Proportional Pressure Control with the Grundfos Hydro MPC

What is proportional pressure control? Proportional pressure is a control method for variable speed pumps which results in reduced pump energy costs. It is a control mode that simply reduces pump head proportionally with flow. This type of control is very common in closed system heating and cooling applications, commonly configured in Primary/Secondary or Secondary Pumping systems where the liquid is pumped to heating/cooling coils or air handling units with modulating control valves.

The Grundfos Hydro MPC system controller (CU352) can provide proportional pressure control in different ways. The simplest way is to use the inlet and outlet sensors that are factory mounted on the manifolds. The CU352 controller will simply do a subtraction to determine the differential pressure. Alternatively, a differential pressure transmitter can be factory supplied if that is desired. The pump curves (5th order polynomial) are loaded into the control as well as the power curves. The CU352 controller can then determine the approximate flow rate at any speed. As flow changes, the pump speed will be adjusted accordingly to follow the appropriate control curve. The control curve with either be proportional pressure (Linear) or Quadratic pressure (a.k.a. Squared) as shown in **Figure 1**.

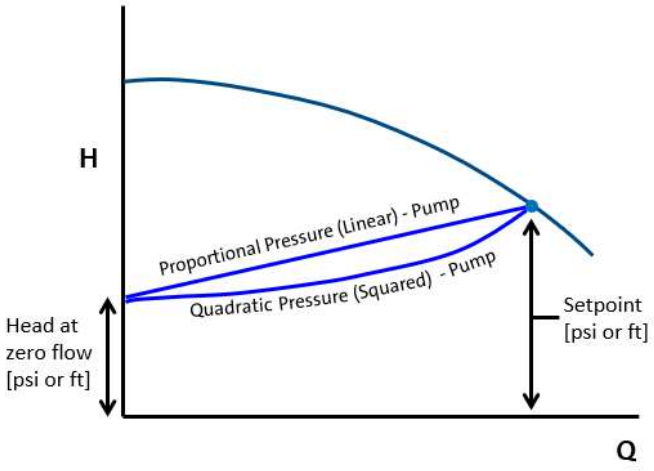


Figure 1 – Proportional Pressure

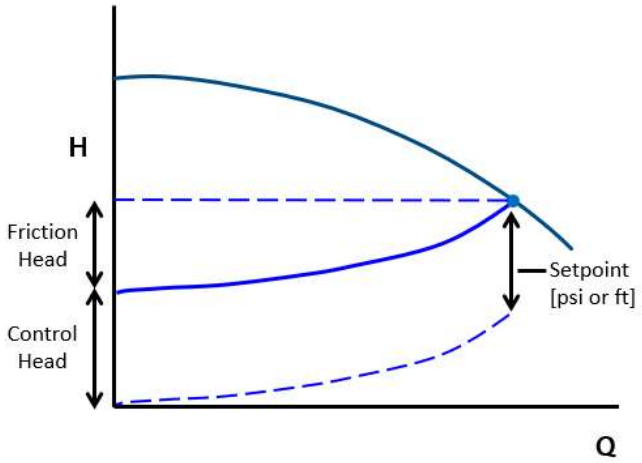


Figure 2 – Remote Diff. Pressure

To define the control curve there must be a setpoint (usually the total design head for the pump system) and a head at zero flow. For example, the design head might be 60 feet with a zero-flow head of 30 feet. As you can see in **Figure 1** the Quadratic setting will result in lower head over the operating range which will result in lower energy costs. A more common approach to controlling pumps in these systems is to install a differential pressure (dP) sensor at a remote location. This is shown in **Figure 2**. This dP sensor is often placed near the farthest coil from the pumping system (sometimes two-thirds the distance). That sensor location is used as a "worst case" scenario whereby if that differential pressure setpoint is maintained throughout the pumps duty cycle, all the other coils will have sufficient pressure to ensure proper flow. In the remote sensor case, the setpoint will be the required head to ensure sufficient flow through the coil, control valve and balancing valve. A simple system with 4 coils is shown in **Figure 3**. This setpoint is also often referred to as the Control Head. If this control head was 30 feet, and the total design head was 60 feet, the resulting control curve would be very similar to the quadratic proportional pressure curve shown in **Figure 1.** In both cases the pump head at zero flow will be 30 feet. It is therefore possible that the control curve for a remote sensor and a control curve for quadratic proportional pressure control can be one in the same.

