ASHRAE 90.1 – 2010 Pressure Boosters

The Department of Energy (DOE or Department) has determined that the 2010 edition of the Energy Standard for Buildings, Except Low-Rise Residential Buildings, ASHRAE Standard 90.1–2010, would achieve greater energy efficiency in buildings subject to the code, than the 2007 edition. Beginning in 2013, States are required to certify that they have reviewed the provisions of their commercial building code regarding energy efficiency, and as necessary, updated their code to meet or exceed ASHRAE Standard 90.1–2010.The scope of the ASHRAE 90.1 standard covers the design of the building envelope, lighting systems, HVAC systems, and other energy consuming equipment including pressure boosters for domestic/service water.

The keys to realizing the full benefits associated with the energy savings opportunities of building energy codes are through compliance and enforcement. In some cases, state laws may exist and preempt federal law, thereby not allowing the adoption or enforcement of a federal law, such as requiring ASHRAE 90.1-2010 to be the state's or local jurisdiction's energy code. Verify your states' energy code adoption at http://www.energycodes.gov/adoption/states.

This document addresses the requirements in ASHRAE 90.1 – 2010 that relate to pressure booster systems.

The changes to requirements for water pressure booster system in commercial buildings are detailed in Chapter 10, Section 10.4:

a) One or more pressure sensors shall be used to vary pump speed and/or start and stop pumps. The sensor(s) shall either be located near the critical *fixture(s)* that determine the pressure required, or logic shall be employed that adjusts the *setpoint* to simulate operation of remote sensor(s).
b) No device(s) shall be installed for the purpose of reducing the pressure of all of the water supplied by any booster *system*, except for safety devices.
c) No booster *system* pumps shall operate when there is no *service* water flow.

10.4a
The first requirement states that the pressure sensor is required to be mounted at the location of the critical fixture in the pipe system or control logic used to simulate a remote mounted sensor. The remote mounted sensor captures the pressure at the critical fixture, which is typically the furthest fixture away from the booster system, and uses this to control the pump system. Likewise, control logic, i.e. Proportional Pressure Control, can be used in lieu of remote mounting the transducer. Both methods accomplish the intent of

this requirement which is to only account for the amount of friction head in the pipe system at any given flow rate.

What is friction head? Friction head is the pressure drop caused by the liquid flowing through the pipe system. The higher the flow the higher the pressure drop or friction head. When designing the pipe system and specifying a booster system, the system designer has to account for maximum friction loss in the pipe system at maximum flow. This maximum friction head for the pipe system is then added to the head requirement for the pump system. When a booster system is maintaining constant pressure on the discharge of the booster system, at lower flows the lower friction head in the system is not accounted for. The result is a higher than required setpoint and this results in excess energy being wasted.

There are multiple formulas for calculating pipe friction loss but all methods are similar in that the formulas simplify to a constant raised to a higher power, i.e. an exponential equation. The Darcy-Weisbach equation is commonly used to calculate pipe friction loss:

$$h_f = f_D*(L/D)*(V^2/2g)$$

where:

- h_f is the head loss due to friction, ft of liquid
- f_D is a dimensionless coefficient called the Darcy-Weisbach friction factor
- L is the length of pipe including equivalent length for loss through fittings, ft
- D is the inside diameter of circular pipe, ft
- V is the velocity of flow, ft/sec
- g is the acceleration of gravity, 32.174 ft/sec^2

Looking at the Darcy-Weisbach equation it can be seen the equation can be reduced to a constant multiplied by the velocity squared. The liquid's velocity is determined by the flow rate (gpm), and the size of the area in the pipe. So the equation can be simplified as follows:

$$h_f = \text{Constant} * \text{gpm}^2$$

This is an exponential equation that defines how the friction head acts on the pipe system. On a graph where head pressure (H) is the y-axis and flow rate (Q) is the x-axis this exponential equation is an upward-sloping, and increases faster as x or flow rate increases, See Figure 1. This shows that friction head is proportionally related to flow rate and that friction head can be determined if flow rate is known.

