MASAR مسار تقنيات Technologies, Inc.

Experience. Innovation. Performance. LEADERSHIP

High Brackish SWRO Plant Case Study

Train G – DuPont HFF Membrane System

This is the first plant case history study that MASAR Technologies, Inc., has conducted and led to the development of its **SMART** real-time monitoring technology and associated **SilentAlarm**™ software system. The 46,000 m^3/day high-brackish RO plant is located in one of the Arabian Gulf countries when it was built and started up in 1984. The membrane system at the plant was based on DuPont's HFF seawater RO membranes due to the high salinities of the incoming feedwater, averaging 11,000 ppm and piped into the plant site from 18 remote wells, with some seawater intrusion.

The 3-stage membrane system conversion was set at 65% at least for the first two years of the plant operation, which also covered the initial performance warranty period. The plant, the first and largest of its kind using the then-new RO technology was being monitored very closely and on a daily basis by the membrane supplier's technical personnel.

As Fig.1 shows, close monitoring and evaluation of the plant performance over the first two years using the standard ASTM normalization method (*ASTM D-4516*), revealed a largely excellent performance trend, with a mildly steady decline, mostly anticipated due to the natural phenomena of virgin polymer compaction, with an assuring trend in the last few months of levelling off, which was expected to last for a long time as long as the operation and monitoring were performed at high level of quality. Only near the end of the 2-year system performance warranty offered by the membrane manufacture, a sudden and ugly turn in the performance started to occur. At that point (*red arrow in Fig. 1 below*), we realized that there may be a serious membrane fouling problem that is finally exhibited in the plant despite all of the physical and analytical indications otherwise for the first full two years of operation!

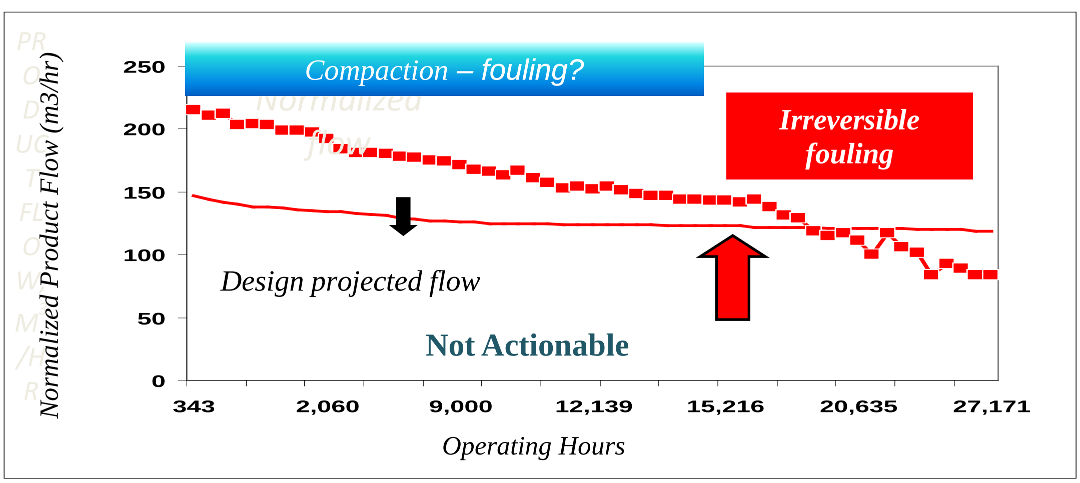

Fig. 1 – ASTM-Normalized Flow Decline Curve for Train E

The sudden and accelerated drop in normalized flow shown in Fig. 1 (red arrow inflection point) and witnessed after 2 full years of seemingly excellent operation, producing 15-20% over design flow, as well as constantly monitored performance was very disturbing. The plant was gold-plated design with an experience contactor and operator. A new thinking and review of the field applicability and technical soundness of the current standard analytical techniques (i.e., *ASTM D-4516 – Standard Practice for Standardizing Reverse Osmosis Performance Data*) was due.

