OWNER'S MANUAL
MODEL PA2000
INSTALLATION, OPERATION & MAINTENANCE INSTRUCTIONS

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DESCRIPTION

The Model PA2000 is a reverse osmosis (RO) water purification system specifically designed for supplying a single patient hemodialysis system in acute application. The system processes ordinary tap water into a purified product fraction and a concentrate reject fraction. The product water output is mostly deionized and extremely well filtered.

IDENTIFICATION OF ITEMS IN THE SYSTEM

Figure 1 shows a left side view of the system with the cover open. The items that the user needs to use in operating, disinfecting, and replacing prefilters are identified and the functions are briefly described. The lettering in bold type corresponds to the labeling on the system.

Figure 2 shows the right side of the system. Again, the lettering in bold type corresponds to the labeling on the system.

FIGURE 1
ITEM IDENTIFICATION & FUNCTION

Conductivity Monitor
Monitors the electrical conductivity of the product or the feed water.

Mute Pushbutton Will silence the audible high conductivity alarm when pressed.

Low Product Quality LED
Alarm lamp glows when product

Alarm & Calibration Adjustments Cover
Gives access to the conductivity calibration and alarm adjustment potentiometers

Power Switch
Turns on electrical power to the unit and also serves as a circuit breaker.

Supply Valve
is used to stop water flow to the system.

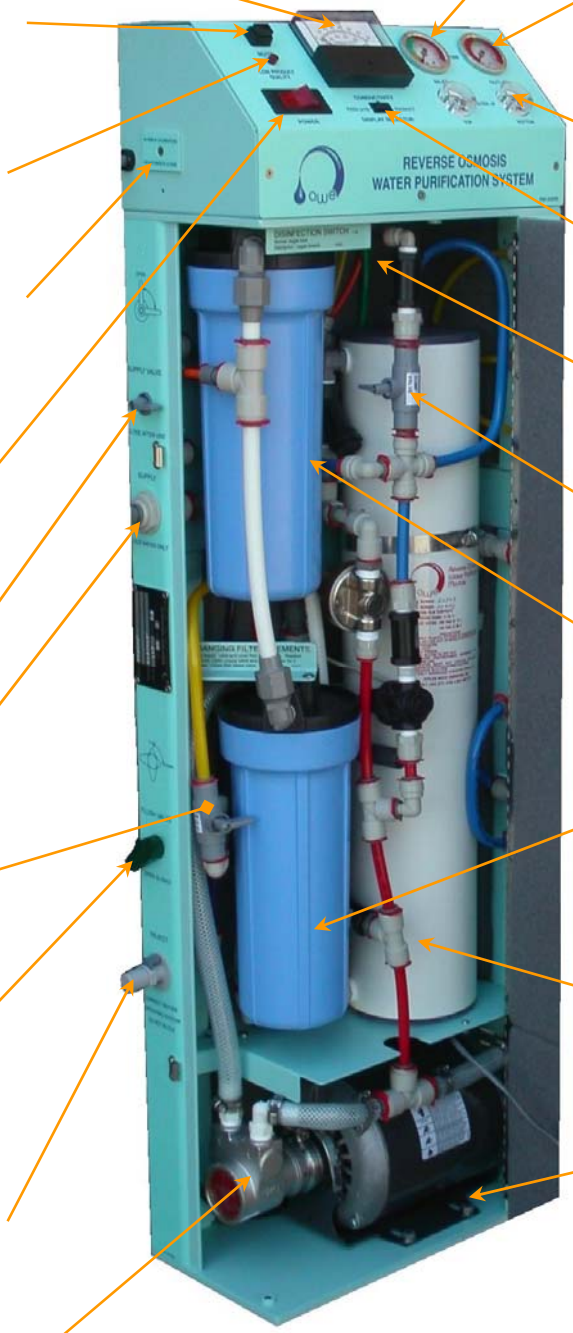
Supply Bulkhead
Is where tap water enters the system

Filter Bleed Valve
Is opened to relieve pressure when changing prefilter elements and to purge air and fines.

Flush Valve opens to increase reject flow to drain. Used in disinfection process and at end of treatment.

Reject QD Bulkhead
Is where the reject water to drain exits the system. Also returns water to disinfection tank

Vane Pump
Increases water pressure.



Pump Inlet Pressure Gauge
Monitors the pressure of the feed water entering the pump after passage through the prefilters and regulator.

Pump Outlet Pressure Gauge Monitors the pressure of the water leaving the pump

Filter ΔP Gauges
Indicate the pressure drop through the prefilters

Display Selector Rocker Switch selects either the feed water or the product water for display on the conductivity monitor

Disinfection Toggle **Switch** is used during disinfection to force the pump to run.