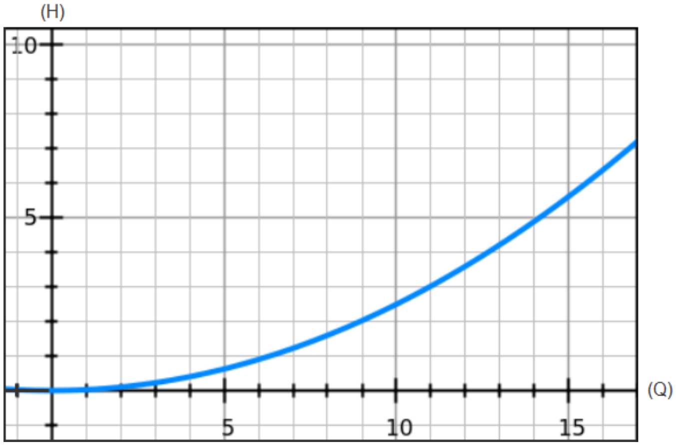

Figure 1 – Friction Head: Flow vs. Head

The friction head requirement in the pipe system is accounted for when the booster system is maintaining constant pressure at the location of the remote mounted sensor. In this situation, if the pressure was measured at the booster system it would be seen that as flow increases the pressure reading increases and as flow decreases the pressure reading at the booster would decrease in a direct relationship with the friction head in the pipe system. See Figure 2, the Control Curve in this case represents the pressure reading at the discharge of the booster system when the remote fixture sees a constant pressure.

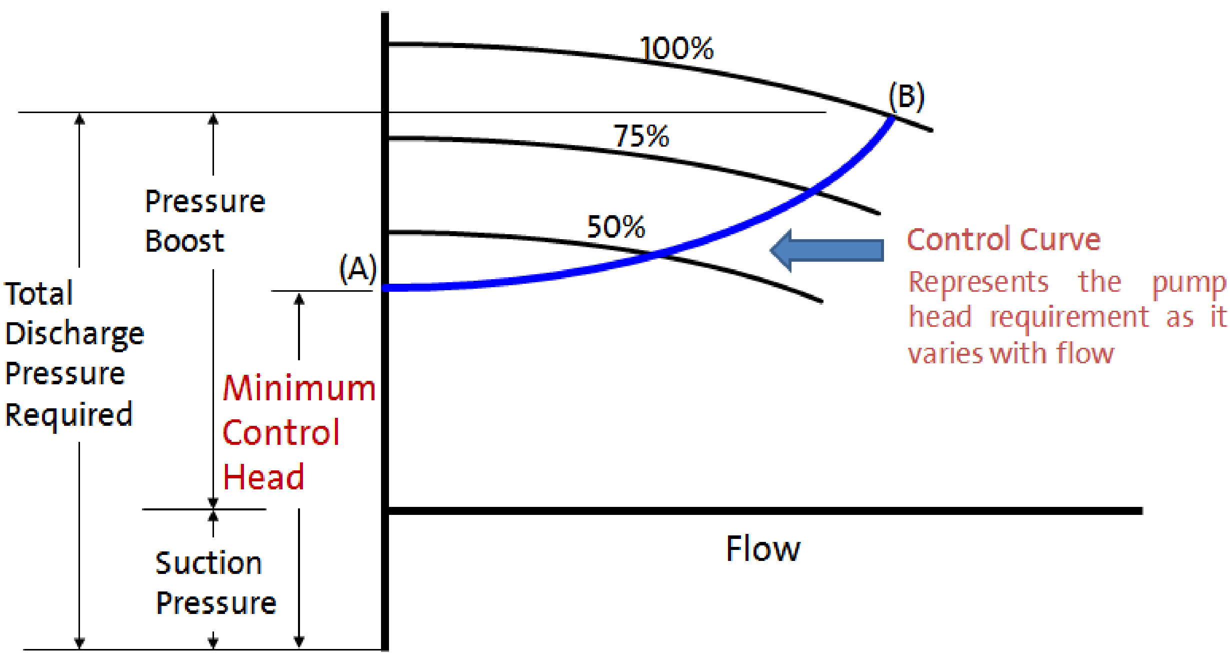

Figure 2 – Proportional Pressure Control Curve

Note that at zero flow where the Proportional Pressure Control Curve intersects that y-axis, point (A) on Figure 2, this pressure does not include any friction head. At maximum flow rate, in Figure B where the Proportional Pressure Control Curve intersects the 100% pump curve, this represents the friction head requirement at maximum flow rate, point (B) on Figure 2. The difference between these two points on the y-axis is the design friction head.

