Ronningen-Petter Filtration Solutions

Removal of Fe and Mn from Drinking Water

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Removal of Fe and Mn from Drinking Water

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Abstract:

Tubular filter systems offer an effective alternative to traditional methods of iron and manganese removal for industrial water uses. When installed as a pre-filter for an ultrafiltration or reverse osmosis system, the use of tubular filter systems can be expanded to include municipal drinking water systems.

The Spectacle Pond Water Production Facility in Littleton, Massachusetts is an excellent example of the use of tubular filter system in conjunction with an ultrafiltration filter for the production of drinking water. Although in this application the tubular filter systems were used only as a prefilter to protect the ultrafiltration membrane, with a different filter media selection, tubular filter systems could be used as a stand-alone system for iron and manganese removal. The flexibility is in the selection of the mesh for the filter. Filtering is possible down to the one micron level.

INTRODUCTION

Tubular filter systems offer an effective alternative to traditional methods of iron and manganese removal for industrial water uses. If an ultrafiltration system is required, tubular filters can be installed as a pre-filter to separate and remove unwanted debris from the water prior to entering the ultrafiltration or reverse osmosis system.

Depending on the system design, tubular filter systems can be used for polishing or as a final filter for a system. System maintenance is reduced with steam sterilization or simply with the clean-in-place (CIP) operation. Tubular filter systems also offer flexibility in the selection of the filter media to meet specific needs. Filtering is possible down to the one micron level.

The success of the Spectacle Pond Water Production facility of the Littleton, Massachusetts municipal water system is an excellent example of combining the use of tubular filters with an ultrafiltration system.

LITTLETON – A SUCCESSFUL COMBINATION OF TECHNOLOGIES

The water from the Spectacle Pond well was meeting all EPA primary drinking water standards. The levels of iron and manganese however, were steadily increasing. These increasing levels resulted in water that had a poor taste and color, and led to customer complaints. The manganese levels measured in excess of 0.7 and the iron level at 0.3. This exceeded the recommended secondary maximum contaminant levels (SMCL) of 0.05 mg/l and 0.3 mg/l respectively. It was also anticipated that future requirements of the SWDA would call for a primary standard of 0.02 mg/l manganese concentration. Additional concerns, due to the potential influence of the Spectacle Pond adjacent to the well, included meeting future goals under the Surface Water Treatment Rule (SWTR) and the Enhanced Surface Water Treatment Rule (ESWTR).

It was decided to pilot test alternative methods for improving the water quality. If possible, a design would be selected that was cost-effective and could meet the current and future regulatory needs.

Alternatives: Standard Pilot Process vs. Ultrafiltration

Tests were conducted using two methodologies for iron and manganese removal: standard sand filter processes and ultrafiltration processes. The standard pilot plant process consisted of two oxidation methods. The first oxidation method for the iron and manganese in the water was through the addition of potassium permanganate. The pH of the water was adjusted with the addition of potassium hydroxide. This was followed with the adsorption of the oxidized iron and manganese through a greensand media.

A second oxidation technique was a pilot scale oxide coated sand filtration process. This consisted of oxidation through the addition of chlorine, pH adjustment with potassium hydroxide, followed by sand filtration.

Although each of these standard processes reduced the levels of iron and manganese to acceptable levels below SMCL, they were eliminated from consideration due to their inability to meet future SWTR and ESWTR needs.

Ultrafiltration

Two ultrafiltration methods of were pilot tested, spiral wound ultrafilter membrane and hollow fiber membrane. Both methods used an ozonation process to promote the oxidation of the iron and manganese. Other than the membrane itself, the only other significant process difference between the two ultrafiltration pilot plants was the addition of an aeration strip of the ozone in the hollow fiber membrane plant.

Incoming water from the well first entered an oxidation chamber where ozone was added to the water. In this section, the iron and manganese in the water is oxidized. Ozone reacts with iron in the following manner:

$$2Fe(HCO_3)_2 + O_3 + 2H_2O \rightarrow 2Fe(OH)_3 + O_2 + 4CO_2 + H_2O$$

The manganese oxidation reaction is as follows:

$$Mn(HCO_3)_2 + O_3 + 2H_2O \rightarrow 2Mn(OH)_3 + O_2 + 2CO_2 + 3H_2O$$

Through this oxidation process, insoluble iron and manganese precipitate is formed.

Following the oxidation from the ozonation chamber, the ozone was then allowed to dissipate (or was stripped with additional air in the hollow fiber membrane plant). Further retention allowed for any remaining ozone to dissipate prior to entering the tubular filters.

