Introduction

RoClean P111 has been used extensively to clean membrane elements and has been shown to provide excellent cleaning results against particulate buildup and bacterial or algal slimes. This cleaning powder is particularly useful for removing fouling from Sulphate Reduction Package Membranes (Filmtec SR90-400). This case study summarises results that have been achieved on SR90-400 membranes on Amerada Hess's South Arne platform using RoClean P111 and a competitor formulation.

South Arne Background

The South Arne SRP consists of three trains of 40,000 (train A), 40,000 (train B), 45,000 (train C) BPD. The system takes its feed from a common seawater intake at 20m depth passing through course strainers heat exchangers, high rate dual media filters and cartridge filters prior to entering the SRP membranes at 20°C. The whole upstream system is intermittently chlorinated with the SRP being shock dosed with SBS to achieve biological control. The system is a classical 75% recovery 2/1 array (32/16 x 6) and has facilities for antiscalant, de-chlorination, biocide and coagulant dosing. There is also a CIP system that provides all conditions necessary for an efficient chemical clean.

The system has operated successfully since its phased start-up in December 2000 (Train A) and August 2001 (Trains B & C) producing between 40 and 125,000BPD of <50mg/l sulphate water for injection. The system had been cleaned on average every 3 months operation using the on site CIP unit. The necessity for cleaning was determined by increasing differential pressures across the first pass membranes.

Between May and July 2002 an increase in the fouling rate and level was seen on the system. The differential pressure first increased as normal and then the feed pressure to maintain the product flow increased dramatically, sometimes by as much as one bar per day. The operator and system designer made strenuous efforts to determine the cause of the problem and to bring the system back into normal operation. Initially, it was thought that mud dumping on the neighbouring drilling rig had contributed to the fouling along with the seasonal algal bloom and it was thought prudent to investigate whether cleaning would restore membrane flux.

Six heavily fouled membranes were removed from the system and sent to Avista Technologies for test cleaning and possible autopsy to ensure that any cleaning undertaken would not cause more problems than it solved.

Test Cleaning and Autopsy

The membranes were wet tested and weighed which revealed that they had gained between 1 and 2 kg of fouling that was reducing the flow rate from the specified 9,000 USGPD to about a third of that value. It was also noted that the weights of the membranes reduced from feed to brine indicating that the fouling was colloidal in nature. From these results a clean was certainly necessary. Of the six membranes, four were cleaned using Avista Technologies chemicals and two with the existing chemicals being used on site at the time.

Table 1: Results of Test Cleans

Cleaner	Serial No	Pre Flow USGPD	Post Flow USGPD	Pre dP psi	Post dP Psi	Pre Rejection % SO_4	Post Rejection % SO_4
E	6869674	2652	3027	4	4	92.86%	97.04%
E	7107947	3101	3393	3	3	96.43%	97.88%
A	6869677	2275	2872	4	3	97.14%	97.78%
A	7107899	3056	3704	3	3	97.84%	98.18%
A	7107792	3063	3855	4	4	97.30%	98.28%
A	7529608	3559	4350	3	4	94.59%	97.27%

E = existing supplier
A = Avista Cleaner

The 4 were cleaned with RoClean P111 followed by P303 and the other 2 with the existing supplier's cleaners. The results shown in table 1 were achieved. Membrane 7529608 was additionally subjected to a second clean using RoClean P111 and caustic to raise the pH to 11.8.

None of the procedures had an adverse effect on the membranes as can be seen in the table but they did not bring the membranes back to full flow.

Autopsy

Avista Technologies selected the element with the lowest flowrate (assumed to have the heaviest fouling) and subjected it to a vacuum test and the destructive tests of autopsy (the other non-destructive tests having been carried out as part of the test cleaning).
On opening, the membrane surface was found to be covered with a thin layer of brown slime probably of an organic nature. Samples of the surface were subjected to XPS and ToF-SIMS analysis to determine the constituents of the foulant. These analyses determined that the layer was indeed organic in nature and mainly consisted of carbohydrates, proteins and other materials consistent with the deposit source being algae and algae decomposition products.

There was no evidence of mineral scale or oil based drilling mud, as was feared. This conclusion allowed the plant operator to continue to clean the units on site to try to recover performance.

Those elements cleaned using the existing suppliers chemicals showed an improvement of approximately 10-15%. The elements cleaned using the Avista products showed improvements of 25-30%. It was believed that further cleaning would be likely to remove more fouling but it was decided that the next step would be to autopsy an element to identify the foulant.

On-Site Cleaning

After completing an average of four cleans on each train using the existing suppliers products and having seen only modest improvements in the plants performance Amerada Hess were keen to evaluate the relative performance of the Avista chemicals in a like for like trial.

It was therefore agreed to clean train 'A' using the existing chemicals and train 'B' using Avista Technologies chemicals to provide a good comparison.

An Avista Technologies engineer joined the team carrying out the cleaning to ensure that any queries in the chemical application could be answered on the spot.

Cleaning Procedure and Results

In general the Operating and Maintenance manual was followed to carry out the clean. A summary of this procedure is detailed below.

