LES ÉQUIPEMENTS LAPIERRE EQUIPMENT

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Technical Session

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Advantages of using an R.O.

-Reduced energy input
-Time and labor saving
-Allows the expansion of sugar operations
-Maximize efficiency of evaporation equipment
-Helps to protect the environment

Reverse osmosis system

The system significantly reduces the time and energy required for the sap evaporation process. It also improves the efficiency of the operation.

The concentration process of the maple sap reduces the volume of green house effect gases into the atmosphere due to reduced combustion of wood or fossil fuels, while greatly contributing to the conservation of long term renewable energy sources.

Concentrating maple sap using a reverse osmosis system
allows the producer to reduce his energy input by 75% or more.

Increase of concentration

The use of reverse osmosis in the maple industry has a direct impact on operation costs. The cost of combustible fuels and labor keep increasing, and will probably remain high into the future. For all these reasons, many producers are looking to reduce their expenses to keep a reasonable profitability of their operation.

R.O. system is more and more targeted to increase the concentration level above 8 brix. It is possible to do so.
However, it will be necessary to plan an additional installation of extra membrane elements.
This installation can be justified by the saving of energy and labor required for sap processing.

The following cost comparison chart and graphic demonstrate the energy-saving generated by the concentration increase of maple sap.

Reverse Osmosis
Economy according to brix level

Evaporation				**300**	Gallons per Hour
Price Oil per Litre					
Price of oil per Gallon				**$2.50**	gallon (US)
Quantity syrup made (season)	**Barrels**	**100**	**32**	**3,200**	Gallons (US)
Worker hourly rate				**$20.00**	Per Hour

Concentration BRIX	2	4	6	8	10	12	14	16	18	20
Output, Syrup per hour (Gallons)	8.4	16.7	25.1	33.5	41.9	50.2	58.6	67.0	75.3	83.7
Oil needed per gallon	**4.00**	**2.00**	**1.33**	**1.00**	**0.80**	**0.67**	**0.57**	**0.50**	**0.44**	**0.40**
Oil cost per gallon	10.00 $	5.00 $	3.33 $	2.50 $	2.00 $	1.67 $	1.43 $	1.25 $	1.11 $	1.00 $
Total cost of oil	32,000 $	16,000 $	10,667 $	8,000 $	6,400 $	5,333 $	4,571 $	4,000 $	3,556 $	3,200 $
Hours of Evaporation	382	191	127	96	76	64	55	48	42	38
Total manpower cost	7,644 $	3,822 $	2,548 $	1,911 $	1,529 $	1,274 $	1,092 $	956 $	849 $	764 $
Total per season	**39,644 $**	**19,822 $**	**13,215 $**	**9,911 $**	**7,929 $**	**6,607 $**	**5,663 $**	**4,956 $**	**4,405 $**	**3,964 $**
	100%	**50%**	**33%**	**25%**	**20%**	**17%**	**14%**	**13%**	**11%**	**10%**