The tubular filter system used in this process was a Ronningen-Petter F Series with a 200 micron filter. This large filter porosity was selected to purposely allow the iron and manganese particles to pass through to be collected in the ultrafiltration system. The role of the tubular filter system was to collect large grit and protect the ultrafilters from any damage that might occur from large debris. (Figure 1)

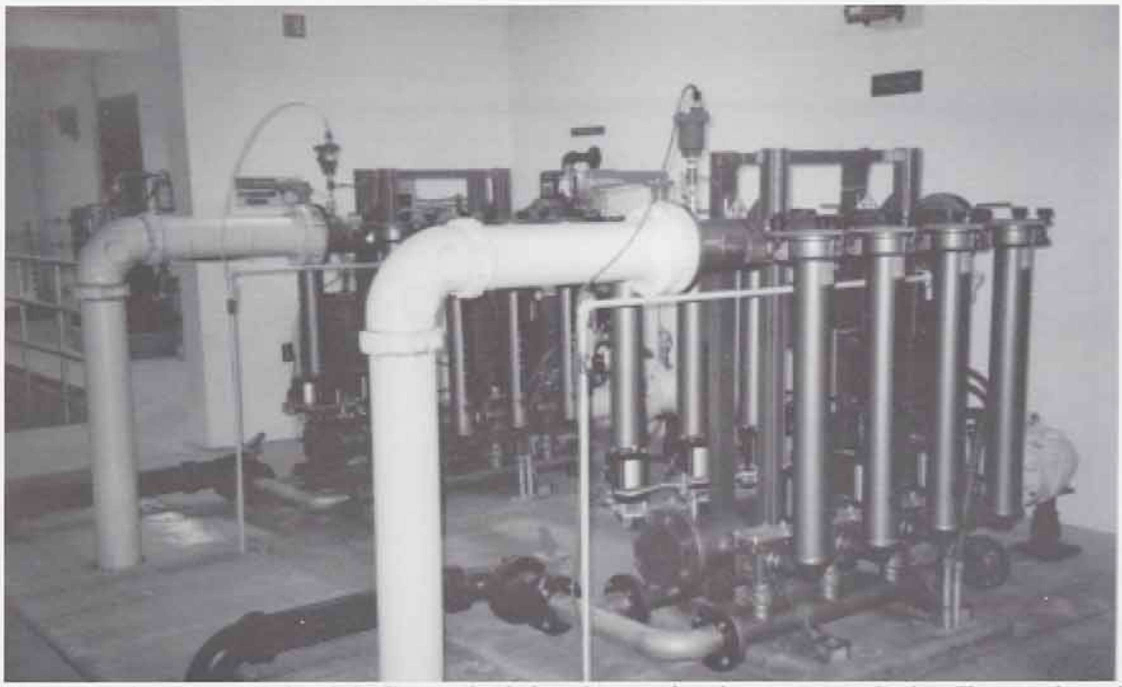

Figure 1. Ronningen-Petter F-Series tubular filters receive the incoming water from the ozone contact chamber. The pumped water leaves the ozone contact chamber at 40 to 50 psi. Prior to entering the tubular filters, the water passes through a flow control valve that adjusts the volume of water to the current ultrafiltration process needs. This volume varies depending on the number of ultrafiltration skids on line (up to four total). The water then passes through a butterfly valve, an air reducing valve, and finally a pressure reducing valve (details shown in Figure 2). This ultimately results in a pressure drop to a maximum of 30 psi to meet the ultrafiltration requirements. This pressure is not optimal for the tubular filters (recommended at 50 psi), however, operations have not been negatively impacted.

From the tubular filters, the water was then passed through the ultrafilters. The ultrafilters collected the iron and manganese particles and any other particles resulting from the ozonation process.

Both ultrafiltration pilot plants worked exceptionally well in the removal of the iron and manganese (up to 94% and 95% respectively). Cleaning the membranes with an acid solution returned them to their original state (the pilot plants were not set up for backwashing, a citric acid backwash was added to the production plant).

Evaluation of the ozonation/membrane filtration process confirmed that this method could satisfy all the primary and secondary water quality goals. The process actually produced water that was better than the conventional adsorption/filtration processes. The membrane process presented a barrier to contaminants and microorganisms while the ozonation process resulted in reduction of tastes, odors, color, radon, and disinfection byproducts. The process also reduced the need for chemicals and the subsequent residual production.

