GRUNDFOS WHITE PAPER

HYDRO MPC ON-BOARD PUMP CONTROL FOR HVAC CIRCULATION

By: Reece Robinson, CBS Lead Training and Content Specialist, Grundfos USA

Introduction

Grundfos Hydro MPC packaged pump systems come standard with on-board pump controls for HVAC Circulation. The CU352 pump controller can be configured to provide a constant, proportional or quadratic differential pressure control across the pumps using the factory installed pressure sensors. This configuration allows for a simple and energy-efficient solution which can eliminate many of the start-up and control challenges associated with HVAC circulation systems.

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Remote vs Local Sensors

In an attempt to optimize energy consumption, the use of a remote differential pressure (dP) sensor is often specified for the pump system control parameter. The goal is to place the dP sensor at a location in the distribution piping that will result in the lowest pump energy consumption while at the same time provide adequate flow to each coil in the system. A simple variable-primary chilled water system with four cooling coils is shown in **Figure 1**. The differential pressure sensor is shown to be measuring across Coil C. Designers will often choose a dP sensor location that is two-thirds or three-quarters the distance between the circulation pumps and the furthest coil. This has become a “rule of thumb” method for sensor placement for many HVAC circulation systems.

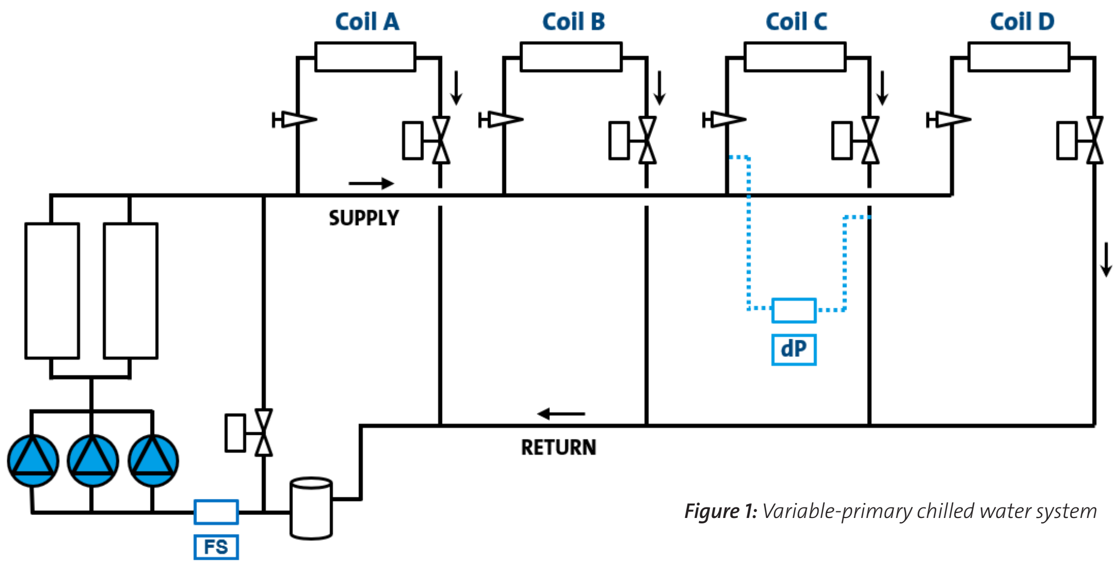

Figure 1: *Variable-primary chilled water system*

The resulting control curve for a remote differential pressure sensor is shown in **Figure 2.** By maintaining a fixed differential pressure across the remote coil, pump speed can be reduced with reducing flow since friction head is also reduced. Point A on the curve indicates the maximum, or design flow, where the total pump design head is needed. This total pump head is the differential pressure control head plus the pipe friction losses to and from the pump to the coil. As flow approaches zero (Point B), the frictional head also approaches zero, with the remaining head being the required differential head across the coil. Pump energy savings is achieved as power is reduced with reduced pump head and speed. **Figure 3** shows a control curve when pump-mounted sensors and quadratic control are used. You will notice this control curve looks very much like the one in **Figure 2** for the remote-mounted dP sensor. Whether the sensor is mounted remotely, or across the pump(s), the total pump head required is still the same. When a pump-mounted sensor is used there will be two setpoints that define the control curve — one will be the maximum (design) pump head (Point A), and the other will be the head at zero flow (Point B). The head at zero flow setpoint will be the same as the setpoint for the remote dP sensor. This illustrates it is possible to achieve the same energy savings and pump control using pump system mounted sensors.