Considering that the original standard method was based on membrane manufacturer's lab tests and procedures, including use of non-representative 30,000-35,000 mg/l salt solution or the so-called synthetic seawater as untreated and non-fouling feed water to unrealistically simulate actual plant seawater compositions, lack of any real-plant pretreatment and centrifugal high-pressure components and other site-specific factors, as experienced in the field, certain corrections to the standard method calculations were made to try to simulate real plant conditions, not just those of the membrane as a black box, as much as possible for this plant. The resulting ASTM-corrected normalized flux decline curve is shown in Fig.2 below.

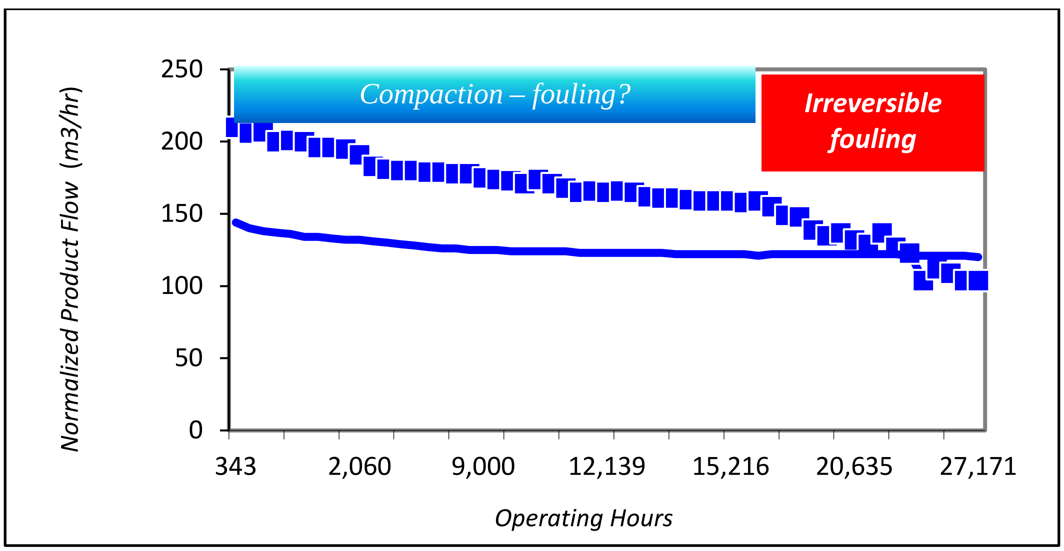

Fig. 2 – ASTM-Corrected Normalized Flux Decline Curve for Train E

It is clear that the corrected normalized flux decline curve looks very similar to the ASTM curve, as far as the end user is concerned. Namely, the resulting trending profile, whether achieved by ASTM method or the corrected method alone, still does not give the plant owner or operator any value in identifying the onset of fouling until it is too late.

The breakthrough in this technology lies in superimposing the two curves on each other to see what the real differences are (*Fig. 3 below*).