15-May-07

Fuel consumption table

Economy

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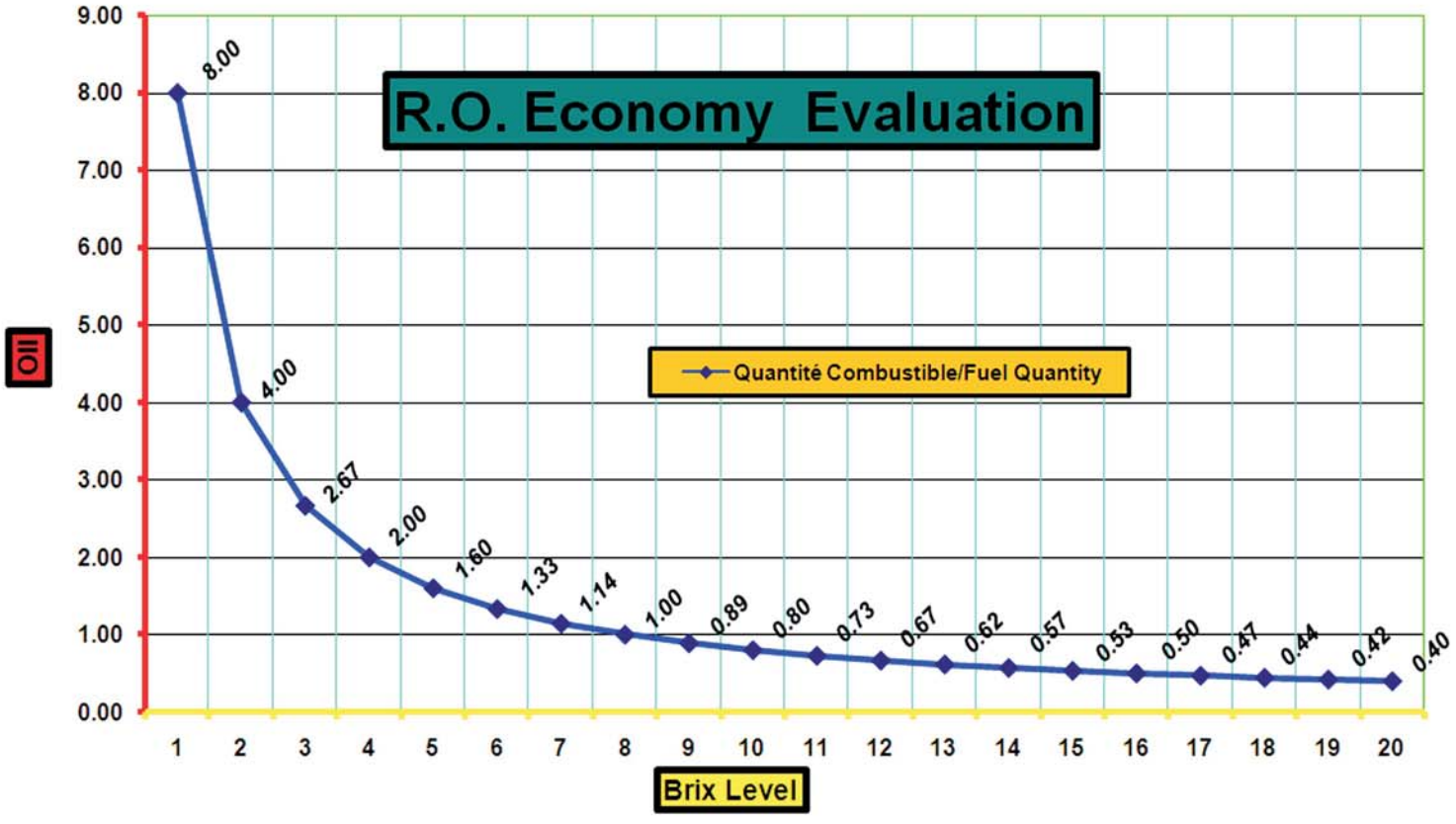


Factors affecting R.O. membrane performance

The technology of reverse osmosis can be complicated. Especially in absence of knowledge for the terminology that describes the aspects of the operation in relation with different variables.

What will follow defines the key terms and offers a quick overview of the factors affecting the performance of the reverse osmosis membrane elements.

Including the effect of pressure, temperature, concentration of organics, sugars, mineral salts contained in the maple sap, and recovery of permeate and the effect of the PH.

Terminology & definitions

Recovery (permeate)
The percentage of the water removed from the raw sap through the membrane. That percentage can be increased by adjusting the concentrate valve.

Rejection (concentrate)
Concentration percentage of solid residue removed from water by the membrane.

Passage
Opposite of the rejection. Concentration percentage of solids dissolved into the liquid going trough the membrane.

Permeate
Purified water produced by the membrane.

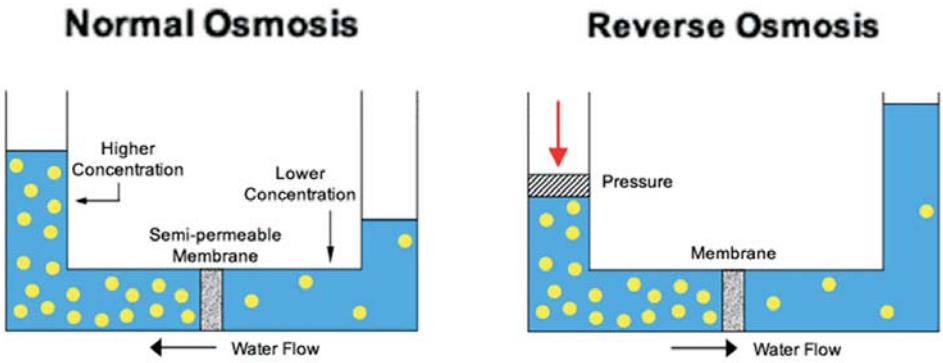
Total flow rate
The flow of the liquid going trough the membrane. Normally measured in liters per minute (LPM) or gallons per minute (GPM).

