Armstrong Design Envelope pumping

With integrated Sensorless control

White paper

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Questions on Data Center Cooling Efficiency?
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HOW DOES SENSORLESS CONTROL WORK?

1. Where does a sensor controlled variable speed pump operate? Understanding where the Sensorless pumping unit must operate

Sensor controlled HVAC systems typically work by maintaining a minimum pressure (differential pressure feedback sensor setting), across an index piping leg, at all flow conditions. The sensor is set to ensure sufficient pressure is available to supply the design flow through the index piping leg in which the sensor is placed. This piping leg typically includes the load (AHU, fan coil, etc), 2-way control valve, strainer, isolating and balancing valves as a minimum.

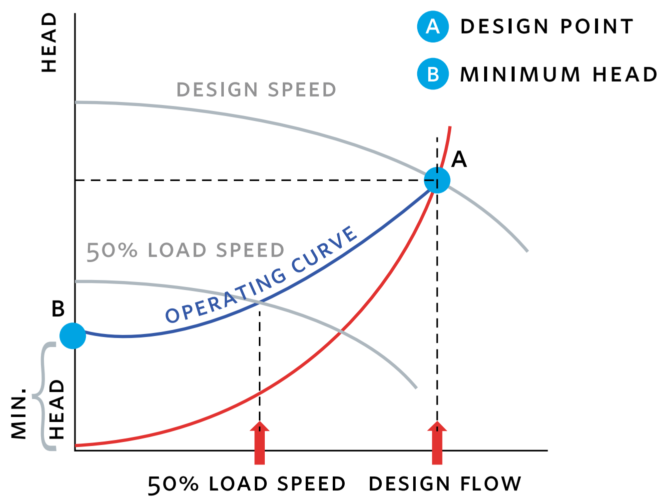

FIG 1. Operating curve for variable flow system with remote sensor

If the sensor is placed across the most remote heat exchanger piping leg, or the remote leg in the highest pressure drop loop, as mandated by ASHRAE 90.1, the sensor setting may be 20% to 40% of the pump design head. This pressure will be maintained at the remote load sensor at all system flows, even zero flow. Thus the sensor setting is the minimum pressure, or head, experienced by the system. The actual pump head at any system load will always be that minimum head value + the actual friction loss in the system distribution piping at the current flow. This can be illustrated graphically on a pump curve as shown in **FIG 1**, with the minimum head/pressure indicated on the ordinate/Y-axis and a quadratic curve formed tracking from that point to the design flow and head, to illustrate where the pump will operate at various load/flow conditions. As friction loss in systems varies as the square of flow change, a quadratic curve is the simplest and most effective illustration of a variable speed pump operating curve in a variable volume system with a single feedback sensor and is the logic used in Sensorless control strategy.

If the sensor is not positioned at the most remote load, the sensor setting would need to be increased to ensure sufficient pressure to deliver the design flow at that piping leg and the rest of the system. If a sensor is positioned in the mechanical room, across the main supply and return headers, the sensor setting/minimum head must then be equal to the pump design head and the operating 'curve' would be a horizontal straight line at the pump design head differential pressure. Emulating these scenarios can easily be accommodated in the Sensorless control program, with a simple parameter value change, though it is not recommended as full potential energy savings would not be realized by the owner.

2 Understand where the pumping unit is operating

Good pump selection software is generally based on pump coefficients, which are derived from extensive pump testing; where flow, head, pump speed and power consumption are recorded at many impeller diameter and flow conditions. The data is mapped into the selection software, enabling the creation of dynamic pump curves. Using entered flow and head values, the software will accurately predict the required pump size, impeller diameter, motor size and power requirement, pump speed and efficiency. Therefore, it's no great leap to understand that, from similar variable speed pump test data, the pump's actual flow and head can easily be understood by monitoring the power and speed of an operating pump.

3 How Sensorless control operates

From section 1 we know where a sensor controlled pump will operate. We also know at what specific flows and heads Design Envelope pumping units are operating by reading the motor power and speed, as detailed in section 2. Sensorless control enables the creation of a 'control curve' which is identical to a remote sensor controlled operating curve and is detailed in the controls software simply by entering the design flow and head [H_{max}] and the minimum system pressure [H_{min}] (the remote sensor setting if one were supplied) into the controls software. This is all detailed in Armstrong's installation and operating instructions, files number 94.81. If the minimum pressure setting (differential pressure required at the remote load to ensure full flow on a design load day) is not immediately know, Armstrong conservatively defaults the minimum pressure to 40% of the pump head. Armstrong sets the control curve on every Design

Envelope pump, with Sensorless control, at the factory. Once the control curve is in place, the Sensorless control program monitors the actual pump flow and head position and adjusts the unit speed, where appropriate, to ensure the operating point is maintained on the control curve at the system curve intersection for any flow/load condition (see **FIG 1** and **FIG 2** for 50% load/flow). Thus, a Sensorless controlled Design Envelope intelligent pumping unit will operate as effectively as a sensor controlled system without the costs and risks involved in acquiring, installing, wiring and maintaining a remote differential pressure sensor.

