Protection of Membrane Systems Utilized for Municipal Water

Introduction

As water scarcity issues around the world become more acute, more municipalities are having to turn to alternative water sources for potable water supplies. Also, many municipalities in coastal areas are seeing the quality of their water sources degrade as sea water intrusion occurs. Some of the non-traditional supplies being utilized, including brackish wells and seawater, have much higher dissolved solids levels which must be removed. Treatment processes using reverse osmosis and/or nanofiltration membranes are becoming popular choices for use in these applications as the cost effectiveness of these processes improve.

The microporous structures of membranes are extremely sensitive to fouling. Without proper pre-treatment, excessive fouling from incoming contaminants, such as sand, silt, and other corrosion causing materials, will lead to performance degradation of the membranes resulting in increased cleaning requirements and potentially premature replacement. This customer application brief discusses how the use of appropriate pre-treatment cartridge filtration can help protect the membranes from fouling leading to reduced operating, maintenance, and capital costs.

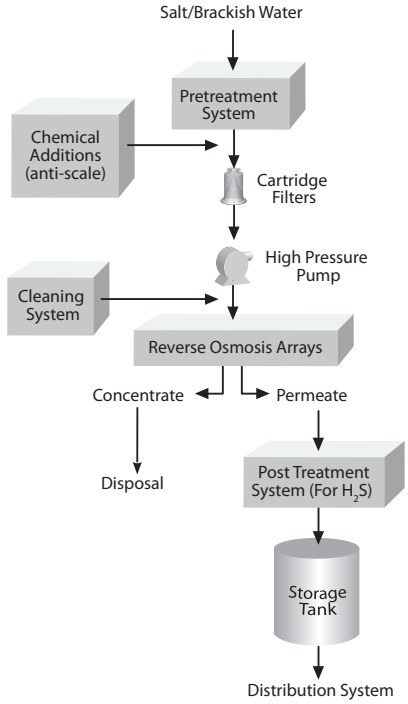


Figure 1. - Municipal Water Filtration using a membrane treatment process

The Process

Figure 1 shows a typical schematic for a municipal water process using a membrane treatment process. The type of pre-treatment depends on the quality of the incoming water supply. Surface waters with high levels of suspended solids may require fixed media filters for proper solids removal. Also, the source water chemistry may need to be adjusted - through acid and/or scale inhibitor feed.

The last step in the pre-treatment process is usually cartridge filtration using nominally rated 1 or 5 µm filters. After cartridge filtration, the water is sent to high pressure pumps which supply the membranes. The required pressure depends on the dissolved solids in the supply water and the desired effluent quality. Pressures can range from less than 100 psi to greater than 1000 psi. As the dissolved solids level of the water increases, higher pump pressures are required to force the water through the membranes. It is common to see the use of both nanofiltration (NF) and reverse osmosis (RO) membranes. NF and RO membranes are similar in design and function - the main difference is in their rejection properties. RO membranes will reject all dissolved salts and inorganic molecules as well as organic molecules with molecular weights greater than 100. NF membranes will reject particles in the size range of 1 nanometer (10 Angstroms) as well as organic molecules with molecular weights greater than 200. The most commonly used membrane elements are spiral wound and 8" in diameter and 40" in length (see Figure 2).

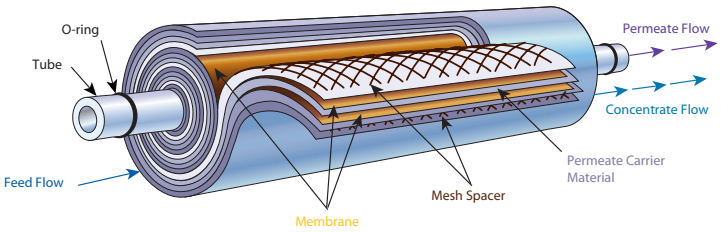
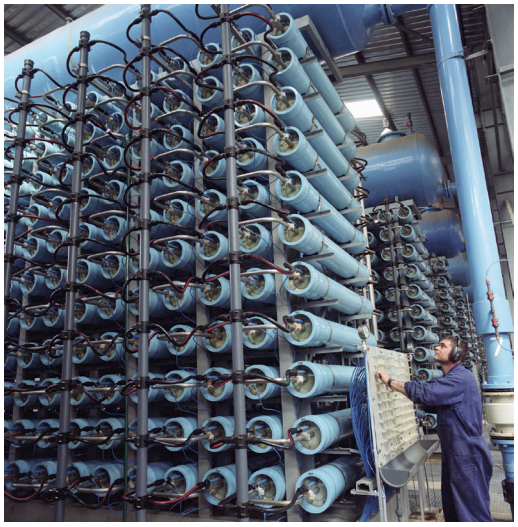


