Version 5.0.1

Reverse Osmosis Membrane

Technical Service Bulletin

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Contents

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Receipt of Elements, Short-Term Storage, and Disposal of Used Elements

Receiving Inspection

After a shipment arrives, conduct a visual inspection of all packages to confirm that:
1. Shipment arrived without damage to the packaging or its contents.
2. All packages listed on the packing list arrived in good order.

NanoH2O strongly recommends inspecting the product for any visible damage or defects immediately upon receipt. If any issues are encountered, please contact an NanoH2O Customer Service representative before accepting the delivery to ensure that your rights are protected. In such cases, NanoH2O will promptly identify possible causes of the damage and determine whether it occurred during transit.

Please notify your carrier or freight forwarder and a NanoH2O Customer Service Representative IMMEDIATELY of any damaged merchandise or product shortages. Each RO element box contains an element with one brine seal installed and one interconnector with four O-rings installed. It is expected that the RO element boxes will only be opened right before loading. Should any brine seals, interconnectors, or O-rings be missing, please notify NanoH2O for immediate shipment of replacement.

Storage

After factory performance testing, elements are preserved in a 0.5 wt% sodium metabisulfite solution and vacuum sealed in oxygen barrier plastic bags.

Maintain elements in their original shipping containers and store in a protected area that is NOT subject to extreme heat (greater than 35°C / 95°F).

NanoH2O elements should NOT be stored in areas exposed to direct sunlight.

Elements stored in 0.5% SMBS solution will freeze below -2°C, however this will not affect the membrane's performance as long as it is thawed in room temperature before installation.

NanoH2O elements should NOT be stored in areas where damage can occur from moving equipment such as forklifts and pallet jacks.

A full standard pallet contains a maximum of 40 (8-inch) diameter element boxes (5 elements wide by 8 elements high). Full standard pallets cannot be stacked on top of each other. A single 8-inch diameter element box can only be stacked 8 boxes high or less.

For long-term storage (greater than 60 days), periodically re-inspect the shipping containers to ensure that there is no physical damage or leakage. Any leakage may indicate a loss of integrity of the membrane element preservative.

For storage lasting longer than 6 months, preserved elements should be visually inspected for biological growth and periodically examined every 3 months thereafter. If the preservation solution appears to be murky, the elements should be re-preserved and vacuum sealed. Another method for checking the integrity of the preservative is through pH measurements. The bisulfite in the preservative can oxidize into sulfuric acid which will cause the pH to drop. If the pH of the preservative drops below 3, the elements must be re-preserved. Please contact NanoH2O Technical Service for instructions and supplies for re-preserving the elements.

Elements stored per the conditions listed in this bulletin, with original factory packaging and vacuum seal intact, are likely to meet expected performance for storage periods up to 12 months and possibly longer.

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Receipt of Elements, Short-Term Storage, and Disposal of Used Elements

Disposal of Used Elements

Used NanoH2O elements should be disposed of in accordance with all local and federal regulations. Used elements can be disposed of as municipal waste provided that no preservation solution or other hazardous liquids remain within the element and there are no deposition of hazardous substances on the membranes at concentrations exceeding regulatory standards.

If the user wants to recycle the elements, the material components by weight of an unused element can be found below:

Material	Weight (kg)	Weight (lb)
Polysulfone	0.81	1.78
Polyester	6.73	14.8
Polypropylene	1.59	3.51
Polyurethane (2Part)	0.83	1.65
Epoxy (2Part)	0.71	1.57
E Glass Roving	1.73	3.81
ABS (Acrylonitrile-Butadiene-Styrene)	0.99	2.18
Polyamide Layer including Nanomaterials	0.05	0.11
EPDM (ethylene propylene diene monomer) Rubber	0.03	0.08

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Element Loading Guidelines

Element loading guidelines provide recommendations to ensure proper and safe installation of NanoH2O RO membrane elements in reverse osmosis (RO) system pressure vessels.

System Flushing

Prior to loading the membrane elements, new systems should be thoroughly flushed with pretreated feedwater to ensure the absence of construction debris, solvents, chlorine or other contaminants that may be harmful to the elements.

Pressure Vessel Preparation

The interior walls of the pressure vessels must be thoroughly cleaned prior to loading membrane elements in order to prevent dust, construction debris or other foreign matter from being deposited onto the membrane surface during start-up. Simply hosing down the interior of the vessels with freshwater is NOT adequate to clean the vessels thoroughly. NanoH2O recommends the use of a sponge ball wrapped in a cloth or towel that has been soaked in a 50% solution of glycerin and chlorine-free water. The cleaning ball may either be pulled through the vessel when attached to a rope or pushed through the vessel when mounted to a PVC flange affixed to an appropriate length of PVC pipe. Use appropriate CAUTION to ensure that the inside surface of the vessel is not scratched or damaged during cleaning.

Membrane Element Storage

NanoH2O RO elements should be maintained in their original shipping packaging and stored in accordance with "Receipt of Elements, Short-Term Storage, and Disposal of Used Elements - TSB 101" and "Membrane Storage Inside Pressure Vessel – TSB 105" guidelines.

CAUTION

DO NOT use oil, grease, petroleum jelly or other petroleum-based compounds to lubricate O-rings or brine seals. Food-grade glycerin may be used for O-ring and brine seal lubrication either directly or in a water-based solution. Approved lubricants for interconnector O-rings, end adapter O-rings or membrane element brine seals include glycerin, silicon-based Molykote III, or other silicone-based lubricants that do not contain hydrocarbons. Contact Technical Support at NanoH2O for further assistance.

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Element Loading Guidelines

Materials Required

- Eye protection
- Safety Shoes
- Protective gloves, (for jobs with post startup bacteria testing of RO permeate, use sterile, powder free exam gloves)
- Other safety equipment and clothing as required by jobsite regulations
- Lubricant (Food grade glycerin and/or approved silicone lubricant)
  (NOTE: Do not use silicon lubricant for ultrapure water applications.)
- Clean towels and rags
- Plastic sheeting to protect and keep clean all permeate piping, endcap adapters, and any system part that will be in contact with RO permeate
- Water for flushing
- Tools and equipment necessary to clean and prepare pressure vessels
- Tools and equipment necessary to remove and replace pressure vessel components and attached piping
  (NOTE: Refer to pressure vessel manufacturer's literature for correct parts and procedures.)
- Critical spare pressure vessel parts and pipe fittings that might break during unloading and loading process
- Endcap adapter shims (See NanoH2O "Vessel Shimming Procedures-TSB 103")

Element Loading

1. Make sure that pressure vessel parts, fittings and connecting piping (especially permeate piping) are removed for RO element installation are protected from dirt and airborne dust and debris. Keep floors and parts clean during the RO element loading process. For jobs where bacteria sampling of RO permeate after startup is required it is good practice to remove endcaps and place on unused, clean plastic sheeting, away from heavy traffic. Cover the endcaps to minimize exposure to airborne debris. Remember, the center port of the endcap carries RO permeate. Do not handle the endcap by touching the inside of the center port.

2. It is good practice to stage RO elements for each pressure vessel prior to loading. RO Elements with standard u-cup brine seals are loaded in the direction of process flow, so the first elements loaded is the concentrate end element. The feed end element will be the last to be loaded. It is strongly recommended to keep RO elements in their plastic bags during the staging process. While the elements are staged for each pressure vessel, record the elements serial numbers and the corresponding pressure vessel number. Make note of the position of each element in each pressure vessel. Later, transfer the loading sequence to Excel spreadsheets.
(NOTE: Many RO systems undergo partial element replacement over the warranted life of the system. It is important to keep accurate and up to date loading sequences by serial number and element age.)

3. Install endcap assembly in the concentrate (brine) end of the pressure vessel. Make sure the retaining ring is properly installed and the thrust cone installed downstream. Refer to pressure manufacturer's literature for installation instructions. Determine if it is preferable to install the concentrate endcap/element adapter into the concentrate endcap or concentrate element before loading. The adapter is supplied by the pressure vessel manufacturer. If it is preferred to have the adapter inserted in the endcap, make sure it is properly inserted and lubricated before installing the concentrate endcap assembly. Secure the concentrate endcap per the manufacturer's instruction.

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Element Loading Guidelines

4. Load the first element (concentrate end element) approximately 2/3rd of its length into the feed end of the pressure vessel. If the concentrate endcap/element adapter was not inserted into the concentrate endcap, make sure that it is properly lubricated and inserted in the concentrate face of the concentrate element before loading in the pressure vessel. Make sure that the u-cup brine seal is properly installed on the upstream (feed end) ATD (anti- telescoping device) of the RO element. (See "Brine Seal Replacement-TSB 114").
(NOTE: Only one u-cup seal is required per element. Never put u-cup seals at both ends of the RO element. U-Cups will only seal if properly oriented on the ATD. See "Brine Seal Replacement-TSB 114" for proper orientation.)

5. Lubricate the u-cup seal with 50% glycerin / and chlorine-free water solution.
(NOTE: If silicone based lubricant is used, only a small amount is needed. Use sparingly as excess amounts could foul the membrane surface.)

6. The product water tubes of each RO element are connected by an interconnector with pre-installed o-rings. Make sure that all o-rings are installed and lubricated properly. Firmly insert the interconnector in the product water tube of the first element with a gentle twisting motion. The interconnector will seat on a shoulder that is recessed about 3 inches inside the product water tube. Never use a hammer or pounding motion to insert interconnectors.

7. With another person holding the first elements stationary, slide the next element on to the interconnector of the first element. Make sure that the ATDs of the two elements touch each other and the interconnector is fully seated within each element.