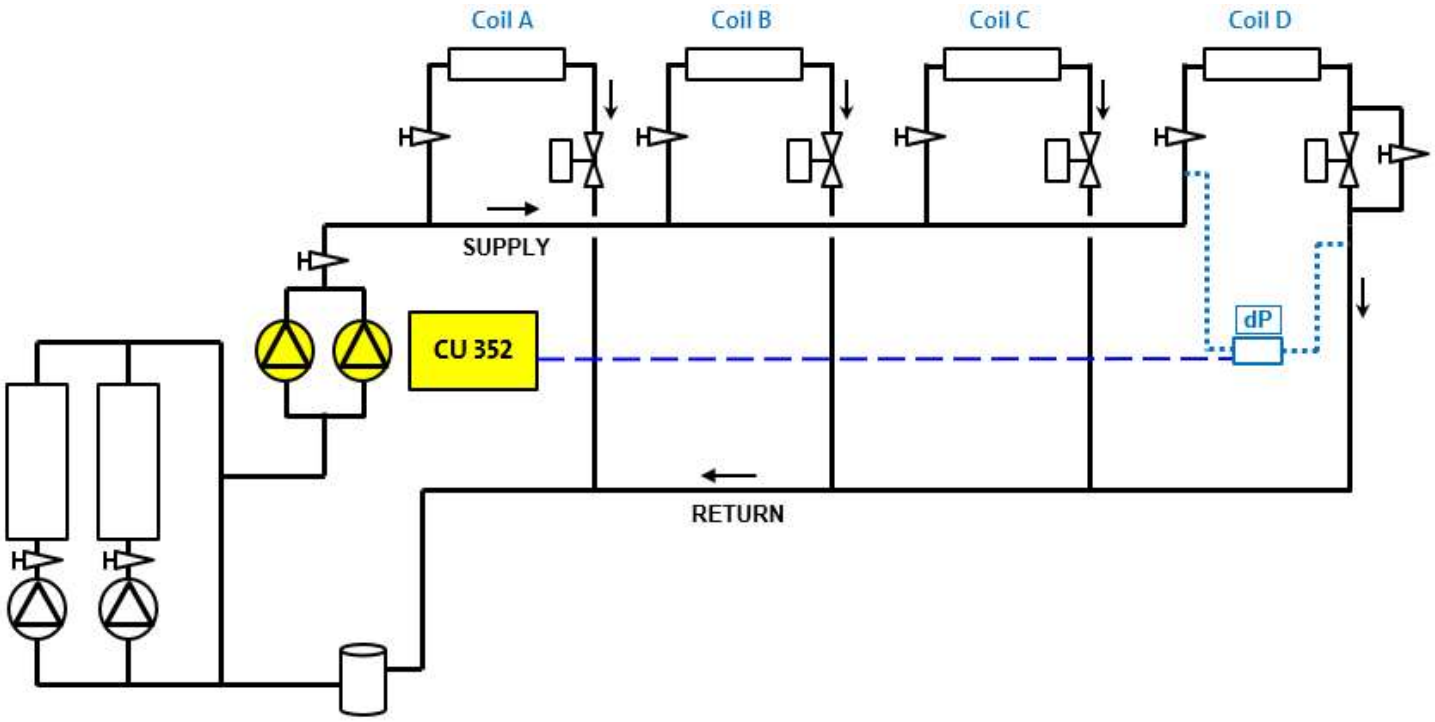
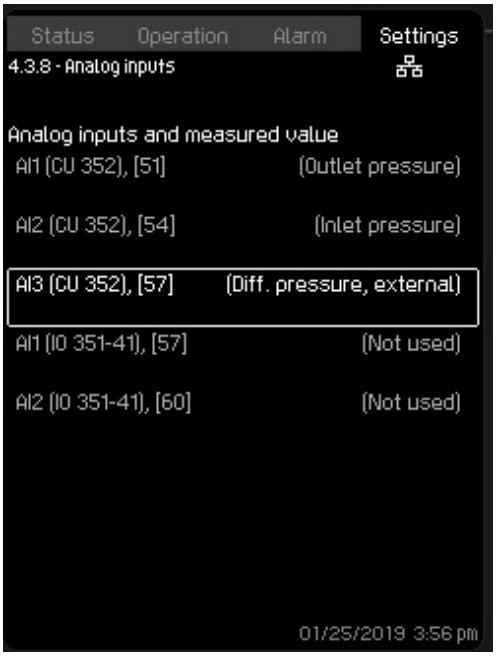
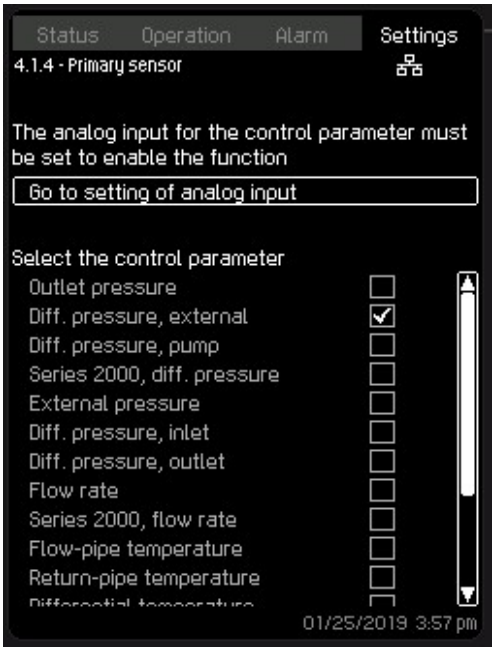


