FILMTEC Membranes

Cleaning Procedures for FILMTEC FT30 Elements

The following are general recommendations for cleaning FILMTEC™ FT30 elements. More detailed procedures for cleaning an RO system are typically included in the operating manual provided by the system supplier. It should be emphasized that frequent cleaning is not required for a properly designed and properly operated RO system, however because of the FT30 membrane's unique combination of pH range and temperature resistance, cleaning can be accomplished very effectively.

Cleaning Requirements

In normal operation, the membrane in reverse osmosis elements can become fouled by mineral scale, biological matter, colloidal particles, and insoluble organic constituents. Deposits build up on the membrane surfaces during operation until they cause loss in normalized permeate flow, loss of normalized salt rejection, or both. Elements should be cleaned whenever the normalized permeate flow drops by Õ10 percent, or the normalized salt passage increases by Õ5 percent, or the normalized differential pressure (feed pressure minus concentrate pressure) increases by Õ15 percent from the reference condition established during the first 48 hours of operation.

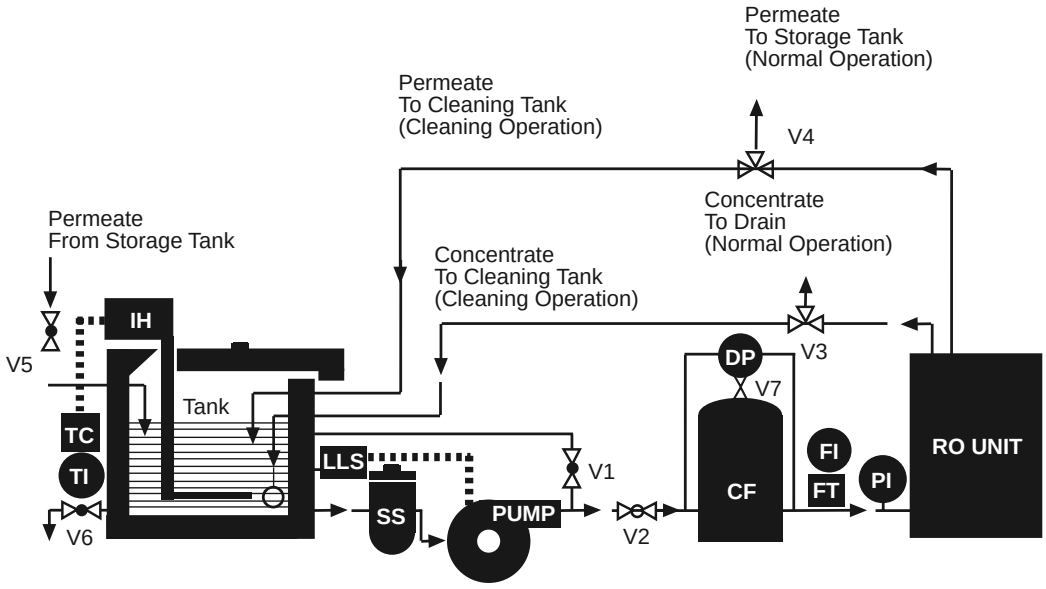
Differential Pressure (èP) should be measured and recorded across each stage of the array of pressure vessels. If the brine channels within the element become plugged, the èP will increase. It should be noted that the permeate flux will drop if feedwater temperature decreases. This is normal and does not indicate membrane fouling.

A malfunction in the pretreatment, pressure control, or increase in recovery can result in reduced product water output or an increase in salt passage. If a problem is observed, these causes should be considered first. The element(s) may not require cleaning. A computer program called FTNORM is available from FilmTec for normalizing performance data of FILMTEC RO membranes. This program can be used to assist in determining when to clean and can be downloaded from our web site.

Safety Precautions

1. When using any chemical indicated here in subsequent sections, follow accepted safety practices. Consult the chemical manufacturer for detailed information about safety, handling and disposal.
2. When preparing cleaning solutions, ensure that all chemicals are dissolved and well mixed before circulating the solutions through the elements.
3. It is recommended the elements be flushed with good-quality chlorine-free water (20°C minimum temperature) after cleaning. Permeate water is recommended; but a dechlorinated potable supply or prefiltered feedwater may be used, provided that there are no corrosion problems in the piping system. Care should be taken to operate initially at reduced flow and pressure to flush the bulk of the cleaning solution from the elements before resuming normal operating pressures and flows. Despite this precaution, cleaning chemicals will be present on the permeate side following cleaning. Therefore, the permeate must be diverted to drain for at least 10 minutes or until the water is clear when starting up after cleaning.
4. During recirculation of cleaning solutions, the temperatures must not exceed 50°C at pH 2-10, 35°C at pH 1-11, and 30°C at pH 1-12.
5. For elements greater than six inches in diameter, the flow direction during cleaning must be the same as during normal operation to prevent element telescoping, because the vessel thrust ring is installed only on the reject end of the vessel. This is also recommended for smaller elements. Equipment for cleaning is illustrated below.