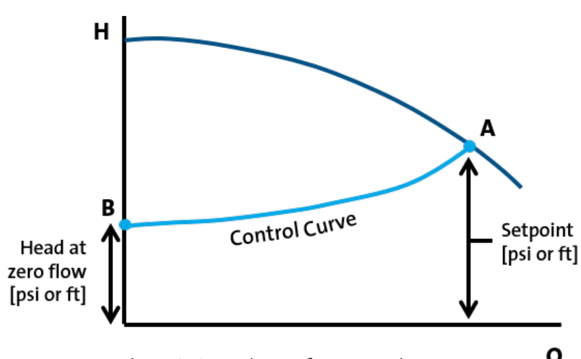

Figure 2: *Control curve for remote dP*

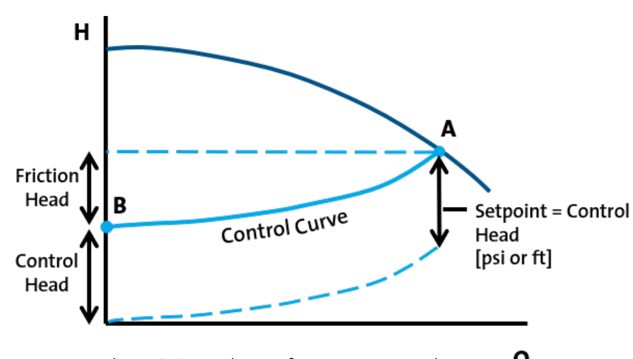

Figure 3: *Control curve for pump mounted sensor with quadratic control*

Remote Sensor Challenges

In theory the remote sensor method should result in the greatest energy savings while providing sufficient pressure to each coil to ensure proper flow. This requires some additional calculations to determine which coil circuit has the greatest pressure drop. For example, if coil B had the greatest pressure drop, the sensor would be placed across that coil instead of coil C.

The challenge comes when theory is put into practice. The reality is what is put down on paper isn't always what is installed at the jobsite. Many projects show the intent of using remote sensors, but often times the sensor locations are not indicated on the construction documents. The two-thirds or three-quarters rule is frequently deployed with little or no success, as those sensor locations turn out to be suboptimal. Grundfos distributors encounter these challenges on a regular basis, and the good news is we have a solution — the Hydro MPC packaged pump system.

Quadratic Pressure Control with Hydro MPC

As shown in **Figures 2** and **3,** a control curve with system-mounted sensors can match that of a remote-mounted sensor. The CU352 controller that is supplied with every Grundfos Hydro MPC system has this capability. **Figure 4** shows the settings needed to configure the system for differential pressure control across the pumps. Hydro MPC systems are supplied with suction and discharge sensors that can be configured for differential pressure control. This system is set up for a maximum flow of 1,700 gpm, with a total pump head of 80 feet and a control head of 40 feet; this is shown for a three pump system in **Figure 5** and **Figure 6.** The control head of 40 feet represents the control head that would have been set for the remote dP sensor.

As an added bonus, which is normally not provided in most installations, the sensor on the suction side can also be configured as a low-suction pressure warning and/or pump stop. This gives an added level of pump protection for Hydro MPC systems.

