QuantumFlo™
an exponential leap in pump technology

[Breaking the Hydro-pneumatic Habit for Boosters]

For some strange reason that is beyond my comprehension, some designers and consultants seem to have an affinity for hydro-pneumatic tanks. When I ask for a reason, it’s always the same: “I need a hydro tank for shutdown of my booster system.”

Since this is the first of a series of re-education topics on the application of 21st Century pumping technologies for 21st Century Problems, I thought I’d open the series with this very provocative subject that will not go quietly into the night.

Don’t get me wrong: I don’t have an axe to grind against these devices. In many cases, tanks are a necessary component for the proper installation of piping systems for Plumbing, HVAC and other applications. I just have a problem with them being used for “shutdown” on a booster system.

The fact of the matter is these tanks don’t enhance shutdown on modern variable speed boosters. In fact, they do NOTHING, and that is the point of this article.

The fact of the matter is these tanks **don’t enhance shutdown** on modern variable speed boosters. In fact, they do NOTHING, and that is the point of this article.

There was a time, however, that these were necessary components in constant-speed booster systems simply due to the fact that constant speed systems are not very energy-effective; so, the tank was an “enhancement” to shut-down, but not required, per se. Let’s look at the purpose of the tanks, which will help us understand why they seem to persist even in modern-day designs.

[The History]

Constant speed booster systems waste energy! This is a fact that all manufacturers have understood from day one. A typical booster system is churning away in the basement of a building for the convenience of the user at the other end of a fixture, at any given time. Boosters have (essentially) a simple job; they “charge” the riser with pressurized water so that when a fixture is opened on an upper floor, the water is available immediately for the user.

Since these times of usage can be sporadic, there is simply no way to know when a user is going to decide that “Mother Nature” is calling, so the riser must be charged and ready. This reality has its inherent “inefficiencies” since many times throughout the day, the pump must either re-start to replenish any lost water in the riser or continue to run as the water is disbursed to the fixture throughout the day. Sometimes these “occasional” loads can last throughout the day, so manufacturers began to realize that this run-time was costing money.

About this time, the hydro-pneumatic tank was developed and packagers began to use the tanks as a way of “storing” this pumped energy so that the pump could be turned off during these low load conditions. This technique worked rather effectively until the advent of variable speed pressure control.

[The Application]

Hydro-pneumatic tanks or bladder tanks work effectively if any of (2) conditions exist.

1. There is a high differential pressure at the inlet of the tank (i.e. Cut in and Cut out)
2. There is a relatively low pre-charge pressure when the cycle begins

The problem is that as these booster systems become more and more accurate in maintaining constant pressure, the first of these conditions above becomes harder and harder to meet. **Without a differential pressure at the tank inlet, there can be NO water storage!**

The advent of variable speed pressure control meant (2) things to the industry.

1. Differential pressure is (essentially) eliminated in the plumbing system making tanks useless.
2. Energy reduction due to constant pressure maintenance created a far greater option for energy savings by regulating pump speed.

What many consultants, who still insist on these tanks forget, is that the hydro-pneumatic tank requires a pre-charge EQUAL to the cut-in of the water pressure before a single drop of water is stored! This allows the tank to use the physics of Boyles Law to store energy in the tank as the pressure is raised proportionately to the fill pressure. This means that whatever you pre-charge your tank to, the final pre-charge will be equal to the cut-out pressure of the pump when it stops filling the tank.

In order to make the tank work effectively and completely empty, however, you must start with a pre-charge equal to the start pressure (call value) of the pump! By getting the pre-charge right, you avoid the possibility of a “dead-leg” due to water never exiting the tank before the pump turns back on again. This does not provide much room for storage as the storage volume is based on the cut-in pressure, the cut-out pressure and the total volume of the tank.

As a rule of thumb, I suggest that a properly-sized hydro-pneumatic tank will store about 10% of its total volume when applied to a constant speed booster with (at least) a 10 PSI differential. Unfortunately, this is not the case of a variable speed booster!

[The Reality]

Since the primary goal of a variable speed booster system is to maintain a constant pressure by varying pump speed, VFD systems do not inherently possess a differential pressure on the control-side (discharge) of the system. The whole concept of variable speed boosting is to adjust the speed to maintain pressure, not to store the overage. The very nature of variable speed pressure boosting does not even consider the application of a hydro-pneumatic tank for pressure storage!

By changing the speed of the pump, the cost savings far outweighs any meager amount of storage that a tank could store in a constant speed application, making variable speed systems cost effective while they are running, not during short shutdown periods. Furthermore, the cost savings far outweigh the cost of running a constant speed pump at a higher voltage and amperage for longer periods of time just to store about 10% tank volume. With this small amount of storage; the shutdown time is very short.

Unfortunately, we still see these tanks on current variable speed designs today. The use of these tanks for current-day VFD applications is misleading as these tanks are NOT designed for any storage whatsoever, they are designed to accommodate the application of (less than state of the art) old PID controllers. Since these tanks still exist on VFD applications, the assumption is that they are performing the same service as they were on constant speed systems, but that could not be further from the truth. VFD systems that utilized hydro-pneumatic tanks are using them for a completely different purpose, to sense low flow!