What is Proportional Pressure Control? Proportional Pressure Control is control logic that simulates a remote mounted sensor. Proportion Pressure Control is a control method that changes the local pressure setpoint at the booster system as the flow rate changes. The ideal way to accomplish Proportional Pressure Control is to use flow rate, whether an actual flow rate or an accurate estimated flow rate, and by knowing what the maximum friction head (calculated design friction head) as the controlling variables. Adjusting the local pressure setpoint based on a squared adaptation function that increases setpoint as flow increases. This will allow for setpoint adjustment (Proportional Pressure Control) to control as close as possible to how the actual friction head is adding to the pipe system overall head requirement. As the flow rate increases the pressure setpoint increases and vice versa as the flow rate decreases the pressure setpoint decreases as is shown on the “Control Curve” in Figure 2.

There are other methods that claim to accomplish Proportional Pressure Control that use the measurement of pump(s) input power or pump(s) speed instead of flow rate.

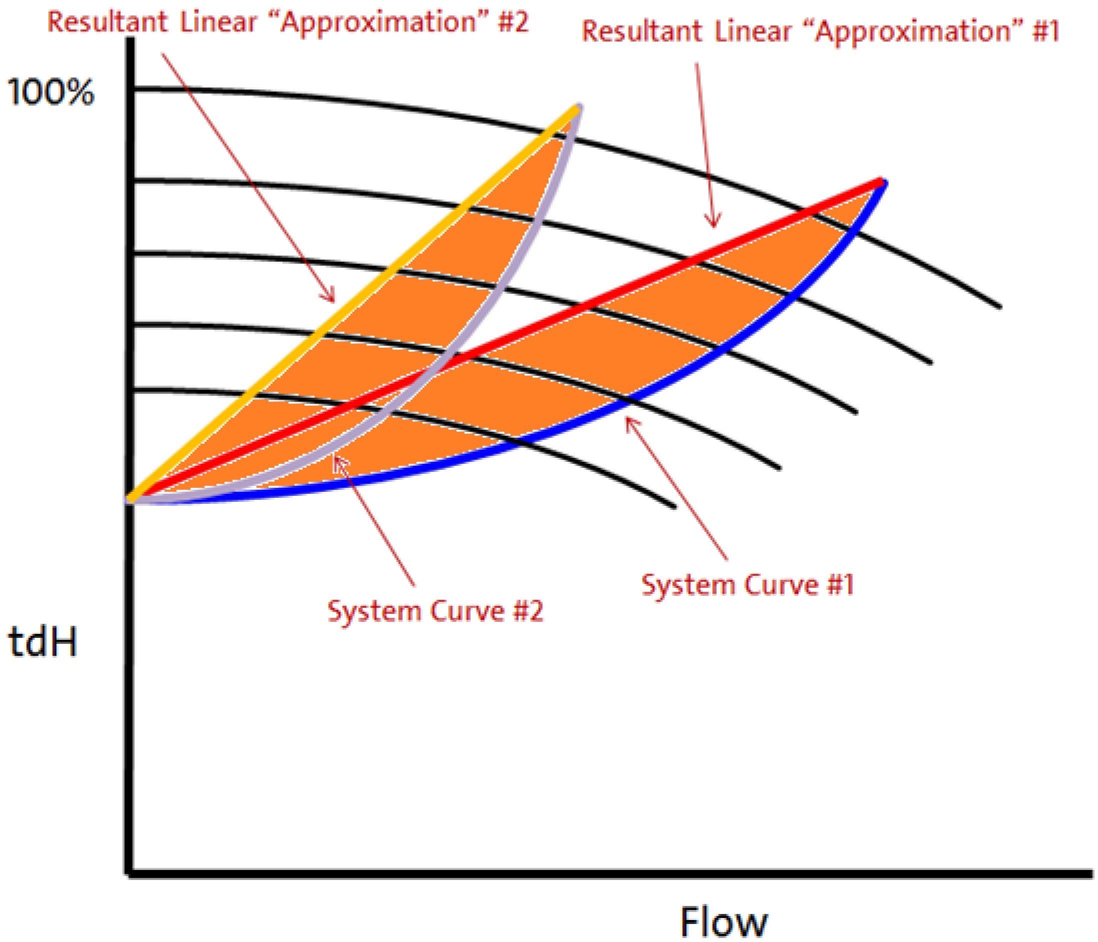

Figure 3 – Linear Approximation for Remote Sensor Simulation

A common method that some system manufactures use for remote sensor simulation is through linear approximation as shown in Figure 3. In this method, the user defines the maximum friction loss at full speed. The controller will automatically adjust the setpoint along the linear approximation line based upon the frequency that the pump/motor is running. An increase in control setpoint is required as speed increases and as speed decreases, the system setpoint also decreases.

There are inherent inaccuracies with the linear approximation method. The accuracy of the approximation is dependent on the system curve not changing. The system curve will be different if for example the suction conditions or the required discharge pressure change. Another source of inaccuracy is the area between the linear approximation and the actual system curve is excess pressure not required and results in wasted energy.

There is the real possibility that the systems using linear approximation will "hunt" or exhibit erratic or oscillating pressure control. This can lead system to damaging pulsations and will not result in the energy savings sought by building owners.

Simplified methods that simulate remote sensor installation are not as accurate and should not be considered true Proportional Pressure Control. These methods are a linear approximation of proportional pressure control at best that depend on all other variables remaining unchanged. Some reasons why the simplified methods will not accomplish the desired proportional control are if the actual application or installation conditions change. These methods rely on the fact that all other variable such as suction pressure, pump performance, and discharge pressure setpoint **Do Not Change**. A common dilemma in most all pump installations is the fact the many times the original system design conditions are different than what was originally designed for.

