Managing Pressure & Power

By Dick Pierce

Variable-frequency drives fuel Arizona utility's growth

Employing variable-frequency drives gave the utility better energy efficiency and accuracy.

Management of water and wastewater is a major issue in the central highlands of Arizona, which receive approximately only 12 in. of precipitation a year. That especially rings true for the city of Cottonwood, a fast-growing town in the Verde River watershed of Yavapai County, Arizona's second fastest growing county.

In 1990, the city constructed the first wastewater treatment plant in the Verde Valley. To handle growing water demands, the city devised a strategic water management plan in 2003 that included creating a modern municipal water system with effective monitoring, control and pumping technology—a development made possible by Danfoss VLT variable-frequency drives (VFDs).

"The Verde River is one of the few perennial rivers in Arizona," said Daniel J. Lueder, development services general manager for city of Cottonwood Utilities. "But the city has to use groundwater resources for our potable water supply. The plan called for forming a municipal water system by acquiring several private water companies, which presented a number of piping and pumping challenges."

Satisfying Demand

In 2004, the city acquired three private water companies—Clemenceau, Cordes Lakes and Verde Santa Fe—and subsequently added the Cottonwood Water Works, Spring Creek Water Co. and Quail Canyon water systems. Currently, there are more than 28 wells in the city's system, with about 10,000 customers—an unusually high well-to-customer ratio compared to parts of the U.S. with more rainfall.

The city's water division is responsible for water supply and distribution, including storage tanks, wells, fire hydrants, pumps and water meters.

"The city's water production system is predominately a direct pumping system," said Doug Ryan of Grand Canyon Pump and Supply's Phoenix location, which provides equipment sales and application support to the water division. "Water is pumped from wells into a holding reservoir. Secondary booster pumps transport the water into building zones and housing developments."

Ryan noted that in the old distribution system design, when the pressure in the hydro-pneumatic tank would, for example, drop to 50 psi, "a pump would kick in to replenish the tank to about 70 psi. But running the pump that way subjected the pipe to a 20-psi pressure change. The pressure change constantly stressed the pipe, creating leaks as the pipe fatigued and aged. In addition, the existing control system created water hammer on the piping system, further compounding the issue."

Effective monitoring, control and pumping technology is critical to Cottonwood's cutting-edge water management plan.

With nearly 100 miles of pipe in the system, water hammer caused significant leakage—as much as five to seven leaks per week in the main line, in addition to one to two leaks in the service lines.

Instead of turning pumps on and off, causing a 20-psi differential, Ryan and Danfoss discussed using VLT Aqua drives to convert nine sites from a fixed-speed hydro-pneumatic system into a duplex variable-speed constant pressure system.

With the constant pressure design, one or more pumps are online at all times to keep the system pressurized.

"We developed a program using the built-in Smart Logic controller to load into the drives to operate in a lead, lag and duplexing sequence," Ryan said. "That means one pump is the lead pump. If [the] lead pump reaches maximum speed, then the lag pump starts maintaining pressure within 2 to 3 psi."

The drive's onboard control intelligence made the conversion easy. There was no need to buy a programmable logic controller and pay a programmer to program the control sequence.

With the new constant pressure design, the average pipe pressure runs in a 60- to 65-psi range. "It really cuts down on leaks by reducing pipe fatigue and system damage," Leuder said.

To drive the pumps, Ryan employed the Aqua Drive variable-frequency drives. "The VLT Aqua Drive is designed specifically for water, wastewater and irrigation pumps," Ryan said. "For this application, the drive was combined with a differential pressure transducer to allow the VLT drive to measure and regulate water pressure. It's more accurate and far more energy efficient than using throttling valves."

"My technician is a huge believer in constant-pressure pumps and the VLT drive," Leuder added. "This design stabilized pipe pressure and practically eliminated water hammer. Water main leakage decreased substantially, so a lot less time is spent digging up and repaving roads to make repairs."

Power Conditioning

Another beneficiary of VLT drive technology is the city's wastewater division, which operates and maintains a 1.5-million-gal-per-day wastewater treatment facility, plus 48 miles of collection system, five sewage lift stations and approximately 80 acres of effluent reuse area.

"Normally, treatment plants use gravity to help pull sewage into the facility," Ryan said. "But this plant is built in the heart of town on top of a hill, so all the wastewater is pumped up to it."

The problem lay with the primary sewage lift station. Three existing variable speed drives were starting to fail. They were replaced with VLT Aqua drives.

"Unlike the previous drives, the VLT Aqua drives incorporate power conditioning," Ryan said. "Other drives require accessory line reactors to smooth out the harmonics on the input power side. Similarly, load reactors on the output side help reduce the effects of high motor wiring capacitance and soften high rates of voltage change that hit the motor at startup.

"With other manufacturers, you have to buy these reactors," he continued. "That adds cost. Plus, the reactors get hot. The reactors on the old drives were mounted directly below the VFDs, so the heat was drawn directly into the drive. The internal control cabinet temperature

Arizona Public Service pays $50 per 1 hp for applying variable-speed drives to pumps.

would reach 140°F. The Aqua Series drives use built-in DC chokes that suppress these transient voltage spikes in a more efficient manner and with far less impact on the cabinet temperatures."

Ryan used the MCT31 harmonic calculation tool to indicate where the existing line and load reactors could be removed. Without the reactors, the internal cabinet temperature stays closer to ambient temperature, saving money on air conditioning. And, because the drive cabinets are rated NEMA 12 and NEMA 4, they can be placed outside if they are shaded from direct sunlight.

Built-in power conditioning also benefitted the water division. Irregular line source voltage was causing a 14% to 17% current unbalance in a utility production well's high-horsepower motor. The motor manufacturer recommends a maximum current unbalance of 7%. During peak electrical usage months in the summer, the city was renting a generator for three to four months to prevent burning out the motor.

Ryan suggested that instead of running a generator to prevent the current unbalance from killing the motor, they simply use a VLT drive as a power conditioner. The drive was able to clean up the three-phase power to reduce current unbalance to less than 1%. It was calculated that the payback on the VFD would be about 2.5 years when compared to the cost of generator rental and would reduce the noise created by the generator that can often disturb local residences.

Lueder also appreciatedthe utility rebate from Arizona Public Service, which currently pays $50 per 1 hp for applying variable-speed drives on pumps.

Altogether, the wastewater division is using two 7.5-hp VLT drives in the treatment facility, two 15-hp drives in an effluent water truck fill station and three 100-hp drives in wastewater lift station applications. The water division employs about 15 drives for submersible well pumps and about 20 for secondary zone booster pumps.

"Grand Canyon Pump is an outstanding company to work with," Lueder said. "I value their professionalism and expertise. We've had a great experience with Danfoss drives. My electrician has been to several training seminars. He's never dealt with factory people with such a wealth of information and willingness to help you personally. It's a company that obviously knows and values customer service. That gives us confidence that Danfoss VFD technology will keep our system running." PS

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