Making a Splash

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Imagine stepping into the shower in the morning, turning on the water, and nothing but a trickle comes out. This is exactly what happened to some residents of Nebraska City prior to a VFD upgrade of their utilities system.

The Nebraska City, NE, area gets its water from wells drilled into groundwater sources. Many factors have affected water supply pressure in and around the city, including regular droughts, an aging water supply facility, and the distance between the water tower and the water supply plant.

Prior to installing a new pump with a motor control using variable-speed drives, the water tower level was maintained exclusively by on/off control. When the level dropped below a certain point, the pump would turn on and pump water into the system; when the level increased to a certain point, the pump would switch off. As a result, there were pressure fluctuations in the system and an enormous – and costly – amount of water was lost due to leaks.

The plant received several resident complaints about fluctuation in the supply pressure. When the tower was down for maintenance, the water supply came straight from reservoirs called "clearwells," which have very little pressure because they're located close to the ground.

"It is a challenge to make sure everyone in the community will have water whenever they turn on their faucet for a drink or get under the shower," says Dean Hauptman, Nebraska City Utilities water plant superintendent.

JEO Consulting Group, Inc. (Wahoo, NE), the company that designed the system, determined that the best solution was to install a single new high service pump with variable-speed drives over one of the clearwells. JEO selected VLT® 8000 AQUA series variable frequency drives from Danfoss Water and Wastewater (Milwaukee, WI) for the system.

In this new pumping system, the drive maintains water pressure by controlling the speed of the pump based upon the demand for water at any given time. As the pressure drops, the drive increases pump speed to maintain the pressure at an optimal level. The new system offers greater energy efficiency and reduced stress on pipes and mechanical components.

The new drives have built-in Class A2 RFI filtering and can be programmed for variable torque operation at 98 percent operating efficiency.

Variable torque loads typically increase the load on the shaft at the square of the increase in speed. For example, if the speed increases by 25 percent the resulting load on the shaft increases approximately 50 percent. Matching the VFD's output (U/f ratio) to the speed-torque curve profile as closely as possible improves energy efficiency and overall process control.

System operators choose between three variable torque curve profiles – VT High, VT Medium and VT Low – and match the closest curve to their application requirements to maximize energy efficiency.

Even operating in variable torque mode, the drive assumes a constant torque mode of operation during start to accelerate the load to the commanded speed. Breakaway torque provides up to 160 percent of rated current for up to 0.5 seconds to produce sufficient torque to begin operation.

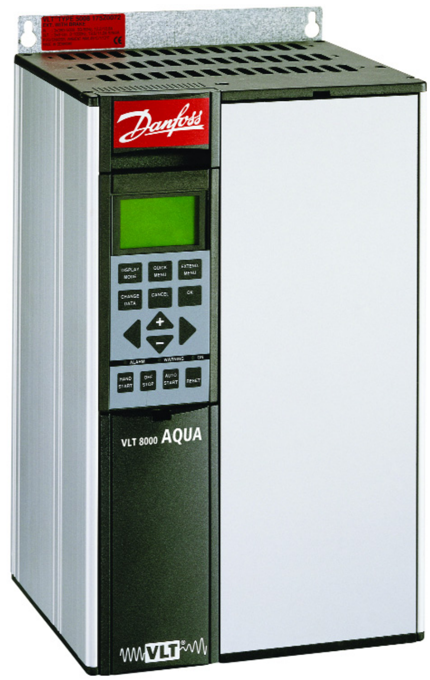
By monitoring the actual load, an automatic energy optimization (AEO) control scheme optimizes the relationship between voltage and frequency without losing energy as heat in the motor. This saves up to 5 percent more than conventional PWM drives.

An automatic sleep mode monitors the input signal determining the output frequency of the VFD – thus, the system's flow/pressure. When the signal decreases to the point that the output frequency (motor's speed) is inefficient and the resulting flow/pressure is negligible, the sleep mode turns the output off to save energy. Once the unit senses the system has reached a point where the motor-driven pump will be effective, it "wakes up" the VFD and operation resumes.

An integral, digital PID (proportional integral derivative) control eliminates overcompensation. No external regulator or low-pass filter is needed. The PID monitors two feedback signals and compares the two setpoints to make its process control decisions.

In the event of a dry start-up, an empty-pipe fill mode function of the drive operates the pump at a specified rate for a preset time, then automatically follows the PID to quickly fill the plumbing system without causing a "water hammer" effect. All acceleration rates and times programmable.

An autoramping function extends ramp-up and ramp-down times by modifying and adjusting fixed acceleration/deceleration rates to suit the system load requirements and prevent nuisance tripping.



The new drives have built-in Class A2 RFI filtering and are programmable for variable torque operation at 98 percent operating efficiency.

An automatic motor adaptation function "tunes" the VFD to its connected motor. It optimizes operation between the drive and the motor by reading and checking the values without spinning the motor and wasting time disconnecting the motor from the load.

To protect itself from AC line voltage disturbances, the drive monitors all three phases and interrupts drive operation for phase loss or if there is phase imbalance. Transients on the AC line are suppressed by MOVs as well as zener diodes for extreme transients.

Full rated motor voltage and torque is delivered down to 10 percent under nominal AC line voltage. During an AC line drop-out, the VFD continues until the intermediate circuit voltage drops below the minimum stop level, typically 15 percent below the lowest rated supply voltage of the VFD.

The VFD incorporates both DC link inductors and motor output protection. The DC link inductor reduces the harmonic distortion currents that the VFD injects back into the AC line. The properly-sized inductor reduces line harmonic currents to 40 percent or less of the fundamental current. No additional AC line reactors or line voltage reduction is necessary.

The dual DC link inductors reduce the input RMS current to less than or equal to the output current for short-circuit protection. This allows unlimited switching on the output without damage to the drive. No additional output reactors or switch interlocks are necessary.

The DC link inductor improves overall efficiency by increasing the power factor and lowering the ripple current in the bus voltage for an almost threefold increase in capacitor and drive life. Motor operation is smooth and quiet. Hall-effect current transducers measure current flowing on all three motor phases for highly responsive and accurate feedback to the VLT control circuit for optimum motor protection and performance.

An UL-recognized (Class 20) open-loop electronic thermal relay, built into the VFD software, guards against motor overheating and thermal overload. No additional sensors or wiring are needed.

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