Figure 2. - Membrane Schematic

Typically, up to 8 membrane elements are connected and installed in a fiberglass housing. To handle the required system flows, these housings are connected in an "array" (see Figure 3). A large municipal water facility will consist of hundreds of membrane elements.



Under pressure, the membranes allow "clean" water molecules to permeate through while acting as a barrier to the dissolved ions such as sodium and chloride (i.e. salt). For brackish/sea water systems, typical recovery rates are 50%. This means for every two gallons of feedwater fed to the membranes, one gallon of filtered water (permeate) and one gallon of dirty water (concentrate) is produced. To increase recovery rates, the concentrate is typically sent to downstream ("second pass") membranes. To achieve the desired water quality, second stage systems are frequently used where the water recovered from the first stage membranes is re-pressurized and sent through another set of membranes. The permeate, typically 50% to 75% of the feedwater, recovered from the membranes may be further treated for sulfur dioxide reduction, or pH adjustment, and then is sent to storage before being supplied to the distribution system. The concentrate is disposed of usually through discharge or deep well injection.

Potential Problems

Due to the extremely tight pore structure, membranes are susceptible to plugging from suspended solid particles. Common sources of these particles in typical municipal water systems are:

- Silt, Sand, other Suspended Solids - originating in the water source (well water, surface water)
- Scale or Corrosion products - generated in the equipment, pipes and tanks upstream of the membrane systems

If not reduced through filtration, suspended solids fouling of membranes may lead to the following issues:

Increased Operating Costs:
Suspended solids fouling will increase the pressure drop across the membranes resulting in higher energy (pumping) requirements for a given water production rate.

Increased Cleaning Requirements:
Once membrane performance degrades to an unacceptable level, cleaning of the membranes is required to restore performance. Membrane cleanings require the system to be taken off line and involve the use of acid and/or caustic based chemicals for reduction of the foulants. Cleanings need to be closely monitored as improper cleanings can result in damage to the membranes. It is also acknowledged that cleanings will not restore the performance of the membranes to original levels.

Pre-mature Membrane Replacement:
If membrane fouling problems persist and frequent cleanings are required, it is likely that replacement of the membranes will be required. Depending on the size of the system, this can translate into expenditures in the hundred of thousands of dollars.

Because of their low unit purchase price, string wound cartridges have commonly been used for pre-filtration to the of membrane systems. The performance of string wound filters is controlled by the yarn diameter and the wind pattern both of which are subject to variations in the manufacturing process. These variations will result in a change in particle reduction efficiency, leading to fluctuating downstream water quality. Additionally, the non rigid nature of yarn increases the tendency for string wound filters to unload the captured contaminants as differential pressures change increasing the possibility of membrane fouling.

The Solution:

Selection of the proper filter cartridge system is critical to achieving cost effective protection of the downstream membrane system. Filter cartridges should have particle reduction efficiencies that are quantifiable and consistent and be of rigid construction so unloading of previously reduced contaminants does not occur. Filter cartridges should also have high dirt holding capacities to reduce required filter change-outs.