8. Slowly push the element stack into the vessel so that 1/3rd of the next element being loaded is overhanging the feed end of the pressure vessel.
(NOTE: Be careful to not push elements too fast as the ATDs can be damaged if they slide roughly over the retaining ring grooves in the pressure vessel.)
(NOTE: Never allow an interconnector to support the weight of an element.)

9. Repeat the steps above until the last element has been connected and is extending only 1/3rd beyond the feed end of the pressure vessel. Make sure that concentrate endcap assembly is installed and secured.

10. Firmly push the entire element stack so that the concentrate end element seats against the concentrate endcap assembly.

11. In most cases, there will be space between the shoulder of the feed endcap adapter and the feed endcap itself that will allow movement of the elements during startups and shutdowns. Excessive movement can lead to o-ring leaks. Shims can easily be added to prevent excessive movement of the elements stack. (Refer to "Vessel Shimming Procedures-TSB 103")

12. Follow pressure vessel manufacturer's and RO unit fabricator's instructions for installation of feed endcap assemblies and all interconnecting piping.

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Vessel Shimming Procedures

Vessel Shimming

Because the face-to-face end plate dimensions may vary among pressure vessel manufacturers, NanoH2O strongly recommends that the element stack within the pressure vessel be shimmed to remove any excess slack. This slack can result in interconnector uncoupling and excessive stack movement during shutdown and start-up.
To ensure the removal of excess slack from the element stack within each pressure vessel, NanoH2O recommends the following method:

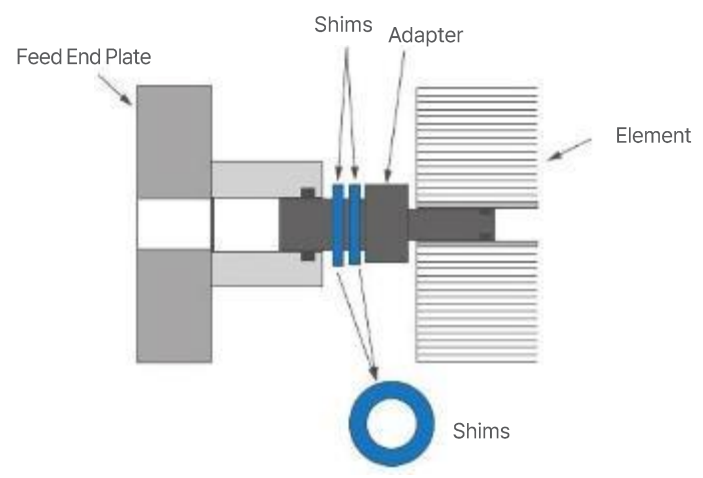
1. Install the REJECT-side end plate and thrust ring (if part of reject-side end-plate assembly), and push the element stack all the way toward the REJECT-end until the element stack is well seated against the REJECT-end end plate.

2. Prepare PVC spacers of varying thickness ranging from 3.17 to 9.52 mm (1/8 to 3/8 inches). These may be cut from a length of PVC pipe with a diameter that will fit over the feed-side adapter.

3. Install as many shims as necessary over the FEED-side inboard adapter until the end plate fits snugly against the shims while allowing the end plate to be installed. A gap of approximately 6.34 mm (1⁄4 inch) between the end plate and the shims is permissible and should not result in interconnector decoupling or other performance issues (Figure 103.1).

4. During the first month of system operation after startup, it is recommended to check the status of the membrane shimming and add shims if there is any space for shimming.

Figure 103.1



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Membrane Element Start-up/Shutdown Procedures

The first time NanoH2O RO elements are placed in service and during normal operational start-up and shutdown, certain precautions MUST be observed to help ensure stable long-term performance from the elements. Below are the normal procedures and precautions for initial start-up and subsequent operation.

Feedwater Requirements

- **Free Chlorine**

Qfx membrane elements show some resistance to short-term chlorine (hypochlorite) exposure. The free chlorine tolerance of the membrane is < 0.1 ppm. Continuous exposure, however, may damage the membrane and should be avoided. Under certain conditions, the presence of free chlorine and other oxidizing agents will cause premature membrane failure. Since oxidation damage is not covered under warranty, NanoH2O recommends removing residual free chlorine by pretreatment prior to membrane exposure.

> CAUTION
>
> Confirm that feedwater introduced to the membrane elements contains no more than 0.1 ppm of free chlorine. Membrane element damage resulting from operation beyond this limit is irreversible and will void the NanoH2O product or performance warranty.

- **Turbidity**

Confirm that RO feedwater turbidity and fouling potential, as measured by a 15-minute silt density index (SDI15), are within the limits specified on the Qfx product data sheet or in the NanoH2O product or performance warranty. Please refer to "Silt Density Index Procedure (SDI15) - TSB 107" for more information. During system start-up, spikes of high turbidity water may pass through the pretreatment system until the pretreatment system stabilizes. These spikes will result in membrane fouling that decreases permeate flow and requires operation at higher pressures to compensate for the decreased flow.

> CAUTION
>
> Membrane elements that have been fouled will suspend and may void (if the foulants cannot be completely removed by chemical cleaning) any product or performance warranty issued by NanoH2O related to permeate flow and/or operating pressure.

- **Temperature**

Confirm that RO feedwater temperature is within the limits specified on the NanoH2O product data sheet. Operation at temperatures exceeding 45°C (113°F) under the high pressure conditions required for SWRO can result in the weakening and compression of the porous polysulfone layer supporting the thin-film membrane. This compression can result in compaction that permanently reduces the permeate flow through the membrane. Please contact a NanoH2O sales representative or technical support team member if you are considering system operation with feedwater temperatures that exceed these limits.

> CAUTION
>
> Impaired membrane permeability caused by high temperature compaction will void any product or performance warranty issued by NanoH2O related to permeate flow and/or operating pressure.

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Membrane Element Start-up/Shutdown Procedures

- **Other Feedwater Conditions**

Prior to introducing the feedwater to the membrane elements, confirm that all other feedwater composition, properties and limiting conditions are in full compliance.

> CAUTION
>
> Failure to comply with limiting conditions may void any product or performance warranty issued by NanoH2O.

Initial Start-up Requirements

- **Pre-Flushing**

Prior to installing the membrane element(s), the system or train MUST be flushed to remove any debris in the pressure vessel ("Membrane Element Flushing - TSB 109").

- **Element Loading**

Confirm that the NanoH2O elements were correctly loaded and that all O-rings and brine seals were properly installed. Confirm that the elements in each pressure vessel were properly shimmed to remove excess slack in the pressure vessel ("Vessel Shimming Procedures - TSB 103")

- **Vent Entrained Air**

Initiate a low pressure flush at 1 - 1.4 bars (15 - 20 psig) to ensure that all air is purged from the membrane elements and pressure vessels prior to the next step. The low pressure flush should be performed with the permeate valves open to drain, the concentrate control valve (the valve that controls the ratio of concentrate flow to permeate flow) fully open, and with a soft-start mechanism or variable speed drive.

- **Membrane Flushing**

Remove membrane preservatives. The membrane elements are shipped after being immersed in a 0.5 wt% sodium metabisulfite solution and drained. In order to remove the preservative, It is recommended to perform a flushing step at the flow rate of 7-9 m3/h per 8 inch PV, applying the lowest possible pressure to achieve this flow, what typically occurs at a feed pressure of 4 bar with a dP of 1.5-2 bar for a 6-7 elements PV.

Ramp up the pressure to achieve normal operation ("Membrane Element Operating Precautions-TSB 106").

The permeate produced for the first 10 minutes of plant operation should be discharged to waste. To ensure the highest quality permeate stream, discard the permeate for the first 1 hour of operation after the initial start-up. Furthermore, prolonged flushing may be necessary depending on the application and required water quality.

> CAUTION
>
> Failure to remove entrained air can result in mechanical damage to the membrane elements due to high hydraulic forces resulting from water hammer.

Notes:
When flushing a membrane element, the permeate valves should be open to drain and the concentrate control valves should also be fully open to avoid damaging the membrane elements. For any flushing operation to be effective, the volume used for flushing should exceed the liquid hold-up volume of the membrane elements. For standard 8-inch x 40-inch elements, assume the hold-up volume is 37.85 liters (10 gallons) for each membrane element. For standard 4-inch x 40-inch elements, assume the hold-up volume is 11.35 liters (3 gallons) for each membrane element. To ensure the highest quality permeate stream, discard the first hour's worth of permeate after initial start-up.

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Membrane Element Start-up/Shutdown Procedures

Operating Requirements – System Start-up

- Concentrate Control Valve Operation

Prior to train or system start-up, confirm that the concentrate control valve is in the fully open position.

CAUTION

NEVER start up a train or system with the concentrate control valve fully or partially closed. After feedwater is introduced to the train or system with the concentrate control valve fully open, slowly close the valve until the desired recovery is achieved. Starting a train or system with the concentrate control valve fully or partially closed can over-pressurize the system, damage the membrane elements, burst piping and create a safety hazard. Train or system permeate recovery should NEVER exceed the maximum safe permeate recovery as recommended by NanoH2O or by its Q+ Projection Software.

- **Control Rate of Pressurization During Start-up**

No train or system should be brought online (pressurized) at a rate faster than 0.7 bar (10 psig) per second.

CAUTION

Rapid pressurization of a train or system can cause mechanical damage to the membrane elements. Such damage can include: cracking of the outer fiberglass shell, failure of the anti-telescoping device and membrane telescoping. Mechanical damage to membrane elements caused by overly rapid pressurization or over-pressurization will void any product or performance warranty.

Operating Requirements – System or Train Shutdown

- Element Flush

Following the system or train shutdown, it is REQUIRED to flush the membrane elements with RO feedwater to remove the high concentrations of salts. Never shut down the RO system or train without immediately flushing the high TDS (Total Dissolved Solids) concentration from the membrane elements.