Concentrate flow
The concentrate flow coming out from the membrane. This concentrate contains all the organic and mineral residues of the liquid. Measured in liters per minute (LPM) or gallons per minute (GPM).

Permeate flow
The flow of permeate produced by the surface of the membrane. Measured in liters per minute (LPM) or gallons per minute (GPM).

Effect of pressure

Feedwater pressure affects both the water flux and salt rejection of RO membranes. Osmosis is the flow of water across a membrane from the dilute side toward the concentrated solution side. Reverse osmosis technology involves application of pressure to the feedwater stream to overcome the natural osmotic pressure. Pressure in excess of the osmotic pressure is applied to the concentrated solution and the flow of water is reversed.
A portion of the feedwater (concentrated solution) is forced through the membrane to emerge as purified product water of the dilute solution side.



Osmosis

The water crosses a semi permeable membrane towards the higher concentration area of the liquid to balance the two solutions. Once the level of the liquid is equivalent, the height difference between the concentrated and the diluted part correspond to the osmotic pressure.

Reverse osmosis

By applying a pressure exceeding the osmotic pressure, the water flow direction will be reversed which is called reverse osmosis.

Effect of temperature

As shown in Figure 2, water flux across the membrane increases in direct relationship to increases in feedwater pressure. Increased feedwater pressure also results in increased salt rejection but, as Figure 2 demonstrates, the relationship is less direct than for water flux. Because RO membranes are imperfect barriers to dissolved salts in feedwater, there is always some salt passage through the membrane. As feedwater pressure is increased, this salt passage is increasingly
overcome as water is pushed through the membrane at a faster rate than salt can be transported.

Figure 2. Effect of Feedwater Pressure on Flux and Salt Rejection

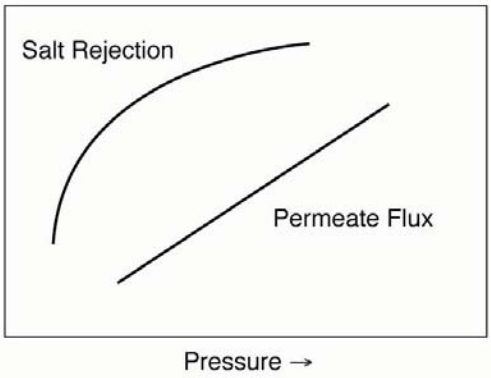
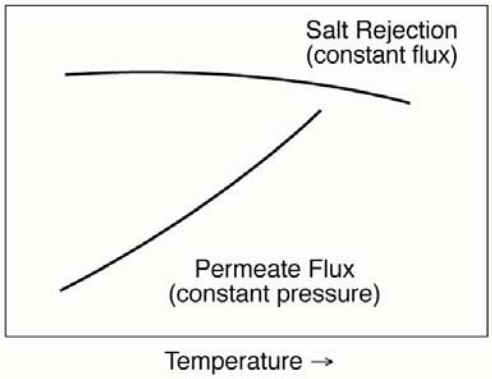


Figure 3. Effect of Feedwater Temperature on Flux and Salt Rejection



As Figure 3 demonstrates, membrane productivity is very sensitive to changes in feedwater temperature. As water temperature increases, water flux increases
almost linearly, due primarily to the higher diffusion rate of water through the membrane.Increased feedwater temperature also results in lower salt rejection or
higher salt passage. This is due to a higher diffusion rate for salt through the membrane. The ability of a membrane to tolerate elevated temperatures increases operating latitude and is also important during cleaning operations because it permits use of stronger, faster cleaning processes.

Effect of salt concentration

Osmotic pressure is a function of the type and concentration of salts or organics contained in feedwater. As salt concentration increases, so does osmotic pressure. The amount of feedwater driving pressure necessary to reverse the natural direction of osmotic flow is, therefore, largely determined by the level of salts in the feedwater.

Figure 4. Comparison of Operating and Cleaning Parameters for FT30 Thin-Film Composite Membrane and a CA Membrane

