Reverse Osmosis Membrane

Technical Service Bulletin 113

Membrane Cleaning

To maintain the performance and efficiency of NanoH2O elements, the membranes should be cleaned periodically according to NanoH2O's specifications and requirements. Chemical cleaning is helpful in removing contaminants that have accumulated on the membrane surface or in the feed channel either from normal operation or an unexpected increase in feed water fouling potential.

Operating data should be collected and normalized frequently as described in NanoH2O "Data Logging and Performance Normalization-TSB 111". Trends of normalized data are the best indicators for determining when a membrane cleaning is required. A membrane cleaning should be performed when one or more of the following changes have occurred:

- Normalized permeate flow has decreased 10% since startup or last cleaning
- Normalized salt passage has increased 10% since startup or last cleaning
- Normalized pressure drop from feed to concentrate has increased 15% since startup or last cleaning.

Under certain conditions, cleanings may not be needed until changes greater than those listed above have occurred. Please contact NanoH2O for possible site specific cleaning guidelines prior to any cleaning.

Cleaning Chemicals

In many cases, RO elements can be effectively cleaned with a high pH sodium hydroxide solution (NaOH) followed by a low pH citric acid/HCl solution. The common chelating agent, EDTA, can be added to the sodium hydroxide solution if necessary. The recommended concentrations and allowable temperature and pH limits are provided below.

Allowable pH / Temperature Limits

Corresponding Maximum Temperature (°C)		
pH Limit	Seawater RO	Brackish Water RO
≥ 2	40	40
≤ 11	35	35
≤ 12	30	25

Data Collection

It is important to collect the following data during the cleaning process:

Date & Time	Chemical(s) Used	Starting & Ending pH	Starting & Ending Temperature
Recirculation Flow & Time	Soak Time	Observations	

CAUTION

When using ANY chemical, follow accepted safety practices and read all manufacturer's instructions. Consult the chemical manufacturer for further details on handling and disposal. When preparing cleaning solutions, ensure that all chemicals are dissolved and well mixed before circulation the solutions through the elements.

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Recommended Concentrations

Grade	Solution	Concentration	Recommended pH Range	Recommended Temperature Range (°C)
BW R BW ES BW UES	NaOH / RO permeate	Up to 0.1% by weight	10-12	25 - 30
	NaOH, EDTA / RO permeate	NaOH: Up to 0.1% by weight EDTA: Up to 1.0% by weight	10-12	25 - 30
	Citric Acid, HCl / RO Permeate	Citric Acid: Up to 2.0% by weight HCl: Up to 0.1-0.2% by weight	2-4	25 - 30
BW R G2 BW R Dura BW AFR G2	NaOH / RO permeate	Up to 0.1% by weight	11-13	25 - 30
	NaOH, EDTA / RO permeate	NaOH: Up to 0.1% by weight EDTA: Up to 1.0% by weight	11-13	25 - 30
	Citric Acid, HCl / RO Permeate	Citric Acid: Up to 2.0% by weight HCl: Up to 0.1-0.2% by weight	1-3	25 - 30
SW R / R G2 SW GR / GR G2 SW SR / SR G2 SW ES	NaOH / RO permeate	Up to 0.1% by weight	11-13	25 - 30
	NaOH, EDTA / RO permeate	NaOH: Up to 0.1% by weight EDTA: Up to 1.0% by weight	11-13	25 – 30
	Citric Acid, HCl / RO Permeate	Citric Acid: Up to 2.0% by weight HCl: Up to 0.1-0.2% by weight	2-4	25 - 30

Notes:

- Cleaning SWRO membranes at pH 13 is generally not recommended. However if a more aggressive cleaning is required, please contact the NanoH2O Tech Service Team before proceeding
- HCl can be used for making a low pH cleaning solution. Please keep in mind the HCl is a strong acid and it is easy to overshoot the pH well below the recommended limit. NanoH2O recommends starting the low pH solution with citric acid and making final adjustments with HCl.
- Use of generic or proprietary chemical cleaners other than those listed above may be necessary or desired. Please contact NanoH2O and/or the chemical provider to verify the cleaning chemical's compatibility with NanoH2O membranes and for its use in many site specific applications.