CAUTION

Failure to remove the high TDS concentration of the hold-up volume in the membrane elements may result in damage to the elements.

Notes:
When flushing a membrane element, the permeate valves should be open to drain and the concentrate control valves should also be fully open to avoid damaging the membrane elements. For any flushing operation to be effective, the volume used for flushing should exceed the liquid hold-up volume of the membrane elements. For standard 8-inch x 40-inch elements, assume the hold-up volume is 37.85 liters (10 gallons) for each membrane element. For standard 4-inch x 40-inch elements, assume the hold-up volume is 11.35 liters (3 gallons) for each membrane element. To ensure the highest quality permeate stream, discard the first hour's worth of permeate after initial start-up.

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Membrane Storage Inside Pressure Vessel

Short-Term Storage Procedure

If RO system is to remain offline for less than 7 days, then follow the procedure below.

1. When RO system is shutdown, flush with permeate or filtered feedwater while keeping the concentrate valve fully opened to completely displace concentrated feed water within RO elements. The maximum pressure and recommended flow rate for membrane element flushing have been described in "Membrane Element Flushing-TSB 109".

2. If chemical injection is typically used during normal operating condition, the chemical injection must be stopped before flushing begins.

3. Once flushing is complete, RO elements must remain submerged in flush water at all times and not be exposed to air.

4. Flush RO system at least once every 24 hours with filtered feedwater. If the operator suspects potential problem due to biofouling during down periods, then flushing frequencies should be increased or start flushing unit with RO permeate.

5. If feed water for flushing every 24 hours is not available, see Long-Term Storage with Preservative Procedure below.

> Notes:
> Contact with air will dry out the elements. Dry elements will irreversibly lose flux.

Long-Term Storage with Preservative Procedure

If the RO system is to remain off line for more than 7 days, then follow the procedure below.

1. If decline in normalized performance is observed prior to long term storage, performing a clean-in-place (CIP) on the RO system is recommended.

2. Flush the system with permeate or filtered feedwater while keeping the concentrate valve fully opened. The maximum pressure and recommended flow rate for membrane element flushing have been described in "Membrane Element Flushing-TSB 109".

3. Flush the system with a 0.5% solution of sodium metabisulfite (SMBS) solution. Once flushing is completed, RO elements must remain submerged in preservation solution at all times and not be exposed to air.

4. Check preservation solution pH every 30 days. When solution falls below pH 3.0, repeat steps 2 and 3 to re-preserve the elements.

> Notes:
> Any contact with oxygen will oxidize SMBS and reduce effectiveness of preservative.
>
> In certain situations where the polyamide (PA) membranes have been fouled with heavy metals (e.g., Iron (Fe), Cobalt (Co), or Copper (Cu)), the membrane may be oxidized when stored using SMBS. The oxidation can be prevented by adding chelating agents into the preservative. Please contact NanoH2O for advice.

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Membrane Element Operation Precautions

To obtain the maximum service life from your NanoH2O membrane elements, certain precautions should be followed to avoid element damage or impaired performance. Additional requirements may be outlined in your product or performance warranty and in other sections of this technical manual. Should there be a conflict between the values and information provided in this manual and in your warranty, the values and information provided in your warranty supersede those outlined in this manual.

Cautions Regarding Feedwater Quality, Operating Limits and Recommended Good Practices

Failure to observe any of the following may result in irreversible damage to your membrane elements, shorten the membrane element's useful life and void the product warranty.

- The maximum applied pressure shall NEVER exceed the value outlined in the NanoH2O product data sheet.
- The maximum permeate water recovery shall NEVER exceed the maximum safe water recovery specified by NanoH2O's **Q+ Projection Software**.
- The RO feedwater shall contain NO more than 0.1 ppm of free chlorine.
- The RO feedwater shall contain NO concentration of oil or grease.
- The RO feedwater shall NEVER exceed a 15-minute Silt Density Index (SDI15) of 5 or an NTU of 1. Please refer to "Silt Density Index (SDI15) Procedure - TSB 107" in this manual for more information on how to measure SDI.
- The RO feedwater shall NOT exceed a temperature of 45°C (113°F).
- The membrane elements shall be taken offline and chemically cleaned when the pressure differential (ΔP) reaches 1 bar (15 psi) per element and/or 3.8 bar (55 psi) for the housing.
- Only chemicals approved by NanoH2O should be used in conjunction with the operation and maintenance of your membrane
- The pH operating range shall be 2-11 pH. The pH cleaning range shall be 2-12 pH.
- If a more aggressive cleaning is required (ie. pH 13), please contact the NanoH2O Tech Service Team before proceeding.

Cautions Regarding Permeate Valve Operation

RO membrane elements should **NEVER** be exposed to permeate backpressure exceeding the feed or concentrate static pressure. This potential issue is most frequently encountered during system or train shutdown. The permeate valves must remain open during all phases of train or system operation including pre-start-up, flushing, cleaning and normal operation.

CAUTION

Closing the permeate valves during any phase of system or train operation will create a pressure differential across the tail-end membrane elements that can result in ruptured glue lines and an immediate increase in salt passage. Ruptured glue lines cannot be repaired.

The permeate valves may be closed after flushing and cleaning, following a complete system or train shutdown. It is good practice to fully close the permeate valves during extended periods of shutdown to prevent an aerobic environment in the pressure vessels that can lead to biological growth. Be sure to reopen the permeate valve(s) prior to introducting feedwater back into the system or train.

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Membrane Element Operation Precautions

Cautions Regarding Concentrate Valve Operation

Prior to train or system start-up, confirm that the concentrate control valve (the valve that controls the ratio of concentrate flow to permeate flow) is in the fully open position.

> CAUTION
>
> NEVER start up a train or system with the concentrate control valve fully or partially closed. After feedwater is introduced to the train or system with the concentrate control valve fully open, slowly close the valve until the desired recovery is achieved. Starting a train or system with the concentrate control valve fully or partially closed can over-pressurize the system, damage the membrane elements, burst piping and create a safety hazard. Train or system permeate recovery should NEVER exceed the maximum safe permeate recovery as recommended by NanoH2O or by its Q+ Projection Software.

Cautions Regarding the Rate of Pressurization During Start-up

No train or system should be brought online (pressurized) at a rate faster than 0.7 bars (10 psig) per second.

> CAUTION
>
> Rapid pressurization of a train or system can cause mechanical damage to the membrane elements. Such damage can include cracking of the fiberglass outer-shell, failure of the anti-telescoping device and membrane telescoping. Mechanical damage to membrane elements caused by overly rapid pressurization or over-pressurization will void any product or performance warranty.

Chlorine Tolerance

NanoH2O membrane elements show some resistance to short-term chlorine (hypochlorite) exposure. The free chlorine tolerance of the membrane is < 0.1 ppm. Continuous exposure, however, may damage the membrane and should be avoided. Under certain conditions, the presence of free chlorine and other oxidizing agents will cause premature membrane failure. Since oxidation damage is not covered under warranty, NanoH2O recommends removing residual free chlorine by pretreatment prior to membrane exposure.

> CAUTION
>
> Membrane damage caused by oxidation is irreversible and will void your product or performance warranty.

Cautions Regarding the Use of Lubricants

Petroleum-based lubricants should **NEVER** be used in conjunction with NanoH2O RO membrane elements. Approved lubricants for interconnector O-rings, end adapter O-rings or membrane element brine seals include glycerin, silicon-based Molykote III, or other silicone-based lubricants that do not contain hydrocarbons.

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Membrane Element Operation Precautions

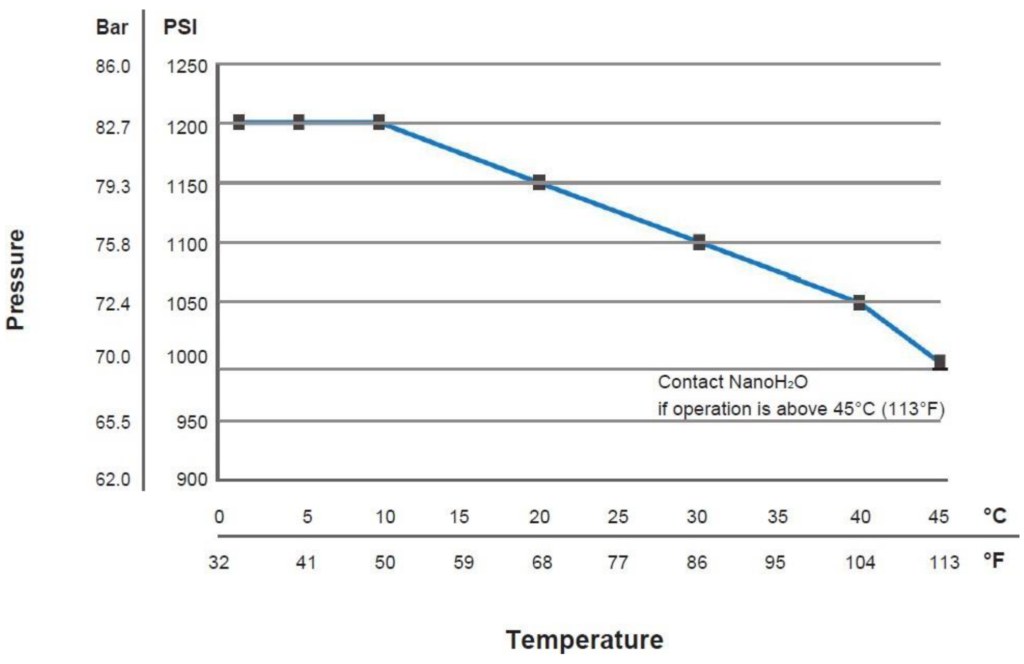
Cautions When Operating at High Temperature and High Pressure

Operation at certain high temperature and high pressure may result in compaction of the polysulfone support layer. Membrane compaction reduces permeability, resulting in higher feed pressure to maintain permeate flow (Figure 106.1).

