By Jon Steele, KRWA Technical Assistant

Old Controls, New Controls – and a Corrosive Water Problem

Technology for utilities has changed dramatically in the relatively few years that I have worked in the industry. I say "few" because even though 38 years may sound like and seem like a lifetime to a person in their early 20s, when you reach your sixties, it seems as though time passed quickly and a person begins to realize how brief a lifetime really is.

The utility control industry has changed tremendously in recent decades. We live in a world that is filled with technology. It is often overwhelming. The changes include moving from old-school mercury switches to AI robotics, self-driving vehicles, and complex algorithmic systems used to buy and sell stocks instantly, cell phones, automated meter technology, smart this – and smart that!

Controlling water levels in storage tanks

Thirty or more years ago, water levels in storage tanks and operation of pumping systems were often controlled with mercury-type mechanical switches. They were simple – but they were effective. Many contained mercury in a sealed glass tube with contact points that completed an electrical circuit when the bulb was physically shifted by pressure or temperature. That would then activate a pump or blower motor such as an HVAC system. Others had contact points on a dial that triggered the start or stop circuit by touching a set point pin on a pressure dial.

This worked, although not ideal, since short cycling could be a problem. Timers were usually installed to help control the problem. Typically with this type of system, the pressure switch was located on the well or pump station wall instead of sensing the pressure at the elevated storage tank where it was primarily needed. I have even seen some systems with a dedicated small water line from the tank back to the well or pumping station to report the actual tank level accurately. Such installations work fine as long as it is not too far away like a few blocks as in a small town. However, when trying to sense the pressure in the mainline leading away from the pump station, the readings are going to vary because of the operation of the pump.

Pressure transducers

Most tank level systems today involve a pressure transducer generally located at the base of the elevated storage tank. A pressure transducer is a small electrical device mounted on a pressure line that converts water

Before today's automation, many water system storage tanks were controlled with the aid of a mercroid type mechanical switch such as this Murphy Safety Switch, Model 6045.

A pressure transducer is a small electrical device mounted on a pressure line that converts water pressure to an electrical signal.

pressure to an electrical signal. The transducer sends a signal to the pumping station via two-way radio or by wire. A logic controller is then used to determine if any action needs to be taken and the appropriate function such as a well pump and a chlorination system may be started or terminated. Those actions are all based on the information sent from the pressure transducer.

Today's control equipment is not designed to deal with an actual pressure reading of 50 psi; however, it does understand the small electrical signal usually in milliamps sent from the pressure transducer. From that signal a programmable logic controller actuates the start, stop or maintain function based on the pre-programmed parameters.

A programmable logic controller (PLC) is a special form of microprocessor-based controller that uses a programmable memory to store instructions and to implement functions for specific purposes.

Automated meter reading

Automated meter reading systems are a great technology and tremendous asset to operating complex water systems. The automated meter reading technology in widespread use is compared to many operators' earlier experiences using a pen and paper, lifting each meter lid, wiping off each meter register and physically reading and writing down each meter reading. Those readings then were provided to the billing clerk who would perform the calculations manually. Present technology allows water utility workers to drive down the street or travel across the water district, with meter readings registering onto laptops or tablets. From there, the download of data goes into the utility billing software. Processes that once required days can now be accomplished in a matter of hours.

Variable Frequent Drives

Another example of modern technology is the new motor control system known as a Variable Frequency Drive (VFD). In short, a VFD is a replacement for the conventional across-the-line motor starter. A VFD can also provide energy savings as noted on a few of the Kansas Rural Water Association energy audits that have been conducted recently. Other factors include better motor protection from voltage or amperage problems, loss of phase, or phase reversal, plus operational features such as PID function.

An example of troubleshooting "smart" technology

With complicated technologies, there also are sure to be some hiccups with the operation. For instance, I have recently been working with a system that has a new fully automated nitrate removal plant. It appears to be well designed and constructed, using high-quality equipment and components. Yet, the operator receives frequent alarm calls at various times of the day and night due to some process failure. He has had many problems ranging from water quality to equipment failures such as switches and sensors and issues with the PLC logic equipment. The city has even asked me to help them "dumb-down" the system to just process water and fill the clear well.

This control system cabinet has an array of equipment that would challenge any operator to troubleshoot.

I received a call from a city councilmember about discolored water and taste and odor problems. I thought that might be due to a sulfate-reducing bacteria, producing hydrogen sulfide gas-iron bacteria type of problem, etc. Upon questioning him about the water's odor, it was clear my speculation about hydrogen sulfide was inaccurate. The councilmember explained how the water smelled; he stated it smells like dirt. There was no rotten egg or sewer smell. I was a bit puzzled since this particular system never had a history of these types of problems before the water treatment plant was constructed. I assured him I would investigate it with the system manager. It turned out the problem was directly linked to a control automation problem. Here's the explanation.