Figure 3 – Secondary piping system with 4 coils

The Grundfos Hydro MPC can be configured to do any of these control modes. If a remote dP sensor is installed, you simply configure the analog input [AI3] as a [Diff. pressure, external] with a location of [external pressure] (Grundfos' way of saying remote pressure). If the header sensors are to be used, you simply configure the Primary Sensor 4.1.4 Step 1 as [Diff. pressure, pump] and configure the outlet and inlet sensors 4.3.8 Step 2 as [Diff. pressure pump, high: *Discharge Sensor*] and [Diff. pressure pump, low: *Suction Sensor*] respectively.

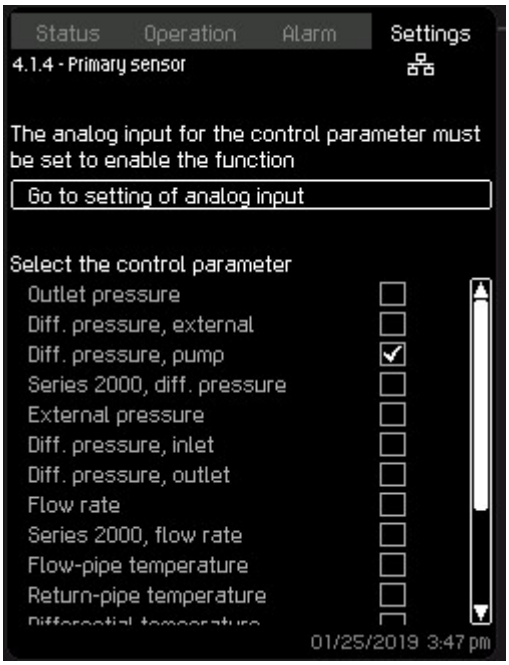


4.3.8 Settings for remote dP sensor



4.1.4 Primary Sensor - for remote sensing

***Step 1*: 4.1.4 Primary Sensor**



***Step 2*: 4.3.8.1.1 Analogs inputs**

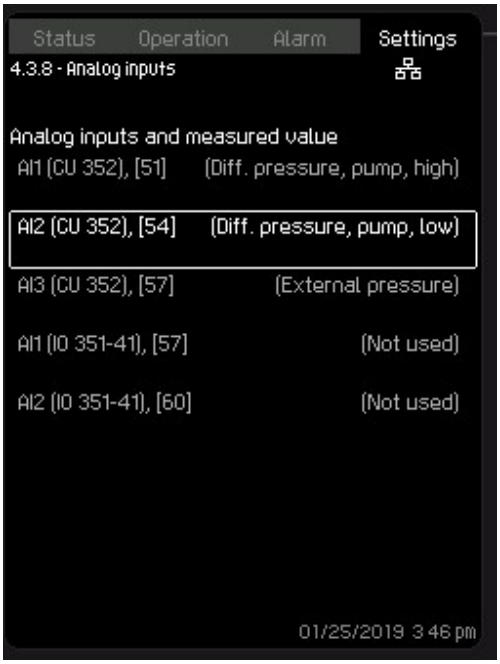
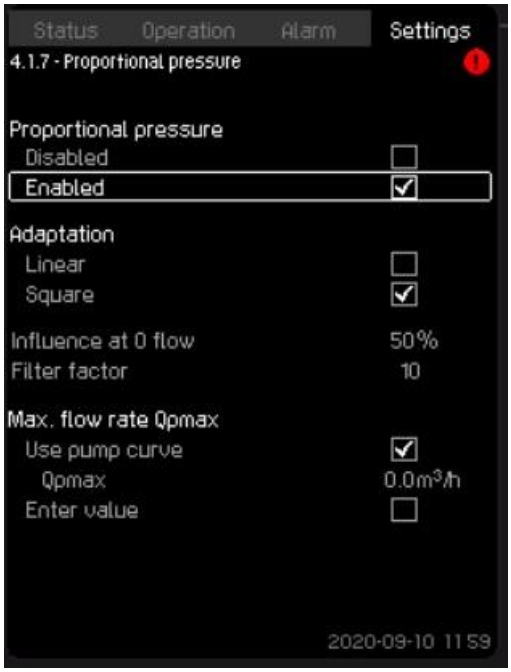