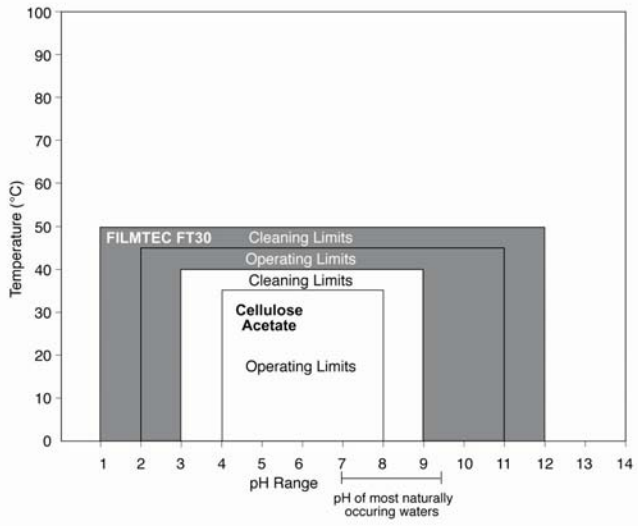


Figure 5. Effect of Increasing Salt Concentration on Flux and Salt Rejection

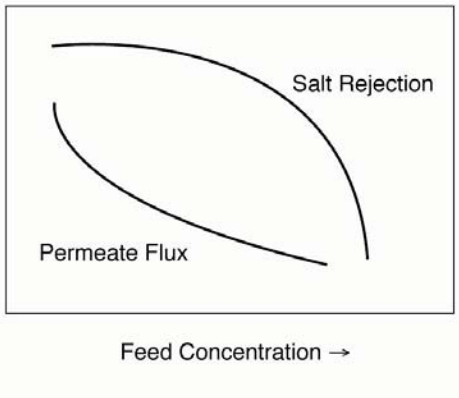


Figure 5 demonstrates that, if feed pressure remains constant, higher salt concentration results in lower membrane water flux. The increasing osmotic pressure offsets the feedwater driving pressure. Also illustrated in Figure 5 is the increase in salt passage through the membrane (decrease in rejection) as the water flux declines.

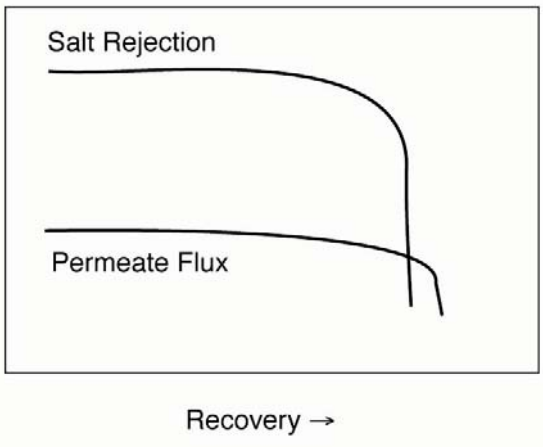
Effect of recovery

As shown in Figure 1, reverse osmosis occurs when the natural osmotic flow between a dilute solution and a concentrated solution is reversed through application of feedwater pressure. If percentage recovery is increased (and feedwater pressure remains constant), the salts in the residual feed become more
concentrated and the natural osmotic pressure will increase until it is as high as the applied feed pressure. This can negate the driving effect of feed pressure, slowing or halting the reverse osmosis process and causing permeate flux and salt rejection to decrease and even stop (please see Figure 6).

The maximum percent recovery possible in any RO system usually depends not on a limiting osmotic pressure, but on the concentration of salts present in the feedwater and their tendency to precipitate on the membrane surface as mineral scale.

The most common sparingly soluble salts are calcium carbonate (limestone), calcium sulphate (gypsum), and silica. Chemical treatment of feedwater can be used
to inhibit mineral scaling.

Figure 6. Effect of Increased Recovery on Flux and Salt Rejection

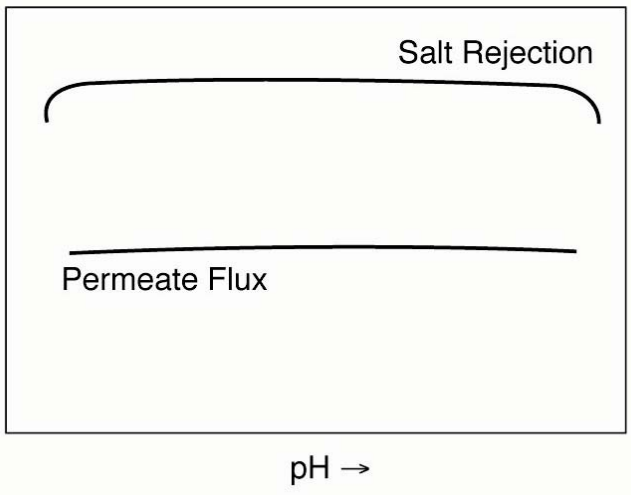


Effect of PH

The pH tolerance of various types of RO membranes can vary widely. Thin-film composite membranes such as FILMTEC FT30 membrane are typically stable over a broader pH range than cellulose acetate (CA) membranes and, therefore, offer greater operating latitude (please see Figure 4). Membrane salt rejection performance depends on pH. Water flux may also be affected.