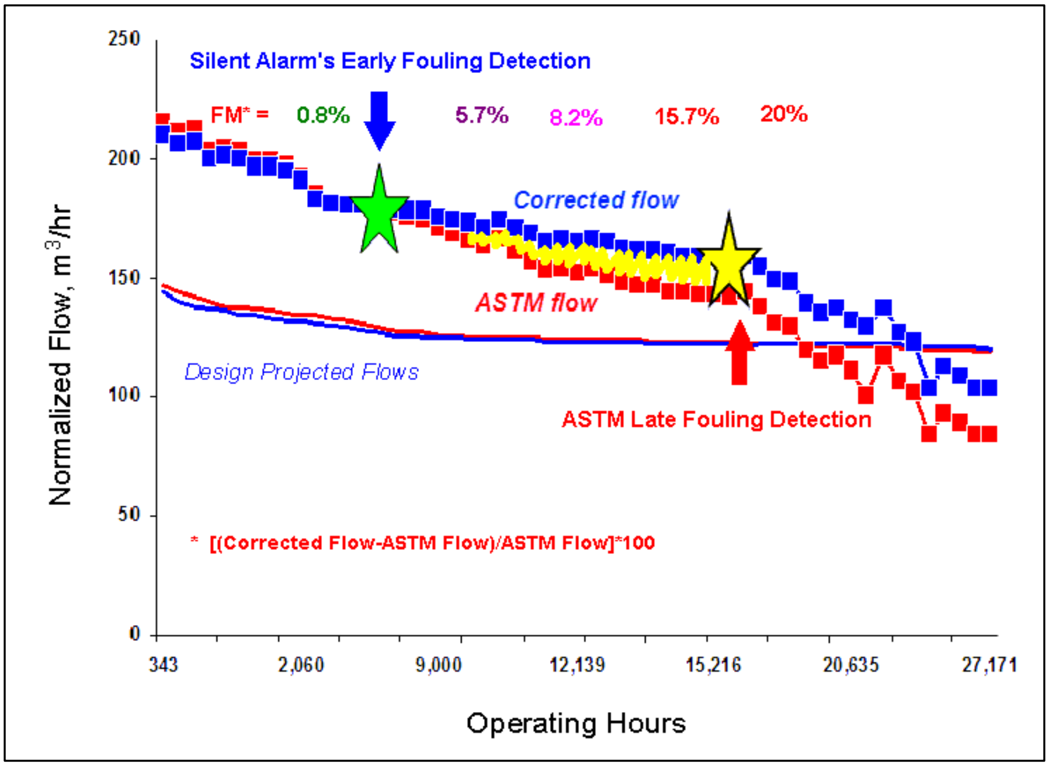

Fig. 3 – Comparative ASTM-Normalized Flows vs ASTM-Corrected Normalized Flows

Since the ASTM trending assumes ideal-condition operation by definition (i.e., *no membrane fouling*), since fouling cannot be modeled, simulated, calculated or predicted in the plant design phase (*Unlike chemical scaling which can be calculated in advance and accounted for in the design projections once the ionic composition of the feed water and the set conversion are known*), it seems that during the first year of operation (i.e., about 8700 hours), the two lines were virtually identical, signifying the fact that there was actually no membrane fouling in the plant since the correction did not make any significant difference. However, starting with the second year of operation, it seems that some fouling started to develop and increase in magnitude as the plant continued to operate, since the corrected curve started to diverge from the ideal curve (i.e., *ASTM-normalized*). It took almost 9 months after the onset of fouling that it started to affect the performance of the plant and only at that point, we came to realize what has been happening all along. Upon panic troubleshooting of the plant to find out what was happening, we discovered the presence of thick mats of algal growth in the media filters, which apparently found their way to the membranes in terms of contaminating the system with biological fouling.

Had this methodology been used in real time from the beginning, it would have alerted the plant operator of the first and early incidence of fouling and troubleshooting would have been initiated immediately, even though the plant appeared to be performing perfectly, and the problem would have been corrected and addressed before it had caused irreversible damage to the membrane system.

After the plant was rehabilitated and a new set of membranes was installed, we received a new set of historical operating data from the plant, covering about 7 years (*~60,000 hours*) of seemingly flawless operation. The data was again uploaded to the **SilentAlarm**™ and analyzed, yielding the comparative flux decline curves in Fig. 4 below. Under non-fouling conditions, as the case in this plant study, the closer the two flux declines curves are together, the lower the fouling potential is, as exhibited by Fig. 4 and Fig. 5 (***FM** profile*) below.

Fig. 4 – Five-Year **SilentAlarm**™ Comparative Normalized Flow Profile for Retrofitted Train E

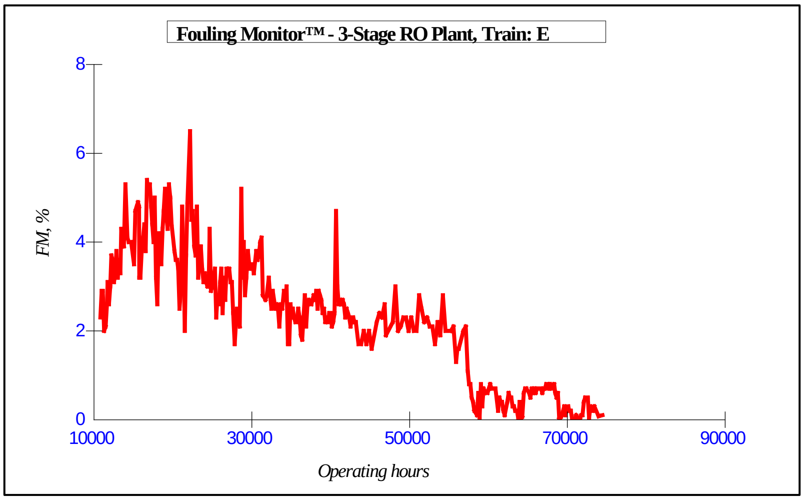

Fig. 5 – Five-Year **SilentAlarm**™ **FM** Performance History for Retrofitted Train E

Five years into the new operation, the plant decided to start raising the overall conversion from 65% to 70% by replacing a select number of membranes, as shown in Fig. 6 below.

