

Technical Service Bulletin

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Foulants and cleaning procedures for sanitary, food processing type composite polyamide RO/NF membrane elements

This bulletin provides general information about the usual foulants affecting the performance of Hydranautics' Composite Polyamide Reverse Osmosis (RO/NF) membrane elements and the removal of these foulants. This bulletin is specific to sanitary, cage wrap type polyamide RO/NF membrane elements used for food processing.

Note: The Composite Polyamide type of RO/NF membrane elements may not be exposed to chlorinated water under any circumstances. Any such exposure will cause irreparable damage to the membrane. Absolute care must be taken following any disinfection of piping or equipment or the preparation of cleaning or storage solutions to ensure that no trace of chlorine is present in the feedwater to the RO/NF membrane elements. If there is any doubt about the presence of chlorine, perform chemical testing to make sure. Neutralize any chlorine residual with a sodium bisulfite solution, and ensure adequate mixing and contact time to accomplish complete dechlorination. Dosing rate is 1.8 to 3.0 ppm sodium bisulfite per 1.0 ppm of free chlorine.

The ONLY exception is that HYDRACoRe 10/50/70 may be exposed to a maximum of 100 ppm chlorine during cleaning.

Note: The use of cationic surfactants should be avoided in cleaning solutions, since irreversible fouling of the membrane elements may occur.

Note: The membrane elements shall not be exposed to feed water containing oil, grease, or other foreign matter which proves to chemically or physically damage the integrity of the membrane.

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Selection and Use of Cleaning Chemicals

There are a number of factors involved in the selection of a suitable cleaning chemical (or chemicals) and proper cleaning protocol. It is recommended to contact the manufacturer of the equipment, the element manufacturer, or a specialty chemical and service supplier for assistance. Once the suspected foulant(s) are identified, one or more cleaning chemicals will be recommended. These cleaning chemical(s) can be generic or can be private-labeled proprietary chemicals. Typically, the generic chemicals can be of technical grades and are available from local chemical supply companies. The proprietary RO/NF cleaning chemicals can be more expensive, but may be easier to use and you cannot rule out the advantage of the intellectual knowledge supplied by these companies. Some independent service companies can determine the proper chemicals and cleaning protocol for your situation by testing at their facility a fouled element pulled from your system.

It is not unusual to use a number of different cleaning chemicals in a specific sequence to achieve the optimum cleaning. Typically, a high pH cleaning is used first to remove foulants like fat/oil or biological matter, followed by a low pH cleaning to remove foulants like mineral scale or metal oxides/hydroxides fouling. There are times that order of high and low pH cleaning solutions is reversed or one solution only is required to clean the membranes. Some cleaning solutions have detergents added to aid in the removal of heavy biological and organic debris, while others have a chelating agent like EDTA added to aid in the removal of colloidal material, organic and biological material, and sulfate scale. An important aspect to remember is that the improper selection of a cleaning chemical, or the sequence of chemical introduction, can make the foulant worse.

Hydranautics recommends that the membrane system operator thoroughly investigate the signs of fouling before they select a cleaning chemical and a cleaning protocol. For most complex fouling phenomena, Hydranautics recommends the following sequence:

1. Flushing with permeate to purge feed solution from the system
2. High pH CIP – Temperature versus pH as per recommendations in this TSB
3. Flushing with permeate until pH on the brine side is below pH 8.5
4. Low pH CIP
5. Acid flushing with permeate
6. Disinfection (when required) with non oxidizing biocide (hydrogen peroxide/ peroxyacetic acid blend). Conducted at or below 77°F (25°C).
7. Final flushing
8. Monitor water flux data for performance normalization immediately after the cleaning to evaluate the efficiency of cleaning