Figure 5 – Settings for Differential Pressure across the headers

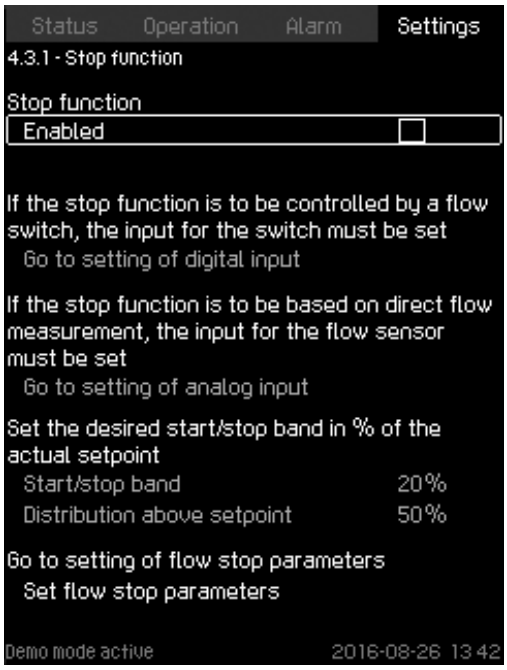
When the header sensors are used, you'll need to set up the Proportional Pressure to Enabled. You will choose Linear or Square (Square = Quadratic). The [influence at 0 flow] setting defines the control curve head at zero flow. So, for example if our total head is 60 feet and our minimum control head is 30 feet, the influence at zero flow is 30/60 or 50%. The last setting for Proportional Pressure is where you define the high flow end of the control curve. If the [Use pump curve] box is checked, the control curve will cross the full speed pump curve at 60 feet of head. If the [Enter value] box is checked, the control curve will start at 60 feet of head and the specific flow rate that is entered [Qpmax]. This allows the user to have a very well-defined control curve.