CAUTION

Reduction in permeability from compaction caused by operation at feedwater temperatures and pressures that exceed NanoH2O's recommended limits will void your product or performance warranty. NanoH2O membrane elements should be operated in compliance with the temperature and pressure recommendations outlined in the following graphs. Please contact NanoH2O Technical Support for additional information.

Figure 106.1



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Silt Density Index (SDI15) Procedure

Protecting the NanoH2O membrane elements from particulate fouling minimizes energy use and allows stable long-term product performance. One of the most common methods to determine acceptable RO feedwater quality is the Silt Density Index (SDI). The SDI was developed to assess the membrane fouling potential of RO feedwater. An SDI test measures the time required to filter a specific volume of RO feedwater through a 0.45-micron filter paper at a feed pressure of 2.1 bars (30 psig). The following provides procedures required to determine RO feedwater SDI.

Test Equipment Setup

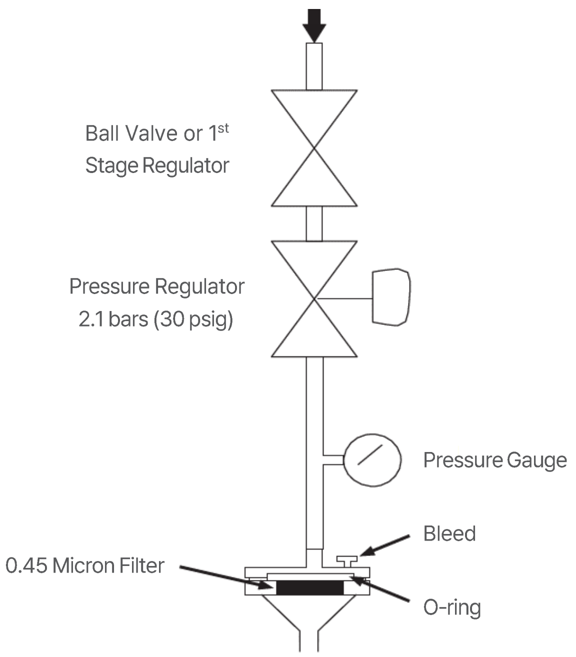
1. SDI kits may be purchased or assembled in accordance with Figure 107.1 below. Follow the SDI instructions on equipment setup.

2. Install the test equipment on a sample tap located on the feedwater piping. The sample should be downstream from all chemical dosing points, cartridge filters and immediately before the RO inlet manifold.

3. Install a new 0.45-micron filter pad in the filter housing and adjust the pressure regulator to 2.1 bars (30 psig).

Tips:
- Prior to use, thoroughly flush the test equipment to remove any contaminants to ensure an accurate result.
- Do not touch the filter pad. Use a dull pair of tweezers (to avoid puncturing the filter pad) to remove the pad from the package and place it in its proper position in the filter pad holder.
- Ensure that the O-ring is clean and properly seated

Figure 107.1



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Silt Density Index (SDI15) Procedure

Test Procedures

1. Measure the feedwater temperature, the temperature should not vary more than +/- 1°C (1.8°F) during the duration of the test.

2. Remove any entrained air from the filter holder housing by either opening the bleed valve or loosening the filter holder (depending on the model used) while slightly opening the ball valve. Once the air has bled from the housing, close the bleed valve or the filter housing.

3. Place a 500 ml (17 fl oz.) graduated cylinder under the filter housing to collect the volume of water that passes through the filter pad.

4. Fully open the ball valve and measure the time required (use a good quality stopwatch) to collect 100 ml (3.4 fl oz.) and 500 ml (17 fl oz.).

5. After five minutes, repeat the test. As before, measure the time required to collect a 100 ml (3.4 fl oz.) sample and a 500 ml (17 fl oz.) sample. Record the time intervals with the flow continuing to run through the filter housing.

6. Repeat the test at the 10-minute interval and again at the 15-minute interval.

7. If the time required to collect a 100 ml sample is greater than 60 seconds, plugging will be about 90% and it will not be necessary to continue the test.

8. After the 5, 10 and 15-minute samples have been collected, measure the water temperature to confirm that the temperature has not varied by more than +/- 1°C (1.8°F).

9. Upon the completion of the test, the spent filter pad should be sealed in a plastic bag, labeled with the time and date of the test and filed for future references.

Calculations

SDI is calculated using the following formula :

$$SDI = P_{30}/T_t = 100 \times (1-T_i / T_f) / T_t$$

SDI	Silt Density Index
P_{30}	% plugging at 2.1 bars (30 psig) feed pressure[2]
T_t	Total test time in minutes[2]
T_i	Time in seconds required to obtain the initial 500 ml (17 fl oz.) sample
T_f	Time in seconds to obtain the final 500 ml (17 fl oz.) sample

Notes:

1. The time required to collect a 500 ml (17 fl oz.) sample should be approximately 5-times greater than the time required to collect a 100 ml (3.4 fl oz.) sample. If the 500 ml (17 fl oz.) sample time is much greater than 5-times that of the 100 ml (3.4 fl oz.) sample, the SDI should be calculated using 100 ml (3.4 fl oz.) sample collection times.
2. The total test time is usually 15 minutes. However, it may be less than 15 minutes if 75% plugging occurs in less than 15 minutes. To obtain accurate SDI measurements, P30 should not exceed 75%. If P30 does exceed 75%, the test should be repeated to obtain T_f in a shorter period of time (T).

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Vessel Probing

A useful diagnostic method to identify membrane performance problems within a pressure vessel is to probe the elements within the pressure vessel in order to identify O-ring or interconnector leaks, locate poorly performing elements, or to identify other problems. Vessel probing involves inserting a length of polyethylene tubing into the vessel permeate channel so that conductivity measurements can be taken from each element within the pressure vessel. If abnormally high conductivity is observed at any individual element, this may be an indication of a poorly performing membrane element, O-ring leak, decoupled interconnector, or other problem.

Setting Up the Equipment

1. Shut down the RO system or train containing the pressure vessel(s) to be probed.

2. Remove the permeate cap from the opposite end of the pressure vessel from where you intend to measure permeate conductivity.

3. Connect a 1¼ inch threaded coupling to the permeate port and thread a 1¼ inch x ½ inch threaded reducer bushing into the coupling. Next, thread onto the coupling a ½ inch nipple and DN 15 (½ inch) ball valve onto the assembly. Finally, thread a ½ inch Parker Fast & Tight male connector for use with DN 10 (⅜ inch) tubing. Remove the metal collar and O- ring from the Fast & Tight fitting.

4. Obtain a length of DN 10 (⅜ inch) O.D. polyethylene tubing. The length of tubing needs to be significantly longer than the length of the pressure vessel being probed.

5. Using a marking pen with permanent ink (non water-soluble ink), place a mark at the point where the furthest membrane element connects to the end adapter. This is the “total length” mark. Then, mark the tubing in 508 mm (20-inch) increments from that point forward. (Black tubing is not recommended as you must be able to observe the markings)

6. Close the ball valve on the probe fitting and restart the RO system or put the train back in service.

7. Allow the system or train to run for approximately 15 minutes to stabilize performance.

8. After performance has stabilized, insert the tubing into the Fast & Tight fitting while opening the ball valve. Insert the tubing down the length of the permeate channel until the “total length” mark is reached.

9. After approximately one minute, measure the conductivity of the water coming out of the tubing. Repeat the reading several times to confirm that the values are consistent. Record the conductivity and the location from which it was taken.

10. Retract the tubing 508 mm (20 inches) to the next mark, wait one minute, repeat the conductivity measurement and record the data and the position from which the data was taken. Repeat this procedure until all element positions have been probed. You may want to slightly close the ball valve to better hold the tubing in place. Once the tubing has been removed from the vessel permeate channel, close the ball valve and continue to the next vessel.

Evaluate the conductivity values along the length of the permeate channel for each individual pressure vessel, then compare the trends of vessels operating in parallel. A sudden increase in conductivity where two elements interconnect indicates a feed to permeate leak that may be caused by a leaking O-ring or a disconnected interconnector. Replacing the faulty O-ring or reseating the interconnector can easily resolve the issue. If interconnectors become decoupled, shim the element stack within the pressure vessel. Please refer to “Vessel Shimming Procedures - TSB 103”

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Membrane Element Flushing

Prior to first use, it is strongly recommended that the membrane elements be flushed. RO membrane elements must also be flushed following system or train shutdown to remove highly concentrated salts from the membrane elements.

Pre-Flush of RO System at Start-up

Prior to installing the membrane element(s), the system or train MUST be flushed to remove any debris in the system and in the pressure vessels.

Ensure that the pressure vessel should make it clean internally and lubricate by 50% solution of glycerin and water ("Element Loading Guidelines-TSB 102").

Prior to initial flushing, please ensure that the elements are correctly loaded and that all O-rings and brine seals are properly installed ("Element Loading Guidelines-TSB 102").

Ensure that the elements in each pressure vessel have been properly shimmed to remove any excess slack in the pressure vessels ("Vessel Shimming Procedures-TSB 103").

Initiate a low pressure flush at 1 - 1.4 bars (15-20 psig) to ensure that all air is purged from the membrane elements and pressure vessels prior to the next step. The low pressure flush should be carried out with the permeate valves open to drain, the concentrate control valve fully open and a soft-start mechanism or variable speed drive.