In assessing the difference between the spiral wound and hollow fiber membranes, it was determined that hollow fiber membranes offered greater advantages for the system. Hollow fiber membranes are operated at significantly lower pressure, are easier to handle and maintain, and are pH and chlorine tolerant. Their configuration allows for backwashing, which improves the overall feedwater recovery and extends the period between chemical cleanings.

Despite the estimated higher cost for the ozonation/membrane filtration (20% higher than conventional adsorption/filtration), Littleton decided to proceed with additional pilot testing of the hollow fiber ultrafiltration process. The additional pilot testing confirmed critical design criteria for the full-scale plant, established backwashing procedures, and established the specific chemical cleaning protocol.

Following the success of the additional pilot testing, the Spectacle Pond Water Production was built in 1997 and went into production in 1998. The plant now removes iron and manganese from 1.4 million gallons of water each day with a recovery rate in excess of 99.9%. The process installed in the production plant is shown below. (Figure 2)

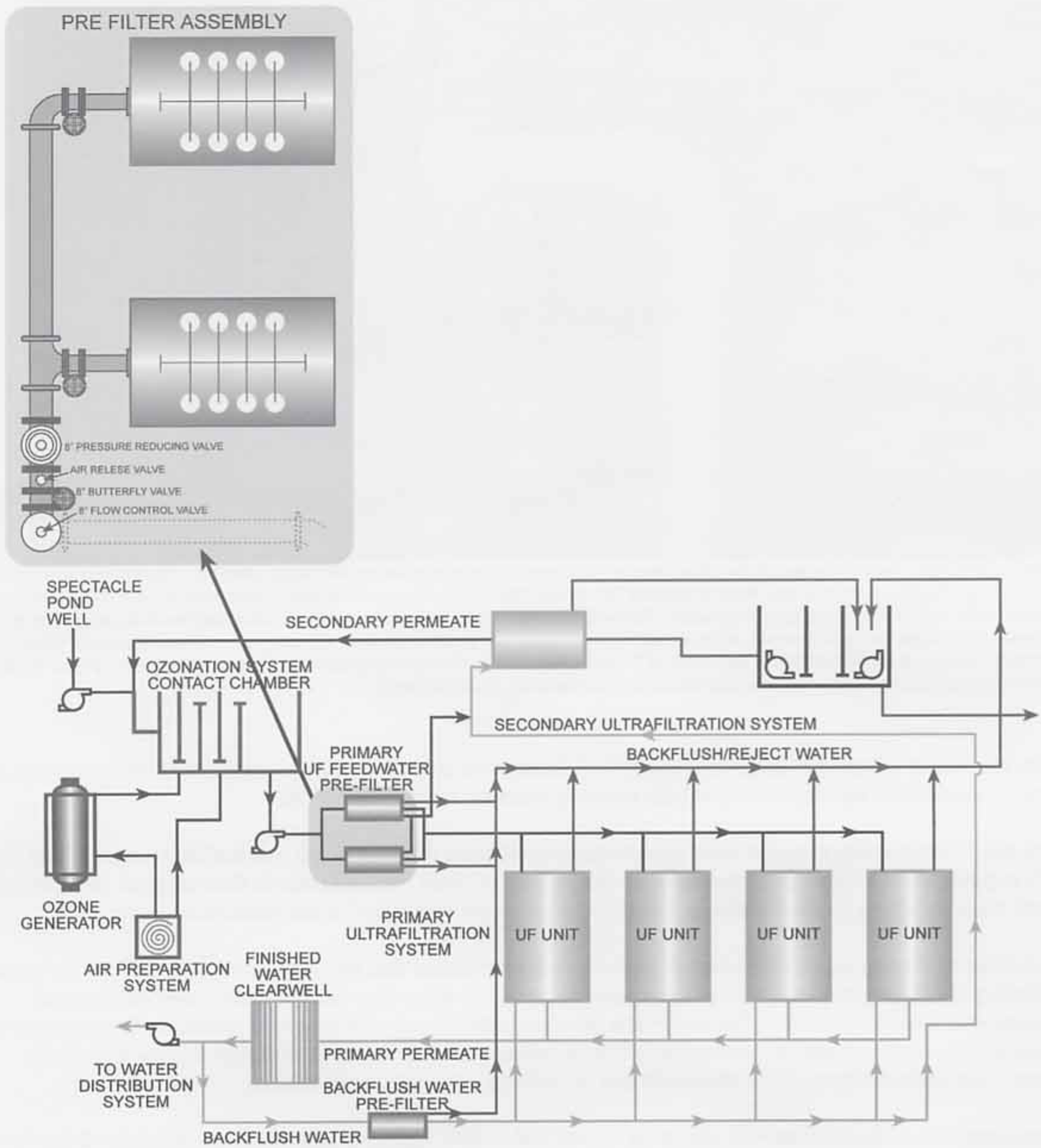

Figure 2. Spectacle Pond Water Production Facility

The Littleton plant is an excellent example of using a tubular filter system in conjunction with an ultrafiltration system. In this case the tubular filter system protects the ultrafilters from the large debris that could damage the ultrafilter membranes. The ultrafilters are needed to separate out the microorganisms from the water for drinking water purposes. In the Littleton facility the ultrafilters are also used to filter the iron and manganese, however, it maybe possible to accomplish much of this filtering with tubular filter systems and a smaller filtering media (down to the micron level). Figure 3. shows the tubular filters and the ultrafiltration filters in their working arrangement.

