



Essential Expertise
for Water, Energy and Air

3D TRASAR® Technology protects membranes from chlorine, and enhances water savings by increasing recovery 20%



Situation

A Nalco customer in North America, is an OEM parts supplier for the automotive industry. Process water is produced by Reverse Osmosis (RO) in this plant. A predetermined amount of SBS is added to the RO feed water to control free chlorine. The free chlorine was measured periodically and was therefore deemed to be in control.

The RO system was run at particularly low levels at ~60% recovery to obtain a stable water production. The relatively low recovery was due to the high conductivity in feed water and high scaling potential at the high pH employed by the system (to prevent excess CO₂ leak through the permeate). There was a desire to increase recovery in order to save water costs, but the existing monitoring system was insufficient to track and detect potential system failures.

Background

Free Chlorine Control

It is well known that polyamide-based RO membranes are vulnerable to chlorine. Long-term exposure to trace chlorine can oxidize the membrane and compromise salt rejections. Commonly, sodium bisulfite (SBS, NaHSO₃) is used to neutralize the residual chlorine. The sulfite dosing rate required to neutralize the residual chlorine in feed water is calculated based on a stoichiometric mass balance and a safety factor as shown in the following equation:

$$\text{Sulfite dosing rate} \left(\frac{\text{eq}}{\text{min}} \right) = \text{Flow rate} \left(\frac{\text{m}^3}{\text{min}} \right) \times \text{Residual Chlorine} \left(\frac{\text{eq}}{\text{m}^3} \right) \times \text{Safety Factor}$$

In order to ensure there is no chlorine in the RO feed water, oxidation-reduction potential (ORP) is monitored in many RO plants.

ENVIRONMENTAL RESULTS

Reduced RO feed water by 20% or 29,800 m³/7.87 million gallons per year



water



asset

Protected membranes from being damaged by free chlorine



ECONOMIC RESULTS

Saving \$66,800 per year

Saving \$10,600 per year for membrane replacement

However, maintaining and calibrating the ORP probe is known to be more difficult than other sensors such as pH, pressure, temperature, etc. due to long-term drifting, contamination, short lifetime of the probe under stressful conditions, etc. In addition, it is inherently not possible to detect all the ORP excursions by manual monitoring. Consequently, membranes are often exposed to chlorine unknowingly in real world situations.

Water Recovery Control

Typically, RO systems are designed with redundancies to ensure reliable water production. For example, RO systems are designed at a moderate water recovery to minimize the risk of abrupt performance loss from scaling and biofouling. However, if better real-time monitoring and closer supervision are available, water recoveries can be increased by 5-15% in the existing system depending on the redundancies in the system design.

Solution

Nalco installed 3D TRASAR Technology for Membranes with ancillary probes and sensors to monitor all the operating parameters. Remote monitoring has been also performed through Nalco 360 Service, a team of experts who monitor and interpret system conditions in real time 24/7, along with service support. Due to the regular maintenance service provided by Nalco, all the operating parameters were acquired seamlessly without a significant error. The ORP reading stayed at around +100 mV, and water recovery at around 60% during normal operations.

One day, however, a Nalco 360 monitoring expert was alerted by an ORP excursion at above +400 mV (Figure 1). A Nalco technical service representative was dispatched to the plant to investigate the cause. While no abnormality was found despite a thorough investigation, the ORP reading returned to normal levels. As the similar ORP excursion occurred the next day, the Nalco rep was dispatched again. At this time, the SBS feeding pump was not feeding chemical intermittently due to 24/7 monitoring. The feeding pump was replaced with a spare pump and the problem was resolved immediately.