Figure 7 shows that water flux and salt rejection for FILMTEC FT30 membranes are essentially stable over a broad pH range. As illustrated in Figure 4, the stability of FT30 membrane over a broad pH range permits stronger, faster, and more effective cleaning procedures to be used compared to CA membranes.

Figure 7. Effect of Feedwater pH on Water Flux and Salt Rejection



Cleaning
The necessity of a proper element wash

All filtration system necessitate cleaning at an interval more or less regular to allow constant flow.

The membrane is a filter. It can retain invisibles molecules and particles. The accumulation of these molecules on the surface of the film result in a gradual decrease of the volume of water passing through the membrane film.

Which results in;
- Reduction of the permeate flux.
- Reduction of the concentrate brix
- A pressure increase

A permeate flow drop of around 10% to 15% should be corrected in the shortest delay by a chemical wash. It is also important to monitor regularly the membrane performance because a major performance drop may result into irreversible damages.
In some cases it may be necessary to wash more than once to bring the membrane performance back.

When washing, you must follow the manufacturer's recommendations. There are different types of membranes available on the market. the cleaning products concentrations may vary from a manufacturer to the other. the cleaning solution's PH (water & detergent) must be adjusted according to the membrane specifications.

We recommend using a PH meter or a PH test paper strip to determine the required detergent quantity to prepare the cleaning solution. Cleaning is always followed by a rinse with sufficient quantity of permeate. For best results, we recommend using a 25°C (77°F) permeate. The minimum quantity required for an 8 inches membrane is 500 gallons. Increase rinse time by five minutes (100 gal.) for every additional membranes mounted in series.

In order to get the maximum lifetime of your membranes you should:

-Follow the manufacturer's recommendations
-Follow up the equipment performance
-Do the proper cleaning and rinsing when necessary

-Never improvise home remedies such as chlorine or other non-recommended products

-Never leave the membrane into a concentrated solution while the equipment isn't running.
-always perform a short rinse after concentration.

Concentration & performance test

The purpose of the log table is to keep a data of all parameters during the operation and performance test of your equipment.
To evaluate the good working order of the reverse osmosis equipment it is important to know the parameters detailed on the concentration & performance test sheet.

1. Brix percentage of the raw sap.
   It is the sap before the concentration process, Take note that the liquid temperature influences the reading on the hydrometer or refractometer. Always check the temperature range of the brix measurement device.

2. Brix percentage of the concentrate.
   This test is normally performed after 15 to 30 minutes of operation. For the measurement follow the recommendations for the raw sap.

3. Permeate flow
   Note the reading of the permeate flow metre in litres or gallons per minute. To know the flow per hour, multiply the data per 60 minutes.
   Ex. : 3 GPM x 60 minutes = 180 GPH

4. Concentrate flow
   Follow the permeate flow procedure.

5. Total flow

To evaluate the total flow. Add the data of the column #3 (permeate) and column #4 (concentrate). The result will be the total flow per minute. Multiplied by 60 minutes you get the total flow per hour. Ex. : 2+8X60= 600 GPH

Take note, this data is influenced by temperature variation. The degree of concentration, the condition of the sap, the condition of the membranes and the operation pressure (PSI)

6. Concentration percentage

The purpose of knowing the percentage of concentration, is to make sure not to exceed the operation recommendation.

Ex. : For a R.O. Equipped with a 600 GPH pump and a membrane of 600 GPH the degree of concentration should not exceed 70%. Although by increasing the filtration surface by the addition of extra membranes, it is possible to surpass this recommendation to obtain a concentrate with a higher level of sugar and minerals.

The osmotic pressure increases with the degree of concentration and has a down effect on the membrane flow.

To determine the percentage of concentration. Divide the permeate flow by the total of the permeate and the concentrate..

Ex. : Column 3 (permeate) = 7.5 GPM
Column 4 (concentrate)= 2.5 GPM
Percentage of concentration 7.5 / (2.5 + 7.5)= 75 % concentration

7. Operation temperature

The operation temperature, is the temperature of the sap at the inlet of the equipment.

The temperature of the sap has a direct effect on the permeability of the membrane. Colder is the sap, lower the flow through the membrane film will be. To make the evaluation of the treatment capacity of the membrane, we must refer to the temperature correction factor.

