MEMBRANE

CLEANING

Equipment Requirements and Procedure

Lewabrane®

LANXESS
Energizing Chemistry

Index

1. Cleaning of RO membrane

Fouling and scaling cannot completely be prevented in an RO system or any membrane system. Therefore, a frequently cleaning is necessary to maintain performance. The necessary cleaning equipment has to be taken into account at the early stages of the planning of an RO system.

In general, a cleaning should be considered if one of the following points are observed

- Normalized permeate flow decreases by 10 %
- Normalized salt passage increases by 10 %
- Normalized pressure drop along the vessel (stage) increases by 20 % of the initial value

It has been industry good experience that RO system cleaning is performed at least once a year in brackish water application, and twice a year in seawater desalination.

The different kinds of fouling are described in the bulletin about fouling and scaling. The following notes summarize the points which are important for the cleaning.

- Membrane fouling can be identified through normalization of membrane performance. Reduction of normalized water permeability of the membrane and increase of pressure drop are first indicators of membrane fouling.
- To get some idea about the fouling/scaling it is helpful to check the water quality (composition of feed water).
- Frequently, presence of fouling substance can be identified by opening the pressure vessel's end plates on the feed and concentrate ends and inspection of element outer surfaces as well as internal surfaces of pressure vessels.
- A gel like structure on the surface is a strong indication for biofouling.
- White crystal structures are often an indication for scaling.
- It is recommended to collect the foulant layer from the surface of the RO element or pressure vessel for further analysis.
- If possible, performance of lead and end elements should be determined by testing the elements in a single element test apparatus.
  If such test is not possible, 1 – 2 elements could be send out for evaluation to a specialized lab.
- This evaluation includes an autopsy of element to determine composition of fouling material on membrane surface, in some cases, cleaning tests.

If the Element performance is too low and cannot be restored by cleaning it should be replaced.

Depending on the type of fouling observed, different types of cleaning strategies must be considered.

1.1 Evaluation of the cleaning chemical

An element autopsy with a surface analysis can help to evaluate the efficiency of the cleaning chemicals.

For the autopsy we recommend to check the first element in a plant to order to check the fouling, and the last element to observe the scaling. The autopsy starts with a visual inspection of the element. Observe whether the feed spacer is still open for flow, or if the element has been damaged.

To get an estimation regarding how severe the fouling or scaling is, the weight of the element is measured before the element is opened by cutting the outer shell lengthwise.

After opening the element, take membrane samples from the leaves and measure flux and salt rejection in coupon test unit, under

the standard test conditions given in the datasheet. Usually at least 6 membrane samples are collected for performance test.

If the flux is below the given specifications the weight and the ash ratio of the foulant are the first steps to get an indication which kind of fouling is on the membrane surface. For identification of inorganic foulants, Inductively Coupled Plasma spectroscopy fouling will help confirm the analysis.

Additionally, a dipping test, where the membrane sample is dipped into a cleaning solution, and afterwards the flux is measured will help to find the best cleaning chemical.

Following cleaning chemicals are recommended depending on the type of foulant:

Type of Foulant	Cleaning Chemicals
Calcium Carbonate Scale	Acid (e.g. HCl, citric acid) or low pH cleaner
Calcium Phosphate Scale	Acid (e.g. HCl, citric acid) or low pH cleaner
Sulfate Scale ($CaSO_4$, $BaSO_4$, $SrSO_4$)	Difficult to remove, sometimes can be removed by the following chemicals:
	Sodium hexametaphosphate (SHMP) with HCl or EDTA with NaOH
Polymerized Silica	Difficult to remove, sometimes can be removed by the following chemicals:
	Ammonium (bi)fluoride with acid (pH 3)
Metal Oxide Fouling (e.g. Fe, Mn, Cu, Ni, Zn)	Acid (e.g. HCl, citric acid) or low pH cleaner or sodium hydrogen sulfite
Colloidal Fouling (organic and/or inorganic)	Alkaline (e.g. NaOH) or high pH cleaner, often with detergent (e.g. Sodium Lauryl Sulfate) or EDTA
Microbiological Fouling	Difficult to remove, sometimes can be removed by the following chemicals:
	Alkaline (e.g. NaOH) or high pH cleaner, often with biocide or detergent
Organic Fouling (Dissolved NOM)	Alkaline (e.g. NaOH) or high pH cleaner, often with detergent or EDTA
Cationic Materials	Difficult to remove by chemical cleaning method.

