membranium	Technical Service Bulletin	Version: 3 Date of validity: 25.05.2016
	Document code: TSB-102	5 pages

Contaminants of the reverse osmosis membranes and their removal from the reverse osmosis composite polyamide membrane elements nanoRO series

This Bulletin provides general information about common contaminants which affect the reverse osmosis composite polyamide membrane elements operational characteristics and methods of their removal. This information applies to the membrane elements with a diameter 2.5, 4, 8 inches.

Note: The reverse osmosis composite polyamide membrane elements should be at no circumstances affected by the organic solvents and oil based products. Any of such impact will cause the membrane irreparable damage. Careful disinfection of the piping and equipment is required; when preparing cleaning solutions you should make sure that there's no even a trace chlorine in feed water provided to RO membrane elements. If you doubt regarding chlorine presence, we recommend to conduct chemical testing. Residual chlorine should be neutralized with sodium bisulfite solution and make sure of contact duration for the complete dechlorination.

Note: During warranty period it's recommended to conduct reverse osmosis membrane elements cleaning in coordination with JSC "RM Nanotech" Center of technical support specialists. If needed JSC "RM Nanotech" specialists can visit your site to provide cleaning technical support. Please, address your inquiry to check service fees.

Note: You should avoid using cationic surfactants which can cause in irreversible decrease of the membrane elements recovery rate.

1. Reverse osmosis membrane elements contaminants

Eventually in the course of standard operation the reverse osmosis membrane elements are subject to contamination with the suspended or low-solubility products which can present in feed water. The most common materials deposited on the membrane elements surface are: calcium carbonate, calcium sulfate, metal oxides, silica, organic or biological deposits.

Character and speed of the salt scale on the membrane element surface depend on the feed water composition. Salt scale is a progressive factor and if not to control it at the early stage it can have negative impact on the reverse osmosis membrane elements performance characteristics within a relatively short period of time.

Regular monitoring of overall system performance is an essential step to identify membrane elements fouling. Fouling influence on the membrane flow is a gradual process and depends on the contaminant nature. In chart 1 you can see anticipated contaminants influence rate on the membrane elements performance.

2. Contaminants removal

Cleaning, washing or system operational parameters changes are required to remove contaminants. Contaminants removal usually should be carried out in the following conditions:

- Normalized filtrate flow (reduced to 25 ^{0}C, see TSB-101) dropped by 15% compare to the calculated flow under normal pressure.

- Permeate electrical conductivity was increased by 15%; salt passage was increased by 15%.
- Pressure drop in the RO pressure vessel while the product water constant flow and recovery was increased by 15%.

Excess of these parameters during operation can cause warranty obligations cancelation.

There is a description below of common contaminants and methods of their removal (chart 1).

2.1. Calcium carbonate scale.

Calcium carbonate deposits mostly from any type of feed water if there is a failure in the antiscalant addition system or in the acid injection pH control system that results in high pH level in feed water. An early detection of the calcium carbonate scaling is absolutely essential to prevent damage caused by crystals on the active membrane layers. Calcium carbonate scale that has been detected at the early stage can be removed by lowering the feed water pH to 3.0 - 5.0 for one or two hours. Longer resident accumulations of calcium carbonate scale can be removed by recycling of 2% citric acid and pH not less than 4.0 through the membrane elements of the solution 1.

Note: Make sure that pH level in any cleaning solution doesn't go below 2. Otherwise reverse osmosis membrane elements will be damaged particularly at the elevated temperatures. pH maximum level should be less than 12. To increase pH level use ammonium hydroxide, to decrease it – sulfuric acid or salt acid.

2.2. Calcium Sulfate scale

The best way of calcium sulfate scale removal from the reverse osmosis membrane element is to apply Solution 2 (chart 2).

2.3. Metal Oxides foulants

Precipitated hydroxides (e.g., ferric hydroxide) are usually removed by using calcium carbonate scale removal method.

2.4. Silica scales

Silica scales which are not related to metal hydroxides or organic substances can be removed using special cleaning methods only. Please contact JSC "RM Nanotech" Center of technical support for further instructions.

6.3.5. Organic deposits

The best method to remove organic deposits (e.g., microbiological gum, mold) is to apply Solution 3. To reduce further foulants' growth it's recommended to treat membrane element with biocidal solution approved by JSC "RM Nanotech". This requires continuous effective treatment: a biocidal solution will have higher efficiency when blocked or cascade type RO system designed for the reserved stand for more than 3 days. For more details please contact JSC "RM Nanotech" Center of technical support.

Chart 1: Signs of RO membrane elements contamination

Contaminant	Common features	Contaminant's removal measures
1. Calcium precipitates (carbonates and	Significant decreasing of salt rejection and small increase of ΔP	To conduct system chemical cleaning with Solution 1

phosphates which are usually detected at the end of the system concentrate)	between feed flow and concentrate. There is also a slight decrease in the system performance.	
2. Hydrated oxides (iron, nickel, copper and etc.)	Salt rejection fast decreasing and ΔP fast increase between feed flow and concentrate. There is also fast decreasing in system performance.	To conduct system chemical cleaning with Solution 1
3. Mixed organic/mineral colloids (iron, organic substances and silicates)	Salt rejection gradual decreasing and gradual increase of ΔP between feed flow and concentrate. There's also gradual decrease of system performance in the course of several weeks	To conduct system chemical cleaning with Solution 2. In case of high contamination level to apply Solution 4.
4.Silicon	Salt rejection gradual decreasing and gradual increase of ΔP between feed flow and concentrate. There's also gradual decrease of system performance in the course of several weeks	To conduct system chemical cleaning with Solution 5.
5. Calcium sulfate (usually detected at the tail elements of system concentrate)	Salt rejection considerable decreasing and ΔP small/moderate increasing between feed flow and concentrate. There's also small decreasing of system performance	To conduct system chemical cleaning with Solution 2.
6. Organic deposits	Salt rejection possible decreasing and ΔP gradual increasing between feed flow and concentrate. There's also gradual decreasing of system performance	To conduct system chemical cleaning with Solution 2. Solutions 3, 4 or 5 are recommended for high fouling rates
7.Bacteriological contamination	Salt rejection possible decreasing and ΔP notable increasing between feed flow and concentrate. There's also system performance considerable decreasing	To conduct chemical cleaning with any type of solution depending on possible mixed contamination. Use solution 4 or 5 at high contamination level

Note: At any circumstances it's important to eliminate the cause contamination origin. Please contact JSC "RM Nanotech" Center of technical support.