Remove membrane preservatives. The membrane elements are shipped after being immersed in a 0.5 wt% sodium metabisulfite solution and drained. In order to remove the preservative, It is recommended to perform a flushing step at the flow rate of 7-9 m3/h per 8 inch PV, applying the lowest possible pressure to achieve this flow, what typically occurs at a feed pressure of 4 bar with a dP of 1.5-2 bar for a 6-7 elements PV.

Ramp up the pressure to achieve normal operation ("Membrane Element Operating Precautions-TSB 106").

The permeate produced for the first 10 minutes of plant operation should be discharged. To ensure the highest quality permeate stream, discard the permeate for the first hour of operation after initial start up. Furthermore, prolonged flushing may be necessary depending on the application and required water quality.

CAUTION

Failure to remove entrained air can result in mechanical damage to the membrane elements due to high hydraulic forces resulting from water hammer.

Notes:
When flushing a membrane element, the permeate valves should be open to drain and the concentrate control valves should also be fully open to avoid damaging the membrane elements. For any flushing operation to be effective, the volume used for flushing should exceed the liquid hold-up volume of the membrane elements. For standard 8-inch x 40-inch elements, assume the hold-up volume is 37.85 liters (10 gallons) for each membrane element. For standard 4-inch x 40-inch elements, assume the hold-up volume is 11.35 liters (3 gallons) for each membrane element. To ensure the highest quality permeate stream, discard the first hour's worth of permeate after initial start-up.

CAUTION

System pressurization and depressurization should be accomplished slowly and should not exceed 0.7 bar/sec (10 psig/sec).

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Membrane Element Flushing

Post-Flush of RO System at Shutdown

It is **strongly recommended** to remove the highly concentrated salts from the system by flushing after every shutdown.

Following the system or train shutdown, it is **REQUIRED** to flush the membrane elements with RO feedwater to remove the high concentrations of salts. Never shut down the RO system or train without immediately flushing the high TDS (Total Dissolved Solids) concentration from the membrane elements.

CAUTION

Failure to remove the high TDS concentration of the hold-up volume in the membrane elements may result in damage to the elements.

Notes:
When flushing a membrane element, the permeate valves should be open to drain and the concentrate control valves should also be fully open to avoid damaging the membrane elements. For any flushing operation to be effective, the volume used for flushing should exceed the liquid hold-up volume of the membrane elements. For standard 8-inch x 40-inch elements, assume the hold-up volume is 37.85 liters (10 gallons) for each membrane element. For standard 4-inch x 40-inch elements, assume the hold-up volume is 11.35 liters (3 gallons) for each membrane element.

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Customer Claim and Complaint Procedure

This procedure is for customers whom NanoH2O ("Manufacturer") have advised to return their purchased product for evaluation in support of a warranty claim ("Return Merchandise").

Before returning the Return Merchandise, customers are required to complete the 'Request for Return Merchandise Authorization Form (see a copy at the end of this bulletin, or download from our website www.nanoh2owater.com) and email the completed form to the email corresponding to your region listed below:

Region	E-mail
Americas	nasales@nanoh2owater.com
Europe, Africa	eumanasales@nanoh2owater.com
Middle East, Egypt	mesales@nanoh2owater.com
Korea	krsales@nanoh2owater.com
China	cnsales@nanoh2owater.com
India	insales@nanoh2owater.com
Southeast Asia	seasales@nanoh2owater.com

Customers will receive a Return Merchandise Authorization (RMA) number by email within 48 hours after submitting the Request for Return Merchandise Authorization form. The RMA number MUST appear on all shipping documents accompanying Return Merchandise to ensure that Return Merchandise is identified, accepted, and routed to the proper department for processing and evaluation. Any Return Merchandise received without an identifiable RMA number will be refused at the expense of delivery charges to the sender.

Please ship all Return Merchandise corresponding to the RMA claim to the Manufacturer immediately upon confirmation of your RMA number by the Manufacturer. Immediate shipping allows for a more accurate analysis of Return Merchandise claims. The Manufacturer must receive the Return Merchandise within 30 days for domestic shipments and 60 days for international shipments from when the RMA number is issued. Failure to comply with this requirement may void your warranty claim, and the Manufacturer will not be liable for any incurred costs (i.e., shipping).

Shipping of Return Merchandise to Manufacturer does not mean that the Manufacturer accepts all responsibility of a warranty claim. The sole purpose of returning the Return Merchandise to the Manufacturer is to carefully inspect the Return Merchandise to determine whether it falls within or outside of the warranty terms. Before any conclusions are determined through analysis of the Return Merchandise, all expenses will be the customer's responsibility.

Merchandise should be prepared for shipment and packaged per the Packing and Shipping Requirements detailed below :

DO NOT RETURN MERCHANDISE UNTIL YOU HAVE RECEIVED A WRITTEN AUTHORIZATION
AND A VALID RMA NUMBER FROM NANOH2O WATER SOLUTIONS

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Packing and Shipping Requirements:

- Flush membrane elements with RO permeate for a minimum of 30-minutes at pH 6-8 to ensure that any hazardous liquids contained in the Return Merchandise are flushed out and for safe handling of the Return Merchandise.

  LIQUIDS CONTAINING A STRONG ACID OR AN ALKALI CLEANING SOLUTION ARE CONSIDERED TO BE HAZARDOUS FOR TRANSPORT AND MUST BE FLUSHED OUT BEFORE SHIPMENT.
- Before shipping, please follow the Manufacturers' Membrane Element Storage Procedure (see " Receipt of Elements, Short-Term Storage, and Disposal of Used Elements – TSB 101") to preserve the Return Merchandise
- Before shipping, the Return Merchandise must be vacuum-sealed in a leak-proof polyethylene bag and securely packaged in a cardboard box to keep the RO element hydrated and protect it from physical damage during shipment

  DURING SHIPMENT, TAKE PRECAUTIONS TO ENSURE THAT MEMBRANE ELEMENTS ARE PROTECTED FROM FREEZING OR PROLONGED EXPOSURE TO TEMPERATURES EXCEEDING 35°C (95°F).

Please ship Return Merchandise to the following address :

NanoH2O Cheongju Plant

NanoH2O QA Team 39, Baekbong-ro, Heungdeok-gu, Cheongju-si,
Chungcheongbuk-do, 28441, Republic of Korea.

Attention : YunBum Chung, QA Manager
Phone : +82 043 261 9973
Email : ybchnhy@nanoh2owater.com

RMA# :______________________________.

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Customer Claim and Complaint Procedure

Warranty Claim Validation Procedure

Return Merchandise submitted under a warranty claim are evaluated according to the following procedure:

1. Initial Element Inspection

- Visual inspection of the core tube, anti-telescoping device (ATD), and element's fiberglass outer wrap – to determine if the Return Merchandise components sustained damage due to improper handling, installation, or operation.
- The Return Merchandise will be weighed to determine any variances in weight, indicating fouling or scaling.
- If the Return Merchandise fails to pass either of the initial inspections stated above, the warranty replacement will not be approved. The customer will be billed for any expenses incurred for analysis of the Return Merchandise.
- A vacuum or air leak test will be performed to determine if the Return Merchandise has a mechanical leak. Return Merchandise failing the vacuum or air leak test will be autopsied to determine whether the leak is covered under the Material and Workmanship Warranty, or was caused by improper use, operation, or handling of the Return Merchandise.
- Elements passing the initial inspection will be wet tested to determine current membrane performance.

2. Element Wet Test:

- The Return Merchandise will be wet tested to determine the current salt rejection and permeate flux under Manufacturer's standard test conditions.
- The wet test data will be compared with performance data at initial release of the merchandise (ex-works NanoH2O CJ plant) and warranted performance values.
- Based on the wet test data results, the Manufacturer will proceed with further analysis as decided by the customer.

3. Determination

- Return Merchandise found to comply with warranted performance values will be returned to the customer at the customer's expense ("freight collect"). The customer will be billed the evaluation fee for each Return Merchandise evaluated.
- Return Merchandise found to be defective based on the Material and Workmanship Warranty will be replaced or credited to the customer according to the applicable warranty terms and conditions.
- Return Merchandise performing below warranted performance values regarding salt rejection, permeate flow, or both, will be replaced or credited to the customer according to the applicable warranty terms and conditions.

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Customer Claim and Complaint Procedure

General Conditions

The customer is responsible for prepaying the shipping charges of the Return Merchandise. The Manufacturer will not accept any Return Merchandise unless it is prepaid. The Manufacturer may request that the customer issue a valid purchase order covering all work related to the warranty inspection, such as analytical work.

When inspection of the Return Merchandise by the Manufacturer concludes that a defect did not cause the warranty claim in material and workmanship:

- The Return Merchandise shall be returned to the customer at the expense of the customer (freight collect); and
- The customer will be billed for the Return Merchandise evaluated including autopsy and house analysis.

When inspection of the Return Merchandise by the Manufacturer concludes that a defect caused the warranty claim in material and workmanship:

- The Return Merchandise will be shipped to the customer free of charge. Please review your warranty for the terms and conditions applicable to your purchase order.

All terms, conditions, and specific remedies outlined in the customer's applicable warranty shall apply in processing all warranty claims. Please contact NanoH2O through the email address corresponding to your region listed above for further questions.

The customer is responsible for returning the Return Merchandise to the Manufacturer for membrane analysis. The warranty claim will not be accepted unless the membrane analysis is complete.

The Manufacturer advises the customer to complete the Request for Return Merchandise Authorization Form, including "The option for prior compensation request" on the form if replacement RO membrane elements are required to prevent the shutdown of your RO system while the Manufacturer conducts the warranty claim inspection.