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Cleaning Procedure

1. If the unit does not have an adequate amount of permeate flush at shutdown, flush all vessels with RO permeate until the feed-concentrate process water is completely displaced. RO permeate used for flushing and mixing of cleaning chemicals must be free of any chlorine or other oxidizing agent.

2. Prepare a high pH NaOH solution per the allowable pH and temperature guidelines.

3. Introduce cleaning solution at a rate of 75 liters per minute (20 gallons per minute) per 8-inch diameter vessel.

4. Do not allow any feed-concentrate process water displaced from the introduction of cleaning solution to enter the cleaning tank. If the initial volume of cleaning solution returning to the tank is extremely dirty, discard that as well.

5. Recirculate the cleaning solution at a rate of 151 liters per minute (40 gallons per minute) per 8-inch diameter vessel for a period of 45 minutes.

6. Allow solution to soak if it has been determined that an extended soak time is beneficial to the cleaning process. Extended soak times typically range from 1-12 hours.

> Notes:
> Soak times are usually established based on operator knowledge of previous results or a detailed foulant analysis.

7. Flush the high pH cleaning solution from the vessels using RO permeate until the flush water pH exiting the vessel is close to the flush water pH entering the vessel. (Be sure to have an adequate amount of RO permeate stored before cleaning is initiated). If a soak period was introduced, recirculation of cleaning solution may also be required prior to flushing.

8. Closely monitor the pH of the cleaning solution during the cleaning process and adjust the pH as needed.

9. Measure the temperature and flow of the cleaning solution during the start, middle and end of the recirculation periods.

10. Never allow the vessel pressure drop to exceed 4 bar (60 psi) during any point in the cleaning. This applies to each pressure vessel housing FIVE OR MORE elements. If vessels contain less than five elements, contact NanoH2O for pressure limit guidelines.

11. Once the high pH solution has been rinsed from all pressure vessels and piping as described in Step 7, proceed with a low pH cleaning using citric acid. HCl or the combination of Citric Acid and HCl can be used for making the low pH cleaning solution. Follow the appropriate pH and temperature limits. Flows, recirculation time, and maximum differential pressure for the low pH cleaning are the same as the high pH cleaning.

12. Once the low pH cleaning is complete, flush the spent solution from the vessels using RO permeate until the flush water pH exiting the vessel is close to the flush water pH entering the vessel.

13. Cleaning chemicals may be present in the permeate after cleaning. Upon restart (post-cleaning), RO permeate should be directed to drain for a minimum of 10 minutes. Please note that the permeate conductivity is usually elevated after a cleaning and may take some time to stabilize.

14. Contact NanoH2O with the RO operating data taken prior to and 48 hours after cleanings.

> Notes:
> Direction of cleaning flow through the pressure vessels must always be in the same direction as feed flow during normal operation. Cleaning equipment, supply piping and return piping MUST be free of any contaminants or free standing water before beginning the cleaning process

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Reverse Direction Cleaning.

Reverse Direction Cleaning is believed to be very helpful in removing front end fouling, in case of biofouling which is common to many seawater RO plants. In general, the guidelines specified above and the cleaning solution, pH, and temperature limits used for standard cleaning are also applicable to reverse cleaning. However, certain precautions must be considered, as addressed below.

- Scaling

Cleaning in the forward direction is always recommended if scaling is present. In fact, scaling must be removed before doing any reverse direction cleaning. The crystals that form during scaling can have very sharp edges that can damage the membrane surface, and reverse direction cleaning can potentially cause greater damage than normal cleaning if these crystals are not removed first.

CAUTION

The forward direction cleaning should be performed first, followed by the reverse direction cleaning.

