Get the Most from Your Membranes

Lessons from Maui's 10-year operation

More than a decade ago, Maui County, Hawaii became a pioneer in the use of low-pressure membrane filtration for drinking water. Ten years later, the Maui Department of Water has successfully operated and maintained its membrane investment and now boasts one of the longest running drinking water systems in the world, using the original membrane modules. At a time when membrane filtration for municipal applications was met with significant skepticism, Maui was experimenting with coagulants and cleaning regimes that have now become standard practices in membrane treatment all over the world. The county's operating experience and ability to achieve long membrane life have served as a benchmark for proper membrane maintenance and care for the municipal industry.

Membrane Pioneers

The Department of Water Quality, an agency of Maui County, provides water to approximately 34,000 service connections using four low-pressure membrane filtration systems. Each of the four plants use Memcor pressure-driven membrane modules; two of these installations are still running with the original membranes after nearly 10 years of around-the-clock operation (see Table 1).

Known in the state for having some of the most difficult waters to treat, Maui sought a technique that would produce reliable water while minimizing land requirements. The raw water at each of the county's four membrane plants has distinct characteristics in terms of solids and minerals. In general, the waters have the following properties:

- Kamoke and Iao – Turbidity spikes up to 600 NTU: high algae
- Lahaina – High algae; color over 25 true color units
- Olinda – Elevated iron; color between 180 and 200 true color units; low alkalinity

The longest running plant, Lahaina, began operation in 1997. The membrane system was selected following comprehensive pilot studies conducted in 1995. In these initial studies, several membrane systems were repeatedly exposed to high turbidity spikes (>600 NTU) over several months. The county ultimately selected a system that revealed no decline in finished water quality while demonstrating no decline in capacity or recovery following backwash and clean-in-place (CIP) operations. The membrane modules achieve greater than 6-log removal of bacteria and produce turbidity levels of less than 0.1 NTU, regardless of changing feedwater conditions.

Pretreatment using chemicals and/or short detention periods helped to reduce fouling related to high organics, iron and algae. For minimal capital cost, pretreatment could be installed to reduce backwashing, cleaning and, ultimately, operating costs.

Maintain Investment Daily

Achieving long-term operation begins with proper system design, including instrumentation and intelligent control systems that provide both control and diagnostic capabilities. All facilities in Maui are equipped with programmable logic controllers (PLCs) and SCADA workstations, giving operators precise control over the plants' membrane systems. In-situ integrity testing is conducted automatically every 24 hours to evaluate the entire system, including membranes, valves, gaskets and fittings, to ensure that the barrier between the feed water and finished water is intact.

Second, a membrane filtration system is not unlike other treatment technologies such as rotating equipment, automatic valves, electronic controls and instrumentation. All these components require routine maintenance to keep them operating efficiently and reliably. Developing and conscientiously adhering to a routine maintenance schedule is an easy way to achieve long-term, reliable performance.

Plant	Capacity	Pretreatment	Operational
Lahaina	2.5 mgd	Chemical & sedimentation	1997
Olinda	1.8 mgd	Chemical & sedimentation	1998
Kamole	6.75 mgd	Chemical	1998
Iao	2.5 mgd	None	1999

Diligent systems monitoring by plant operators is also important for long-term operation. Using diagnostic reports generated by the PLC, operators can identify and correct anything that could have a long-term negative impact on the membrane system. The "backwash profile" is one such diagnostic report that graphically depicts individual pressures, air and water flow rates throughout the cycle. Plant operators analyze these graphs and look for any discrepancies from established, base-line criteria. If the flows, pressures, or even the timing are not quite right, the effectiveness of the backwash will be diminished, leading to more frequent chemical cleaning and the potential for long-term problems. Identifying and fixing any problem early is an easy way to protect your investment.

Analyze Small Changes

Of all the issues that affect membrane life, maintaining flux and plant capacity is the most important. Scheduled process audits conducted by the membrane manufacturer help to identify and correct any loss in flux or capacity before the membranes are permanently affected.

Process audits have two primary objectives: inspection and evaluation of both the mechanical components and the process performance. The mechanical inspection verifies that all equipment such as valves, pressure regulators, flowmeters, pumps and blowers are working properly. Any mechanical problems are identified and necessary adjustments or repairs are made. Membrane modules may be pulled from the system and inspected.

During the process inspection, each step of the operating sequence is analyzed in detail. Actual performance data, water quality and chemical cleaning results are analyzed to determine if there have been any changes in performance that could be attributed to changes in raw water or other "events."

All four of Maui's membrane filtration plants undergo process audits at least once a year. In two instances, the process audit identified that subtle changes in the raw water quality were the culprit in declining performance. As a result, minor changes to the CIP process were made for a continued long-term operation at peak performance.

As another example, a decline in cleaning efficiency at the Kamole plant prompted a membrane autopsy, which revealed a problem with algae growth due to conditions in the watershed. Based on the findings of this process audit, the cleaning regime was changed to include citric acid and a surfactant, including hydrogen peroxide (H2O2). The new cleaning regime fully restored the membranes to their original state. The membranes are still running today, eight years later.

A similar situation occurred at the Olinda plant with declining CIP intervals where the standard cleanings were becoming ineffective at removing fouling. The process audit uncovered high levels of iron in the water that were not being effectively removed during normal cleaning. A new cleaning regime using metabisulfite proved to be effective and made a tremendous improvement in flux recovery after CIP. The plant gained between one and two years of extended use from the membranes as a result of the new CIP process. The cleaning regime was patented, and is now used at other Memcor locations to treat iron fouling in places where membranes would normally need more frequent replacement.

Embrace innovation

While the Maui Department of Water Supply has been efficiently operating with its original polypropylene membranes, low-pressure membrane technology has continued to evolve as fiber research and system designs have advanced. To that end, the Olinda plant was retrofitted, after almost nine years of operation, to take advantage of improvements that will allow for increased capacity at significantly lower operating costs.

After 18 months of successful pilot testing, oxidant-tolerant polyvinylidene (PVDF) membranes were found to produce greater capacity with less cleaning. The PVDF modules are the same dimensions as the original modules, allowing them to be easily installed into the existing systems. Piping and control changes were conducted to use a lower pressure air backwash, reducing energy costs. Once the change is complete, the plant will benefit from greater capacity and reduced operating costs in the same footprint.

Conclusion

The Department of Water Supply's long-term experience with operating and maintaining low-pressure membranes for drinking water filtration has helped the county to cost-effectively achieve its drinking water quality and supply goals well into the future. While low-pressure membrane filtration continues to evolve, diligent system monitoring and scheduled process audits will continue to play a major role in protecting your investment by maintaining long-term, useful membrane life.

Lahaina WTF III

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MC-MAUldr-CS-0509