***Step 3a*: 4.1.7 Settings for Proportional Pressure - Enable Proportional Pressure**

***Step 3b*: Change Influence at 0 flow to 50%**

***Step 3c*: Max. flow rate Qpmax: Check box "Use pump curve"**



***Step 4*: 4.3.1 Disable - Stop Function Step**

***Step 5:* 4.4.1.2 Disable - Dry Run Function**

An example of this control curve (solid red) starting at 1500 gpm/60 feet is shown in **Figure 7**. The dashed control curve below would be the result of checking the [Use pump curve] box in the Proportional Pressure setting as this curve intersects the full speed pump curve at 60 feet.

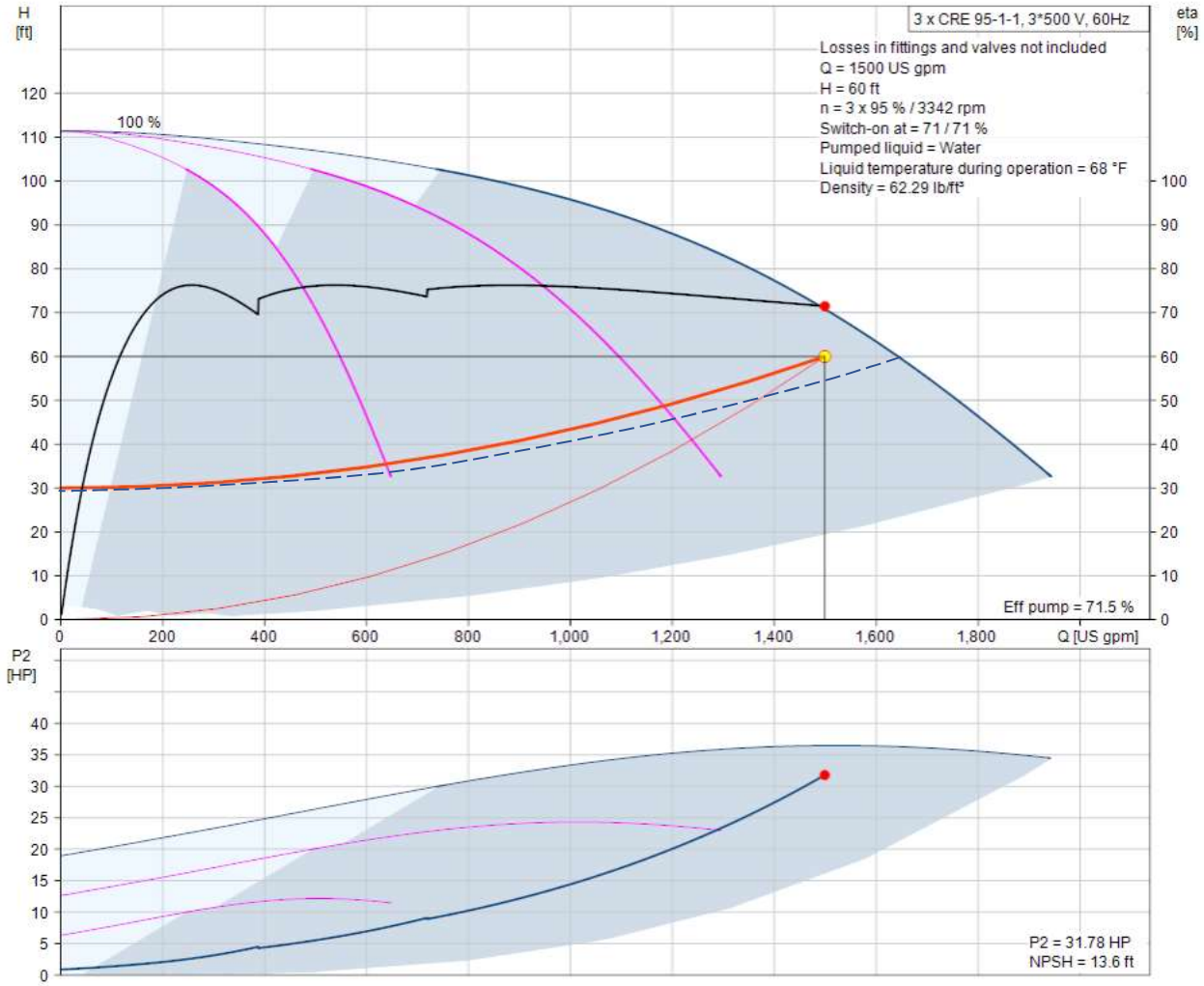


Figure 7 – Control Curve for 1500 gpm at 60 feet

What else can we learn from Figure 7?

1. This pump curve shows 3 parallel connected pumps. The control curve can be set to go across any number of pumps. For example, of one pump was a backup pump the control curve could start at 1000 gpm.
2. Pump 2 and pump 3 both start at 71% speed. Most VFD pump controls will start additional pumps based on a preset speed or frequency (95% or 58 Hz etc.). The Grundfos CU352 controller will stage pumps based on efficiency. You will notice that the efficiency drops to below 70% at around 390 gpm. With both pumps 1 & 2 in operation between 390 and 740 gpm, the pump efficiency stays between 74 and 76%. Then at 740 gpm the third pump is started, and the efficiency once again increases.

Communication to the Building Management System

Hydro MPC systems can be supplied with communication capability to a Building Management System (BMS), the most common protocols being BACnet MS/TP, BACnet IP, LON, Modbus RTU and Modbus TCP.

1. The Primary Sensor must be connected to the Hydro MPC via analog signal (4-20mA or 0-10V).