When the customer receives replacement membrane elements by prior compensation request, the Return Merchandise must be shipped immediately to the Manufacturer following membrane replacement. If the Return Merchandise is not returned within two months, the customer is responsible for the compensation membrane elements at current pricing plus shipping charges.

The membrane elements delivered under prior compensation will be billed to the customer at their recent purchase price if the conclusion of the analysis of the used membrane elements is that the problem has not been caused by the membrane supplier.

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Customer Claim and Complaint Procedure

Request for Return Merchandise Authorization Form

Date			
Customer Name			
Customer Address			
Email			
Phone		Fax	
Original Purchase Order #			
Original Purchase Date			
Plant Location / Shipping From			
Merchandise Being Returned (Model #)			
Quantity Being Returned			
Date Merchandise was first put into service			
Reason for Return	(Please state whether this is related to a warranty claim, fouling analysis, cleaning study, over-stocking, etc)		
Evaluation and/or testing services requested			
Prior Compensation Request	☐ Yes ☐ No		
Membrane Elements Model and Quantity for prior compensation			
Purchase Order number covering requested services (if applicable)			
Have the elements been exposed to hazardous materials or substances?	☐ Yes ☐ No		
If yes, what materials or substances was the element exposed to?			
What was the feedwater source?			
Additional Comments			

FOR AND ON BEHALF OF

(Signature)

Company Name :
Name :
Title :
Date :

By signing this form, you acknowledge and accept the conditions of "Return Merchandise Authorization Procedure-TSB 110".

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Customer Claim and Complaint Procedure

RO Membrane Element RMA Request Form
New or Used Elements Removed from Original Packaging

Section 1

TO BE FILLED OUT BY REQUESTOR			
Name of Requestor		**Date of Request**	
CUSTOMER INFORMATION			
Company Name			
Address/ Region			
Contact Person			
Phone/ Mobile		**Email**	
REPORTED PROBLEM			
☐ Low Flow (High Feed Pressure)		☐ High Permeate Conductivity (Low Rejection)	
☐ High Differential Pressure		☐ Visual Product Defect	
☐ Other:			
TIME WHEN PROBLEM FIRST OCCURRED			
☐ Before Element Installation			
☐ At Startup (Less than 24 hours of continuous operation)			
☐ After Startup (2 to 14 days)			
☐ Other:		Months After Startup	
ELEMENT INFORMATION			
Element Model			
No. Returned Element(s)		**No. Elements Affected**	
Please note the element serial number and location within the system (e.g. 140XXXXX- Vessel B7- Position 1-8)			
1. Serial (FRP) No.		Position/PV	
2. Serial (FRP) No.		Position/PV	
3. Serial (FRP) No.		Position/PV	
4. Serial (FRP) No.		Position/PV	
NOTES			
Has the element(s) to be returned been exposed to Hazardous Materials? ☐ Yes ☐ No			
If Yes, Please provide details below (or attach to this document) and advise customer that MSDS sheets for all hazardous materials have to be submitted along with this RMA request. If approved, the same MSDS sheets are to be included with the returned elements.			
COMMERCIAL CLASSIFICATION			
☐ Warranty Claim		☐ Non Warranty Replacement	
☐ Non Warranty Credit		☐ Billable Technical Service Evaluation	
☐ No Charge Technical Service Evaluation		☐ Application Engineering	

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Customer Claim and Complaint Procedure

Section 2

SYSTEM INFORMATION				
Plant Location				
☐ New		☐ Replacement		
Plant Configuration / Array				
System Recovery (%)				
Start-Up Date				
Project Capacity				
Total Number of Elements				
Application				
CIP conditions/ Period				
Pretreatment				
Feed Water Source	☐ Well	☐ Surface Intake	☐ Seawater	☐ Municipal Waste
	☐ Municipal Supply	☐ Industrial Waste	☐ Other ( )	
Permeate Use	☐ Drinking	☐ Reclamation	☐ 2nd Pass RO Feed	
	☐ Ion Exchange Feed	☐ Other		
REPORTED PROBLEM				
Data Collection frequency	☐ Daily	☐ Per Shift	☐ Other	
Data Format	☐ Hand Written	☐ Excel Spreadsheet	☐ Normalization	☐ SCADA
Normalization	☐ NANOH2O NanoH2O	☐ DOW	☐ TorayTrak	☐ Hydranautics

Section 3

TO BE FILLED OUT
REQUIRED TEST
☐ As Received Visual Inspection
☐ Re-Wet Test
☐ Autopsy
☐ Dye Test- Rhodamine B (Pink)
☐ Other:

Section 4

INFORMATION FOR CUSTOMER SERVICE		
No of Elements to be Returned		
Serial Numbers or Customer PO		
Commercial Classification	☐ Credit	☐ Replacement
Further Instructions		
RMA NUMBER		

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Customer Claim and Complaint Procedure

Commercial Invoice

Sender : **Email Address :** **Phone Number :**	**Recipient :** NanoH2O Cheongju Plant, QA Team 39, Baekbong-ro, Heungdeok-gu, Cheongju-si, Chung cheong buk-do, 28441, Republic of Korea Attn: YunBum Chung **Email Address :** ybchnhy@nanoh2owater.com **Phone Number :** +82-43-261-9973 **Tax ID/VAT/EIN Number :** 142-86-03436

Invoice Date			Invoice Number				
Waybill Number			Sender's Reference				
Carrier			Recipient's Reference				
Quantity	Country of Origin	Description of Contents	Harmonized Code	Unit Weight	Unit Value	Sub Total	
Total Net Weight			Total Declared Value: (USD)				
Total Gross Weight			Freight & Insurance Charges: (USD)				
Total Shipment Pieces			Other Charges: (USD)				
Currency Code			Total Invoice Amount: (USD)				
Type of Export			Terms of Trade				
Reason for Export							
General Notes							

The exporter of the products covered by this document declares that, except where otherwise clearly indicated, these products are of Korea, Republic Of preferential origin.

I/We hereby certify that the information on this invoice is true and correct and that the contents of this shipment are as stated above.

Name : Position in Company : Signature :	Company Stamp

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Data Logging and Performance Normalization

In order to properly troubleshoot membrane performance issues, identify system operational issues, develop cleaning and maintenance procedures and ensure the validity of the product/system warranty, it is critical that feedwater quality and system performance data be recorded and filed on a regular basis so that such information is readily available for review in the event of a performance problem or a warranty claim.

Why is Data Collection Important?

Because RO membrane performance can be affected by a variety of factors, such as a change in feedwater quality or a change in operating conditions, the only way to determine whether your membranes are performing as expected is through regular collection and routine analysis of feedwater quality and system performance data. This information can then be evaluated over time to determine whether membrane performance is tracking as expected or if adverse trends develop which then require corrective action. All data collected should be systematically logged and filed for future access to allow analysis of longer-term performance trends that may require troubleshooting or support a warranty claim.

CAUTION

Failure to maintain the minimum data logging requirements identified herein or to make such data available to NanoH2O upon request may result in voiding your product/system warranty.

Why Normalize Data?

RO membrane performance will vary depending on feedwater characteristics, feedwater composition and operating conditions. Parameters such as feedwater temperature, feedwater TDS, membrane fouling, or system recovery will change key membrane performance characteristics such as feed pressure, permeate flow and permeate quality.

To determine whether changed performance is the result of changed feedwater or operating conditions, or whether it is due to a change in actual membrane performance, operating data must be taken at regular intervals and then “normalized” to baseline reference conditions. Whether changed performance is apparent or actual can only be determined by comparing “normalized” performance over time with baseline performance. To ensure optimized membrane performance and a long service life, it is important that any changes in membrane performance be identified and corrective action be taken as quickly as possible. A complete record of normalized data is therefore essential for users to realize the best performance and longest operating life of NanoH2O RO membrane elements.

Causes for Changes in Apparent Membrane Performance

Certain changes in the operating parameters of the RO system or train will result in changes in RO membrane performance. Such changes can result in an apparent or actual change in permeate flow or quality. Below is a list of the changed conditions that typically affect RO membrane performance.

Technical Service Bulletin 111

Data Logging and Performance Normalization

Conditions Resulting in Reduced Permeate Flow:

1. A reduction in feedwater temperature will result in a reduction in permeate flow if there is no corresponding increase in the feed pressure. An increase in the feedwater temperature will likewise result in an increase in permeate flow if there is no corresponding decrease in the feed pressure.

2. Decreasing the RO feed pressure will result in a reduction in permeate flow as a consequence of reducing the net driving pressure (NDP) across the membrane elements. NDP is the available effective pressure required to drive permeate through RO membranes. NDP is a function of the applied feed pressure, pressure losses, feed/concentrate osmotic pressure and permeate pressure.

3. Increasing the permeate backpressure will result in a reduction in permeate flow, due to a reduction in the available NDP.

4. An increase in the feedwater TDS will increase the osmotic pressure and result in a loss of permeate flow due to a reduction in the available NDP, unless the feed pressure is also increased.

5. Increasing the system recovery (the ratio of permeate flow to feed flow) will result in an increase in osmotic pressure, which will reduce the NDP, thus a reduction in permeate flow.

6. Membrane surface fouling will cause a decrease in membrane permeability and a subsequent reduction in permeate flow.

7. Fouling of the membrane element's feed/brine spacer will increase the feed/concentrate pressure drop across the membrane elements operating in series, causing a decrease in NDP for the elements at the end of the system and resulting in a reduction in permeate flow.

Conditions Resulting in Increased Permeate Salinity:

8. An increase in the feedwater temperature without a corresponding change in permeate flow will result in an increase in permeate salinity.

9. A reduction in the plant/train permeate flow reduces the rate of water flux through the membrane, causing an increase in permeate salinity because there is less permeate to dilute the salts that have passed through the membrane.