General Precautions in Cleaning Chemical Selection and Usage

- If you are using a proprietary chemical, make sure the chemical has been qualified for use with your Hydranautics membrane by the chemical supplier. The chemical supplier's instructions should not be in conflict with Hydranautics recommended cleaning parameters and limits listed in this Technical Service Bulletin.
- If you are using generic chemicals, make sure the chemical has been qualified for use with your Hydranautics membrane in this Technical Service Bulletin.
- High-quality water must be used for flushing, cleaning, and disinfecting membranes. Water must be chlorine free for RO and NF systems.
- Minimize temperature differences between cleaning and rinse steps. The temperature difference should not exceed 20°F (11°C).
- Use the least harshest cleaning regimen to get the job done. This includes the cleaning parameters of pH, temperature, and contact time. This will optimize the useful life of the membrane.
- Clean at the recommended target temperatures to optimize cleaning efficiency and membrane life.
- Use the minimal amount of chemical contact time to optimize membrane life.
- Be prudent in the adjustment of pH at the low and high pH range to extend the useful life of the membrane. A "gentle" pH range is 4 to 10, while the harshest is 2 to 11.2.
- Hydrochloric acid is the preferred acid for membrane cleaning. Straight nitric acid solutions are not recommended because of potential oxidizing effects on NF membranes.

- Frequent disinfection with a non oxidizing biocide (hydrogen peroxide/peroxyacetic acid blend) may cause premature membrane degradation.
- Enzymatic cleaning may provide enhanced cleaning results for RO/NF membranes because chlorine cannot be used on these membranes.
- Oil and biologically-fouled membranes should not use a low pH clean-up first as the oil and biological matter will congeal.
- Cleaning and flushing flows should usually be in the same direction as the normal feed flow to avoid potential telescoping and element damage.
- When cleaning a multi-stage system, the most effective cleaning is one stage at a time so cleaning flow velocities can be optimized and foulants from upstream stages do not have to pass through down-stream stages.
- Flushing out detergents with higher pH permeate can reduce foaming problems.
- Verify that proper disposal requirements for the cleaning solution are followed.
- If your system has been fouled biologically, you may want to consider the extra step of introducing a sanitizing biocide chemical after a successful cleaning. You must be sure that the biocide is compatible with the membrane, does not create any health risks, is effective in controlling biological activity, and is not cost prohibitive.
- For safety reasons, make sure all hoses and piping can handle the temperatures, pressures and pH's encountered during a cleaning.
- For safety reasons, always add chemicals slowly to an agitated batch of make-up water.
- For safety reason, always wear safety glasses and protective gear when working with chemicals.
- For safety reasons, do not mix acids with caustics. Thoroughly rinse the 1st cleaning solution from the RO system before introducing the next solution.

Description of Cleaning Solutions

Note: The notation (w) denotes that the diluted chemical solution strength is based on the actual weight of the 100% pure chemical or active ingredient.

Solution 1: This is a high pH cleaning solution (target pH of 11.0) of 0.1% (w) of NaOH (sodium hydroxide) and 0.3% (w) of Na-EDTA (sodium salt of ethylenediaminetetraacetic acid). It is useful in the removal of organic foulants of natural origin, colloidal foulants of mixed organic/inorganic origin, and biological material (fungi, mold, slimes and biofilm). Na-EDTA is an organic-based chelating cleaning agent that aids in the sequestering and removal of divalent and trivalent cations and metal ions. This is considered to be a harsh cleaning regimen. **Note: Do not exceed maximum pH and temp limits for specific elements. See Table 1.**

Solution 2: This is a low pH cleaning solution (target pH of 2.5) of 0.5% (w) of HCL (hydrochloric) acid. It is useful in removing inorganic scale (e.g. calcium carbonate, calcium sulfate, barium sulfate, strontium sulfate and metal oxides/hydroxides (e.g. iron, manganese, nickel, copper, zinc) and inorganic-based colloidal material. HCL acid, a strong mineral acid, is also known as muriatic acid. HCL acid is available in a number of concentrations: (18 ° Baume = 27.9%), (20 ° Baume = 31.4%), (22 ° Baume = 36.0%).

