Variable Flow Systems" we have reviewed End Of Line Relief designs that prevent the pump from operating against a closed system and maximise the energy saving potential available from well-designed variable flow system.

The related issues of dead leg and low flow pump protection are considered separate design requirements, which will be covered in this article.

The Pressure Independent Control Valve has become the most widely used valve when designing variable flow systems, delivering overall cost and energy savings.

The Pressure Independent Control Valve is used for flow balancing, differential pressure control and temperature control in variable flow heating and cooling systems, combining these 3 functions in one valve. Pressure Independent Control Valves suit a variety of primary and secondary applications including air handling units, plate heat exchangers, fan coil units and chilled beams.

The PICV Valve is typically installed at the terminal unit replacing the traditional 2 Port Control Valve, Commissioning Valve and DPCV, removing the need for additional system balancing valves and DPCVs The PICV Valve will operate effectively at all differential pressures between the minimum and maximum rating for the valve. Pump speed must be controlled to maintain a minimum pressure differential at a selected point (or points) in the system. The most energy efficient approach is to locate a differential pressure sensor across or close to the index sub-branch. When all the PICV Valves are approaching their closed positions, there needs to be a path open for flow to prevent the pump operating against a closed system. An effective end-of-line relief and low-flow-pump-protection strategy is therefore essential to prevent dead legs, poor temperature response, poor return temperature control and pipework vibration.

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Low Flow Pump Protection

Figure 1 below is an extract from the CIBSE Knowledge series showing the operating zone of a variable speed pump in a system operating at constant pressure with remote differential pressure sensing.

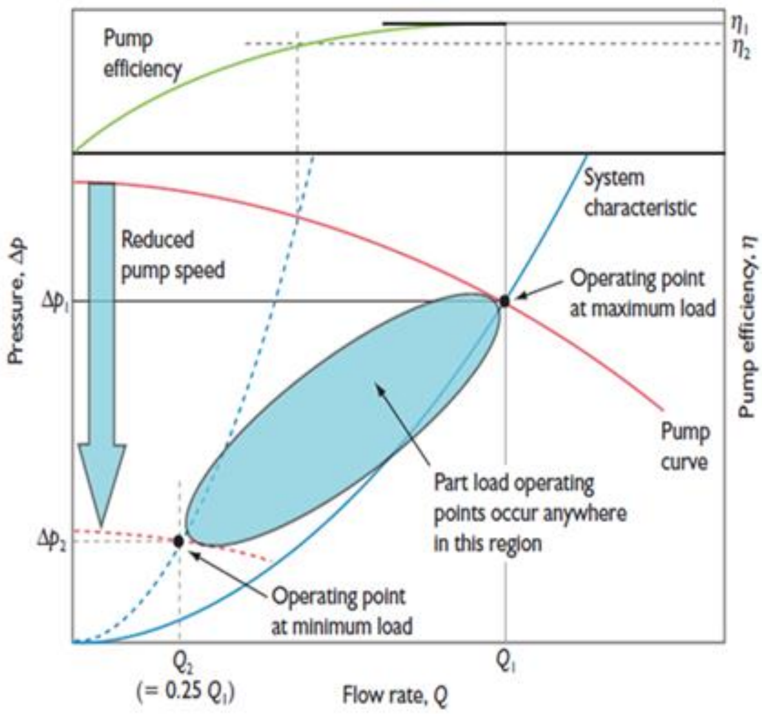

Figure 1: Operating Zone of a variable Speed Pump

The flow rate represented by Q2 in Figure 1 is the minimum turn down point for the pump which should be established from the pump manufacturer for the pump actually installed.

The system should be designed to provide sufficient pump relief volume equal to or in excess of the minimum turn down point when the majority/all of the PICV's have closed.

Failure to allow for this will result in the pump operating against a closed head, since the PICV's and CFV's which are still open, will effectively constrain the flow rate to the flow rate selected.

If the pump operates against a closed head it has been found that pulsations can be generated in the water flow which can be transmitted along the piping system.

The PICV Valve is designed to respond rapidly to changing pressure conditions within the system and can, depending on the system characteristics, start to close and open in sync with the pulsation frequency causing system vibration. If the pump selected is oversized and the system has insufficient pump relief volume the vibration can be extremely severe.

Figure 2 is a graphical representation of a typical pump and system with maximum and minimum flow rates with constant ΔP control.

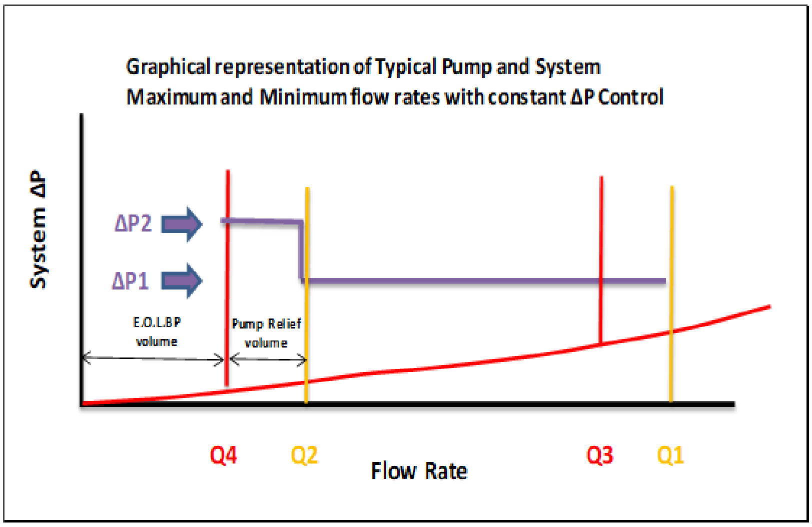

Figure 2: Typical Pump and System Flow Rates with constant ΔPControl
(Source: Dennis Taylor, Director FloControl Ltd.)