Flow rate is what determines how friction head adds to the overall head requirement, not pump(s) speed or not pump(s) input power. The pump(s) input power or speed are only references and can provide approximations if other variables do not change but are simply not as reliable of a method as using flow rate.

The pressure at the booster system is proportionally related to the flow requirement. Accurate Proportional Pressure Control can simulate the remote mounting of the pressure sensor and save costs associated with remote mounting the sensor. The end result of both control methods, a booster system controlling on constant pressure using a remote mounted pressure sensor or a booster system with Proportional Pressure Control using a pressure sensor mounted near the booster system, can save energy by allowing for reduced pressures at lower flow rates and by accounting for the amount of friction head in the pipe system at any given flow rate.

Pros and Cons of Remote Mounting the Sensor compared to Proportional Pressure Control

Remote Mounting the Sensor

Pros:

Constant Pressure at remote fixture

Cons:

Additional cost of installation

- Additional control wiring and routing to remote/furthest location
- Labor to install control wiring

Trouble shooting booster system

- Locating remote sensor at later date
- Extended downtime trouble shooting system
- Cost of downtime

Pressures fluctuations at other fixtures depending of pipe system

Proportional Pressure Control

Pros:

Lower cost of installation

- No additional control wiring to route
- No additional labor to install control wiring

Trouble shooting booster system
Sensor is located near booster system so easy to replace if necessary

Cons:

Depending on pipe system pressure may fluctuate at remote location.

10.4.2 b

The second point ASHRAE 90.1 2010 addresses in 10.4.2b is prohibiting the use of pressure reducing valves (PRVs) except where used as safety devices. This effectively eliminates the use of constant speed systems that utilize across the line motor starters instead of variable frequency drives (VFDs). Constant speed pump will always operate along their full-speed pump curve. The portion of the curve above the pressure setpoint is excess pressure that requires a PRV to reduce the actual pressure to the desired pressure. See Figure 4. The net result of fixed speed pumps pumping against a PRV is a large amount of wasted energy and can be seen in Figure 4 in the red area of the curve.

