Utilizing Reverse Osmosis to Recover Waste Water from a High Purity Water Treatment System
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Prepared Discussion

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This paper presents a thorough explanation of a growing problem facing users of high purity water- that is high volumes of waste water generated by various water treatment technologies such as Reverse Osmosis (RO). The authors present the problem facing Entergy Nuclear very clearly and explain the thought process and step by step attempts to reduce considerable volumes of waste generated in this application. I applaud the authors for their persistence. The final solution was to install a second "Recovery" RO system to purify some of the primary RO concentrate. The result was an impressive 50 to 70% recovery of the primary RO's concentrate back to into the system feed inlet.

With advances in membrane technologies and reductions in costs, RO has truly become a very reliable and cost effective means of primary deionization. The system design and installed at Entergy not only takes advantage of membrane technology by utilizing RO, but also adds Degasification Membranes and Electrodeionization (EDI) as additional membrane technologies which can produce continuous, chemical-free water.

The downside of RO is the high volumes of waste water generated with standard systems. By design, the authors chose a very good approach to increase overall recovery of the system, and that is to recover EDI waste water to the RO inlet. The RO system appears to be a standard two stage, single pass design which operates at 68.75% normal recovery.

It is generally accepted that a three stage system allows up to 85% recovery. The industry also frequently returns final stage permeate to the first stage RO feed, improving system rejection and gaining highest available recovery. Very often we use inline boost pumps or PEI turbochargers. In this case, the authors elected to reduce water consumption by taking a similar but distinct approach. Due presumably to space restrictions, they chose instead to install an independent Recovery RO system.

The chlorinated, unfiltered, surface water provided by the city poses several problems for the RO membranes. Since the water is chlorinated, it must be dechlorinated and the authors provided activated carbon filters for this purpose. Second, since it is unfiltered, the water will have high suspended solids loading, and must be efficiently filtered to protect the RO membranes from plugging. Finally, the surface water nature is prone to fouling due to the seasonal fluctuations in suspended solids and total organic carbon (TOC). While multimedia filters can provide adequate suspended solids removal, activated carbon filters are not reliable for TOC reduction, therefore a low flux rate of 8-14 gfd would be recommended for the primary RO membranes unless a low pore diameter ultrafiltration (UF) module is used to replace the Multimedia Filters.

Questions Arising from the Paper

In the interest of a more informative discussion and evaluation of this project, I pose the following questions to the authors.

1. No RO design information was given. At maximum recommended surface water flux (14 gfd) a minimum of 48 membranes, in a 5:3 array would be necessary. What is the design membrane flux and array of the primary RO?
2. Very little RO design information was given for the recovery RO. The concentrate water does not seem very challenging. What design considerations were given and how did these considerations affect performance?
3. No payback calculations were supplied. In the current stagnant economy, it seems that any capital spending or increased maintenance budgets are extensively scrutinized. Please provide the specific operating costs calculations (outsourcing and electricity and any other consumables) of the secondary RO versus reduction in waste water.
4. This paper does a good job of explaining the benefits of outsourcing, but does not show the cost comparison to either capital equipment purchase or lease. It would be of interest to evaluate the operating costs of outsourcing versus operating costs of a system owned by the end user (replacement elements, chemicals, electricity, and labor).
5. Degasification Membranes are an efficient means to remove Oxygen and Carbon Dioxide from the RO permeate, and EDI will produce high purity water without chemical regeneration. The carbon filters and softeners between the Degas Membranes and EDI system is unusual. EDI modules are now capable of handling hardness up to 2 ppm as $CaCO_3$, so the softener should not be necessary. Please elaborate on the reasons for the softener. What is the hardness into the EDI modules, and how does this affect operation?
6. It seems as though fouling is a concern for both RO systems. All membrane systems need periodic cleaning to maintain flux and rejection. What is the frequency of cleaning? Have other measures such as improved pretreatment (i.e. Ultrafiltration) been considered? Why or Why not?