Get That Added Boost

Specifying Domestic Water Booster Pumps

By Greg Cunniff, P.E.

In tall buildings the pressure provided by a municipal water system is generally not sufficient to provide adequate pressure at the top of the building. As an example, municipal water systems typically provide maximum pressures in the range of 100 to 150 psi. This translates to buildings of 20 to 30 stories. Above this height the building will require a domestic water pressure booster system.

If a booster system is employed then the next issue to address is how to supply a substantially varying flow rate with relatively constant flow rate pumps. To accomplish these tasks the industry has utilized several types of pressure booster systems. They can be loosely categorized as follows;

1. Open tank storage systems.
2. Closed tank hydropneumatic systems.
3. Tankless systems — constant volume pumps.
4. Tankless systems — variable volume pumps.

Open tank storage systems utilize an open atmospheric tank located at the top of the building. These kinds of systems are the simplest in terms of pump control. The pump operation is controlled by a simple level control in the tank. The tank volume and pump flow rate are typically sized to prevent short cycling of the pump.

Since the tank is open to atmosphere it is subject to corrosion. In addition, the tank requires additional floor space. As a result, these kinds of systems have not been utilized with any frequency for a number of years.

Closed tank hydropneumatic systems utilize a closed pressurized storage tank, generally of the captive are type. The advantage to a captive air pressurized storage tank over an open atmospheric storage tank is in the size of the tank. The captive air tank will be substantially smaller than the open tank.

Control of the pump is also relatively simple using a pressure switch to start and stop the pump. Pressure differences between pump on and off is generally in the range of 20 to 30 psi. Again, the tank volume and pump flow rate

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Booster pumps give high-rise buildings that added "boost" needed to provide adequate water pressure at the top of buildings.

are typically sized to prevent short cycling of the pump.

During periods of low demand the pump may be off for long periods of time. For this reason the system is better suited for applications where demand reaches design flow for a relatively short time and is low for a high percentage of time. Even with a captive air tank corrosion can be an issue.

Tankless systems are better suited for larger buildings where the size of a storage tank is prohibitive and the long term maintenance of a storage tank is a consideration. In addition, closer control of water pressure is possible with tankless systems employing staged or variable volume pumps.

The design objective of a booster system is to provide a stable pressure to the fixtures at the very top of the building and avoid short cycling of the pumps and shortened operational life.

Calculating the pressure requirement for tall buildings is a function of several variables.

The booster system pressure is the sum of the height of the building, the residual pressure at the top of the system for operation of plumbing fixtures, and the friction losses in the piping. From this total one can subtract the available municipal water pressure.

As an example, using a 40-story building with a 12' floor-to-floor profile, the static height of the building is 480' or 205 psi. For flush valve fixtures a residual pressure of 20 psi is acceptable. Friction losses could be anywhere from 10 to 25 psi considering backflow preventers and piping. Using the higher figure gives a required pressure of the booster system of 250 psi. If the municipal water system has an available pressure of 100 psi at maximum demand the booster system would be sized for 150 psi.

Furthermore, the pressure rating of piping and fixtures must be taken into account. As a result tall buildings can be divided into pressure zones to limit the maximum pressure in any one area of the piping system.

In order to size the pumps we also have to size the flow rate through the booster system.

This is generally done using fixture counts or fixture units and converting this to flow rate or gpm. Fixture counts in fixture units are available in plumbing codes or the ASHRAE Guide. The conversion of fixture units to flow rates is accomplished by use of the Hunter Curves.

The Hunter Curves are curves that convert fixture units directly to gpm. The curves are based on use patterns observed in actual buildings and take into account the demand factor for domestic water systems, since not all the fixtures will be calling for water at the same time. What we want to avoid, of course, is oversizing the pumps because that's an unnecessary expense. In addition, oversizing the pumps could also shorten their life if they short cycle frequently.

Now that we have calculated the maximum pressure and the maximum flow rate required we can make a decision on the pumps needed and how best to control them. There are several ways to take a constant flow rate and convert it to variable demand.

This could be accomplished with equal sized pumps in a duplex or triplex configuration. However, if the pumps were of equal size and there was a wide variation in flow (as in an apartment building), it would be difficult to keep the pumps from short cycling.

Systems using this on-off type of control typically use a smaller (jockey) pump in combination with a larger pump(s). The jockey pump is controlled to maintain the pressure at low flows. The larger pump(s) plus the jockey pump are controlled to maintain the pressure at high flow.

With the cost of variable speed drives for pumps being more competitive we can now operate pumps at variable speed. With variable speed drives, duplex and triplex systems can use pumps of equal size and best efficiencies. The pumps can be sized for maximum efficiency rather than maximum flow.

Municipal water systems are also converting from open atmospheric water towers to variable speed systems for the same reasons, abandoning water towers for new uses.

The other major element to today's pressure booster system is the control function. The control system consists of a remote mounted pressure sensor or transducer, a controller and a controlled device or pump.

The pressure transducer takes a mechanical signal and converts it to an analog signal. The signal is sent back to the pump (digital) controller. The controller takes this input and compares it to the system pressure setpoint. This differential is converted to a control signal and sent to the pump's variable speed drive to change pump speed.

Digital controllers can now use a time function in the control algorithm to prevent offset and hunting of the variable speed drive. This can take the form of an integral function in a PI (proportional plus integral) controller or an additional derivative function in a PID (proportional plus integral plus derivative) controller for more stable operation.

Another benefit of variable speed control is energy consumption. Pumps can now be selected based on their best efficiencies rather than the maximum flow rates of the system.

In summary, variable speed booster pump systems will efficiently deliver water to the top story of a building employing proven variable speed drive pump systems in conjunction with the latest control technology. ■

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