Cleaning System Flow Diagram



TANK	Chemical Mixing Tank, polypropylene or FRP	DP	Differential Pressure Gauge
IH	Immersion Heater (may be replaced by cooling coil for some site locations)	FI	Flow Indicator
		FT	Flow Transmitter (optional)
TI	Temperature Indicator	PI	Pressure Indicator
TC	Temperature Control	V1	Pump Recirculation Valve, CPVC
LLS	Lower Level Switch to shut off pump	V2	Flow Control Valve, CPVC
SS	Security Screen–100 mesh	V3	Concentrate Valve, CPVC 3-way valve
PUMP	Low-Pressure Pump, 316 SS or non-metallic composite	V4	Permeate Valve, CPVC 3-way valve
		V5	Permeate Inlet Valve, CPVC
CF	Cartridge Filter, 5-10 micron polypropylene with PVC, FRP, or SS housing	V6	Tank Drain Valve, PVC, or CPVC
		V7	Purge Valve, SS, PVC, or CPVC

Suggested Equipment

The equipment for cleaning is shown in the Cleaning System Flow Diagram. The pH of cleaning solutions used with FILMTEC elements can be in the range of 1 to 12 (see Table 2), and therefore non-corroding materials should be used in the cleaning system.

1. The mixing tank should be constructed of polypropylene or fiberglass-reinforced plastic (FRP). The tank should be provided with a removable cover and a temperature gauge. The cleaning procedure is more effective when performed at a warm temperature, and it is recommended that the solution be maintained according to the pH and temperature guidelines listed in Table 2. It is not recommended to use a cleaning temperature below 15°C because of the very slow chemical kinetics at low temperatures. In addition, chemicals such as sodium lauryl sulfate might precipitate at low temperatures. Cooling may also be required in certain geographic regions, so both heating/cooling requirements must be considered during the design. A rough rule of thumb in sizing a cleaning tank is to use approximately the empty pressure vessels volume and then add the volume of the feed and return hoses or pipes. For example, to clean ten 8-inch diameter pressure vessels with six elements per vessel, the following calculations would apply:

   A. Volume in Vessels

   $V1 = \pi r^2 L$

   $= 3.14\ (4\ in)^2\ (20\ ft)\ (7.48\ gal/ft^3) / (144\ in^2/ft^2)$

   $V1 = 52\ gal/vessel\ (0.2\ m^3)$

   $V10 = 52 \times 10 = 520\ gal\ (1.97\ m^3)$

   B. Volume in Pipes, assume 50 ft. length total 4" Sch 80 pipe

   $Vp = \pi r^2 L$

   $= 3.14\ (1.91\ in)^2\ (50\ ft)\ (7.48\ gal/ft^3) / (144\ in^2/ft^2)$

   $= 30\ gals\ (0.11\ m^3)$

   $Vct = V10 + Vp = 520 + 30 = 550\ gal.$

   Therefore, the cleaning tank should be about 700 gals (1.5 m^3).

2. The cleaning pump should be sized for the flows and pressures given in Table 1, making allowances for pressure loss in the piping and across the cartridge filter. The pump should be constructed of 316 SS or nonmetallic composite polyesters.
3. Appropriate valves, flow meters, and pressure gauges should be installed to adequately control the flow. Service lines may be either hard piped or hoses. In either case, the flow rate should be a moderate 10 ft/sec (3 m/sec) or less.

Cleaning Elements In Situ

There are six steps in the cleaning of elements:

1. Make up cleaning solution.
2. Low-flow pumping. Pump mixed, preheated cleaning solution to the vessel at conditions of low flow rate (about half of that shown in Table 1) and low pressure to displace the process water. Use only enough pressure to compensate for the pressure drop from feed to concentrate. The pressure should be low enough that essentially no permeate is produced. A low pressure minimizes redeposition of dirt on the membrane. Dump the concentrate, as necessary, to prevent dilution of the cleaning solution.
3. Recycle. After the process water is displaced, cleaning solution will be present in the concentrate stream. Then recycle the concentrate to the cleaning solution tank and allow the temperature to stabilize.

Table 1. Recommended feed flow rate per pressure vessel during high flow rate recirculation

Feed Pressure[1] (psig)	(bar)	Element Diameter (inches)	Feed Flow Rate per Pressure Vessel (gpm)	(m^3/hr)
20-60	1.5-4.0	2.5	3-5	0.7-1.2
20-60	1.5-4.0	4[2]	8-10	1.8-2.3
20-60	1.5-4.0	6	16-20	3.6-4.5
20-60	1.5-4.0	8	30-40	6.0-9.1
20-60	1.5-4.0	8[3]	35-45	8.0-10.2

1. Dependent on number of elements in pressure vessel.
2. 4-inch full-fit elements should be cleaned at 12-14 gpm (2.7-3.2 m^3/hr).
3. For full-fit, 400 and 440 sq. ft. area elements.

