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A COMPARISON OF REVERSE OSMOSIS MEMBRANE CLEANING METHODS (U)

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A Comparison of Reverse Osmosis Membrane Cleaning Methods (U)

SUMMARY

Testing was conducted at TNX to evaluate the reverse osmosis (RO) cleaning methods in use at the F/H Effluent Treatment Facility (ETF). The present ETF membrane cleaning protocol involves a low-pressure-no-permeation method using NaOH. This work has examined the effectiveness of the present ETF method, due to the lack of improvement following the cleanings sometimes observed.

This study has evaluated both low pressure (15-20 psi with no permeation) and high pressure (200 psi with permeation) cleaning methods with sequential cleanings using NaOH and Filmtec Alkaline Cleaner. The importance of the cleaning sequence with these two chemicals was also examined.

The amount of flux which could be restored was found to be very dependent upon the sequence in which the cleaning steps were performed. The NaOH-then-Filmtec sequence returned the clean water flux to pre-fouled conditions or better and substantially improved the DFs; whereas, a Filmtec-then-NaOH sequence restored only 90% of the pre-fouled flux values and only slightly improved the DFs. No significant differences were observed between cleaning operations at low or high pressure.

IWT recommends that the ETF use a two-step cleaning process of NaOH followed by the Filmtec alkaline cleaner. This cleaning method should restore performance to pre-fouled conditions.

INTRODUCTION

ETF biofouling problems with the reverse osmosis membranes [e.g., Siler (1991a-1991c)] have been studied and several potential improvements discovered. However, the question of cleaning efficiency at the ETF has not been addressed. In addition, the

need for additional cleaning capability to maintain or restore the membranes to their designed capacity has also been questioned.

The normal practice in the membrane industry is to clean the membranes using low pressure independent of the cleaning reagent used. This will be sufficient provided that the membrane fouling is on the surface and not down in the pore structure. Low pressure cleaning will not force cleaning solution into the pores and thus subsurface fouling could remain.

An experimental program was implemented to address the question of RO cleaning efficiency. The objective was to evaluate the present method of low-pressure cleaning against high-pressure cleaning and to compare the effectiveness of NaOH and Filmtec Alkaline Cleaner, which had been shown earlier to be superior to NaOH.

EXPERIMENTAL PROCEDURE

The basic experimental procedure was outlined in report #WSRC-RP-91-431. Detailed operating instructions can be found in TNX operating procedure #679T90039.

Severe membrane fouling was achieved using a solution containing salt, sparingly-soluble metals, and $1.E7/ml$ bacteria. A flux loss of 20-30% and a DF loss of over 50% resulted after processing the bacteria. Two cleaning methods [low pressure (15-20 psi) with no permeation and high pressure (200 psi) with permeation] were tested. Two cleaning reagents (NaOH and Filmtec Alkaline Cleaner) were also evaluated. The low- and high-pressure cleaning tests were performed sequentially after fouling the module. Two versions of this experiment were carried out: first the membrane was cleaned with NaOH then with Filmtec cleaner, and then the reverse order was tested. Each cleaning was performed at 35°C, and the unit was rinsed and a standard salt test (2,000 mg/l $NaNO_3$) was performed.

RESULTS AND DISCUSSION

A summary of the cleaning tests is given in Figures 1-4. It can be seen in Figure 1 that the NaOH cleaning successfully restored the water flux. However, the flow-averaged DF (Figure 2) was only partially restored by caustic cleaning. The DFs increased from 30 to 80 and 20 to 35 for water recoveries of 0 and 90%, respectively. A low-pressure Filmtec Alkaline Cleaner cycle was required to restore the DF performance. Here the DFs increased to 117 and 50 at 0 and 90% water recovery, respectively. Bacterial adhesion evidently remained after cleaning the membrane with caustic and Filmtec cleaner was required to completely restore performance.

Cleaning in the reverse order, Filmtec cleaner followed by NaOH, was not as successful. It can be seen in Figure 3 that this methodology was not as effective at restoring performance, as a

10% flux loss remained. Also, as can be seen from Figure 4, the flow-averaged DFs only increased from 35 to 60 and 45 to 65 at water recoveries of 0 and 90%, respectively. A second cleaning with NaOH restored the DF.

The differences observed in the cleaning sequences most likely stem from the fact that the membrane foulant matrix is extremely complex. The presence of both colloidal inorganic hydroxides and a bioslime results in a foulant with strong adhesive tendencies. This foulant would require breakdown of the inorganic colloids on which the bioslime is adsorbing onto. The NaOH appears to successfully dissolve the hydroxides into a form with reduced adhesion. This allows the Filmtec cleaner to attack the bioslime, and hence the membrane is restored to pre-fouled conditions. The Filmtec cleaner does not have the ability to modify the inorganic portion of the foulant and thus cannot reach all of the bioslime present on the membrane surface. The same result would probably occur if an acid cleaner (e.g., oxalic acid) were used prior to the Filmtec Cleaner.

CONCLUSIONS AND RECOMMENDATIONS

The RO bacterial fouling can be restored by a two-step cleaning process: cleaning the membrane with NaOH followed by Filmtec Alkaline Cleaner. A second cleaning is required to restore salt DF.

IWT recommends that the membranes at the ETF be cleaned via the same process. Approximately 20-50% improvement in salt DF can be expected, based on the lab-scale tests. Complete restoration of the water flux would also be anticipated.

QUALITY ASSURANCE

The work described in this report was performed according to the guidelines in the SRS QA manual. The data collected during these tests were recorded in laboratory notebook #WSRC-NB-90-257.

REFERENCES

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Siler, J. L., "Remediating Biofouling of Reverse Osmosis Membranes(U)", WSRC-RP-91-1059, October 22, 1991.

Figure 1. Water Flux Data Resulting from Cleaning with NaOH Followed by Filmtec Alkaline Cleaner.

Figure 2. Flow-Averaged DF Improvements Resulting from Cleaning with NaOH Followed by Filmtec Alkaline Cleaner.

Figure 3. Water Flux Data Resulting from Cleaning with Filmtec Alkaline Cleaner Followed by NaOH.

Figure 4. Flow-Averaged DF Improvements Resulting from Cleaning with Filmtec Alkaline Cleaner Followed by NaOH.

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