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Recommendations on operation, start-up and shut-down of the water treatment systems with spiral wound membrane elements

This Bulletin provides general information regarding operation, launch and shut-down of the systems with spiral wound membrane elements made by JSC "RM Nanotech" as well as cleaning guidelines before elements application.

1. OPERATING PROCEDURE

1.1. Reliable operation of spiral wound elements is achieved by the appropriate preparation of feed solution and optimized hydrodynamic modes while operation.

1.2. Feed water requirements:

- TSS 5 microns size shouldn't exceed 1 mg/l;
- Turbidity – not more than 1 NTU;
- Oxidation – not more 5 mgO_2/L;
- Content of active chlorine, organic solvents and strong oxidizers (ozone, bromine, iodine) – not less than 0,1 mg/l;
- Content of solved aluminum – less than 0,1 mg/l (less than 0,05 mg/l in case of silicon presence);
- Content of dissolved iron – less than 0,3 mg/l (less than 0,05 mg/l in case of silicon presence);
- Content of manganese – less than 0,1 mg/l;
- Content of cationic polymers and cationic surfactants – less than 0,1 mg/l;
- SDI – less than 5;
- LSI shouldn't exceed 1,0 for operation without antiscalant and 2,6 for operation with antiscalant.

Excess of any parameter can cause warranty obligations cancelation.

For continuous and stable operation of the reverse osmosis systems it is recommended to pre-treat feed water to turbidity below 0,2 NTU and SDI to the level 1-3.

1.3. Chemical compatibility with some materials.

1.3.1 Free chlorine and other oxidizers (permanganate, ozone, bromine, iodine) are not allowed in feed water while reverse osmosis membrane elements operation. Even small amount of free chlorine in feed water can cause an irreversible destruction of the membrane selective layer. End-users should be confident that oxidizer doesn't flow into feed part of the membrane system.

In order to be confident that membrane is not affected by oxidizer JSC RM Nanotech recommends to control oxidation-reduction potential at the feed of the reverse osmosis system in

order to continually control presence of oxidizer in the feed water. Oxidation-reduction potential number shouldn't exceed 300 mV except for wastewater. If oxidation-reduction potential number reached 300 mV the preventive measures to reduce this number should be taken, for example, by dosing into feed water solution of sodium metabisulphite. When oxidation-reduction potential number reached 350 mV, a reverse osmosis system operation should be stopped before oxidation-reduction potential number decreases to 300 mV. In case of issues with active chlorine removal from the reverse osmosis system feed water you should request assistance from JSC RM Nanotech's Center of technical support.

1.3.2 Catalysts of membrane oxidization with free chlorine are transition metal ions, such as iron and manganese. If presence of such ions in the water is unavoidable you should take measures to remove 100% of free chlorine from the feed water.

1.3.3 Cationic polymers and cationic surfactants can cause irreversible changes of composite polyamide membrane characteristics. It's not recommended to use such materials during operation and chemical cleaning of the reverse osmosis membrane elements.

1.3.4 Glycerin can be used to lubricate the rubber washers. Oil based products application as lubricants can cause membrane elements damage.

Presence of the indicated materials in the feed water can cause warranty obligations cancelation.

1.4. Technical data and operating conditions

1.4.1. General information

Individual flow and rejection of the membrane elements are specified in passport supplied with each element.

Nominal rejection of 2521 and 2540 membrane elements is achieved after 100 hours of continuous operation on test solution.

Nominal rejection of 4040 and 8040 membrane elements is achieved after 48 hours of continuous operation on test solution

- Flow of each single element in a lot may vary for ±15% for elements 4040 and 8040 and for ±20% for elements 2540 and 2521.

Recovery of each membrane element 1 m (40 inches) long must not exceed 15% for all types of membrane elements, except sea water elements. Recovery for sea water membrane elements must not exceed 10%. For continuous and stable operation of sea water membrane units it is recommended to maintain recovery on each membrane element 1 m long within 6 – 8%.

• Operating pressure may vary:

for sea water from 4,5 up to 7 MPa,

for brackish water from 1 up to 4 MPa,

for slightly salted and tap water from 0,5 up to 2,0 MPa depending on the salt content of feed water, temperature, recovery, operation life of the membrane elements.

- Pressure drop must not exceed 0,07 MPa on each element and 0,4 MPa on each pressure vessel.

- Feed water temperature must not exceed 45^0C. At pH 10 maximum temperature of the feed water must not exceed 35 ^{0}C.

- Time of chemical cleaning of the membrane elements within the range of pH 1-12 shouldn't exceed 4 hours while cleaning frequency not more than once a month (see TSB – 102).

1.5. Measuring of membrane elements recovery rate and temperature compensation.

Passport specifications of the membrane elements are calculated at operation pressure and feed water temperature 25±2 ^{o}C. The recovery rate of the membrane element is dropping off while feed water temperature decreasing. Below you can see a table of adjustment factor (K) value for the new membrane element recovery rate calculation depending on the feed water temperature:

Chart #2. Adjustment factor of the temperature offset

t, ^{o}C	K_T	**t, ^{o}C**	K_T	**t, ^{o}C**	K_T	**t, ^{o}C**	K_T
10,0	1,71	**15,0**	1,42	**20,0**	1,19	**25,0**	1,00
10,5	1,68	**15,5**	1,40	**20,5**	1,17	**25,5**	0,98
11,0	1,65	**16,0**	1,37	**21,0**	1,15	**26,0**	0,97
11,5	1,62	**16,5**	1,35	**21,5**	1,13	**26,5**	0,96
12,0	1,59	**17,0**	1,32	**22,0**	1,11	**27,0**	0,94
12,5	1,56	**17,5**	1,30	**22,5**	1,09	**27,5**	0,93
13,0	1,53	**18,0**	1,28	**23,0**	1,07	**28,0**	0,92
13,5	1,50	**18,5**	1,25	**23,5**	1,05	**28,5**	0,90
14,0	1,48	**19,0**	1,23	**24,0**	1,03	**29,0**	0,89
14,5	1,45	**19,5**	1,21	**24,5**	1,02	**29,5**	0,88

Recovery rate of the membrane element (Qt) while given temperature (t) is counted according to the formula:

$$Q_t=Q_{25}/K_t,$$

Which means that while temperature decreasing from 25^0C down to 10^0C, the recovery rate of the membrane element will go down by 1,71 times (see the chart).

