Water Technologies & Solutions
case study

an effective solution for sulfate removal in the Oil & Gas industry

SUEZ's SWSR NF membranes and chemicals decrease CIP frequency and improve system availability – optimizing reservoir pressurization in oil production wells.

challenge

One of MODEC's Floating Production Storage and Offloading (FPSO) was facing frequent Clean-In-Place (CIP) operations on their Seawater Sulfate Removal Unit. This in turn was impacting the plant downtime and reducing hydrocarbon production each month. MODEC observed that post-CIP the pressure gradient continued rising without any periods of stability and approached the manufacturer's recommended limit of 400kPa within 12 to 15 days. This situation decreased the duration of maximum water injection pressure availability and impacted oil production. While sulfate levels were still at levels below 100ppm, MODEC was interested in alternative products and solutions that would allow them to extend the time between CIP campaigns and maximize injection availability. By passing the SRU was not an option given the risk of adverse consequences.

Fig 1 – MODEC FPSO

Importance of sulfate removal

Reducing sulfate in injection water prevents scale formation and mitigates corrosion in the injection well, which can reduce oil recovery and even irreversibly plug the well itself. The interaction that happens between sulfate ions present in seawater with barium (Ba) and strontium (Sr) in subsea reservoirs can compromise formation permeability and lead to souring in the presence of sulfate reducing bacteria.

Sulfate removal is critical in these applications as it prevents loss of reservoir productivity and limits the substrate needed for the sulfate-reducing bacteria to produce hydrogen sulphide.

solution

Membrane selection

In 2016, SWSR membrane for sulfate removal from seawater was validated for use on other SUEZ's client owned or operated fields. The approval was granted at the conclusion of an extensive pilot that demonstrated over 99.8% sulfate rejection over a period of six months, despite varying water qualities with challenging SDI levels and biological loads.

Considering approval from said SUEZ's other client and the results seen on other platforms, SUEZ proposed the SWSR-440 NF membrane for the SRU found on MODEC's vessel. MODEC's expectations were to achieve a low level of sulphate in the permeate (never exceeding 100ppm) and to minimize the increase in pressure drop in order to decrease CIP

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frequency (maximize CIP campaigns). With SUEZ's proprietary 3-layered membrane construction, the SWSR-440 membrane was well suited to meet the customer's expectations.

Equipment design

The Sulfate Removal Unit (SRU) on MODEC's FPSO consisted of two identical trains (A and B) with three membrane banks per train: two parallel banks (A and B) in 1st stage and one bank (C) in 2nd stage, fed from 1st stage.

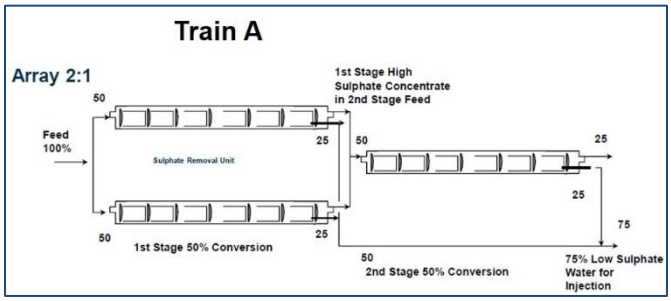

Fig 2 – Schematic of Train A

The two trains (A and B) had the following fixed flows:

- Feed = 140 m³ / h
- Permeated = 105 m³ / h
- Reject = 35 m³ / h

Train A performance pre-membrane change out

SUEZ installed SWSR-440 membranes on Train A after the previous membranes (competitor) were removed after a 3-year campaign while Train B remain equipped with the competitor's membranes as they had a remaining life of approximately 2-years. On train A, the competitor's campaign was terminated due to a rapidly increasing differential pressure (DP) immediately post CIP. To illustrate this better, MODEC observed that post-CIP the DP of 270 kPa reached the CIP trigger point of 360 kPa within 12-15 days of operation.

results

Train A DP performance after membrane change out

Immediately after installing SUEZ membranes on Train A, a significantly lower initial DP was observed. This was expected as the membranes were brand new compared to the competitive product that was changed out. Upon review of historical data MODEC noticed a lower initial DP when compared to the competitor product. The SUEZ SWSR-440 membrane started with a DP of 170 kPa whereas the competitive membrane showed a DP of 198 kPa, which is 15% higher. With a lower DP, SUEZ recommended to initiate a CIP when the DP reached 250 kPa. While conservative, this practice enabled the operators to push the DP target in incremental stages always ensuring that DP recoverability can be achieved. This practice is fundamental to increase the life of the membranes in the long term. With this practice, campaigns of 45-60 days could be achieved by pushing the DP to 400 kPa under special cleaning regime.

With a 250 kPa setpoint, initial observations demonstrated a 28-day cycle between CIPs, with the average being 30 days thereafter. After 12 months of operation, the membrane is still operating as when originally installed with DP's in the range of 170-185 kPa and CIP campaigns of 30 days. This is a significant improvement compared to the cycles observed on Train B or previously witnessed on Train A. CIP frequency has indeed decreased by 50-60%.

Figure 3 shows the improvement in DP achieved with the SWSR-440 membrane suggesting that a straight like for like replacement with the SUEZ product allowed MODEC to reach new lows in initial DP and to continue operations uninterrupted, albeit with longer CIP intervals and better system availability.