Explanation:

- Q1 is the maximum capacity of the pump installed
- Q2 is the minimum turndown for the pump installed
- Q3 is the maximum system capacity
- Q4 is the minimum system capacity
- ΔP1 is the control differential pressure selected to control the pump at constant pressure
- ΔP2 is the differential pressure setting to be used to control the pump relief volume

Whilst the pump is maintaining a fixed system ΔP and the system flow rates are between Q2 & Q3 the system is under control and working within the operating zone shown in Figure 2.

At the point the system flow rate turns down to Q2, the minimum turn down point for the pump, the flow rate from the pump becomes constant.

If the PICV's continues to close, the pump starts to operate against a closed head and the system ΔP will start to rise.

If this condition was allowed to continue, even though the system ΔP is well within the ΔP for the PICV Valve, pulsations created by the pump could cause the PICV Valve to close and open at the pulsation frequency and cause the pipework to vibrate.

To avoid this condition a “Low Flow Pump Protection Valve” and second ΔP sensor are introduced into the system, as a by-pass across the pump and the control sensor respectively, as shown in Figure 3 below.

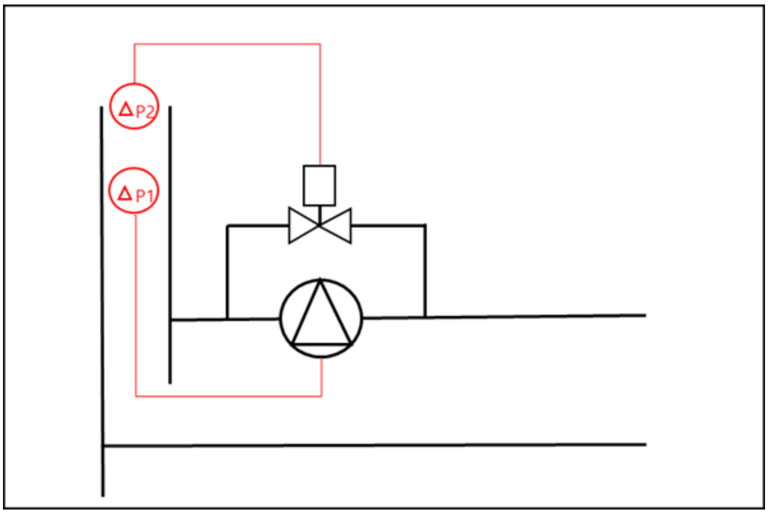

Figure 3: Low Flow Pump Protection Valve

The Low Flow Pump Protection Valve is a PICV Valve fitted with an Electric 0-10V Modulating Actuator set up to operate from the normally closed position.

The Low Flow Pump Protection Valve is sized to provide the pump relief volume capacity which is equal to the minimum pump turn down flow rate minus the cumulative End Of Line By-pass flow rate of the system.

The Low Flow Pump Protection Valve is designed to provide relief, only when the system requires it, hence it is energy efficient. The differential pressure sensor ΔP2 is set circ. 2 kPa above the pump control ΔP1 setting.

It is good practice to systematically operate the Low Flow Pump Protection Valve through full valve stroke every 24hrs to purge the system and exercise the valve. This can be achieved via the BMS or locally at the actuator by selection of the appropriate dip switch.

General system considerations:

- Install PICVs on the terminal units to provide flow, temperature and pressure control in variable flow systems with a constant flow valve (CFV) for End Of Line By–pass.
- Address the End Of Line By-pass and low flow pump protection strategies separately.

End of line by-pass strategy:

- Install an externally adjustable constant flow valve (CFV) as an End Of Line By-pass valve on each branch of terminal units to avoid dead legs, circulate chemicals and ensure good temperature response. For more detail please refer to our "Minimum Flow Circulation in Variable Flow Systems" article).
- Set the End Of Line By-pass valve to 2% of the flow rate of the branch. This flow rate should be kept to a minimum to avoid wasted energy usage.

Low flow pump protection strategy:

- Install a Low Flow Pump Protection valve, which should be a Pressure Independent Control Valve, and a secondary ΔP sensor close to the pump to avoid any water pulses and potential pipe vibration (See Figure 3).
- The Low Flow Pump Protection valve (Pressure Independent Control Valve) should be fitted with a 0-10V modulating actuator and set up to operate from the normally closed position.
- The Low Flow Pump Protection valve should be sized to provide the pump relief volume capacity which is equal to the minimum pump turn down rate minus the cumulative End Of Line By–pass flow rate of the system.

Need some help? Please call our office or book an appointment with one of our engineers.

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