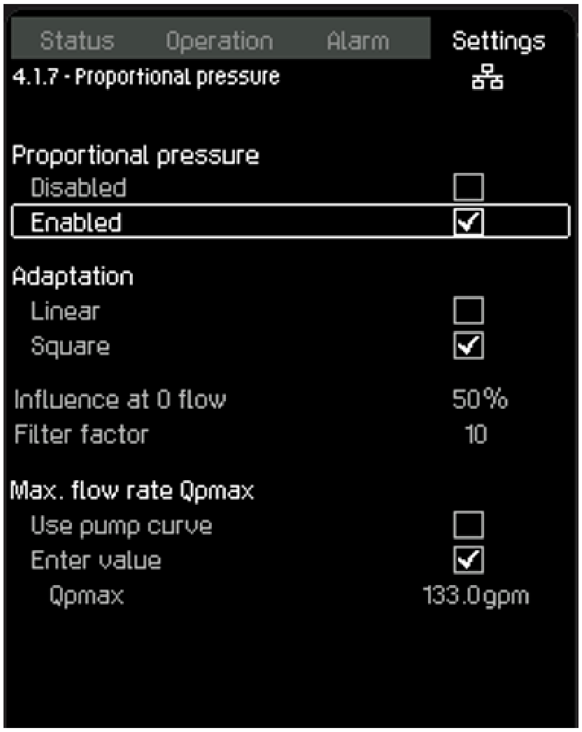

Figure 4: *Proportional & quadratic control settings for CU352*

Setpoint and Control Head Adjustments

Once the system has been commissioned, the system differential pressure setpoint and the control head can be changed either on the control interface itself, or through the Building Management System (BMS). Optimal energy consumption can be achieved by adjusting the setpoints down until insufficient cooling or heating is noticed.

Optimized Energy Consumption through Efficiency Based Cascade Control

The CU352 will control pumps based on efficiency in order to optimize energy consumption. If operating two pumps uses less power than a single pump, the controller will switch on a second pump. If three pumps use less power than two pumps, a third pump will be started and so on. Looking again at **Figure 5** *(page 4)* you will see a requirement of 1,000 gpm at 54 feet can be met by operating just two pumps *(darker blue region shows full operating range of two pumps)*. Each pump is only operating at 81% speed at this point, and the pump efficiency is 70.8% with a corresponding motor requirement of 19.2 brake horsepower. **Figure 6** *(page 4)* shows three pumps in operation for the same requirement of 1,000 gpm at 54 feet. By cutting in the third pump, the overall pump efficiency has been increased to 77.4% with a corresponding motor requirement of 17.7 brake horsepower; this represents a horsepower reduction of 8%. The CU352 controller continually monitors pump performance and any changes in the setpoint or control head will not require a resetting of the pump sequencing. Efficiency based sequencing is automatically adjusted for changes in setpoints. This efficiency based sequencing is standard in all Hydro MPC systems.