A chemical cleaning of the membrane elements is required when the membranes' unit recovery rate decreasing by 1,15 times in comparison with the passport specification data in conversion to the feed water temperature t=25^0C.

For example: Flow rate of pressure vessel after 48 hours of operation at the temperature 20^0C was 10 m^3/hour. Filtrate normalized flow (in conversion to the feed water temperature 25^0C, see the chart) will be $Q1_{25}$ =10*1.19=11,9 m^3/hour.

After 2 months of operation while feed water temperature 10^0C and the same operating pressure the recovery rate equaled 6 m^3/hour, which means $Q2_{15}$=6 m^3/hour.

Calculate the recovery rate in conversion to the feed water temperature 25^0C, i.e. $Q2_{25} = Q1_{15} * K = 6*1,71=10,26$ m^3/hour, where K=1,71 (data from the chart).

Consequently, the membrane elements pressure vessel recovery rate decreasing adjusted with the feed water temperature while constant operating pressure is equal to 11,9/10,26 = 1,16 times, i.e. chemical cleaning of the membrane elements should be carried out.

2. START-UP AND SHUT-DOWN OF THE SYSTEM WITH SPIRAL WOUND MEMBRANE ELEMENTS

2.1. First launch.

Each element is preserved with a solution containing 1% of sodium metabisulphite. Before RO unit launching all membrane elements should be washed form preservatives during 1 hour at operational pressure followed by permeate drop.

In case membrane unit is used for drinking water production or food water supply it's recommended to wash elements during 1-2 hours. Attention! Preservatives ingestion can cause irritation of the digestive tract, mulligrubs, diarrhea or other similar symptoms.

For ultra-pure water production it's recommended to extend system washing time up to 24 hours for decrease of TOC concentration up to 50 mkg/L (feed water TOC level is expected at 0 rates).

In order to prevent destruction of the membrane elements the following should be observed:

- Do not allow excessive feed pressure and feed flow above the levels indicated in the specification.
- Avoid hydraulic hammer during start-up, operation and shut-down of the reverse osmosis systems.
- Take measures for protection of the membrane elements from the back pressure on the permeate side. The pressure from permeate side under no circumstances must exceed pressure at the feed of the membrane element.
- During start-up of the reverse osmosis system the feed pressure must be increased up to the operating level gradually within 30-60 second (at the max. rate of 0,1 MPa/sec)
- Take measures for prevention of membrane elements' operation in dead-end mode without concentrate discharge.
- Feed water, permeate and concentrate analysis should be conducted during operation.
- The following rules should be observed for operation of permeate and concentrate valves operation:

  2.2. Permeate valve operation.

  - Membrane elements should never be affected by pressure from the permeate side (when permeate static pressure exceeds concentrate static pressure) during operation nor during start-up/shut-down of the membrane unit.
  - Permeate valve should be always opened during launch, cleaning, shut-down and standard operation of the membrane unit.
  - Closing of the permeate valve during any phase of operation will cause pressure

differential across the tail end of the system and most likely will result in irreparable damage to the glue lines of the tail element(s).

- The permeate valve should be open first and then concentrate valve prior to re-introducing feed water while start-up.
- Permeate valve may be closed during shut-down only when water off into the system.

Violation of the above mentioned requirements can cause warranty obligations cancelation.

2.3. Concentrate valve operation.

Concentrate valve should be fully open during system start-up. Gradual close of the concentrate valve to create operating pressure and recovery should be started only after the feed water introducing into the system.

2.4. Membrane system shut-down

During membrane system shut-down the feed pressure must be decreased from the operating level to zero gradually within 30-60 seconds (at the max. rate of 0,1 MPa/sec)

- For the reverse osmosis and nanofiltration systems designed for the treatment of the surface and underground water sources with salt content up to 5 g/L it' recommended to conduct hydraulic cleaning of the membrane elements with low permeate recovery feed water before system full shut-down. Usually for this purpose the concentrate valve is slightly opened which allows removing from the membrane elements highly concentrated brine solution. Feed water supply on the basis of one input membrane element shouldn't exceed 17 m3/h for 8040 elements and 3,5 m3/h for 4040 elements to avoid mechanical damage as a result of telescoping.
- For the reverse osmosis systems designed for water desalination with salt content more than 5 g/L before system shut-down it's recommended to conduct hydraulic cleaning of the membrane elements with permeate (desalinated water) with low permeate recovery. Feed water supply on the basis of one input membrane element shouldn't exceed 17 m3/h for 8040 elements and 3,5 m3/h for 4040 elements to avoid mechanical damage as a result of telescoping. Permeate outfall should be opened.
- Sea water desalination systems at no circumstances should stay unwashed due to the risk of membrane envelopes blow-out as a result of osmotic pressure produced from permeate side during system shut-down as well as because of high probability of scaling on the membrane elements surface.

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