The Magazine For Pump Users Worldwide

Reprinted from October 2007

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Putting Critical Disinfection to the Test

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How digital dosing technology helped a public utility overcome challenges in its critical disinfection operations.

Clean Water Services is the sanitary sewer and surface water management utility for more than 500,000 people located mostly in urban Washington County in northwest Oregon. We operate four wastewater treatment plants and 39 pump stations, construct and maintain flood management and water quality projects, and manage flow in the gently meandering Tualatin River to improve water quality and protect fish habitat.

Within the Tualatin watershed, we maintain nearly 800 miles of sanitary sewer line and 450 miles of storm sewers. Our facilities clean an average of 58 million gallons of wastewater and recycle 28.5 dry tons of biosolids daily. We must meet extremely stringent discharge permit limits because we are a major source of water for the Tualatin – our effluent makes up about 25 percent of the river's volume in the summer.

We are able to provide a higher level of wastewater treatment than 98 percent of the treatment facilities in the nation because two of our facilities, Durham and Rock Creek, perform advanced biological and tertiary chemical treatment of effluent. The cleaned wastewater that leaves these facilities nearly meets drinking water standards and is discharged into the Tualatin River or used to irrigate school playgrounds, fields, parks and golf courses.

The treatment of sewage involves the initial capturing of waste material through primary settlement. At the secondary stage, where biological treatment begins, carbon is removed. Next, nitrogen nutrients and phosphates are removed biologically at the advanced secondary level. Tertiary treatment involves chemical and physical processes, where secondary effluent is fed into tertiary treatment tanks to be chemically clarified. Here, we carefully dose aluminum sulfate into the flow to entrain dirt particles and to precipitate phosphate as aluminum phosphate. It is then filtered, and finally chlorinated and de-chlorinated before it is discharged into the Tualatin.

A digital dosing pump is used for alum delivery in the Rock Creek facility. The entire range of these pumps is available via a 4-mA to 20-mA control signal that allows the operators to change the dose from any SCADA terminal, so the the SCADA controller was changed from VFD flow matching to a dose controller. The operators no longer have to physically go to each individual pump to adjust its stroke.

The dosing monitor is integrated with the gas vent through a local control box. It detects no flow on the suction stroke and opens the gas vent.

This high degree of performance is the result of our engineers overcoming several challenges through the years.

First, at the tertiary Rock Creek facility (which was named EPA Plant of the Year for 2006), we experienced great difficulty in finding parts for eleven obsolete 15-year-old 3-phase VFD diaphragm alum pumps and hypochlorite pumps used for chemical dosing. Sourcing these components was a very serious issue. After all, our Durham and Rock Creek facilities were the first to meet the state's phosphate TMDL (total maximum daily limit) of 70 parts per billion (ppb). Testing showed that some rainwater samples had more phosphate than we were allowed to discharge. (The state has since revised the regulation to permit 100-ppb).

Our need to optimize dosing operations was demanding. Because most of the chemical dosing pumps were chosen and installed by the lowest bid contractor – without our staff's ability to specify the pump – we ended up with different pumps on each plant expansion. The diaphragm pumps selected by the low bid contractor used 3-phase motors and VFDs. The SCADA system matched the speed of the pump to the water flow and the chemical dose was set by manually adjusting the stroke setting on the pump, meaning the operators had to physically attend to each pump to make the adjustment.

The motor had to maintain a minimum speed setting to prevent overheating, which resulted in overdosing during low flow periods. As we optimized operations over the years, we continually reduced the dose of chemicals. But because engineers typically size a pump for maximum demand five to ten years in the future, this often leads to the pump being too big for normal operation. The pump then runs at low speed and a low stroke setting.

A digital dosing pump used for hypochlorite delivery in the Durham facility.

The next challenge was to design and build a system that met our tight operating limits with a pump that addressed these issues. Pacific Service & Supply Co., Inc. (North Plains, OR), a local vendor, brought us a Grundfos DME 150-4 (150-lph/39-gph) digital dosing pump to test prior to its general release to the market.

After inspecting the internal construction of this pump, we operated it satisfactorily on a test panel and then installed it as a temporary replacement for a peristaltic hypochlorite pump on the critical disinfection system. The 110-VAC single-phase pump performed an 800:1 turndown that matched our minimum low flow demand – something the peristaltic pump couldn't turn down enough to meet. The peristaltic also required a tubing change during the test period, but the trial pump required no attention.

The output of this alum pump can be sized to match current and future plant demand by simply pushing a button.