3M Purification has the following cost effective filtration solutions for existing and new municipal water membrane systems:

Existing Installations:

For existing installations using 2.5" OD filter cartridges, use of the 3M Purification Micro-Klean™ RT series is recommended. Micro-Klean RT series filters are rigid, grooved, polypropylene melt blown cartridges, manufactured to tight specifications. Compared to the use of standard string wound filters, Micro-Klean RT series filter cartridges offer the following advantages:

- Rigid Structure – reduces potential for filter unloading and subsequent downstream contamination resulting from pressure swings and/or higher differential pressures
- Grooved Structure – results in enhanced contaminant holding capacity for increased filter life and fewer filter change-outs
- Lower Initial Pressure Drop – translates into longer filter life and /or higher flow capabilities

Micro-Klean™ RT Series Filters

The above product features allow Micro-Klean RT series filters to provide for improved protection of downstream membrane elements compared to conventional string wound filters. Due to their higher dirt holding capacities, Micro-Klean RT series filters can also offer a lower total cost of filtration compared to string wound filters. For more information on Micro-Klean RT series filter cartridges please request 3M Purification literature piece # LITCPPOLYKLN.

New Installations:

For new system installations, use of the 3M™ High Flow series filter systems is recommended. The 3M High Flow series filter system utilizes large diameter (7") radially pleated cartridges in a compact housing design. High efficiency polypropylene microfiber media is used in the High Flow cartridges resulting in consistent, predictable particle reduction efficiencies. In comparison with conventional 2.5" filter cartridges, the 3M High Flow series filter system the following advantages:

- Higher Particle Removal Efficiencies (99.9%) - providing for optimum protection of downstream membranes.
- High Flow Capability - the unique construction of the 3M High Flow series filters permits flow rates up to 500 gpm in a single cartridge.
- Compact Housing Design - the high flow capability results in a smaller housing required for a given flow rate translating into reduced up-front capital expenditure requirements and footprint.
- Ease of Use - with fewer required cartridges, filter change-outs are much easier. Also, the High Flow system incorporates a "twist-to-lock" cartridge seating mechanism providing for a positive indication of proper sealing reducing the possibility of bypass.

3M™ High Flow series filter system

Figure 4 shows the benefits of the 3M High Flow series filter system vs. a conventional 2.5" cartridge system for a 2000 gpm flow requirement. For more information on the 3M High Flow series filter system please request 3M Purification literature LITCHF1.

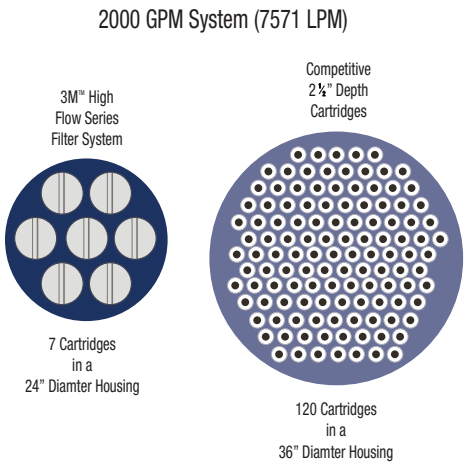


Figure 4. - 3M™ High Flow Series Filter System vs. a conventional 2.5" cartridge system

Conclusion

Proper cartridge filtration is a critical component of a membrane system. Failure to properly reduce suspended solid contaminants can lead to increased energy requirements, increased off-line cleaning requirements, and premature membrane replacement.

For existing systems with filter housings using 2.5" cartridges, 3M Purification recommends the use of Micro-Klean™ RT series filter cartridges. The rigid structure of Micro-Klean RT series filters allows for consistent, reproducible downstream water quality providing for proper membrane protection from suspended solids fouling. The grooved structure of Micro-Klean RT series filters results in higher dirt holding capacities compared to conventional string wound filters translating into lower total filtration costs.

For new installations, use of the 3M™ High Flow series filter system is recommended. The high efficiency media incorporated into the 3M High Flow filter cartridges results in optimum protection of downstream membrane elements. The high flow capability, up to 500 gpm per cartridge, translates into smaller filter housings and lower capital expenditures than conventional 2.5" cartridge systems. For a given flow rate, the 3M High Flow series filter system can require up to 90% fewer cartridges as conventional 2.5" cartridge systems, drastically reducing filter change-out labor and time requirements.

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