Efficiency — Two Pumps vs. Three Pumps

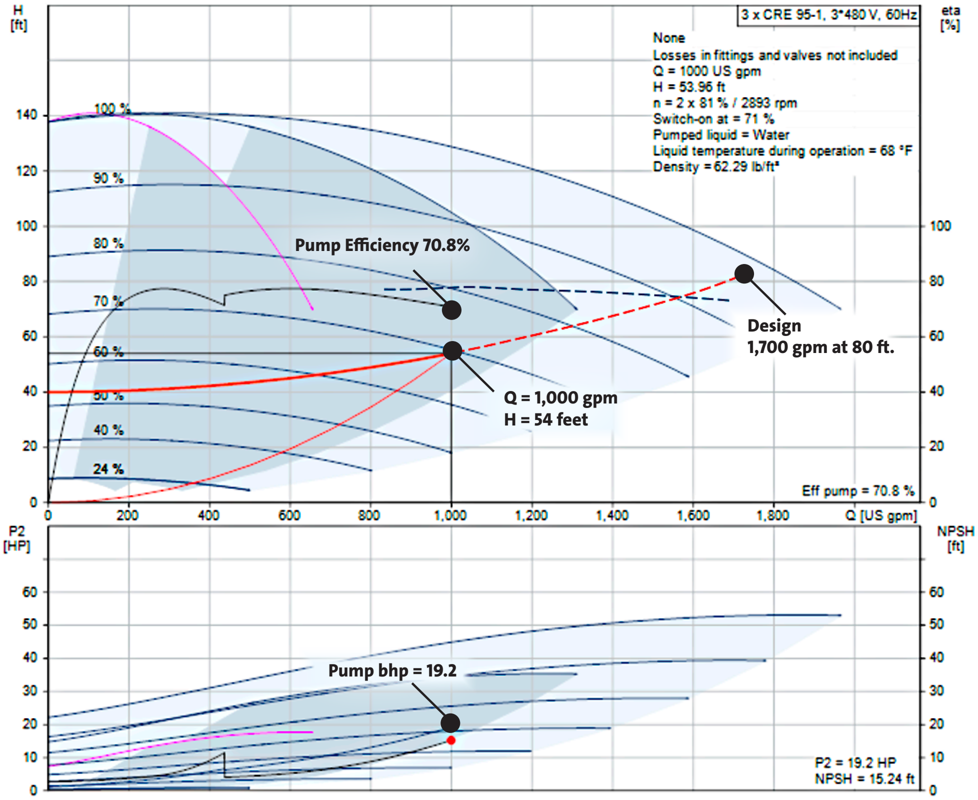

Figure 5: *Two pumps in operation, 1000 gpm, 54 feet, 19.2 bhp*

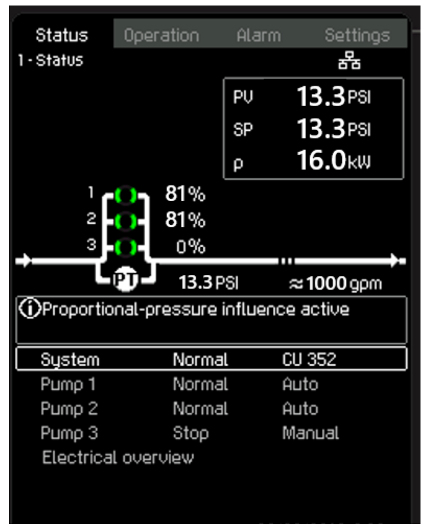

Figure 7: *Two pumps in operation*

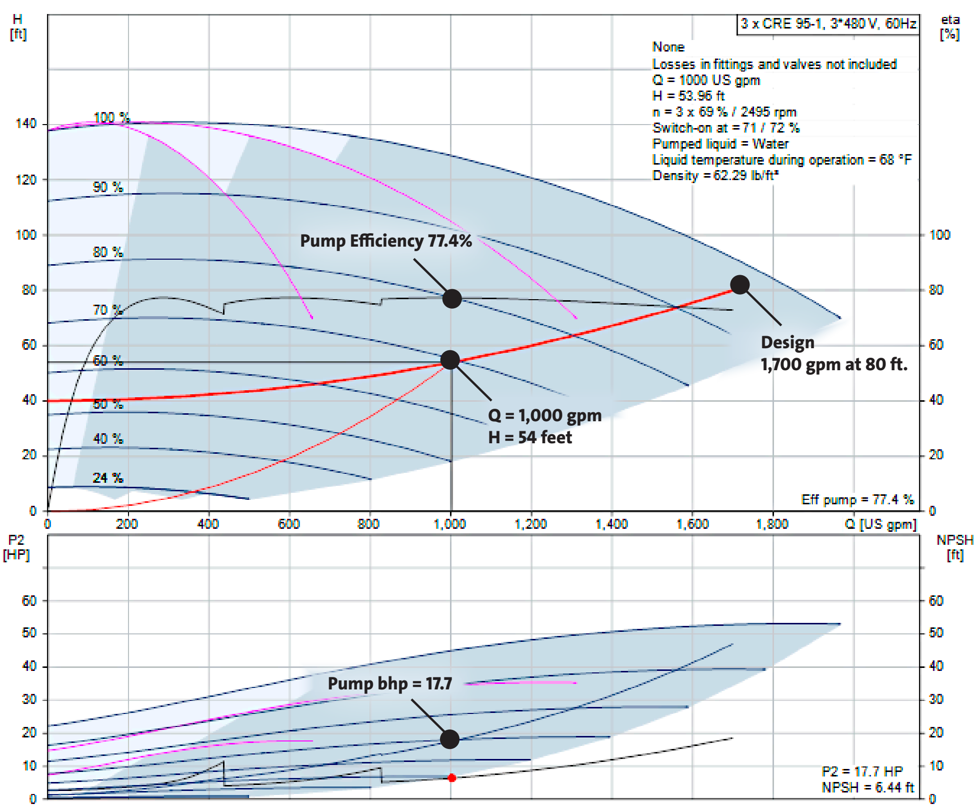

Figure 6: *Three pumps in operation, 1000 gpm, 54 feet, 17.7 bhp*

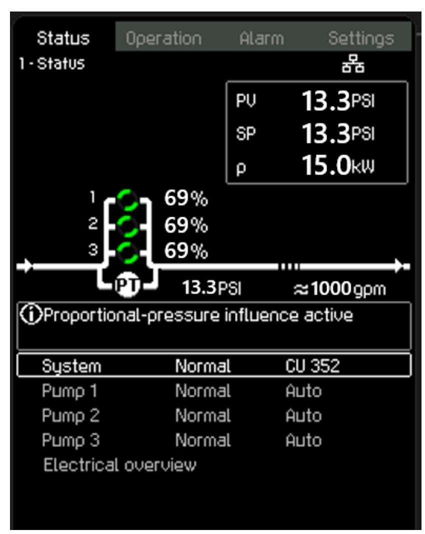

Figure 8: *Three pumps in operation*

Secondary Sensor

If it is desired that a remote dP sensor must be used, Hydro MPC systems can easily be configured. Setting up a remote dP sensor is done by simply setting that sensor up as the primary, then adding it as a third analog input as shown in **Figure 9.**