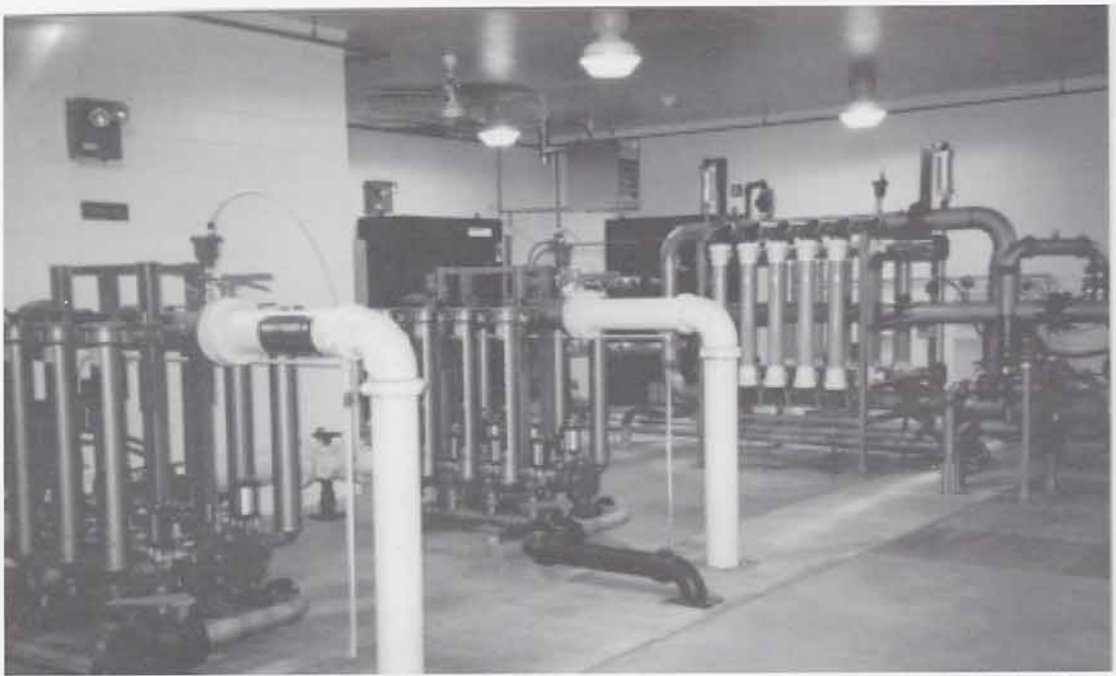

Figure 3. Tubular filters in the foreground filter larger debris from the incoming water prior to it entering the ultrafiltration filters in the background.

OTHER WATER FILTERING USES FOR TUBULAR FILTER SYSTEMS

There are many industrial water uses that do not require the sub-micron filtration attributes of an ultrafiltration system. For these applications, the use of tubular filter systems is a viable and cost effective alternative. Tubular filter systems offer the ability to easily meet the specific filtering needs based on the unwanted material/particles to be filtered. Filtering down to the one micron level is possible with the correct media selection. Tubular filter systems also are designed for clean-in-place operation, reducing operational and maintenance costs.

Using a series of tubular filters, much like the Littleton example, could allow for prefiltering the water with a larger screen for rough filtering the water prior to its introduction into the final tubular filter for polishing.

Post chlorination of the water would remove any unwanted organisms from the water prior to the industrial application. If the application involved heating the water, the post chlorination might not be necessary.

For additional information on tubular filter systems such as the Ronningen-Petter F Series used in the Spectacle Pond Water Production Facility or other applications for tubular filter systems in the production of clean water, please contact:

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Telephone (269) 323-1313, FAX (269) 323-2403, **www.filtration.eaton.com**

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