GENESYS INTERNATIONAL

Application Guide

Application Guide 2

Clay deposit removal from membranes

Extract from the paper "Cleaning Clay from fouled membranes", presented at Euromed 2008, Jordan, Desalination Co-operation among Mediterranean countries of Europe & the MENA region, 9-13 November 2008.

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Genesys membrane laboratories in Madrid have observed that the majority of deposits found on reverse osmosis membranes are clay based aluminosilicates. These deposits are difficult to remove with traditional cleaning chemicals. Genesol 703 is a speciality membrane cleaning chemical designed to effectively remove these and other deposits, thus reducing membrane cleaning frequency and associated costs. Results of cleaning trials on actual membranes are presented.

Membrane clay deposits

Within the lifetime of most reverse osmosis (RO) systems some fouling will adversely affect membrane performance, with the nature of the foulant generally being determined through membrane autopsy. Autopsy results show that the major constituents of these deposits are aluminosilicates or clays.

Clay minerals are generally categorized as being <2µm in size and are formed by the gradual chemical weathering of silica bearing rocks which over time are transported into natural water sources. They will therefore occur in all RO feed waters. Their small size make them difficult to extract from feed water using conventional physical-chemical pretreatment methods.

Clay minerals have traditionally proved difficult to remove effectively from membranes using conventional cleaning chemicals. The incomplete removal of these deposits leads to a higher cleaning frequency, an increase in operational costs and also an enhanced potential for membrane damage.

Structural characteristics

There are two main characteristics of clay minerals which effectively reduce the efficiency of traditional cleaning chemicals, namely plasticity and impermeability to water.

Clay minerals have a structure that deforms and compacts under pressure, effectively increasing blockage of the pores at the

Fig 1: **Clay deposit removed from membrane surface during autopsy**

membrane surface and reducing membrane flux. In response to the reduction in membrane flux the operator is generally forced to increase the Net Driving Pressure (NDP) of the system which serves only to increase deformation of the deposit, further tightening it against the membrane surface. This reduces the porosity of the deposit to cleaning solutions making it more difficult to remove.

Due to their crystal sheet structure and the presence of hydrogen bonds some clays are naturally impermeable to water, which provides a natural protection and resistance to the crystal interlayer.

In order to be effective at fully removing clay deposits, we must use an approach which overcomes the lack of porosity caused by the plasticity and swelling of the deposit and also the relative impermeability of the crystal structure to water and cleaning solutions.

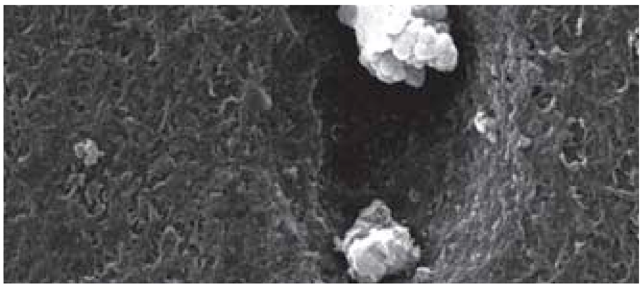

Fig 2: **SEM-EDX membrane autopsy picture of aluminosilicates showing abrasion at the membrane surface**

Operational effects of clay deposits

The principal consequence of membrane fouling by clay minerals is an increase in hydraulic resistance which results in a greater energy requirement to operate the process.

The formation of highly impermeable deposits by clay minerals on the membrane surface will lead to significant problems in maintaining permeate flux, with frequent cleaning eventually being required to maintain system operation. The primary effects of fouling by clay particles in a membrane system will be seen mainly in the elements in the first positions. However if this problem remains untreated fouling will gradually effect all membrane elements. The effects will include a reduction in membrane flux, an increase in salt passage and also an increase in delta-P. Membrane damage through abrasion processes are commonly identified (see Figure 2) during membrane autopsies performed on systems fouled with clay mineral deposits. This damage is caused by a combination of compression of the crystalline structure against the membrane due to increased operating pressures and also poor cleaning practice.

Fig 3: **Effects of clay deposits on membrane performance parameters**

Genesol 703

The structural reaction of clays to pressure means they require immediate effective removal in order to prevent the deposit from becoming less porous through further compaction. Genesol 703 was developed in order to provide a low dosage, cost efficient cleaning chemical to effectively overcome the plasticity and impermeability of the clay structure, providing complete removal of the deposit and reducing the required membrane cleaning frequency.

Cleaning results

Product efficacy was determined using a laboratory cleaning rig on different reverse osmosis membranes that autopsy techniques had proven were fouled with aluminosilicates. Genesol 703 has been compared with different commodity chemicals testing their effectiveness at restoring the flux rates of sections of the same membrane with the same degree of fouling. The percentage change in flux was calculated against the original flux after the cleaning step was completed. All cleaning cycles were performed at 35°C for two hours.

The results in Table 1 show that a 1% solution of Genesol 703 had the most significant effect of restoring membrane flux with a 14.57% increase in measured flux after the cleaning programme when compared to a variety of surfactants, chelants and sequestrants under the same conditions of temperature and pH. The micrograph picture in Figure 4 shows the membrane surface free from clay deposits after application of Genesol 703. Genesol 703 has also been successful at removing clay deposits and restoring flux in severely fouled membranes with a flux increase in excess of 200% after cleaning.

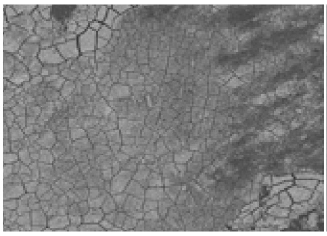

Fig 4: **SEM Micrograph showing aluminosilicate deposit detail on RO membrane surface prior to cleaning with Genesol 703**

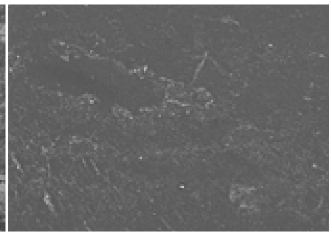

Fig 5: **SEM Micrograph of same RO membrane surface after cleaning with Genesol 703, showing complete deposit removal**

Mode of action

The first stage of removal occurs at the water/surface interface of the clay deposit. Surface tension decreases, helping the cleaning solution overcome the impermeability of the material and allowing it to penetrate the inter-layer space of the clay structure. Consequently, the clay becomes more porous to water, allowing more active chemical to penetrate and disrupt the "body" of the deposit.

There is also a secondary, physical action which increases the cleaning efficiency at the membrane surface resulting in "double edged" approach to deposit removal. This action removes blockages from the membrane pores caused by the swelling effect of the hydrated clay particles. During cleaning with Genesol 703, permeate salinity increases so the osmotic pressure is higher than the feed water Net Driving Pressure (NDP). As a result of this change in osmotic pressure the permeate flow reverts back to "natural" osmosis. The flow of water moves from the lower pressure permeate side to the higher pressure feed channel. This movement of water is sufficient to physically disturb and lift the deposit from the pores at the membrane surface. The solution containing the deposits is then removed via the brine outlet limiting the potential for membrane abrasion.

Summary

The results demonstrate that Genesol 703 is a technically and economically viable cleaning chemical for the removal of clay deposits from membranes. Efficient removal at low dosage rate will reduce the required membrane cleaning frequency, thus lowering downtime and operating costs.

No	Chemical	Flux change(%)
1	3% citric acid	-9.16%
2	2% chelant/surfactant	-5.87%
3	2% surfactant/sequestrant	+0.02%
4	1% Genesol 703	+14.57%

Table 1: **Comparison of different cleaning solutions on brackish water membrane**

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