Table 1.1: Chemical cleaning by type of foulant

The fouling on the membrane could be a mixture of various foulants. In such the case, it is then recommended to start with alkaline cleaning, followed by acidic cleaning.

Usually, cleaning at temperatures between 30-40°C (35°C recommended) is much more effective than cleaning at low temperatures.

Table 1.2 shows restrictions for min - max pH range for given cleaning temperatures.

	Temperature of cleaning solution		
	≤ 35 °C	≤ 40 °C	≤ 45 °C
pH range:	1 – 12	1,5 – 11	2 – 10

Table 1.2: Temperature and pH range for cleaning

1.2 Cleaning equipment

It is important to carefully select the materials of construction for the cleaning equipment.

The designer should take into consideration that the cleaning may be carried out in pH range of 1 - 12, and at temperature of 35°C (in certain cases up to 45°C).

The volume of the cleaning tank should be close to the volume of the empty pressure vessels plus the piping. A good rule of thumb is to assume approximately 50 liters for an 8" element, and 13 liters for a 4" element, plus the piping volume (approx. 20 % additionally).

The cleaning pump flow capacity should be equal to number of pressure vessels in the first stage times 130 l/min for 8" membrane unit and 30 l/min for a 4" membrane unit.

1.3 Cleaning conditions

The cleaning should be carried out at following conditions (see table below).

There should be no recirculation of the flushing water. Each stage should be cleaned separately.

Cleaning parameters	Cleaning conditions
Make-up water	Softened water or permeate, free of heavy metals, residual chlorine, or other oxidizing agents
Required quantity of cleaning solution	40–80 liters per 8-inch element
Cleaning operation pressure	Low pressure (100-200 kPa preferred)
Min. feed flow rate	110 l/min for each 8-inch vessel
Temperature	as high as possible; however max. 45°C (including heating of pumps). For cleaning solutions of pH higher than 11, the maximum temperature of cleaning solution should not exceed 40 C.
Type of cleaning	Alternation of circulation and soaking, each stage separately
Circulation period	0.5–1.0 hour (repeat 2–3 times) is recommended
Soaking period	2 – 24 hours incl. circulation time (depends on type of fouling)
Final flushing period	Min. 1 – 2 hours, depending upon application

Table 1.3: Cleaning conditions

1.4 RO membrane cleaning chemicals

Several producer of RO membrane cleaning chemicals are on the market. Please assure that the cleaning agent can be used with the Lewabrane® RO membrane elements. The following chemicals and concentrations can be used depending on the foulant.

Contaminant	Chemical Reagent	Cleaning Conditions
Calcium scale Metal hydroxides Inorganic colloids	Citric acid 1 – 2 %	pH value: 1-2
Organic or bacterial material	Alkaline solution or Dodecyl Sodium Sulfate (DSS, Sodium Lauryl Sulfate) 0.01-0.025% with alkaline solution or Polyoxyethylene Sodium Lauryl Sulfate (PSLS), 0.1- 0.5% with alkaline solution	pH value: 11-12 Adjust with sodium hydroxide, or sodium tripolyphosphate or sodium triphosphate

Table 1.4: RO membrane typical cleaning chemicals and conditions

Be aware that the pH range for RO membrane cleaning is 1-12.

The procedure of RO membrane chemical cleaning is similar to that for RO system flushing, except that the cleaning chemicals must be removed by flushing the RO system with pre-treated raw water for 1-2 hour. The RO elements should be cleaned in the operating direction to avoid telescoping.

The effectiveness of the chemical cleaning may be evaluated by comparing the performance of the plant using the initial conditions with feed water, or if possible, using the test conditions given on the Lewabrane® datasheet.

During cleaning operation, the valve on permeate line, of stage being cleaned, should be open. Otherwise, membrane delamination may occur.

1.5 Safety precautions

- Please read the MSDS (Material Safety Data Sheet) of the cleaning chemicals carefully and follow the instructions.
- Always wear safety glasses and gloves.
- Be aware of the high and low pH values of the cleaning solutions.
- The vessels and pipes can be hot due to high temperatures of the cleaning solutions.

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