8. Pressure of operation

An other important element during the operation, or when conducting a performance test. The pressure has a direct effect on the flow and the permeability of the membrane. To raise the level of concentration requires an increase of the pressure to maintain the flow. Although for the long life of the membranes, it is preferable to operate at a lower pressure than the recommended limit.

Always perform the performance test at the same pressure. It is important to maintain a good reference,

9. Corrected permeate flow

Divide the reading of the permeate flow meter by the appropriate temperature correction factor.

Concentration and performance log table

Date **Hour**	**1**	**2**	3	4	5	6	7	8	9	
	% Brix of the maple sap	**% Brix of the concentrate**	**Permeate flow (GPM)**	**Concentrate flow (GPM)**	**total flow (3 + 4) x 60**	**% Concentration** **3 / (3+4)**	**Operation temperature**	**pressure of operation**	**corrected permeate flow**	**Test**
	2%	8 brix	7.5	2.5	600 GPM	75%	13 C	375 PSI		concentration

HOW TO TEST MEMBRANE PERFORMANCE

When purchasing a new R.O., or a new membrane. The second day of use, check the performance of the membrane after a warm wash and cold permeate rinse.
The permeate flow meter reading will be your reference 100%

To check the condition of a membrane, you must concentrate permeate. We recommend that you set the pressure at 225 PSI and adjust the concentrate flow at 3 GPM.

Example :

Table 1 Data establish the 100% performance

Date	Time	Permeate Temp ° C/F	Permeate Flow
March 10, 2006	**11:50**	**8°C / 46.4 °F**	**5.2 GPM**

Once the data reading is taken, you divide the permeate data flow by the temperature correction factor. The permeate flow is influenced by the temperature. Higher is the sap temperature, higher will the permeate flow be and vise-versa.

Table 2 Correction factors

Temp ° C	Temp ° F	Correction factor		Temp ° C	Temp ° F	Correction factor
0	32.0	0.672		13	55.4	1.000
1	33.8	0.695		14	57.2	1.028
2	35.6	0.719		15	59.0	1.055
3	37.4	0.742		16	60.8	1.084
4	39.2	0.766		17	62.6	1.112
5	41.0	0.790		18	64.4	1.142
6	42.8	0.816		19	66.2	1.170
7	44.6	0.842		20	68.0	1.200
8	46.4	0.866		21	69.8	1.229
9	48.2	0.893		22	71.6	1.259
10	50.0	0.919		23	73.4	1.289
11	51.8	0.946		24	75.2	1.319
12	53.6	0.973		25	77.0	1.350

HOW TO CALCULATE MEMBRANE PERFORMANCE

To figure the 100% capacity of the membrane at 13°C (55.4°F)

5.2 GPM / 0.866 (correction factor 8°C (46.4°F) = 6.00 GPM
This result must be written down to compare the performance of the membrane year after year.
Therefore, if we wish to revise the performance of the membrane at a given moment, we must redo the above exercise and compare the result to the original test of the membrane.

Ex. : If we get 5.5 GPM at the second test (corrected at 13OC) the performance of the membrane would be:

((6.00 - 5.5) / 6.00) x 100 = 8.3% performance loss

OR

5.5 / 6.0 = 91.7% efficiency

Table 3 membrane performance listing

# membrane 28736465	Data reading	Temp ° C	Temp ° F	Corrected data to 13°C / 55.4
2000	5.2	8	46.4	6.00 (100%)
2001	5.1	10	50.0	5.50 (91.7%)
2002				
2003				
2004				
2005				

START UP

- Install the membrane according to the instructions showed on the recirculation vessel.

- Before inserting the membrane in the pressure vessel, make sure that the u-cup o'ring on the membrane and all the o'rings on the adaptors are in perfect condition.

- Always lightly coat the u-cup and all the o'rings with silicone base lubricant before their installation.

- Once the membrane installation is completed, connect all the high pressure hoses to the reverse osmosis and at the base of the recirculation pump(s).

- Plug the electric cord of the recirculation pump to the reverse osmosis.

- Make sure that all the plumbing is in good condition.

- If the equipment was stored in an unheated room, warm up the room for 2 days before starting the pumps. This precaution will avoid damage to the pumps if ice has formed inside of the system.

- To start the equipment open the valve on the sap feed line and let the sap fill the unit by gravity.
  It is important to thoroughly rinse the membrane before you begin the concentration. You must follow the rinse instruction and start the equipment.