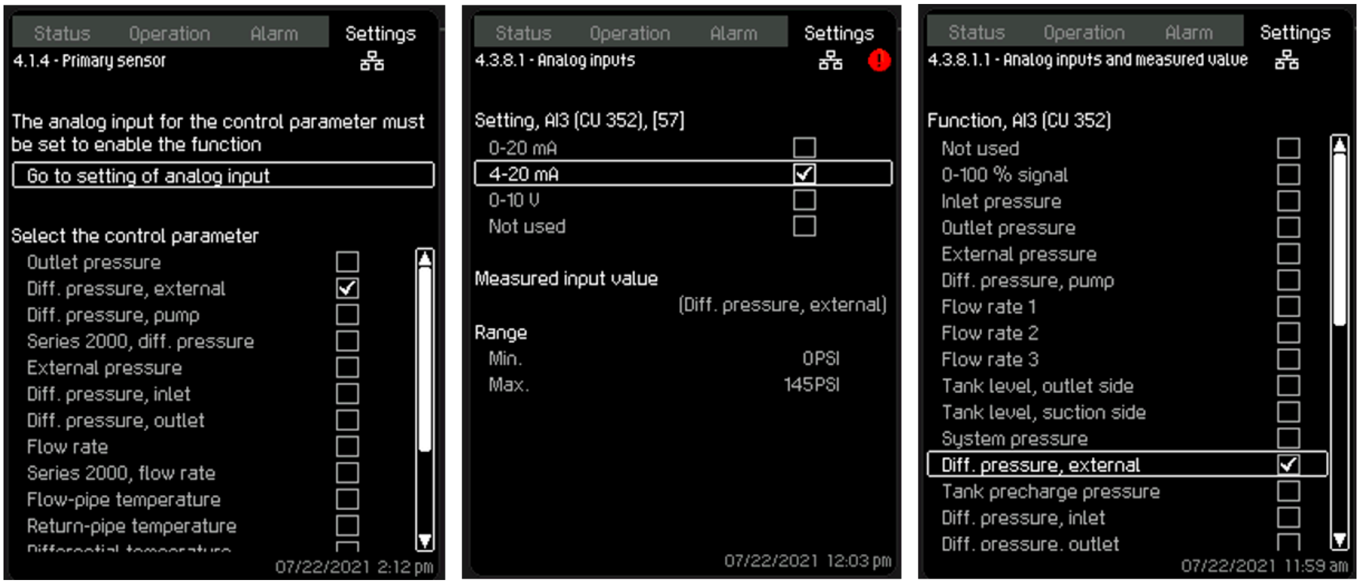

Figure 9: *Setting up remote dP as primary sensor*

The Hydro MPC can be configured to revert back to the system mounted sensors in the event that a remote dP signal is lost or no longer being transmitted to the CU352 controller. A quadratic control mode can be configured to begin operation automatically, should the remote dP sensor signal stop being transmitted. **Figure 10** shows the setup for a secondary sensor measuring differential pressure across the pumps. When the remote dP signal is lost, the Hydro MPC system will revert to the secondary sensors, automatically ensuring sufficient flow throughout the system and will indicate an alarm, alerting the operators the dP sensor signal has been lost.

Figure10: *Configuring secondary sensor control*

Conclusion

Grundfos Hydro MPC systems offer a simple way to achieve optimum control and efficiency in one prepackaged solution delivered to the jobsite. The system comes complete with all necessary sensors and includes the most efficient control sequence for parallel controlled pumps. Connection to the Building Management System (BMS) is easy, with a single connection point. All pump and control information can be adjusted and monitored by the operators and maintenance staff. All system setpoint changes can be done through the BMS, and all alarms and system status can be viewed as well.

Visit grundfos.us/pei to learn more about Department of Energy (DOE) pump energy index (PEI) requirements and PEI ratings on specific Grundfos models.