2. The system set-point can be adjusted via an analog input or through the BMS. If for example BACnet is used, the setpoint will need to be configured in percent of the feedback sensor range. If the feedback sensor is 0-145 psi and the setpoint is 13 psi for example, the setpoint from the BMS will be 8.9% (13/145 = 0.089 or 8.9%). Alternatively, the BMS can be set up to output an Analog signal of 4-20mA or 0-10 volts. The CU 352 would then be set up for an external influence that reduces the setpoint by a percentage. In this case the influence would reduce the local setpoint according to the analog input percentage. For example, if the local setpoint was 15 psi but a 13 psi setpoint was desired and the analog signal type was 4-20mA, the signal would need to be at 86.7% (13/15 = 0.867). There are 16 mA between 4 and 20 therefore the signal would need to be 86.7% of 16 added to the 4. Therefore, to achieve a 13 psi setpoint the signal would need to be 17.9 mA [(0.867 x 16) + 4 = 17.9].

Secondary Sensor

Another key feature of the CU352 is the secondary sensor. If the Primary sensor signal is lost, the Hydro MPC can revert to the header sensors until the primary sensor signal is restored. An example of this would be if the remote dP signal is lost, the header sensors will take over, maintaining a differential or proportional pressure across the pumps until the remote dP sensor signal is restored.

Note: Hot Side / Cold Side Pump Location: Start-up Wizard when selecting either Air-Conditioning or Heating need to select pump location - denote Hot side or Cold side

Heating: Boiler Pump Setup, Pumping into the boiler (Return) "Cold side" & leaving boiler (Supply) "Hot side"

Cooling: Chiller Pump Setup, Pumping into the chiller "Warm side" (Return) and pumping out of chiller "Cold side" (Supply).

Diff. pressure pump, high: Discharge Manifold Sensor

Diff. pressure pump, low: Suction Manifold Sensor