Membrane element conditioning

Prior to perform Maple sap concentration. it is important to follow these instructions.

the membrane composing the element is called hydrophobic in it's original state, meaning it will allow water through it's pores with difficulties.
The purpose of the conditioning is to make the membrane hydrophilic.
This way the membrane will allow water to pass freely through its pores at a lower pressure.

Procedure

STEP 1 Rinse with water to drain for 15 minutes
Note:If no permeate is available, you can then use tap water.If using tap water, make sure this water does not contain alarge mineral load. It must also be chlorine free. We also recommend to test the PH. the PH should read between 6 and 7.5

STEP 2 Recirculate 85°F (29.4°C) water in the wash tank for 30 to 45 minutes following the wash cycle instructions.
This step can be performed with or without membrane cleaner, depending if the element is new or used.

STEP 3 Rinse to drain with 500 gallons of water.
You can now proceed to concentration.
Note:At the end of your first concentration day, we recommend performing a mild chemical wash (check manufacturer's PH recommendations), followed by a thorough rinse with permeate water.

Trouble shooting
Problems & solutions

P: The feed pump starts, but it stops as soon as my finger is off the feed switch.

S: Check if the feed pressure reaches at least 20 psi.

1 Check the feed valve, it must be open.
2 Check the prefilters, they may have to be replaced.
3 Check if the plumbing is not plugged or damaged.
A bad joint or bad seal will allow air in the system causing this problem.
4 Check the feed pump.

P: The feed pump starts, but the R.O. Stops as soon as I press on the high pressure switch.

S: Check if the feed pressure reaches at least 20 PSI.

1 Replace the pre-filter cartridges.
2 Check for obstruction of the feed line or the feed pump.
3 Check the feed pump.

P: The performance of the R.O. Equipment drops once it is started.

S:

1 Make sure the recirculation pump is running. Just place your hand under the recirculation pump motor if you feel air circulating the motor is running. If the recirculation system does not operate the membrane will foul rapidly.

Problems & solutions

2 At the beginning and the end of the sugar season, it is important to do a tight follow up of the membranes condition. During these periods, it is necessary to wash the membranes more often to keep a good level of performance.

In the first days of the operation due to the cytoplasmic cells activity inside the maple, the sap has a tendency to foul the membranes. These cells produce an antifreeze like substance, which protects the maple during the winter frost. Frequent wash will be necessary during that period to avoid fouling.

P: The recirculation pump does not operate

S: Normally when the recirculation fails, it will cause a complete stop of the R.O. The out of order light will come on.

1 Control panel.

A Check if the breaker is on the set position.(reset if necessary) (Note: on older models the equipment will keep on running if the recirculation breaker is out. But on the newer models, if a breaker is out it will impossible to restart the equipment.

B Check if the recirculation overload is on, if it is out, the R.O. stops and the out of order light comes on.

C Check the electric wiring to the plug and the connections in the motor. (The R.O. Will keep on running despite the recirculation is out.)

Problems & solutions

2 Recirculation motor

A Check if the recirculation motor can turn freely, using a flat screw driver at the base of the motor.

B If the motor turns freely check the electric wiring to the motor. If the wire connections and the power are fed properly through the electric circuit, the motor will have to be repaired or replaced by a qualified technician.

P: There is a squealing noise coming out one of the electric motors

.

S: It is not generally a very serious problem. Most likely it is a bearing failure, due to excessive wear or rust cause by dampness. Although it must be repaired immediately before extensive damage occurs. A qualified technician can replace the bearings and check the pump to make sure it is in good running order.

Storage procedure

At the end of the crop. It is time to prepare your equipment for storage. To begin, you must make sure that you have a good volume of permeate to allow a proper wash and rinse of your membranes.

1 Even if you send your membrane(s) to be washed at the manufacture. It is important to wash and rinse the membranes before pulling them out of the recirculation vessel.