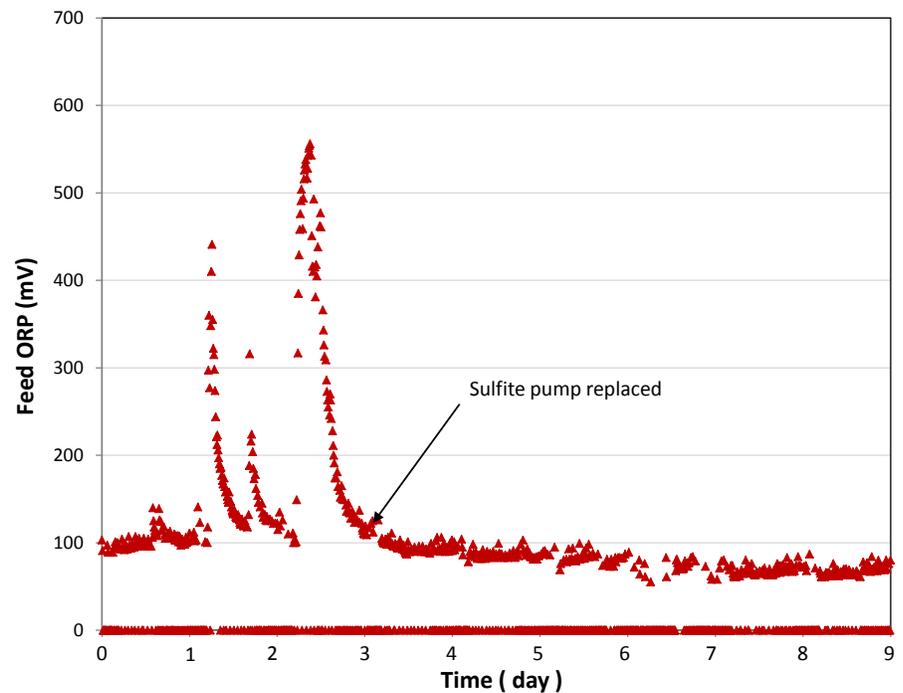


Figure 1 – ORP time curve acquired real time remotely through Nalco 3D TRASAR technology.

In an effort to seek opportunities to increase water recovery, the membrane permeability that indicated the extent of membrane fouling was remotely monitored through Nalco 360 Service. The permeability remained relatively stable throughout the entire filtration cycles. This suggested there was room to increase water recovery. Nalco decided to return a portion of concentrate recycled back to the feedwater to save fresh water as shown in Figure 2, where the amount of concentrate recycled was directly translated to the amount of fresh feed water saved. Simultaneously, the same amount reduction was expected in concentrate production.

As a first step, 20 gpm (or 4.5 m³/hr) of concentrate was recycled back to the feed line using a recycle loop shown in Figure 3. After confirming there was little change in permeability for two weeks through Nalco 360 Service, concentrate recycle flow rate was raised to 30 gpm (or 6.8 m³/hr), which was around 20% of the feed water flow originally used (160 gpm or 36.3 m³/hr). As a result of the partial concentrate recycle, overall water recovery increased from 60% to 73% as summarized in Figure 3.

Solution Background

3D TRASAR technology for Membranes is a remote monitoring and control platform employing patented TRASAR technologies. When it is applied to RO, it remotely monitors

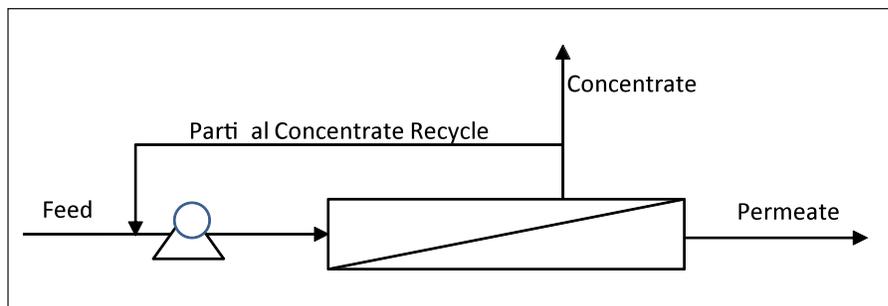


Figure 2 – A partial concentrate recycle to save fresh feed water.

