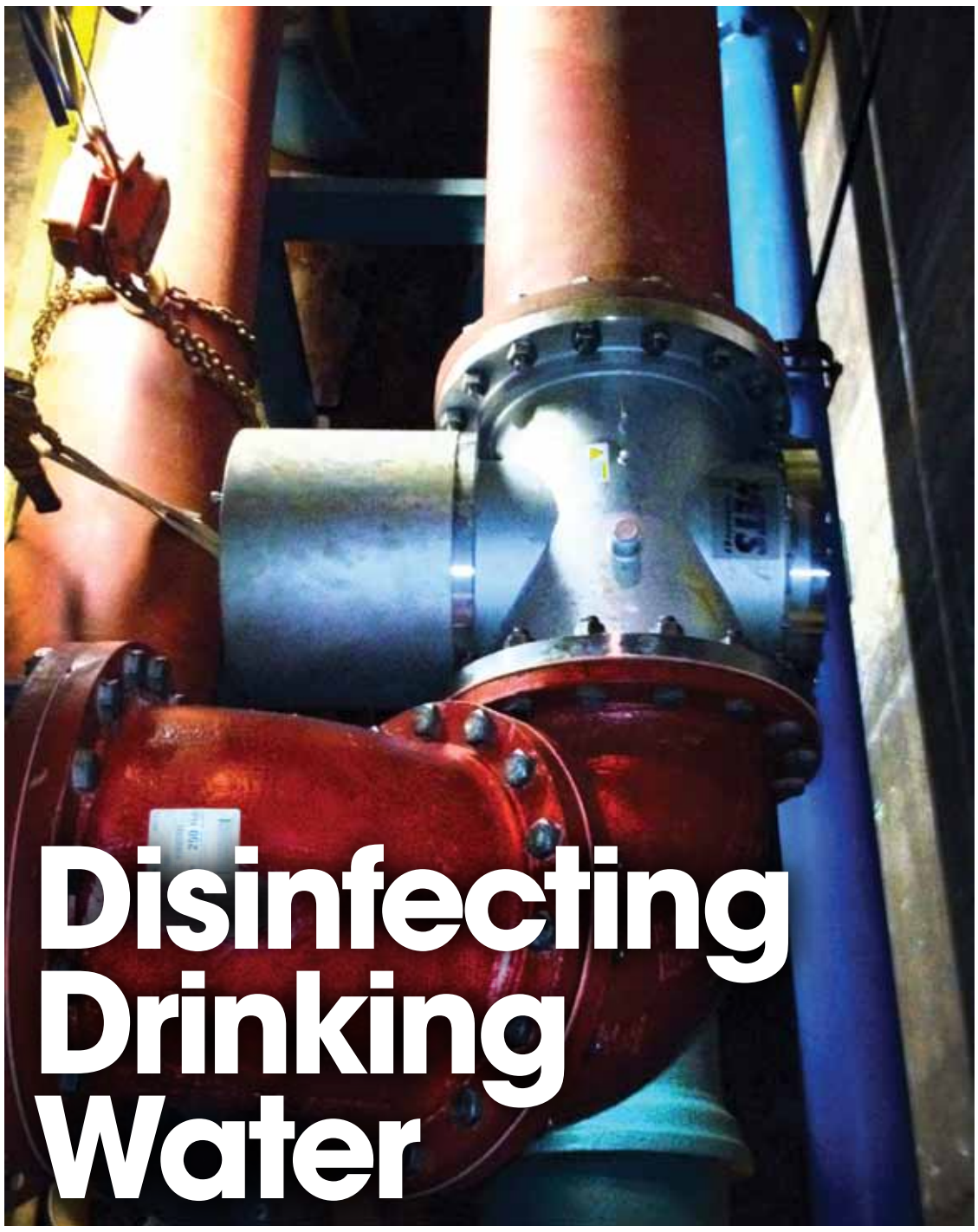

Disinfecting Drinking Water

By Jon McClean

Illinois city installs UV drinking water systems

The city of Moline, Ill., is located in the heart of the Midwest, tucked between the banks of the Mississippi and Rock rivers in Rock Island County. Moline is one of four cities that make up the Quad Cities, along with Rock Island, Ill., and Bettendorf and Davenport, Iowa.

Moline's Water Div. provides continuous high-quality water to approximately 43,500 residents, and utilizes the Mississippi River as its source to treat, pump and meter water to more than 17,000 homes and businesses. The variable quality of the water in the Mississippi poses unique treatment challenges to the Water Div. Moline's LT2 water study revealed that significant levels of *Cryptosporidium* are periodically present in the source water. The staff believe these levels were under-reported due to limitations in the sampling and detection methods. The city has acted to provide enhanced public health protection in this regard. Its drinking water supply system requires about 5 million gal of water on an average day and must function dependably and continuously to protect public health and sustain the standard of living and local economy.

A Cost-Effective Solution

The city of Moline carefully examined a variety of alternate disinfection methods, including ozone and membrane technologies. Ultraviolet (UV) technology was selected, as it was more economical than other technologies in both capital cost and annual operating costs. The city chose to add validated UV systems to provide an additional barrier for the filtered water, which will improve water quality and ensure that chlorine-tolerant organisms, such as *Cryptosporidium*, are not present. The city selected ETS-UV systems by Neptune Benson. These machines are third-party validated in accordance with the U.S. Environmental Protection Agency (EPA) Guidance Manual and are manufactured in Beaver Dam, Wis.