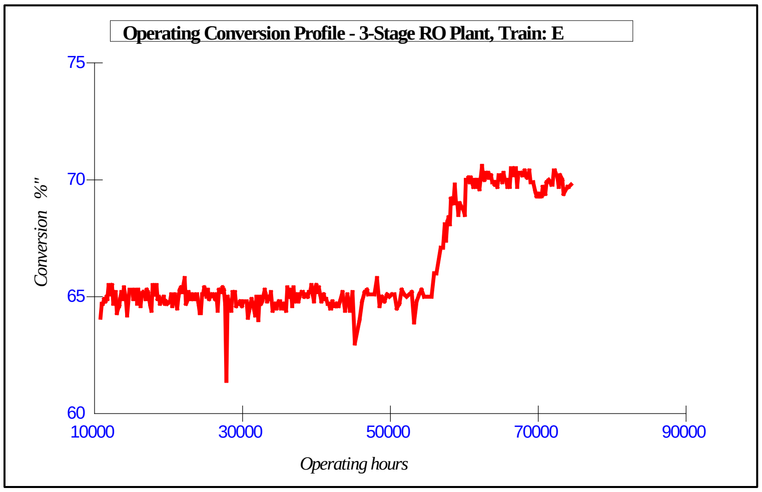

Fig. 6 – Five-Year Membrane System Conversion History for Train E

Field experience shows that when membrane plants operate at steady **FM** values under 3%-5%, non-fouling conditions prevail due to sound plant design, good operation and maintenance procedures, and lack of major fouling sources. However, when the operating conversion was increased at this plant by adding new high-flux membranes preferably to stage 1 at 59,145 hours of operation, a remarkable corresponding increase in the fouling potential of the system was observed, as exhibited by the dramatic increase of the **FM** from almost 0% to 1.75%, a 175% increase relative increase, as Fig. 7 below shows, probably due to creating hydraulic imbalance in the system..

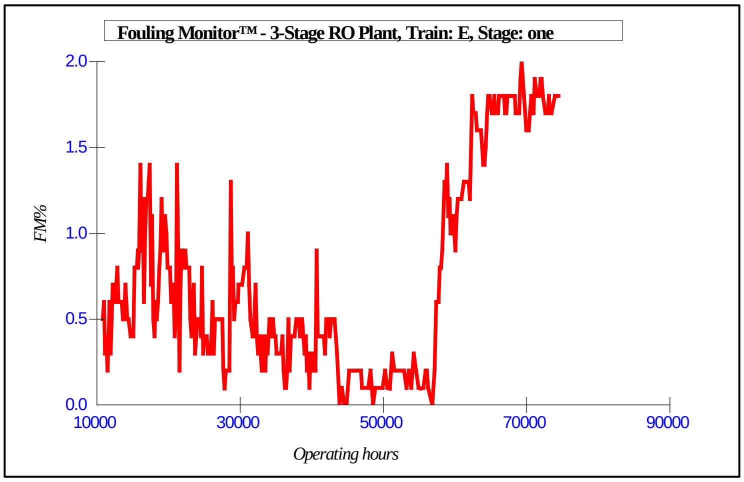

Fig. 7 – Five-Year **SilentAlarm**™ **FM** Performance History for Retrofitted Train E, Stage 1

Nevertheless, non-fouling condition still prevailed as the **FM** was still well below the average **FM** observed at fouling plants (i.e., *less than 3%-5%*). **It may even be possible to further increase the conversion to** a higher attainable value by monitoring the **FM** behavior. Thus, monitoring the **FM** in real-time provides a **unique tool allowing the optimization of the operating conversion and flux** as long as the two flux decline curves stay close to each other, while maintaining acceptable membrane pressure drops and cleaning frequencies.