The entire range of this digital dosing pump is available via a 4-mA to 20-mA control signal, allowing operators to modify the dose from any SCADA terminal without having to physically go to each individual pump and adjust its stroke. As such, we changed our SCADA controller from VFD flow matching to a dose controller.

This pump can initially act as a small pump and be adjusted to full capacity at a later time. For example, a 39-gph pump can be rescaled so the maximum output of the pump at the 20-mA control signal is only 20-gph. In other words, a single pump can be sized to meet current and future demands. Because we have constantly optimized and reduced tertiary alum doses during our transition to biological phosphorus removal, we need a smaller pump now; a few years down the road the maximum output could be raised as demand increases due to increased flow to our plant. Pushing a few buttons can adjust the maximum output of this pump to match our plant needs.

This range allows us to use the same pump for other applications requiring different doses. We installed eleven of these 39-gph digital dosing pumps with Profibus control at Rock Creek to replace the obsolete units, and used the same model for both alum and hypochlorite at different flow rates. Fewer pump models equate to fewer inventory parts, and a spare pump can be used in many applications. We have significantly reduced chemical doses from the original design, allowing us to operate at the lower limits of the pumps. Additional pumps are scheduled for replacement.

We also experienced problems with our diaphragm/check valve style solenoid-type hypochlorite odor scrubber pumps at the Durham tertiary wastewater treatment plant (EPA Plant of the Year in 2005). A mist-type odor control tower was found to have a 13 second detention time. Those pumps injected hypochlorite in a pulse every 20 seconds, so there were periods of untreated odors escaping and wasted chemicals.

At the short stroke settings, the pumps frequently got gas-bound and airlocked from off gassing of the hypochlorite. With a short stroke, the gas bubbles compressed and expanded as the diaphragm moved back and forth, effectively stopping the delivery of hypochlorite.

The new Grundfos dosing pump discharges are continuous except for a very brief, rapid fill stroke, so the hypochlorite dose matches the odor demand. There is no "water hammer" with the new pumps, unlike the old solenoid pump's sudden sharp pulse of chemicals when the solenoid activated, followed by significant periods of no chemical flow between the next solenoid pulse. The new dosing pumps have not encountered that problem because their 100 percent fast fill stroke executes regardless of dose rate.

The solenoid pump stroke was short at low dose rates and could not clear the gas produced by the hypochlorite. The Grundfos hypochlorite pumps use an optional dosing monitor to signal a local control box to bleed off the gas if it's not cleared on a suction stroke.

The pump makes several strokes to clear the gas in the supply and return to normal operation. If it fails to clear the gas, a no-flow alarm signal is sent to the SCADA system

Our local equipment supplier integrated the dosing monitor and the gas vent with a local control box. The dosing monitor detects no flow on the suction stroke and opens the gas vent. The pump makes several strokes to clear the gas in the supply and return to normal operation. If it fails to clear the gas or the chemical flow failure is a result of a different problem, a no-flow alarm signal is sent to our plant's SCADA system.

We installed seven Grundfos DME 48-3 (48-lph or 12-gph) pumps for both hypochlorite and caustic, since the same model pump can deliver a lower dose of caustic soda to the odor control tower utilizing the 1000:1 turndown rate available on the smaller pumps. A simple exterior button runs the pump at 100 percent speed for initial priming or flushing with water when taking the pumps off line.

The disinfection system (predictably) had its worst problems matching hypochlorite dose to actual demand during late night and early mornings in summer. At low plant flows, the 3 phase VFD diaphragm pumps overdosed because they required a minimum speed setting for cooling. When the stroke was reduced to meet the demand, they would air lock

The same model dosing pump delivers a much lower dose of caustic soda to the odor control tower utilizing the 1000:1 turndown rate to set the maximum output much lower. A simple exterior button runs the pump at 100 percent speed for initial priming or flushing with water when taking the pumps off line.

due to the hypochlorite off gassing, so minimum speed and stroke settings had to be set to avoid delivery interruptions. The warm summer temperatures increase the off-gassing by the hypochlorite. These pumps were replaced with peristaltic pumps to address the gas locking issue. But while they solved the gas locking problem, the peristaltics could not turn down enough to meet both the low flow dose rate and peak demands. They required frequent tubing replacement and a leak would cause expensive damage to the roller assembly.

The Durham plant plans to eventually replace all of the alum and hypochlorite disinfection pumps with the same pump that Rock Creek uses, standardizing the pump across the organization to meet our current lowest dosage needs and our future peak demands.

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