2 Disconnect the pressure hoses from the pressure vessels and the electric cord from the R.O.

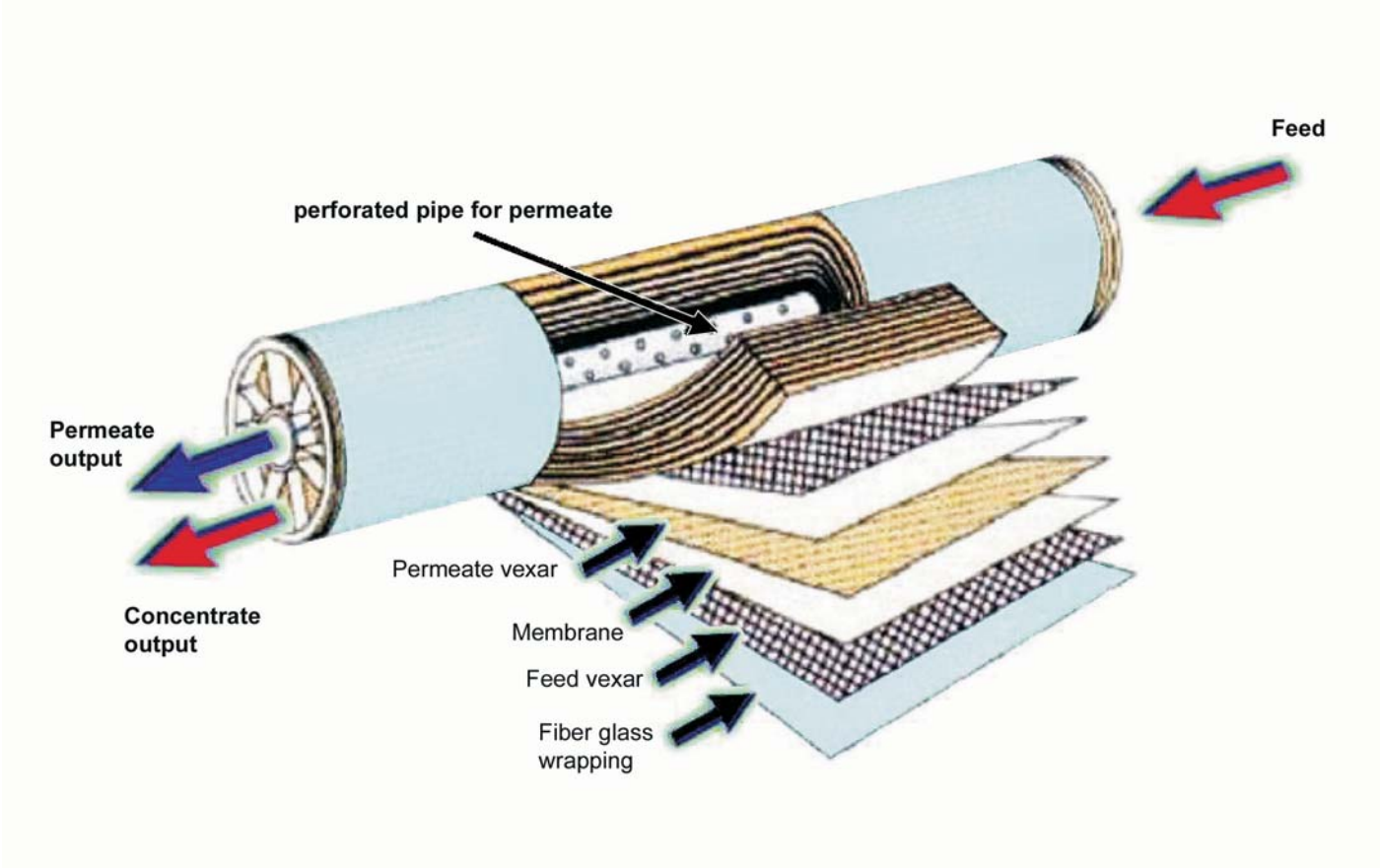
3 Unfasten the bolts from the top lid(s) and pull the membrane(s).

4 Insert the membrane(s) in the canister(s). If you send the units to the factory, add 1 litre of permeate to the canisters. The membranes must be kept in a damp environment. Long storage solution : for each 8” x 40” membrane: mix ½ cup of SMBS (sodium metabisulfite) with 4 gallons (18 litres) of cold permeate and 1 gallon (3.75 litres) of glycerine. Mix well and add the solution to the membrane in the storage canister.
For 4” x 40” membrane mix 1/8 of a cup of SMBS to 1 gallon (4.5 litres) of cold permeate and add 1 litre of glycerine, mix well.

5 Drain the unit and all pumps completely.

6 It is strongly recommended to store the R.O. In a dry and heated room. This precaution will avoid certain problems due to humidity and bad surprises caused by an incomplete drainage.

Membrane



Membrane
Semi permeable film that retains the organic and minerals while allowing water to pass through.

Feed mesh (vexar)
Mesh which acts as a feed channel and for the membrane recirculation.

Permeate mesh (vexar)
A fine mesh that allows the permeate to flow towards the perforated tube at the center of the element.

Sources of information

-Filmtech (Dow chemicals)

-Complete filtration resource (CFR)