Solution 3: This is a disinfection solution. Hydrogen peroxide or a solution of hydrogen peroxide with peroxyacetic acid can be used for disinfection. Special care must be taken that transition metals (Fe, Mn) are not present in the feed water, since in the presence of transition metals, oxidation of the membrane surface may occur resulting in membrane degradation. The concentration of hydrogen peroxide in the disinfection solution should not exceed 0.1%. The water temperature should not exceed 77°F (25°C) and the application of hydrogen peroxide should be done in acidic conditions.

Important: It is recommended that the SDS of the cleaning chemicals be procured from the chemical supplier and that all safety precautions be utilized in the handling and storage of all chemicals.

Table 1: Hydranautics pH and temperature limits for cleaning for sanitary, food processing type composite polyamide RO/NF membrane elements

Membrane	Continuous Operation	Maximum Cleaning Temp		
		Above 50 °C	≤50 °C	≤45 °C
		Above 122 °F	≤122 °F	≤113 °F
DAIRY NF	3 to 9	Not allowed	1.8 to 10.5	1.8 to 11.0
HYDRACoRe 10/50/70	2 to 11	Not allowed	1.5 to 11.0	1.0 to 12.0
DAIRY RO	2 to 10	Not allowed	1.8 to 11.0	1.5 to 11.5
DAIRY RO-HF	2 to 10	Not allowed	1.8 to 11.0	1.5 to 11.5
DAIRY RO-HT	2 to 10	Not allowed	1.8 to 11.0	1.5 to 11.5
DAIRY RO-HS	2 to 10	Not allowed	1.8 to 11.0	1.5 to 11.5
SanRO (all)	2 to 10	Not allowed	1.8 to 11.0	1.0 to 12.0

Note: The above cleaning parameters denote the maximum temperature limits for a corresponding range of pH. Cleaning operations performed at the extremes may result in a more effective cleaning, but can shorten the useful life of the membrane due to hydrolysis. To optimize the useful life of a membrane, it is recommended to use the least harshest cleaning solutions and minimize the contact time whenever possible. The pH of the feed stream or cleaning solution should be closely monitored and controlled. The pH meters used to measure and control pH should be regularly calibrated to ensure accuracy. It is typical to re-circulate cleaning chemicals through the system for 30-45 minutes. Extended soaking is possible, but at less aggressive pH levels. See page 7 for more information on cleaning and flushing procedures.

Table 2: Cleaning and flushing flow rates per pressure tube

(Pressures are not to exceed 60 psi (4 bar) at inlet to tubes.)

Element Diameter	GPM	LPM
4-inches	9 to 12	34 to 45
6-inches	18 to 24	68 to 91
8-inches	36 to 48	136 to 182

Note: In cases where the pressure drop in the membrane elements is excessively high, the cleaning flow rates should be limited to 1/3 of the normal cleaning flow rate initially. This will help prevent the element from telescoping and the feed spacer from migrating. As the foulant is removed, the cleaning flow can slowly be brought up to normal cleaning flow rates.

Table 3: Cleaning solution volume requirement per element

(These volumes do not include initial volume dumped to drain and volumes required for piping, filters, etc) Element Size (inches)	Volume of Cleaning Solution*	
	(US Gallons)	(Liters)
4-inches	2.5	9.5
6-inches	5	19
8-inches	9	34

(*) These are the minimum values recommended for sizing of the cleaning tank. Actual volume used during cleaning can be higher as more than one cleaning tank volume may be required in case of heavy fouling.

RO/NF Membrane Element Cleaning and Flushing Procedures

The RO/NF membrane elements can be cleaned in place in the pressure tubes by recirculating the cleaning solution across the high-pressure side of the membrane at low pressure and relatively high flow. Cleaning procedures may vary dependent on the situation. The time required to clean a system can take from 2 to 4 hours. Typically, cleaning is conducted between 113-122°F (45-50°C) and chemical disinfection is conducted at or below 77°F (25°C). It is recommended to take water flux data for performance normalization immediately after the cleaning to evaluate the efficiency of cleaning.