Series 4300 Design Envelope: 0810-050.04
Integrated intelligent variable speed with Sensorless control

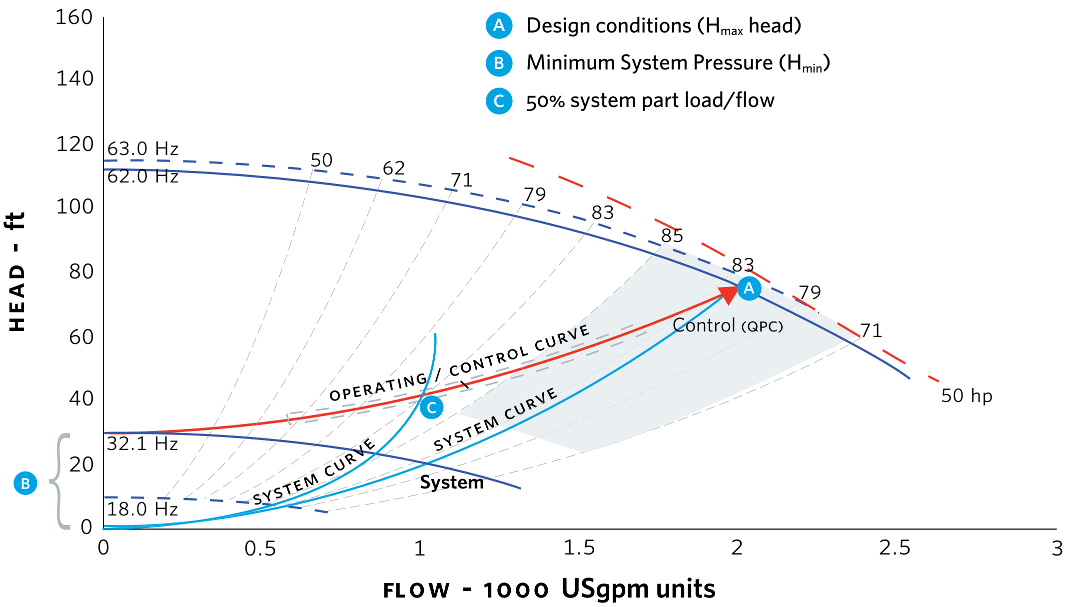

FIG 2. Variable speed operating curve/Sensorless control curve

4 How Parallel Sensorless Pump Control operates

Multiple single Sensorless control pumps cannot operate effectively in larger systems. If installed as such, each Design Envelope pumping unit will operate by producing its share of the present load flow requirements, as usual; however at lower loads all the pumps will continue to reduce speed together instead of units staging off. Armstrong solved this issue by integrating a Parallel Sensorless pump controller on one of the multiple pumps. The controller is wired to all single pump controls and reads the Sensorless information from each. The system control curve is mapped into the controller and the controller intelligence then meets the system flow while staging the pumps on and off to maintain optimum pump energy usage (see **FIG 3**). This is accomplished by operating the pumping units at the best pumping efficiency level for the required flow. This controller is available for all Sensorless pumping units to a total quantity of 4. This can be up to 4 operating pumps or up to 3 duty/1 standby. The controller can also be supplied on other Sensorless pumping units where the controls are supplied stand-alone and then mounted on a wall. Some of the customer installation cost value is lost in this configuration, however the Parallel Sensorless controller will perform equally well.

PSPC - Parallel Sensorless pump control

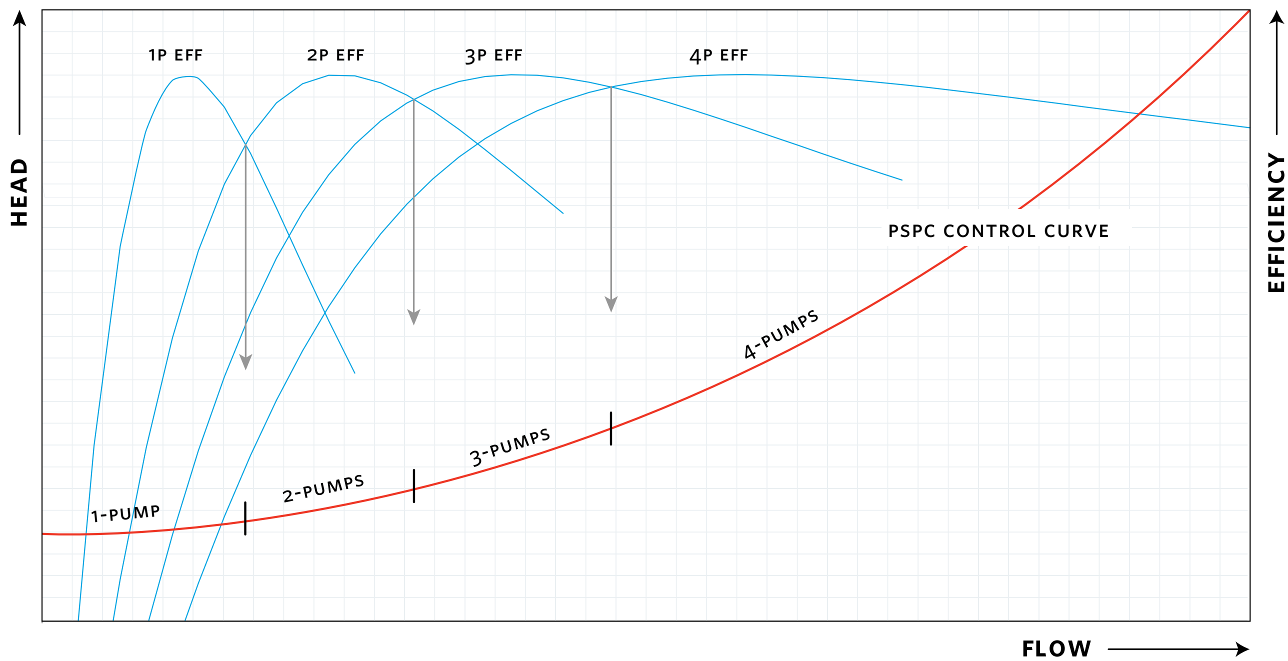

FIG 3. Parallel Sensorless staging for optimized energy usage

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