- Limitation of Differential Pressure across Pressure Vessels

Since there is no thrust cone at the feed end of a pressure vessel, telescoping of RO elements, during reverse direction cleaning, may occur if differential pressure exceeds a certain value. NanoH2O recommends dP (vessel differential pressure) not to exceed 40 psi (2.75 bar) during the reverse direction cleaning for pressure vessels of five or more elements. In practice, the control over dP can be achieved by gradual increase of the reverse direction cleaning flow rates. NanoH2O recommends reducing the flow rates to 1/3 of the normal cleaning flow rates for heavily fouled elements and to 2/3 of the normal cleaning flow rates for lightly fouled elements as follows as reference only:

Fouling Condition	Starting Flow Rate per 8" Vessel	Maximum Flow Rate per 8" Vessel
Lightly Fouled Elements	6.7 gpm (25 lpm)	26.7 gpm (100 lpm)
Heavily Fouled Elements	6.7 gpm (25 lpm)	13.3 gpm (50 lpm)

CAUTION

Exceeding the stated differential pressure (dP) during reverse cleaning may lead to irreversible damage to the membranes. It is always recommended to start cleaning with a low flow rate and increase it slowly in steps observing the actual dP values

- Limitation of End Cap Adapters

There exist several types of end cap adapters employed in the industry. When considering reverse direction cleaning, it is important to verify the type of the adapter installed in pressure vessels. **Adapters having a shoulder OD, at the membrane side, of 45 mm and below should not be used for reverse direction cleaning.** Only those end cap adapters that have an OD of 45 mm and higher, and fully sit on the element ATD, should be used.

CAUTION

Adapters having a shoulder OD, at the membrane side, of 45mm and below should not be used for reverse direction cleaning.

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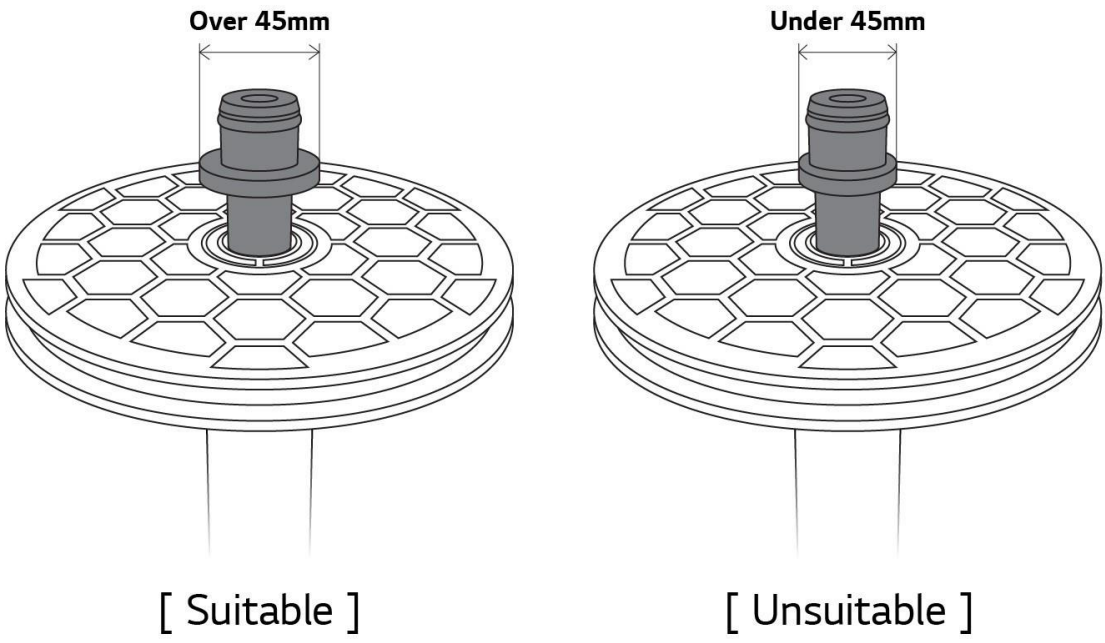
Figure 113.1



- Additional Considerations for Reverse Direction Cleaning

Entrapped air, water hammer, fast pressurizing, etc should be avoided during reverse direction cleaning. If possible, thrust cone/ring should be moved to the feed end before reverse direction cleaning.

Notes:
Never clean the RO membrane from the permeate side. This can lead to permeate backpressure which will irreversibly damage the membrane.