That city has a very new reverse osmosis treatment plant. As most readers may know, RO produces very acidic water since all the buffering minerals are basically removed from the water. I have seen RO bottled water that can be as low as 5.5 on the pH scale. That level of pH in a public water system is a recipe for disaster because the water is corrosive. First and foremost, would be the leaching of lead and copper from piping. The next concern would be any mineral deposits on the hundred-year-old cast iron main lines. In this case, the acidic water was dissolving mineral deposits on the inside of the cast iron distribution system pipes. Customers were having discolored water that at times smelled like dirt, as the councilman had stated.

I understood what was happening but did not know why the treatment plant wasn't performing properly. After some thorough line flushing, the operator and I headed to the treatment plant to review the problem. After studying the system and discussing the operations with the operator, I collected samples for pH and Langelier Index analysis. The cause was becoming evident; correcting it would another issue. The PLC control system in the plant was reading the pH of the finished water was 8.0. However, we had no way to verify this since the operator did not have a portable pH meter. The lab samples were analyzed for corrosiveness. The sample results indicated a very low pH of 6.0 which would be extremely corrosive.

Further investigation was needed as to why and what would be needed to correct the problem. In the meantime, I collected another lab sample and discussed the process with a senior lab tech. We collected another sample with the pH adjusted up to 7.8 with a sodium hydroxide caustic solution, which is what the plant was using to adjust the pH of the finished water. At a pH of 7.8 the water was acceptable so we set the finished water's target pH of 7.8 to 8.

As I mentioned, the treatment plant is a fully automated system with an Allen Bradley PLC controller. There are pH sensors installed on each treatment skid on the discharge piping just after the caustic injection point sending a pH value back to the PLC. In turn, it interprets the data and activates the caustic pumps to the proper amounts of sodium hydroxide solution to inject into the system based on the pH value seen by the inline pH probes. Then it adjusts the feed rate of the caustic pumps to achieve the desired programmed pH value. That all sounds great and would be great in a perfect world if everything was functioning as it should. But what was happening was that the pH probes were forming a film on the sensors from the buffering solution giving an artificially elevated pH reading to the PLC. That was the reason the PLC was telling the caustic pumps to slow down because it read the pH as too high. In reality, it is too low and more caustic is needed to achieve non-corrosive water in the distribution system.

My recommendation to the system was to move the pH probes further from the caustic injection point to achieve a better mixing action. That would reduce the probe scaling. The city also needed to purchase a potable pH meter so that the finished water could be checked daily to ensure the target pH was being achieved regardless of what pH value the in line probes were reading. They also seemed to be inherently plagued with calibration and short life issues so they were disregarded due to their unreliability.

Other plant functions due to logic control issues have also been dealt with. At one point, the operator was so frustrated with the automation he suggesting installing a switch to bypass the PLC entirely and operate the plant manually. His request was to just "dumb the system down" so people would be in control instead of the automation dictating incorrect operations. We did a mild version of that, setting up the caustic feed pumps to operate manually to give the operator full control of the rate to deliver the correct pH value based on the portable pH meter readings.

This photo shows an example of a new control system display at the city of Otis, Kansas.

For a water system, eliminating any water hammer problem through programmable controlled start-up and shut down cycling makes the VFD a game-changer. And probably one of the best features is the programmable set point feature (PID). This allows operation of the system at a programmable pressure without a storage tank of any kind depending upon demand, pumping system design limitations, etc.

If the pumping output capability is adequate to satisfy the system's peak demand, then a VFD drive set up for PID function will serve just fine. This is a great system for maintaining distribution system pressure while a storage tank is out of service. It beats installing a relief valve, turning on the pumps and bleeding water off down the ditch when the demand declines. Such a process wastes untold amounts of water and expense. A signal from a pressure transducer directly on the drive's control circuit is needed to make this PID system work properly. The drive is then set up for PID function and becomes basically in a constant state of correction to maintain the programmed set point. To further explain, the motor rpm is used to control the output flow rate or gpm of the pump which in turn maintains the desired psi set point. The chlorination can be a little tricky but a smart valve that maintains desired residual based on flow rate is the optimum solution/ Sometimes I have installed a chlorination shut down switch to stop the chlorination process when the flow ceases. Or the chlorination system can be coupled directly to the VFD control circuit, opening a relay to shut down the power to the chlorination pump when the pump output falls to zero or below 40 hertz.

Before today's automation, many water system storage tanks were controlled with the aid of equipment such as this Honeywell level indicator (chart recorder). This unit was installed in the 1990's and remains in service today.

Watch for training – and the new "training trailer"

Kansas Rural Water provides excellent classes throughout the year that address programmable logic controllers, motors and drives, and electrical systems. In addition, KRWA's new training trailer that will soon hit the road will include many components for hands-on training. The goal is to help water and wastewater system operators know about control devices and other equipment and technology.

Jon Steele has been employed by KRWA as a Circuit Rider since 1995. Jon is certified as a water and wastewater operator. He has more than twenty-five years experience in public works, construction and industrial arts.