"The city is pleased to have Neptune Benson ETS-UV as our partner for this important project. We have found the Neptune Benson ETS-UV team to be knowledgeable, responsive and goal oriented during the multiyear process that lead to the selection of the reactors for our demanding drinking water application," said Greg Swanson, general manager for Moline Utilities. "Their technical expertise and communication skills have played a crucial role in working with our consultant partner and satisfying the design requirements of our primacy agency."

UV System Benefits

UV light is a safe and proven alternative for disinfection that is free of the harmful byproducts associated with conventional chemical disinfection. Using UV light for disinfection does not compromise the taste, color or odor of the water, and it is now a typical process barrier in drinking water facilities across the U.S. Unlike with chemical disinfectants, organisms are not able to develop any tolerance to UV light. Delivering the correct UV dose is assured by the validation of UV reactors using third-party test houses. These independent facilities verify the performance claims from the equipment manufacturer, and provide a detailed report that sets out the performance envelope of the UV system across a range of water flow and UV transmittance.

Eight SX-635-16 UV systems are being installed in the existing filter gallery, together with in-line transmittance monitors. Space was tight, so additional computational fluid dynamics (CFD) models were required to verify that the performance of the UV systems would not be adversely impacted by the proximity of butterfly valves and complex manifold geometry.

When low water transmittance of 70% is recorded, all eight UV systems will operate. When the water quality improves to a transmittance of 80%, six UV systems will operate at an average flow rate of 1.2 million gal per day (mgd) and it is anticipated each filter will run up to 2 mgd to accommodate future growth. The systems are validated to achieve a 2.5-log removal of *Cryptosporidium*. Online transmittance monitors continuously measure the UV transmittance of the water being disinfected, and the power to the lamps is varied to ensure that the target UV dose is always delivered across a range of water transmittance and varying flow rates.

The ETS machines are designed to allow access to the UV systems from one side, so the UV chambers were installed close to the filter walls. The ETS machines are fitted with automatic wipers that keep the quartz from fouling. The wipers are driven by a motor and are fully automated. Iron, organic matter and manganese all will foul the quartz sleeves, which would reduce the effectiveness of the disinfection process. Lamps will require replacement annually, and the quartz sleeves that house the UV lamps will require replacement every five years. Quartz deteriorates when continuously exposed to UV light, and becomes "solarized." This reduces the disinfection performance and would prevent proper disinfection if UV monitors were not fitted.

As often is the case with drinking water filter galleries, space was limited. The design of the manifold pipe work to house the UV system was a concern, as was the location of the butterfly valve, as both could, in theory, alter the flow patterns across the UV lamps.

Demonstrating Performance

To understand the impact of the installation design on the performance of the UV system, in particular the inlet pipe geometry, ETS carried out extensive CFD modeling to demonstrate that the UV system would match the performance of the validation when installed.

The CFD models showed that the proximity of the inlet butterfly valve could detrimentally affect the performance of the UV systems when the valve was not fully open at the maximum flow. The color changes in the CFD models show the differences in velocity; high velocity is shown moving toward the red color, and lower velocities are shown in blue. High velocity means that particles or organisms in this region do not spend as long in the lamp intensity, and sub-optimal UV disinfection therefore is a risk. When the UV system is operated at maximum flow, the valve is fully open, so no velocity changes are observed across the UV lamp assembly.

EPA requires the UV system to treat at least 95% of the water delivered to the public. A rigorous operating procedure has been implemented to exceed that requirement. Detailed records are maintained at all drinking water facilities to record "off-specification" volumes of water each month, and records are taken of the flow, UV transmittance of the water and UV dose, as well as several operational readings. Regular reference checks will be carried out by facility staff to ensure that the UV monitors are performing and that every possible step is taken to ensure the adequate treatment of the water being sent forward.

UV light will continue to be a key barrier across the U.S. to ensure that the drinking water supply is safe and wholesome. w&wd

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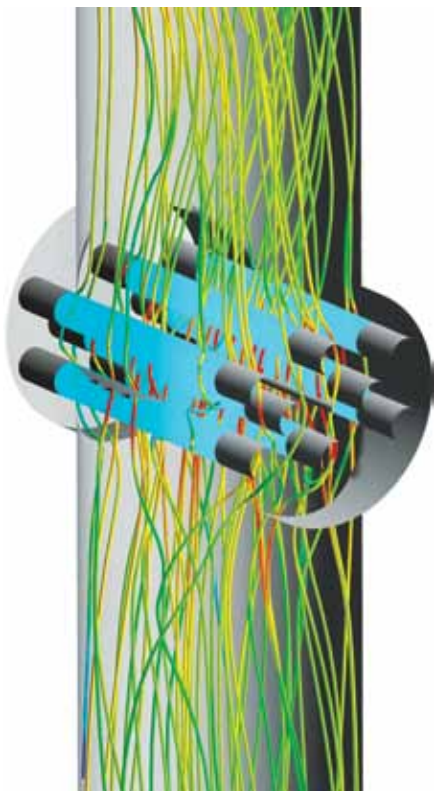

Color changes in computational fluid dynamics models indicate velocity changes, which ultimately gives insight into the performance of UV systems.