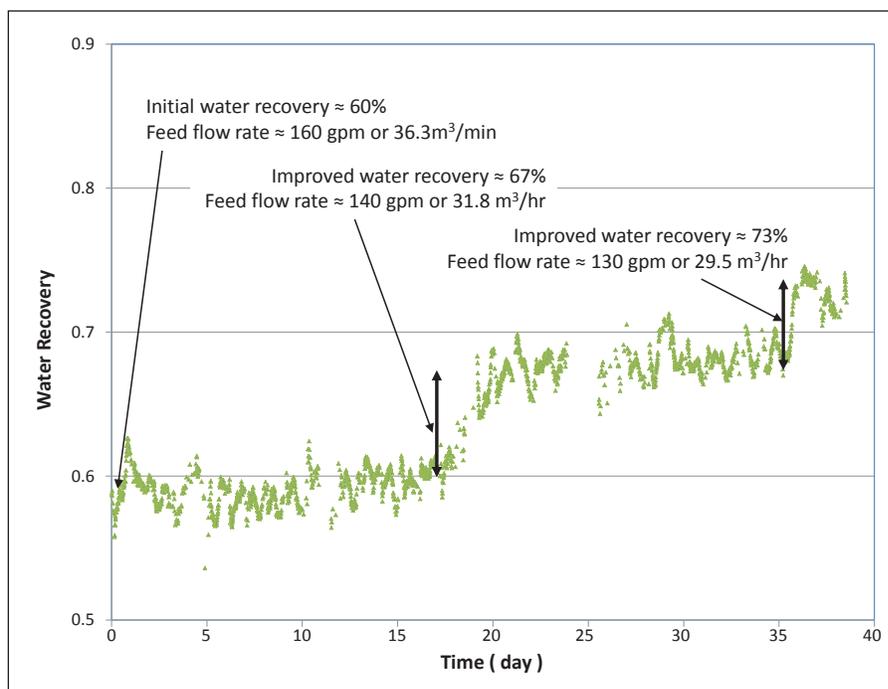


Figure 3 – Gradual water recovery increase by increasing concentrate recycle flow to save fresh feed water.

all the relevant system parameters real time including but not limited to the following:

- Pressure loss in prefilter
- Feed, interstage, concentrate, and permeate pressures
- Feed and permeate flow rates
- Feed and permeate conductivity
- pH, temperature, ORP, antiscalant dosage in feed
- Chemical inventories of acid/base, antiscalant, cleaning agents, etc.

3D TRASAR Technology for Membranes posts all the acquired data on the 3D TRASAR Web from which weekly reports are generated and, if required, alarms are generated automatically to alert system abnormalities and chemical inventories. In addition to data acquisition, 3D TRASAR technology can directly control feed pH, antiscalant dosage, and provide ORP surge protection.

Nalco 360 Service is a web-based service that allows monitoring of more detailed system performance by automatically trending the operational data already logged in the 3D TRASAR Web. Experts obtain alerts for prefilter replacement, membrane cleaning, and other action items before they are required. Nalco's dedicated monitoring experts also monitor the system 24/7, generate periodic reports, and respond to any service requirement.

Environmental/Economic Results

When 3D TRASAR Technology and Nalco 360 Service were combined with a regular maintenance and calibration of the

system, ORP excursion could be controlled seamlessly. As a result, Nalco protected \$10,600 worth of membranes from being damaged by chlorine.

By raising water recovery, feed water flow decreased by around 20% from 160 gpm (36.3 m³/hr) to 130 gpm (29.5 m³/hr). Annual water savings were estimated at 29,800 m³/7.87 million gallons considering the down time. Annual water cost savings were \$67,000. Savings of chemicals due to the reduced fresh water volume were extra.

Conclusion

Chemical additions in the RO system are performed based on stoichiometric mass balance assuming all the components that consist of the chemical dosing system are working properly. However, Nalco has experienced this assumption is not correct in various locations for various reasons. Some are listed here.

- **Bent/ruptured chemical tubing** – chemical feeding rate can be partially or fully diminished

- **Insufficient mixing in day tank** – high concentration in bottom and low concentration in top causes effective chemical feeding rate decline over time.
- **Chemical shortage** – no SBS feeding causes membrane oxidation
- **Metering pump failure** – Chemical feeding pump tends to fail gradually, abruptly or intermittently due to wear, mechanical breakdown, sticky pump heads, etc.
- **Leak in pipes, tubes, fittings, and mechanical seals of metering pump**

Saving fresh water by raising concentrate recycle flow is not difficult in principle. However, if performed without real time monitoring and close supervision, it can turn out to be disastrous. 3D TRASAR Technology for Membranes, which includes the services of the Nalco 360 Expert Center, provides all the required monitoring disciplines that allow RO systems run at tighter conditions without raising risks.

Nalco reports Environmental Return on Investment (eROI) values to customers to account for contributions in delivering both environmental performance and financial payback.

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