Application Guide 6

Biofouling control of RO membranes during operation & shut down

Correct preservation of off-line systems is vital to ensure that membranes do not degrade during prolonged shut down and that the system is not repopulated on restart.

Membrane autopsy results from the Genesys Membrane laboratories in Madrid indicate that 35% of the foulants identified on reverse osmosis (RO) membrane surfaces during autopsy are organic in nature containing significant levels of biomass.

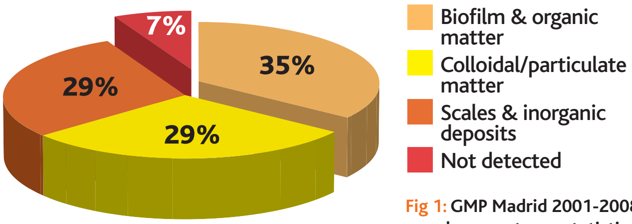

Fig 1: GMP Madrid 2001-2008 membrane autopsy statistics

Biofouling in RO systems can be defined as the growth of biomass on the membrane surface which is sufficient to cause operational problems. The effects of biofouling will show as an increase in differential pressure (dP), with a consequent reduction in flux, and increase in pumping and electrical costs. Severe biofouling may result in membrane degradation and physical damage. During operation the increase in dP is usually observed in the lead elements of the system, closest to the source of contamination, however telescoping and compaction may occur in the rear elements.

Fig 2: Pressure related compaction

Fig 3: Severe microbiological fouling

During off-line periods biofouling can occur throughout the entire plant if shutdown procedures are not followed correctly. Consequently on start up problems of reduced flux, increased dP and salt passage may occur across the entire system.

At the RO design stage analysis of feed water, SDI tests and ionic water analyses indicate the colloidal fouling and scaling potential of the water. Less thought is given to the microbiological content of the water and the consequent biofouling potential of the operational system. This is usually only given consideration when membrane performance is affected.

Every RO system has a different biofouling potential. The feed water source, pre-treatment (both chemical and physical), maintenance, cleaning regime and system downtime all contribute to the biofouling potential of a system.

Site specific financial and operational factors must be considered when selecting a suitable method of control. It is therefore difficult to recommend a "single" best treatment regime for all biofouling issues. Taking this into account the objective of this application guide is to give an overview of the most common methods of control and also the available methods for determining the presence of biofouling within a membrane system

Identification : The definitive method for identifying the presence and nature of biofoulants on a membrane is via autopsy. Care must be taken to select the correct element for autopsy with biofouling usually occurring in the first elements of a system. In order to enable representative samples to be taken the membrane must be packaged correctly (free of SBS and/or biocides) and despatched within 24 hours of removal from the plant. SEM–EDAX (Scanning Electron Microscopy – Energy Dispersive X-ray Analysis) and microbiological identification and counting techniques are used to examine the membrane surface for the presence of microorganisms.

Contamination Source : Similar procedures applied to pre-treatment **cartridge filters** or **0.45 µm SDI papers** can be used to evaluate the source of the contamination, this is a suitable method for determining the presence and type of fouling (by colloidal mater and some metal oxides) in the feed water, but does not give an indication of the degree of fouling affecting the membrane elements. Also bacteria counts cannot be 100% reliable as in some cases there may not bacteria present in the feed water, but there are nutrients which will assist the bacteria growing on the membranes.

Biofouling Control - Chemical pre-treatment

On-Line Chlorination & Halogens (NaClO+Cl2 gas+ClO2, chloramines, Bromine, etc)

Use of halogens is limited due to the potential oxidation of polyamide membranes. The effectiveness of chlorine depends mainly on feed water pH and exposure time (usually 20-30 minutes of contact time is required).

The oxidation reaction is catalysed by the presence of trivalent cations (Fe^{3+}/Al^{3+} chemical symbol) common to RO feed waters.

Typically on surface waters chlorine is added continuously to the intake to give a free residual chlorine concentration of 0.5-1.0mg/le. In order to protect polyamide membranes from oxidation de-chlorination is required upstream of the membranes using sodium bisulphite solution (**Genesys RED**) or activated carbon filtration.

Fig 4: Biofilm sampling prior to embrane autopsy & identification

It is recognised that chlorine oxidizes and breaks down natural organic matter (NOM) present in the feed water to more easily biodegradable by-products providing a nutrient source to micro-organisms. In addition as no chlorine is present on the membrane surface biofilm growth can occur requiring more frequent sanitization.

Off line chlorination (system sanitization) : This process is designed to limit the amount of bacterial ingress into the membrane system from contaminated pre-treatment systems.

In order to sanitize the pre-treatment and distribution system chlorine is applied at regular intervals determined by the degree of fouling. Feed water is sent to drain before reaching the membranes and ORP/ Redox is used to measure chlorine levels before returning to normal service.