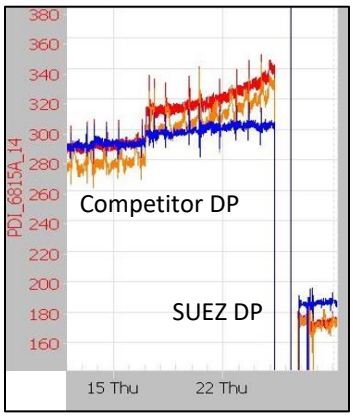

Fig 3. Competitor 3-yr vs Suez New membranes

Train A sulphate removal performance after membrane change out

Although the main interest from MODEC was to ensure that a like for like replacement enabled them to increase availability, another important criteria was sulfate removal performance. Initial effluent sulfate levels were excellent with 1 to 2 ppm reported by

MODEC at the start of operations. This is in contrast to 3 to 4 ppm reported when the competitor's membranes were first installed on the same train 3-years ago. After 12-months of operation, Sulfate levels in the effluent from SUEZ SWSR-440 membranes were less than 5 ppm.

SDI, particle size, free chlorine remained the same in the competitor's and SUEZ campaigns.

Chemical Products

In addition to the benefits provided by the SUEZ SWSR-440 NF membrane, MODEC's FPSO also benefited from SUEZ market leading chemical cleaners and anti-scalants.

The main chemicals provided by SUEZ and their respective dosages on this particular SRU are the following:

- Chlorine – maintain above 0.2 ppm after FMM (multi-media filter).
- BioMate* MBC2881B – 300 ppm for 1 hour every 2 / week (before FC (cartridge filter)).
- MemChem* DCL40BR – 6 ppm continuous after FC (deaerator after SRU).
- Hypersperse* MDC150BR – 5 ppm continuous.

Combining SUEZ chemicals and membranes enabled a new level of optimization that cannot be easily replicated when combining products from separate vendors. The unique know-how of chemicals and membranes enabled SUEZ to decrease operating costs for MODEC and to improve SRU availability.

Conclusions

This membrane replacement with MODEC verified that the new SUEZ membranes could be used as a like for like replacement in an SRU designed by another OEM with competitive membranes and achieve superior pressure drop and sulfate removal performance. By combining SUEZ membranes and chemicals, MODEC was able to achieve better plant operability, lower opex and improved availability.

The results of the new SUEZ's membranes (SWSR-440) are summarized below:

- Significant improvement in campaign time between CIPs and consequently and increase in number of hours at maximum pressure in the oil production wells (shorter SRU downtime).
- Sulfate removal levels reaching 99.8%
- Significant decrease in maintenance requirements and operator hours associated with a lower frequency of CIPs (50%-60% less than with competitive products); due to the combination and optimization of membranes and chemicals.
- Lower operational risk associated with valve wear and start up procedures post frequent CIP
- Lower overall treatment cost (less CIP chemicals, up to 43% reduction) associated with SUEZ chemicals and membrane optimization
- Reduced risk of accidents in handling chemicals and CIP (occupational health)

Next steps

A 30-day campaign between CIPs is excellent for MODEC compared to other FPSOs (normal 8 to 15 days). MODEC would like to keep their CIP DP target at 360 kPa and try to reach 45 – 60 days between CIPs. This will be investigated and studied on MODEC's FPSO with the SWSR-440 membrane.

To further improve this SRU system, SUEZ recommends to:

- Check FMM filtration efficiency and always try to keep at > 50%. Monitor particle size (1, 5 and 10 microns)
- Change Train B to SWSR-440 membranes
- Use SUEZ chemicals to achieve current level of optimization. Changing chemical suppliers will negatively impact membrane performance.
- Check the Filtration efficiency of Cartridge Filters
- Improvement in chlorination (keep 0.5 to 0.8ppm at the FMM output) or dose a non-oxidizing biocide continuously (BioMate MBC781).

spotlight on products

SWSR-440 NF Membrane

SUEZ used its optimized NF-SRU membrane (SWSR-440) with a triple layer that requires a lower feed pressure, has a lower DP and achieves a level of sulfate in permeate water inferior to competitive products.

The SWSR-Series is SUEZ's latest nanofiltration (NF) innovation. With nearly 30-years' experience in NF membrane manufacturing, SUEZ has advanced its NF

membrane to further improve the low fouling properties. What results is a smoother surface enabled by our proprietary membrane design, allowing for more efficient cleanings and a lower pressure gradient (less adhesion). It should be noted that after each CIP, the operating pressure is readily restored to original levels.

Fig 4 – SWSR Membranes on MODEC system

The SWSR-Series is designed to produce consistently low sulfate water for injection helping to:

- Prevent strontium and barium sulfate scale in injection well
- Better mitigate well souring by reducing sulfate;

The SWSR-series incorporates a true Nanofiltration membrane that features:

- High rejection of sulfate and hardness meeting reservoir injection requirements.
- High transmission of sodium chloride into the permeate minimizing the operating pressure.
- Physical barrier for any suspended particles, bacteria, pyrogens and colloids.

The SWSR-Series can be stored for a period of 12 months in its original packaging at the ambient temperature up to 100°F (38°C).

Membrane Chemicals

Successful membrane cleaning relies on both the effectiveness of the cleaning compounds, their professional application and the design and operation of the cleaning equipment. SUEZ offers best practice advice on cleaning system design and cleaning procedures to ensure effective results that will protect against irreversible membrane fouling.

SUEZ's line of cleaners has been developed and improved based on decades of application data in waters throughout the world. Our chemicals are formulated to function on all types of Sulfate Removal Units and are proved to reduce operational complexity and downtime associated with poor membrane performance.

When combined with SUEZ membranes, we are able to fine tune a SRU system to maximize CIP campaigns and achieve performance levels like those observed by MODEC and described in this case study.

we're here to help

If you'd like to talk with SUEZ about your water and waste challenges in the Oil & Gas industry, please reach us through our website by using the "contact us" form.