3. Cleaning Solutions

Chemical solutions recommended for the RO membrane elements cleaning are listed below in chart 2. Suitable solution can be determined by chemical analysis of the contaminant. A detailed study of analysis's results will provide the key information to determine the best cleaning method. Registration of the applied methods and obtained results will provide information to be used for the development of methods and solutions which are the most suitable for the available feed water conditions.

Chart 2. List of recommended cleaning solutions

Solution	Component	Concentration, %	pH correction	Temperature
1.	Citric acid	2-4	Adjust to pH 2 using sulfuric or salt acid	35-40 ^{0}C
2.	Sodium tripolyphosphate Tetrasodium salt of ethylenediaminetetraacetic acid (Na_4EDTA)	2 1	Adjust to pH 10,5-11,0 (see chart 3) using sulfuric acid or salt acid	30-35 ^{0}C
3.	Sodium tripolyphosphate Sodium dodecylbenzene sulfonate	2 0,025	Adjust to pH 10 (see chart 3) using sulfuric acid or salt acid	30-35 ^{0}C
4.	Alkaline NaOH Sodium laurel sulfate	0,1 0,025	Adjust to pH 11,0 -11,5 (see chart 3) using alkaline or tetrabutyl ammonium hydroxide (up), sulfuric acid or salt acid (down)	35 ^{0}C max
5.	Alkaline NaOH	0,1	Adjust to pH 11,0 -11,5 (see chart 3) using alkaline or tetrabutyl ammonium hydroxide (up), sulfuric acid or salt acid (down)	35 ^{0}C max

Besides the above mentioned other special cleaning solutions can be allowed for application after coordination with JSC "RM Nanotech". All solutions are designed for the use at the highest temperatures up to 35-40°C (see chart) during cleaning time up to 60 minutes (solution 1) and up to 30 minutes (solutions 2-4).

Solutions should be prepared on the basis of chemical agent's measuring based on the quantity of water to be used during cleaning. Free chlorine desalinated water (permeate) should be used for the solutions mixing. Mix solutions extensively before use. pH-meter should be regularly gauged. Typical time for chemical cleaning with each solution depending on the temperature is 30 minutes – 2 hours, see chart 3.

Chart 3. pH, temperature and time limits for membrane elements chemical cleaning

Membrane element type	Continuous operation		Max temperature during chemical cleaning		
	36- 45^{0}C	**Up to 35^{0}C**	**36- 45^{0}C**	**26- 35^{0}C**	**Up to 25^{0}C**
nanoRO KM	3-10	2-10,5	2-10,5	1-11	1-12
nanoRO K	3-10	2-10,5	2-10,5	1-11	1-12
nanoRO KC	3-9,5	2-10	2-10,5	1-11	1-12
nanoRO KH	3-9,5	2-10	2-10,5	1-11	1-12
nanoRO KCH	3-10	2-10,5	2-11	1-11,5	1-12,5
Chemical cleaning time, minutes			**Not more than 30**	**30-60**	**60-120**

Please consult JSC "RM Nanotech" Center of technical support if continuous operation or chemical cleaning at temperature level more than **45^{0}C** is required.

4. Membrane elements cleaning and flushing

Reverse osmosis membrane elements in pressure vessels are flushed by cleaning solution recycling from the feed side at low pressure and at a relatively high flow. A system of chemical cleaning of the membrane elements is required for this purpose.

General procedures for the reverse osmosis membrane elements cleaning:

1. To flush pressure vessel by pumping clean free chlorine produced water from the cleaning tank (or an equal source) for a few minutes.
2. To mix fresh volume of the selected cleaning solution in the cleaning tank using produced water. Volume of the cleaning solution is determined based on the quantity and sizes of the membrane elements (see chart 4). This volume doesn't include volume required for the feed water driving out and volume of pipes, filters and etc.

Chart 4. Volume of cleaning solutions for one membrane element.

Membrane element size	Solution volume, liters
2540	3
4040	10
8040	40

3. To circulate the cleaning solution through the pressure vessels for approximately one hour, or within a required period of time at the flow rate 7-10 m3/h for vessel with 8040 elements and at the rate 2-2.5 m3/h for 4040 elements.
4. It's recommended to control temperature and keep required pH level of the cleaning solution in accordance with chart 2 and 3.
5. To drain and wash the cleaning tank after flushing; to fill it with the produced clean water for cleaning.
6. To flush the membrane elements by pumping clean free chlorine produced water from the cleaning tank (or equal source) for a few minutes.
7. After reverse osmosis system flushing, launch the system with the filtrate and concentrate valves opened until clean water free of any foam or residuals from the cleaning substances runs (usually within 15-30 min).

Note: Alkaline cleaning should be conducted first before a combined acid based chemical cleaning.

Center of technical support
JSC RM Nanotech
224D Dobroselskaya Str.,
Vladimir, 600031, Russia
www.membranium.com
Tel +7(4922)474001
Fax +7 (4922) 474001