10. An increase in the feedwater salinity will result in an increase in permeate salinity because an RO membrane rejects a fixed percent of the total salts.

11. An increase in the system recovery (the ratio of permeate to feed) will increase permeate salinity because this has the effect of increasing the average salinity of the feed/brine in the system.

12. Membrane surface fouling results in less permeate flow and thereby less permeate to dilute the salts that have passed through the membrane.

13. Mechanical leaks caused by O-ring leaks or failure can allow high TDS feed/brine to leak into the permeate without passing through the membrane or allow feed to bypass an element's brine seal.

14. Membrane surface damage can be caused by exposure to free chlorine.

By normalizing plant data, the reviewer can determine if changes in membrane performance (in either permeate flow or quality) result from operating under different feed pressure, salinity or temperature conditions and, therefore, conclude if changes in performance are only apparent or actual. Actual changes require corrective action to remove surface foulants, locate and correct O-ring leaks, or prevent further membrane damage due to oxidation.

Graphing normalized data over time provides a useful picture of RO system performance and will identify how and when performance may have changed. Adverse changes in performance trends can then be reviewed in light of other data and plant operation logs to determine what happened, when it happened, and what can be done to correct the problem.

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Data Logging and Performance Normalization

Data Collection Procedures

The following tables identify the data to be regularly collected and the frequency of collection.

NanoH2O RO Membrane Minimum Logging Requirements

RO Feedwater Characteristics - Required Data:

Parameter	Frequency of Collection	Comment or Unit of Measure
Salt Density Index (SDI)	Once per day (every 24 hours)	Please refer to "SDI Procedure TSB 107"
Turbidity	Once per shift (every 8 hours)	Nephelometric Turbidity Units
Temperature	Once per day (every 24 hours)	°C or °F
Conductivity (μS)	Once per day (every 24 hours)	
Feedwater Chemical Analysis	Once per month	

RO Permeate System or Each Train – Required Data:

Parameter	Frequency of Collection	Comment or Unit of Measure
Conductivity (μS)	Once per day (every 24 hours)	
Flow	Once per shift (every 8 hours)	
Pressure	Once per shift (every 8 hours)	

RO Concentrate System or Each Train – Required Data:

Parameter	Frequency of Collection	Comment or Unit of Measure
Conductivity (μS)	Once per day (every 24 hours)	
Flow	Once per shift (every 8 hours)	
Pressure	Once per shift (every 8 hours)	

Operating Conditions for RO System or Each Train:

Parameter	Frequency of Collection	Comment or Unit of Measure
Pressure Differential for each stage	Once per day (every 24 hours)	
Cumulative Hours of Operation	Once per day (every 24 hours)	

Operating or Maintenance Events for RO System or Each Train:

Parameter	Frequency of Collection	Comment or Unit of Measure
System or Train Start-up	As applicable	Record date and time
System or Train Shutdown	As applicable	Record reason for shutdown, date, and time
Membrane Cleaning or Flushing	As applicable	Record reason for cleaning, chemical(s) used, method or procedure, concentration, date and time. Record results following cleaning.

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Data Logging and Performance Normalization

Data Normalization Equations

To obtain normalized permeate flow, use the following equation :

$$Qn = Q_a * (NDP_n / NDP_a) * (TCF_n / TCF_a)$$

Q_n	Rate of permeate flow (vol/t) normalized to standard conditions
Q_a	Actual flow rate (vol/t)
NDP_n	Net Driving Pressure at standard conditions (expressed as units of pressure)
NDP_a	Actual Net Driving Pressure (expressed as units of pressure)
TCF_n	Temperature Correction Factor for temperature at standard conditions
TCF_a	Temperature Correction Factor for temperature at the actual conditions

To obtain the Net Driving Pressure, use the following equation:

$$\text{Net Driving Pressure} = P_f - \tfrac{1}{2} \Delta P_{fb} - \text{Avg. } P_{osmf} - Pp + P_{osmp}$$

P_f	Feed pressure (expressed as units of pressure)
ΔP_{fb}	Pressure drop between the feed and brine systems (expressed as units of pressure)
Pp	Permeate pressure (expressed as units of pressure)
Avg. P_{osmf}	Average Feed Osmotic pressure - weighted average (expressed as units of pressure)
P_{osmp}	Permeate Osmotic pressure - weighted average (expressed as units of pressure)

To obtain the Average Feed Osmotic pressure, use the following equation:

$$\text{Avg. } P_{osmf} = 0.0385 * C_{fc} * (t + 273) / (1000 - C_{fc} / 1000) / 14.5$$

C_{fc}	Average feed concentration (expressed in ppm)
t	degree Celsius

To obtain the Permeate Osmotic pressure, use the following equation

$$P_{osmp} = 1.8 * C_p / 55850 * 0.0821 * (t + 273) * 14.7 / 14.5$$

C_p	Permeate concentration (expressed in ppm)
t	degree Celsius

To obtain the Temperature Correction Factor (TCF), use the following equation

$$TCF = \exp\{ K * [1 / 298 - 1 / (273 + t)] \}$$

K	The reaction rate constant depends on the membrane model.
t	degree Celsius

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Data Logging and Performance Normalization

To obtain normalized Salt Passage, use the following equation:

$$\%SP_n = (EPF_a / EPF_n) * (STCF_n / STCF_a) * \%SP_a$$

$\%SP_n$	Percent Salt Passage normalized to standard conditions (%)
SP_a	Percent Salt Passage at actual conditions
EPF_a	Element Permeate Flow rate at standard test conditions
EPF_n	Element Permeate Flow rate at actual conditions
$STCF_n$	Salt Transport Temperature Correction Factor at standard conditions
$STCF_a$	Salt Transport Temperature Correction Factor at actual conditions

To obtain the actual Salt Passage, use the following equation :

$$\%SP_a = C_p / C_{fc}$$

C_p	Permeate concentration (expressed in ppm)
C_{fc}	Average feed concentration (expressed in ppm)

To obtain the Salt Transport Temperature Correction Factor, use the following equation :

$$STCF = \exp\{ K * [1 / 298 - 1 / (273 + t)] \}$$

t	degrees Celsius
K	The reaction rate constant depends on the membrane model.

To obtain the Normalized Differential Pressure, use the following equation :

$$NDP = DP*((QF_n+QC_n)/(QF_a+QC_a))\text{^}(1.5)$$

DP	Differential Pressure (expressed as units of pressure)
QF_n	Feed flow at standard test conditions
QF_a	Feed flow at actual conditions
QC_n	Concentrate flow at standard conditions
QC_a	Concentrate flow at actual conditions

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Biocides for Disinfection and Storage

The periodic use of biocides may be required to control or eliminate biological growth in the feed/brine spacer or on the membrane surface, especially in cases of long-term storage. The following is general information on the application, use and handling of generic biocides that are suitable for use with NanoH2O's membrane elements.

Specialty chemical biocide products are formulated and distributed by a number of independent companies and marketed under various trade names. These products have typically been qualified by the chemical manufacturer for safe and effective use with composite polyamide seawater RO membranes. NanoH2O makes no representations as to either the efficacy or safety associated with such use and any such use by NanoH2O Customers is done at the sole risk of the Customer and the chemical manufacturer.

Below is a list of generic biocides approved for use.

CAUTION

Prior to use, review all applicable Material Safety Data Sheets (MSDS) and follow all manufacturer instructions and applicable governmental regulations with regard to the use, handling and disposal of biocides.

- Isothiazolin

Many manufacturers of water treatment chemicals distribute Isothiazolin under the trade name Kathon. Commercially available solutions typically contain 1.5 wt% of the active ingredient Isothiazolin. Please check the product literature to confirm the active ingredient concentration. Kathon is an effective biocide to maintain sanitary conditions in NanoH2O membrane elements at concentrations of 15 ppm to 25 ppm and may be used for system or train disinfection, or for long-term storage.

- Sodium Bisulfite

Sodium Bisulfite may be used to inhibit biological growth in the system or train when dosed daily at concentrations of 500 ppm for 30 to 60 minutes. Sodium Bisulfite at a concentration of 1 wt% may also be used to inhibit biological growth during long-term storage.

- Hydrogen Peroxide

A 0.1% to 0.2% solution of hydrogen peroxide (or a solution of hydrogen peroxide with paracetic acid) may be used for system or train disinfection. See caution statement below.

- DBNPA

The standard method to apply DBNPA is slug (intermittent) dosing. The amount of DBNPA used depends on the severity of the biological fouling. With a water less prone to biological fouling, using 10 – 30 ppm of the active ingredient for 30 minutes to 3 hours every 5 days can be effective.

CAUTION

Hydrogen Peroxide is a strong oxidizing agent and should not be used when transition metals such as iron or manganese are present in the feedwater. Oxidation of transition metals on the membrane surface will result in irreversible damage causing a reduction in salt rejection. Feedwater temperature should never exceed 25°C (77°F) when exposing membrane elements to a Hydrogen Peroxide solution. Hydrogen Peroxide should NOT be used for disinfection during long-term storage as its efficacy degrades with time.