Table 2. pH range and temperature limits during cleaning

Element Type	Max Temp 50°C pH Range	Max Temp 35°C pH Range	Continuous Operation
SW30, SW30HR	3-10	1-12	2-11
BW30, TW30, XLE, NF90	2-10	1-12	2-11
SR90, NF200, NF270	3-10	1-11	3-10

4. Soak. Turn the pump off and allow the elements to soak. Sometimes a soak period of about 1 hour is sufficient. For difficult fouling an extended soak period is beneficial; soak the elements overnight for 10-15 hours. To maintain a high temperature during an extended soak period, use a slow recirculation rate (about 10 percent of that shown in Table 1).
5. High-flow pumping. For the alkaline cleaning solution, feed the cleaning solution at the rates shown in Table 1 for 30-60 minutes. For the acid cleaning solution, feed the cleaning solution at the rates shown in Table 1 for less than 20 minutes. The high flow rate flushes out the foulants removed from the membrane surface by the cleaning. If the elements are heavily fouled, a flow rate which is 50 percent higher than shown in Table 1 may aid cleaning. At higher flow rates, excessive pressure drop may be a problem. The maximum recommended pressure drops are 15 psi per element or 50 psi per multi-element vessel, whichever value is more limiting.
6. Flush out. Prefiltered raw water can be used for flushing out the cleaning solution, unless there will be corrosion problems (e.g., stagnant seawater will corrode stainless steel piping). To prevent precipitation, the minimum flush out temperature is 20°C.

Additional notes: Check the pH during acid cleaning. The acid is consumed when it dissolves inorganic precipitates. So, if the pH increases more than 0.5 pH units, add more acid. Total circulation time for an acid cleaning solution should not exceed 20 minutes in length. After that time, it's possible for the solution to be fully saturated and the foulants can precipitate back onto the surface. If the system has to be shut down longer than 24 hours, the elements should be stored in a 1 percent solution (by weight) of sodium metabisulfite. For large system evaluation, it is recommended that this be done in a single element test stand that is included in the original system design.

Multistage Systems

For multistage (tapered) systems, the flushing and soaking operations can always be done simultaneously in all stages. High-flow recirculation, however, should be carried out separately for each stage, so the flow rate is not too low in the first stage or too high in the last. This can be accomplished either by using one cleaning pump and operating one stage at a time, or by using a separate cleaning pump for each stage.

Cleaning Chemicals

Table 3 below lists suitable cleaning chemicals. Acid cleaners and alkaline cleaners are the standard cleaning chemicals. The acid cleaners are used to remove inorganic precipitates including iron, while the alkaline cleaners are used to remove organic fouling including biological matter. Sulfuric acid should not be used for cleaning because of the risk of calcium sulfate precipitation. Preferably reverse osmosis permeate should be used for the cleaning solutions, but prefiltered raw water will also work in most cases. The raw water can be highly buffered, so more acid or hydroxide may be needed with raw water to reach the desired pH level, which is about 2 for acid cleaning and about 12 for alkaline cleaning.

Table 3. Simple cleaning solutions for FT30 membrane

Foulant \ Cleaner	0.1% (W) NaOH and pH 12, 30°C max. or 1.0% (W) Na_4EDTA and pH 12, 30°C max.	0.1% (W) NaOH and pH 12, 30°C max. or 0.025% (W) Na-DDS and pH 12, 30°C max.	0.2% (W) HCl	1.0% (W) $Na_2S_2O_4$	0.5% (W) H_3PO_4	1.0% (W) NH_2SO_3H
Inorganic Salts (for example, $CaCO_3$)			Preferred	Alternative	Alternative	
Sulfate Scales ($CaSO_4$, $BaSO_4$)	OK					
Metal Oxides (for example, iron)				Preferred	Alternative	Alternative
Inorganic Colloids (silt)		Preferred				
Silica	Alternative	Preferred				
Biofilms	Alternative	Preferred				
Organic	Alternative	Preferred				

Notes:

1. (W) denotes weight percent of active ingredient.
2. Foulant chemical symbols in order used: $CaCO_3$ is calcium carbonate; $CaSO_4$ is calcium sulfate; $BaSO_4$ is barium sulfate.
3. Cleaning chemical symbols in order used: NaOH is sodium hydroxide; Na_4EDTA is the tetra-sodium salt of ethylene diamine tetraacetic acid and is available from The Dow Chemical Company under the trademark VERSENE* 100 and VERSENE 220 crystals; Na-DDS is sodium salt of dodecylsulfate; Sodium Laurel Sulfate; HCl is hydrochloric acid (Muriatic Acid); H_3PO_4 is phosphoric acid; NH_2SO_3H is sulfamic acid; $Na_2S_2O_4$ is sodium hydrosulfite.
4. For effective sulfate scale cleaning, the condition must be caught and treated early. Adding NaCl to the cleaning solution of NaOH and Na_4EDTA may help as sulfate solubility increases with increasing salinity. Successful cleaning of sulfate scales older than 1 week is doubtful.
5. Citric Acid is another cleaning alternative for inorganic salts.

FILMTEC Membranes
For more information about FILMTEC membranes, call the Dow Liquid Separations business:
North America: 1-800-447-4369
Latin America: (+55) 11-5188-9277
Europe: (+32) 3-450-2240
Japan: (+81) 3-5460-2100
Australia: (+61) 3-9226-3545
http://www.filmtec.com