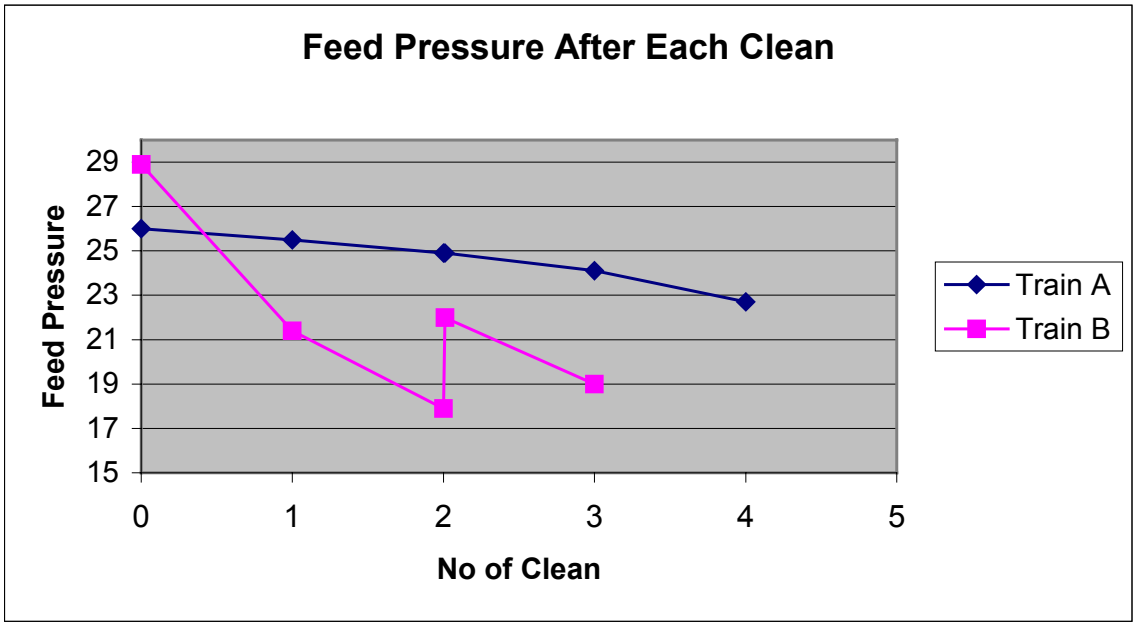
- Shut down the train to be cleaned and flush out the seawater until 5mS/cm conductivity or better is reached.
- Clean the SRP with the relevant cleaning solution circulating/soaking the solution for a period of up to 2 hours (Avista, or 5 hours existing supplier) at 40°C.
- Drain down the unit and flush the membranes with at least 2 volumes of potable water.
- Neutralise spent solution in CIP tank before disposal.
- Start up the unit and evaluate feed pressure. If this is not satisfactory, repeat the clean until no further feed pressure reduction is seen on start-up.

Train A

Four cleans were carried our with the existing chemicals. Each batch was made up with 400 litres (566kg) of alkaline cleaner and 200 litres of additional detergent in 15m^3 of potable water. Each clean had a beneficial effect, reducing the feed pressure to the membranes and resulting in a 3.3 bar drop overall. (See Figure 1 overleaf)

Train B

Three cleans were carried out with Avista RoClean P111. Each batch was made up with 300kg of RoClean P111 in 15m^3 of potable water. Each clean had a beneficial effect as with
the existing suppliers' chemical but a single Avista clean gave 6 bar feed pressure reduction indicating much more efficient



The results are tabled along with the design condition:

	Feed Flow	**Feed Press**	**Differential Pressure**		**Permeate Flow**			**% R**	**SO_4^{-2}**
	(m^3/hr)	(NET) (barg)	1st Pass (mbar)	2nd Pass (mbar)	1st Pass (m^3/hr)	2nd Pass (m^3/hr)	Total		
Train A/B Design Setpoints	354	16 - 20	1400 - 1800	1200 – 1600	205	60	265	75	<50
Train A before	326	26.0	1728	1633	143	72.7	215.7	66	52
After 4 Existing Cleans	323	22.7	1725	1433	152.2	73.8	225.2	69.9	ND
Train B before	324	28.9	1485	1640	145.8	88.7	234.4	72.5	44
After 3 Avista Cleans	332	21.4	1500	1616	157	89.9	245	73.5	73

ND = not determined

foulant removal. After a second clean was completed it was felt that the system had recovered enough to increase the production output which gave a consequent rise in feed pressure. The third clean again reduced this feed pressure.

With both trains, a short term increase in Sulphate passage was seen after each clean, as is normal, but no long term detrimental effects were incurred and the plant returned to <50 mg/l sulphates after a few days operation.

Conclusion

The cleaning process produced substantial reductions in feed pressure indicating significant fouling layer removal and Avista RoClean P111 showed benefits compared to the existing cleaners with four cleans using the existing suppliers product resulting in less system recovery than a single Avista clean.

Using Avista cleaners is also more cost effective as the CIP cycle is significantly shorter, reducing system downtime and the weight of chemical used is about half reducing chemical and shipping costs.

The results convinced Amerada Hess to continue using RoClean P111 to remove the buildup of fouling on the membranes and, to date, train A has had 2 applications of RoClean P111 and train B has been cleaned with a further single application of RoClean P111.

This has improved the trains output to close to design conditions producing around 260m^3/hr of permeate with a sulphate level of <50mg/litre reported on the train that has operated since cleaning. The feed pressure has also been restored to around 20 bar at these flows.

This case study is presented by kind permission of Amerada Hess.

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