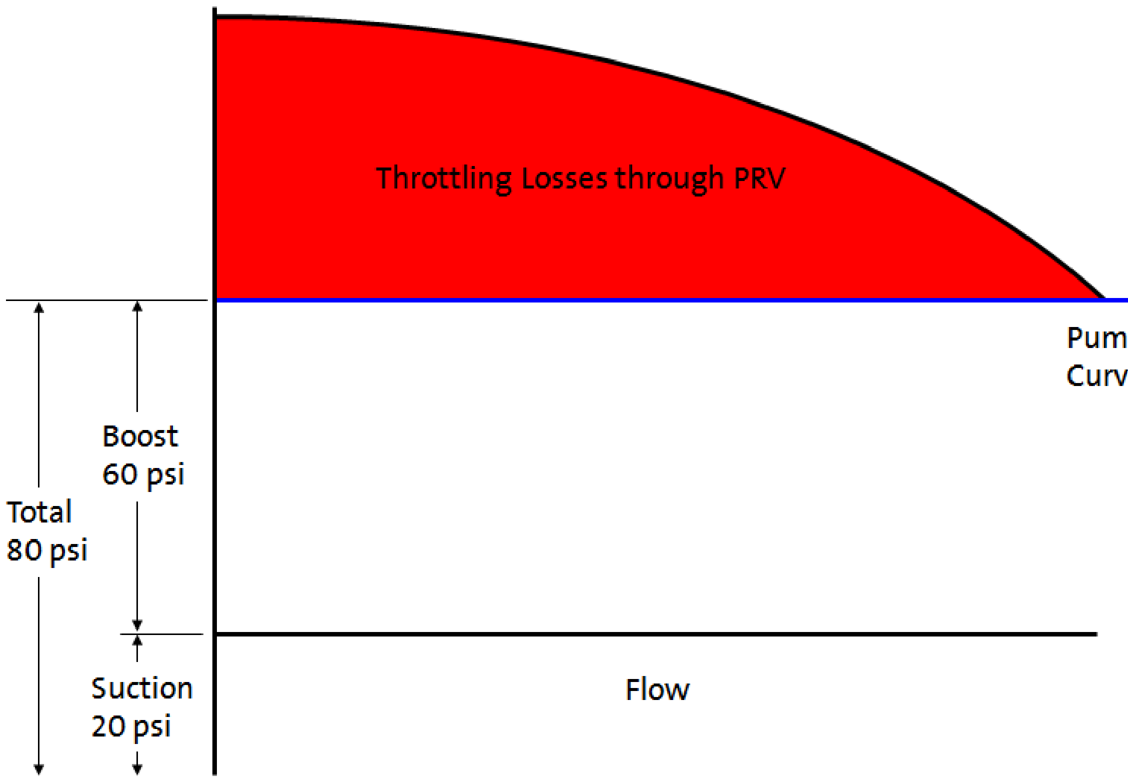

Figure 4 – Constant Speed Pump Pumping Against PRV

Variable speed controlled pumps reduce the speed of the pumps so the curve of the pump(s) exactly match the required pressure and even small reductions in pump speed can lead to large reductions in brake horsepower requirement for the pump(s). The net result is a potential for large savings in energy compared to fixed speed pumps pumping against a PRV.

10.4.2 c

The last point that section 10.4 covers in regards to pressure boosters is the need for systems to effectively shut down when there is no demand in the system. Gone are the days when systems would utilize thermal sensing valves that would simply open and dump heated water into a drain while continue to run. It's easy to see how much energy was wasted in those types of systems. Today nearly all systems are designed to shut down when there is no demand in the system. The difference in maximizing energy savings by effective shut down can come from a combination of effective system design with properly sized tanks and intelligent control algorithms that turn on and off pumps at optimal points of operation.

Grundfos is able to provide a single source solution for your packaged pressure boosting needs with the Hydro MPC / BoosterpaQ designed with the reliability and energy savings in mind to meet the needs of the ASHRAE 90.1 – 2010 standard. The Hydro MPC / BoosterpaQ also meets safe water standards with NSF-61 Annex G certification, full integration capabilities in Building Automation Systems (BAS), and full logging and display capabilities to shows full energy savings and water usage information.

References:

http://www.energycodes.gov
ANSI/ASHRAE/IES Standard 90.1-2010
User's Manual for ANSI/ASHRAE/IES Standard 90.1-2010