This method is aimed at sanitizing the pre-treatment system reducing bacterial contamination into the RO and as such has no direct effect on existing biofilm growth on the membrane surface. This process should therefore be used in conjunction with approved non-oxidising biocides such as Genesol 30. While oxidising biocides are unable to control bacteria on the membrane surface Genesol 30 has the advantage that it can reach the membrane surface killing the bacteria with no detrimental effect on the polyamide structure.

The dose and frequency of application is determined by the degree of bacterial ingress to the system and the consequent effects on operating parameters; flux, dP and salt rejection.Hydrogen Peroxide & Peracetic Acid and formaldehyde

Hydrogen peroxide or a combination of hydrogen peroxide/peracetic acid and also formaldehyde are sometimes used as a method of disinfecting RO membranes. However there is a danger of oxidation of polyamide membranes which can be further catalysed by the presence of iron and manganese which limits the practical application of this method.

Non–oxidising biocides : Due to the potential damage to polyamide RO membranes caused by oxidising biocides it is often preferable to use non-oxidising biocides to control biofouling. These biocides areapplied through normal dosing pump or introduced via CIP tank and do not require additional "neutralising" treatment or carbon filtration.

Genesol 30 : fast acting biocide : Off-line Sanitization: dose at 300 mg/L for periods up to 60 minutes.

On-line application: in non-potable applications Genesol 30 dose at 400mg/l for 30 minutes.

Genesol 32 : long lasting biocide : Off line Sanitization: dose at 1,000 – 1,500 mg/litre (0.1-0.15%) for a period of 6-8 hours followed by an alkaline clean.

On-line Dosage: on line the product should be dosed at 700-1000mg/litre 0.07-0.1%) for 8-12 hours once every 5-21 days depending on the severity of the fouling.

In cases of severe fouling or for seasonal operation at higher ambient temperatures it can also dosed at 5-50 ppm continuously 24hours per day.

Genefloc ABF : is a flocculant with biocidal and algaecidal properties. A dosage of 2-10 mg/l can reduce the silt density Index, replace iron and aluminium coagulants and inhibit algae and bacteria growth in pre-filters, cartridges and membranes.

Preventative treatment –membrane cleaning : In reality biofouling in an RO system is successfully controlled using a combination of preventative biocide treatment in conjunction with a well designed & effective membrane cleaning programme.

The extremes of pH combined with surfactants used in cleaning will kill the majority of bacterial cells, However inefficient cleans may not remove the remaining nutrient rich biomass from the system giving any remaining viable cells the opportunity to rapidly multiply into viable populations . A well designed and applied cleaning regime will remove the biomass from the system preventing rapid re-growth. Using different chemicals will help to avoid resistance to a particular biocide developing within the microbial population.

Efficient removal of biofilm is achieved using alkaline cleaning chemicals and depends on temperature, pH, contact time and good cleaning practice. In addition **combining alkaline detergents and biocide cleaning steps will improve santitisation.**

Off-line preservation : All membrane environments contain a viable population of microorganisms which will grow and degrade the membranes if the system is not treated correctly on shut down. It is recommended by membrane manufacturers that the system must firstly be flushed with permeate to remove highly concentrated water and avoid mineral deposition. Any plant that will be stopped for over 24 hours should be treated to limit potential microbiological fouling.

Non –oxidising biocide :
Genesol 32 for membrane preservation and storage:

24-36 hours 300mg/l = 0.03%
36-168 hours 500mg/l = 0.05%
1-4 weeks 800mg/l = 0.08%
1-6 months 1000mg/l = 0.1%
>6 months (drain & refill every 6 months)

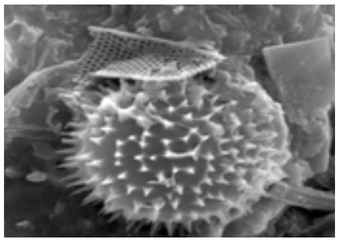

Fig 5: **SEM-EDAX showing biofouling on membrane surface**

Sodium Bisulfite (SBS)– Genesys RED : Used as a method for inhibiting growth of aerobic bacteria at a concentration of 1%. Care must be taken to avoid the ingress of air into the system if using this method.

It must be noted that SBS is not a biocide, it works by removing oxygen from the water, so aerobic bacteria will not survive. It has no effect on anaerobic bacteria and the solution must be refreshed regularly when it becomes exhausted.

Conclusions

All aquatic environments have a bacterial population and if not controlled in an RO plant biofouling may cause significant operational problems with a consequent impact on costs and performance. Increased cleaning frequency, increased pumping costs, reduced permeate quality and decreased membrane life make good bacterial control essential.All systems are different and it is therefore difficult to assess the fouling potential. A combination of biocide application with thorough cleaning practice is an efficient way to control microbial activity and ensure efficient plant operation.

Always follow membrane manufacturers' guidelines with respect to application of oxidising biocides.

Correct preservation of off-line systems is vital to ensure that membranes do not degrade during prolonged shut down and that the system is not repopulated on restart.

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