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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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Membrane Cleaning

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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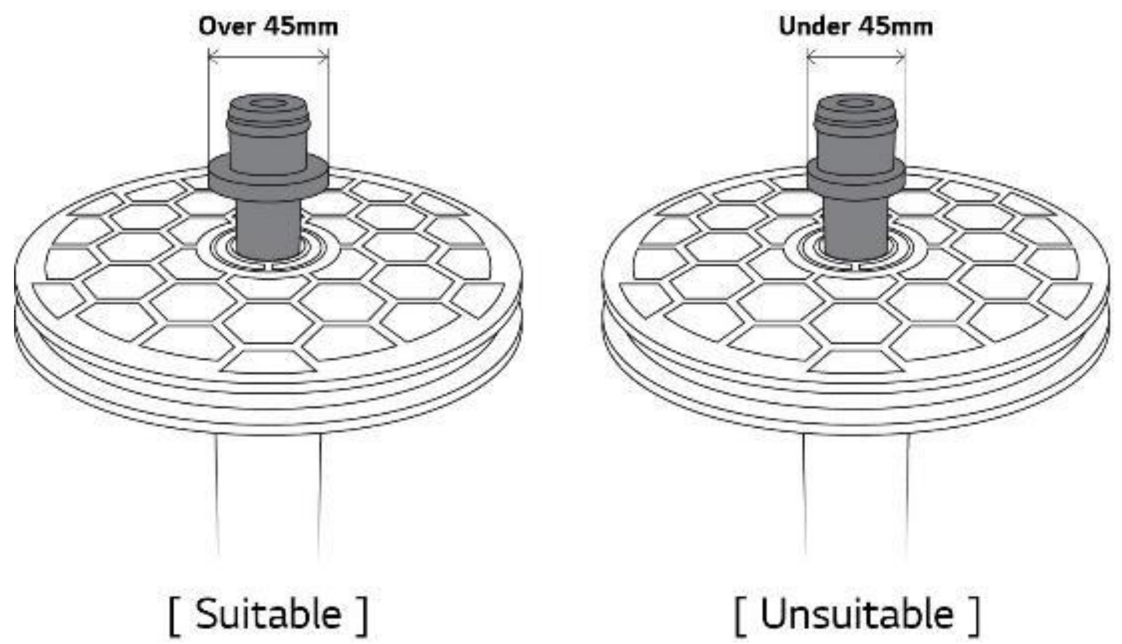
Figure 113.1

Suitable and Unsuitable end cap adapter



· 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.

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Brine seal Replacement

All NanoH2O RO elements are shipped with brine seals installed. If for some reason the brine seal is missing or damaged, installation of a new brine seal will be required. Brine seals, which prevent feed water from bypassing the RO element, need to be properly oriented in relation to the direction of feed flow. The standard brine seal installed on all NanoH2O RO elements is the U-Cup shaped style.

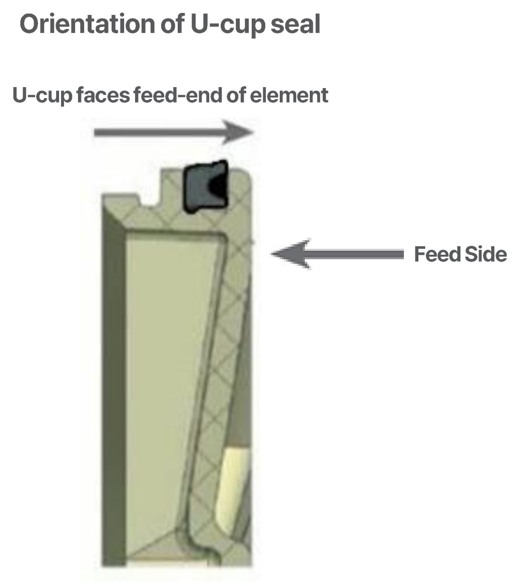
U-Cup Style Brine Seal

Install brine seal with the U-cup facing the feed end of the element as shown in Figure 114.1. Feed water flow will cause the seal to expand and seal against the inside diameter of the pressure vessel. For loading, lubricate the seal with either glycerin or silicone lubricant and load only in the direction of flow.

CAUTION

DO NOT use oil, grease, petroleum jelly or other petroleum-based compounds to lubricate O-rings or brine seals. (See "Element Loading Guidelines-TSB 102").

Figure 114.1



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RO Element Start-Up Consideration and Checklist

Successful RO element performance, both short term and long term, depends on handling, operation, and maintenance in accordance with all published guidelines and limits. Specific guidelines and limits can be found in:

- Performance projection software, Q+
- Element Specification Sheets
- Standard and Custom Warranties
- Tech Service Bulletins

Please refer to all appropriate documents to become familiar with the guidelines and limits for a specific project. As an RO element manufacturer, NanoH2O's scope of supply and liability is limited. The considerations and items presented below are intended as a general reference and are not to be considered all inclusive for any specific project.

Feedwater Source and Pretreatment

- New wells are properly flushed and within SDI and turbidity limits.
- Intake or well flows are able to provide continuous design feed flow to all RO units.
- All pretreatment processes are ready as designed and will meet SDI targets.
- New depth filtration media and carbon are properly installed, backwashed, and rinsed.
- New cartridge filters are properly installed, sealed, rinsed, and free of any chemical leachate.
- Chemical tanks are filled with proper chemicals.
- Chemical injection points are properly located.
- Chemical suction and discharged piping are installed as designed.
- Provisions exist for proper chemical mixing and draw-down measurement.
- If dechlorination is part of pretreatment process, carefully review design, operation, and means of detecting chlorine residuals.

Instrumentation, Sampling, and Monitoring

- Each RO stage requiring monitoring and performance tracking contains provision for reporting: permeate flow, concentrate flow, feed pressure, concentrate pressure, permeate pressure, feed conductivity, permeate conductivity, feed temperature, and feed pH.
  (Note: This includes individual stages of a multi-stage RO unit)
- Instruments are properly located and installed.
- Instruments are calibrated to the manufacturer's specifications.
- SCADA (Supervisory Control and Data Acquisition) if provided is functioning and available for retrieval of historic operating data.
- Data collection routine for startup and long term operation has been established.
- Data normalization and analysis routine has been established.
- Arrangements have been made to use either NanoH2O's QSee normalization program or direct transmission of data (in spreadsheet form) to NanoH2O for review and entry into QSee.
- Sample valves are located in the feed, permeate, and concentrate piping of each RO stage to be monitored
- Sample valves, or taps, are located in the permeate piping of each RO pressure vessel.
  (Note: sampling must occur at the end of the vessel where the permeate is collected and sent to the RO array permeate piping header)
- Sampling valves and piping exist to allow permeate flow path probing of each pressure vessel.

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RO Element Start-Up Consideration and Checklist

RO Element Handling

- Elements have been stored in their original packaging.
- Elements have been stored in a freeze-protected area, not exposed to direct sunlight, or temperatures that exceeded 35°C at any time.
- Preservative of elements stored more than 60 days has been spot checked
  (Note: Elements are preserved in a sodium bisulfite solution which may weaken over time. If the pH level of the preservative solution is less than pH 3, contact NanoH2O for re-preserving instructions)
- Only approved lubricants are to be used for element loading.
- For RO units requiring permeate bacteria testing at start-up, special handling and protection should be used to prevent contamination of permeate flow path parts and fittings.
- All pressure vessels are shimmed in accordance with vessel manufacturer guidelines.
- Element serial numbers and loading sequence have been recorded.

Auxiliary and Support Systems

- Shutdown and start-up flush systems are ready as designed.
- Proper flush water source is available.
- Flush lines and tanks have been pre-flushed and sanitized as required
- CIP system is ready as designed.
- All CIP lines have been properly flushed.
- All CIP temporary spool piping is ready.
- Energy recovery devices, associated instrumentation and sample valves are properly installed.
- Piping to and from the ERDs has been properly flushed.
- Provisions have been made to direct design permeate flow to drain without back pressure, if needed during initial start-up.
- Provisions have been made for concentration discharge at design flow without backpressure that exceeds design.

RO Unit Startup and Operation

- Functional testing has been performed to assure that control logic, RO unit shutdowns, and alarms will function as designed.
- All feed piping to the RO stage entry point has been flushed and sanitized as required.
- Permeate pressure relief is operational and installed as designed.
- Permeate piping is open, free, and clear of any restrictions causing a backpressure that exceeds the limits of the RO elements.
- Feed pressure will be applied at a rate that does not exceed 10 psi (0.7 bar) per sec.
- Provisions have been made to vent entrapped air from all feed, concentrate and permeate piping prior to start of the high pressure pump.
- Anti-siphon protection has been provided to assure that all RO stages remain full of flush water upon shutdown.
  RO elements will not be exposed to air when off line.
- Provisions have been made to allow RO units to run continuously during the first 48 hours of operation.
- Critical spares parts (RO elements, O-rings, adapters, interconnectors, rupture discs) are available on site.

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Spare Parts

NanoH2O recommends using spare parts as shown in the table below. Please contact NanoH2O through the email address or region TS engineer for the details.

Part-Number	Description	Description/Application	Quantity (percentage as a total membranes)	Note
3443396	8" SW Interconnector	8" SW Interconnector, ∮17.3(0.68") ID Tube. Use with all other 8" diameter Sea water elements. Uses 3579970 O-rings.		No need as the customer will have one extra per Pressure Vessel
3603395	8" BW Interconnector	8" BW Interconnector, ∮20.5(0.81") ID Tube. Use with all other 8" diameter brackish water elements. Uses 3579970 O-rings.		No need as the customer will have one extra per Pressure Vessel
3579970	8" Interconnector O-ring	O-ring for 3443396 and 3603395, Size 3-912, 4 required per interconnector.	0.5%	Percentage in a total number of membranes
TROSUB0001	8" Brine Seal	Used for all 8" diameter elements	0.5%	Percentage in a total number of membranes
3605452	4" Interconnector	4" element Interconnector-∮20.5(0.81") ID Tube. Use with all other 4" diameter elements. Uses 3607354 o-rings		No need as the customer will have one extra per Pressure Vessel
3607354	4" Interconnector O-ring	O-ring for 305452, Size 2-116, 4 required per Interconnector	0.5%	Percentage in a total number of membranes
3607350	4" Brine Seal	Used for all 4" diameter elements	0.5%	Percentage in a total number of membranes