Ultrafiltration Will Improve Treated Water from the Mighty Mississippi

United States communities are taking an increasing interest in reverse osmosis, microfiltration, and ultrafiltration.

By Jonathan Pressdee and Adam Kramer

Faced with headlines announcing outbreaks of waterborne diseases, promulgation of more stringent disinfection byproduct requirements, and increasing economic viability of membrane-based treatment technologies, communities across the U. S. are taking a greater interest in reverse osmosis, microfiltration, and ultrafiltration. The growing interest in chemical-free pathogen removal and multiple barrier protection has in turn stimulated an increase in the size and sophistication—as well as the number—of membrane treatment facilities and projects.

A 78-mgd ultrafiltration (UF) membrane plant under construction near Minneapolis takes membrane filtration to new heights and exemplifies local government commitment to providing high quality drinking water. When it is completed in June 2005, the Black & Veatch-designed (www.bv.com) Columbia Heights Membrane Filtration Plant will be the largest membrane facility treating potable water in the world. It will consistently provide low-turbidity filtered water and high-log removal of microbial contaminants, such as *Cryptosporidium* oocysts and viruses, providing a higher quality drinking water to Minneapolis Water Works (MWW) customers through the addition of UF to further purify lime-softened and clarified Mississippi River water.

When it begins operation this summer, the MWW's 78-mgd Columbia Heights Membrane Filtration Plant will be the largest membrane facility treating potable water in the world. (Courtesy/Credit: Black & Veatch)

The decision to add UF was prompted by multiple goals and considerations including the need to address future threats and ensure compliance with the Interim Enhanced Surface Water Treatment Rule (IESTWR). Membranes provide an effective barrier to chlorine-tolerant microbial contaminants without introducing chemicals that could potentially form harmful byproducts. Addition of UF also replaced obsolete sand filters that were at the end of their useful life, having served the MWW admirably for more than 90 years.

The MWW selected Black & Veatch to evaluate pretreatment alternatives and provide retrofit design, construction, training, and start-up services. The project, launched in 2002, entailed detailed evaluation of a full-range of water treatment technologies through a progressive review process that included a peer review panel of nationally recognized experts. The project team included individuals whose leadership of international Awwa Research Foundation (AwwaRF) research on implementing membrane filtration and worldwide experience with membrane facilities—including the particular system designed for the MWW—armed the team with the knowledge of what to expect and how to address critical issues. (The AwwaRF [www.awwarf.org] is a member-supported, international, nonprofit organization that sponsors research to enable water utilities, health agencies, and other professionals to provide safe and affordable drinking water to consumers.) It's always a major challenge to retrofit an existing plant with a new process while keeping the existing facilities in operation. But applying a still-emerging technology at such a large scale and to treat a most challenging water source proved to be an even greater challenge. Identifying the best approach through pilot testing including performance life-cycle costing and then accurately applying the pilot results to full-scale performance for a treatment capacity of 78-mgd was no small order.

The project team incorporated advanced design tools as well as filtration technology in development of the UF facility, as evidenced by this 3-D drawing of the filtration building lobby with a view of the membrane gallery. (Courtesy/Credit: Black & Veatch)

First Things First

Following the performance evaluation bid to select the most appropriate technology, the MWW wisely decided to continue pilot testing. Assisted by the design engineer and membrane equipment supplier, the MWW conducted extended pilot testing to optimize the design and confirm operational settings for a successful plant start up. As a control measure for the pilot investigations, the consultant recommended that two identical pilot units be used to accurately determine the benefit of each adjustment. An additional benefit of the pilot program was identification of water quality changes that were not apparent during the initial testing phases. Pilot testing was conducted under a strict protocol agreed upon with the Minnesota Department of Health, the regulating agency. The pilot plant experiments mimicked full-scale operation to achieve accurate scale up.

A major impact was noted during the spring of 2002 as temperatures rose and melted snow in the watershed. A shift in water quality entering the plant caused a change in membrane performance that required adjustment to chemical cleaning procedures during these events. With membrane filtration, filtered water turbidity remains low during these events. However, increases in head loss across the membrane surface leads to more frequent backwashing and cleaning of the membranes, which decreases effective filtration time and hence output of treated water.

A strategy was developed to better handle this event and adjustments were incorporated into the design. Additional chemical feed pumps were incorporated to supply alternative chemicals during these fouling events. By testing these alternative cleaning agents during the next snow melt event in 2003 and 2004, the team will develop and implement strategies to address water quality upsets that can adversely affect membrane performance. These strategies will be well proven and in place when the plant begins operation in mid-2005.

The Grand Scheme of Things

The project team incorporated advanced design tools as well as filtration technology in the upgrade of the 90-year-old Columbia Heights Water Treatment Plant, using innovative 3-D design and virtual reality software. A project execution system developed by Black & Veatch facilitates communications among the membrane system provider, the owner, and the designers. This Internet-based collaboration allows geographically dispersed project team members to access and share real-time data.

The entire facility was modeled in a 3-D environment to develop equipment, layout, structures, and piping. The software was used to develop a model of the plant that enabled the MWW to clearly visualize how the plant would look. Various layout alternatives were assessed using the 3-D design software to optimize both equipment orientation and available space.

The new treatment facility will be housed in a single two-level structure consisting of administration and process areas. The administration area will include demonstration, conference, and control rooms, offices, a laboratory, and a lobby furnished with educational displays for the visiting public. Aesthetic features of the new plant will include traditional architecture with brick facades, archways, and tile roofs to match the existing architectural style in the area. Extensive landscaping will provide screening and security.

The process area will house 40 UF membrane units and could be expanded further. Careful attention to detail has ensured that equipment is readily accessible. In addition to the membrane filtration plant, the new facility also comprises a new chlorine cylinder store; aqueous ammonia, fluoride, and corrosion inhibitor storage; and feed equipment.

"Cost-effectively and successfully integrating 40 UF units into an existing operation necessitated special consideration on many fronts," says Black & Veatch Project Manager Chad Hill, who manages the company's Minneapolis office. "Process control and waste disposal required special consideration. The key was to optimize capital and operations and maintenance costs without overly complicating the system."

The consultant has also designed two other large membrane plants, both in Singapore. One is now in operation and the other in the design stage. The firm provided study, pilot testing, design, and supervision of construction, testing, and startup for the Chestnut Avenue Water Works extension project for the Public Utilities Board of Singapore. Completed on a fast-track schedule in just two years, the 72-mgd treatment works is currently the largest operating potable water treatment facility in the world incorporating membrane filtration. The project earned the top prize in the Association of Consulting Engineers Singapore Design Excellence Awards for 2003 for innovative design, which included an immersed membrane system. GE

Mr. Pressdee, is a Senior Process Specialist and a member of Black & Veatch Corporation's global team of water and wastewater treatment technology specialists. He is currently based the company's Minneapolis office. Adam Kramer, P.E., is Director of the Minneapolis Water Works.