[The Water Balloon Theory]

There still appears to be a contingent in the industry that insists that the laws of physics no longer apply to the world and that hydro-pneumatic tanks can be used and are (in fact) necessary on variable speed booster systems which have no differential pressure. Perhaps the problem here is NOT the “physics” but rather, a dirty little secret that some don’t care to discuss. Some manufacturers still use these tanks because of an inherent flaw in the design of their drives PID; the inability of the drive to sense when there is a no-flow condition.

PID (proportional, integral, derivative) control is the algorithm inside the drive itself that many call the “anti-hunting” software. This algorithm takes values from a variety of electronic sensors built into the drive to determine either how fast or slow to run or even to run at all. Over the years, these devices have become smarter and smarter and (some manufacturers) have even been able to determine when there is no longer flow across the pump, much like the QuantumFlo iQFlo™ program has done in “award-winning” fashion!

Unfortunately, some of these technologies have not changed in 10-15 years, such as the integral motor-drives which some manufacturers still produce. The PID in these devices is old and slow and (in many cases) it cannot tell when there is a no-flow condition. This is a problem as the drive needs to shut off during these conditions or the pump will begin heating the water due to pump churn which is also wasteful from an energy perspective. The simple fix for this problem is a small diaphragm-type, hydro-pneumatic tank which acts like a water balloon.

We all remember having water-balloon fights as kids, particularly in the hot summer months. How does a water balloon have anything to do with badly tuned PID? As previously mentioned, these older PID algorithms simply don't know when the pump is churning as the pressure control gets more and more accurate. Remember that PID works on differential and if that differential is very tight, it can "fool" the PID into thinking that the pump is still under a demand when it is actually just churning water in the casing. That's where the tank comes in. Since the PID cannot tell that there is flow anymore, the booster senses that the system pressure is met and (after a timed delay) it begins "testing" for no flow by raising the speed of the pump slightly, creating a higher pressure in the discharge of the booster.

Think of this higher pressure as entering the hydro-pneumatic tank in the same way that you fill a water balloon from the water spigot. When you clamp your fingers over the top of the balloon, the water will not flow, but as you release your finger just prior to tying it closed and plopping it over someone's head, the water leaks out due to the elasticity of the rubber compressing the water out of the balloon.

By speeding the pump up momentarily, some of the water that is typically not moving in the casing now has an "escape" to the small tank. Its diaphragm acts like the water balloon, trying to push the water back out, but if there is no more flow in the system, the water has nowhere to go, so the net effect is that the pressure in the header rises slightly due to the pressure imparted by the tank with an equal and opposing force as when it entered (Boyles Law at work once again).

If the pressure stays high, the tank proves that there is no flow, if the water escapes (like releasing your fingers from the water balloon), the system pressure does not rise and resets beginning the timeout

[The Solution]

Now that we understand that hydro-pneumatic tanks are ineffective on variable speed systems, except for those systems that have ineffective PID, let's look at the solution which QuantumFlo provides. No QuantumFlo booster system requires a tank either for storage of water at no flow conditions (which cannot happen on VFD systems due to the lack of differential pressure) or for the lack of PID technology since iQFlo's award-winning algorithm can sense very low flows that most flow switch or paddle-wheel flow sensors cannot.

We guarantee that the hydro-pneumatic tank is not required for our systems to work properly and we have over 1,100 systems in the field running without the need of these tanks to prove our point. The key to high energy savings is to design systems that utilize state-of-the-art technologies to react immediately to the demands and drops in system flow. This is the essence of a great pressure booster system; it only runs when it is NEEDED! Unfortunately, for the tank in these applications, the current tide is working against their viability and pressing their extinction from the plumbing, water-storage venue.

[The Coming Code Changes]

ASHRAE 90.1 is an energy standard for mid to high-rise structures sponsored by ASHRAE (American Society of Heating Refrigeration and Air Conditioning Engineers), ANSI (American National Standards Institute) and IES (Illuminating Engineering Society) which specifies those energy conservation technologies and applications which must be implemented by October 2013 for the entire country. A small but otherwise ignored section of Section 10.4.2 requires that all booster systems must NOT create or cause a change in pressure anywhere throughout the building, but rather these potential pressure changes must be recovered in the form of speed reduction.

Since the standards will no longer allow pressure changes to occur, the use of hydro-pneumatic tanks for plumbing-side applications is coming to an end. Without differential pressure, these tanks do not store any water, so the only application that these tanks will be useful for would be for those systems with inefficient PID which use the "water balloon" method of sensing no flow. Consultants need to be aware of the sales techniques used to justify the use of these unnecessary devices in the plumbing system, and knowledge is the key.

Hopefully, by understanding the nuances of these tanks and their applications, the consultant can make a more informed decision as to the necessity of these devices and provide the client with the best possible system without the waste associated with components required simply to "make the product work." QuantumFlo believes that this information is paramount as the industry moves forward toward 21st Century Energy-Engineering and this newsletter will assist in this education.

An ASPE Affiliate Sponsor

A Continuing Education Unit (CEU) provider

ASPE Industry Award Recipient

[How does QuantumFlo keep the "Energy Standard"?]

Visit **QuantumFlo.com** to learn about our Standard 90.1 compliant software, **GreenFlo™**, and other cutting-edge pump technologies from QuantumFlo™.

About the Author

David Carrier is president and CEO of QuantumFlo, Inc., the leader in the manufacturing and distribution of advanced, variable speed controlled, packaged pump systems for commercial plumbing, HVAC, municipal, irrigation and industrial market applications.