A general procedure for cleaning the RO/NF membrane elements is as follows:

NOTE: The permeate valves should ALWAYS remain open when cleaning or flushing the elements. If the permeate valve is closed, the pressure on the permeate line will equalize to the feed pressure. This is likely greater than the concentrate pressure, which will result in the permeate pressure being greater than on the feed side of the tail element. This may result in membrane delamination and performance failure.

1. Perform a low pressure flush at 60 psi (4 bar) or less of the pressure tubes by pumping clean water from the cleaning tank (or equivalent source) through the pressure tubes to drain for several minutes to displace any feed/brine solution from RO/NF membranes. Flush water should be clean water of RO permeate or DI quality and be free of hardness, transition metals, and chlorine.
2. Mix a fresh batch of the selected cleaning solution in the cleaning tank. The dilution water should be clean water of RO permeate or DI quality and be free of hardness, transition metals, and chlorine. The temperature and pH should be adjusted to their target levels. Check and record also the conductivity, turbidity and Iron concentration of freshly prepared cleaning solution.
3. Circulate the cleaning solution through the pressure tubes for the desired period of time. At the start of circulation, send the displaced water to drain so you don't dilute the cleaning chemical and then divert up to 20% of the most highly fouled cleaning solution to drain before returning the cleaning solution back to the Cleaning Tank. For the first 5 minutes, slowly throttle the flow rate to 1/3 of the maximum design flow rate. This is to minimize the potential plugging of the feed path with a large amount of dislodged foulant. For the second 5 minutes, increase the flow rate to 2/3 of the maximum design flow rate, and then increase the flow rate to the maximum design flow rate. If required, readjust the pH back to the target when it changes more than 0.5 pH units. Temperature of cleaning solution should be controlled and kept at maximum allowed value during the whole cleaning cycle for best cleaning efficiency. After each circulation step, check the conductivity, turbidity and Iron content of cleaning solution. If these will increase significantly compared to the initial startup values, the cleaning solution shall be drained and new solution prepared to continue with cleaning to improve cleaning efficiency.

Note: Do not exceed maximum pH and temperature limits for specific elements. See Table 1.

4. A soak and recirculation sequence is usually used during cleaning. The soak time can be from 0.5 to 8 hours depending on the manufacturer's and/or chemical supplier's recommendations. Typically, the cleaning consists of 30 minutes circulation followed by 30 minutes soaking cycles. Caution should be used to maintain the proper temperature and pH during the whole cleaning cycle. Soaking time does increase the chemical exposure time of the membrane.

Note: *Do not exceed maximum pH and temperature limits for specific elements. See Table 1.*

5. Upon completion of the chemical cleaning steps, a low pressure Cleaning Rinse with clean water (RO permeate or DI quality and free of hardness, transition metals, and chlorine) is required to remove all traces of chemical from the Cleaning Skid and the System Skid. Drain and flush the cleaning tank; then completely refill the Cleaning Tank with clean water for the Cleaning Rinse. Rinse the pressure tubes by pumping all of the rinse water from the Cleaning Tank through the pressure tubes to drain. A second cleaning can be started at this point, if required.
6. Once the system is fully rinsed of cleaning chemical with clean water from the Cleaning Tank, a Final Low Pressure Clean-up Flush can be performed using pretreated feed water. The permeate line should remain open to drain. Feed pressure should be less than 60 psi (4 bar). This final flush continues until the flush water flows clean and is free of any foam or residues of cleaning agents. This usually takes 15 to 60 minutes. The operator can sample the flush water going to the drain for detergent removal and lack of foaming by using a clear flask and shaking it. A conductivity meter can be used to test for removal of cleaning chemicals, such that the flush water to drain is within 10-20% of the feed water conductivity. A pH meter can also be used to compare the flush water to drain to the feed pH.
7. Once all the stages of a train are cleaned, and the chemicals flushed out, the system can be restarted and placed into service.

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