Product Dump Valve
Sends product water to reject (drain) for rinsing out after disinfection or cleaning.

Top Prefilter
Contains the first prefilter element, typically a 5 micron sediment filter.

Bottom Prefilter
Contains the second prefilter element, typically a carbon type.

Membrane Module
Separates feed water into product and reject.

Electric Motor
Powers vane pump.

SET UP AND INSTALLATION

FLOOR MOUNTING:

1) Attach mounting feet. Carefully lay the system rear side down on a table with only the bottom end overhanging the edge. Put a blanket or equivalent on the table so the paint on the system is not scratched. Bolt the square tubing pieces to the bottom plate of the system with the 1/4-20 hex bolts, washers, and lock washers provided. Use a 7/16" nutdriver or socket.

2) Attach water connections. Use flexible tubing or hose to bring feed water to the supply bulkhead on the system. The connection into the bulkhead must be made with 1/2" OD tubing. The reject water exits from the reject bulkhead with a quick disconnect for which an adapter to 3/8" ID hose is included. The product water bulkhead is also for 3/8" tubing but an adapter to male GHT (garden hose thread) is included.

HANDTRUCK MOUNTING:

This model is attached to an aluminum handcart with an auxiliary caster for maximum portability. A 16 foot long twin hose assembly is attached. The blue hose is for supplying tap water and the red hose is for discharging reject water to drain. The blue hose has a brass female garden hose thread swivel at the end where it attaches to a tap. It also has a GHT plug closure attached so water won't spill during transport. The system end of the red hose attaches to a tee assembly with a check valve and hose connection on one side and a quick disconnect to fit the reject bulkhead on the other side. The system end of the blue hose must be plugged into the supply bulkhead.

If the PA2000 and hand truck ship separately, they must be assembled together. First lay the PA2000 on a table on its back so that the base overhangs the table. The foam base must first be mounted onto the bottom of the PA2000. Attach the ¼-20 hex bolts to the base with a 9/16" nut driver. The bolts should be tightened so that the foam is compressed to about 50% of its original thickness. Note that the aluminum bar on the foam should face the bottom of the base towards the back of the system. With the hand truck lying down on its back, lift the PA2000 into place. Then thread the two flat headed ¼-20 bolts into the countersunk holes on the bottom of the handtruck plate. You will need a 5/32 inch hex wrench to tighten these bolts into the aluminum bar in the foam.

Carefully stand up the hand truck. The back of the handtruck has a bolted plate with holes that match the mounting bracket holes. Use the ¼-20 hex bolts, washers, and lock washers supplied to secure the PA2000 to the handtruck. You may have to push down or lift up slightly on the PA2000 to align the holes vertically.

Attach the red and blue hoses to the feed bulkhead and reject quick disconnect. Wrap the

The auxiliary caster angle bolts to the "stair climber" tubes at the back of the hand truck with the U-bolts and hardware provided. The angle should be bolted about 14 inches above the floor. Check to see if this places the handle at a comfortable height when tipped back and adjust the height as desired.

FIGURE 2
ITEM IDENTIFICATION & FUNCTION

Bottom Filter Outlet Sample Port Sample here to confirm that total chlorine is less than 0.1 ppm

Product Sample Hose
Used for sampling, to fill disinfection tank, and for preparing bicarbonate

Product Valve opens to supply dialysis machine.

Product Outlet
Dialysis machine connects to male garden hose thread. Cap when not connected

Product Sample Quick Disconnect
Upper part of hose can disconnect here and reconnect onto disinfection tank reject hose for filling tank.

Cleaning Inlet
Suction hose to disinfection tank connects here.

Delivery Valve
Open valve to fill container.

ELECTRICAL CONNECTION: The Awesmosis acute systems come with a grounded power cord with a standard 115 volt, 60 Hz, 15 amp hospital grade cord cap.

INITIAL START UP

Before starting the system for the first time, check all of the water connections for tightness.

Warning: The RO should only be connected to cold water. Hot water could permanently damage the RO system.

Turn on the water supply. Open the supply valve. Open the hinged cover and then open the small blue Prefilter Bleed Valve for a 2 minute purge. The purging gets rid of carbon fines and air in the housings.

The system is shipped from the factory with the module drained of water. Open the green flush valve and let the system flush for 2 minutes before turning it on. Then close the flush valve and turn on the power.

Pull the disinfection toggle switch forward. This will keep the pump running until all the air is out of the system. When stabilized, the needle of the pump outlet gauge should read 170 to 180 PSIG. If the product sample valve is opened, then once the product water flow starts, the needle on the conductivity monitor when switched to read product water will be pegged off scale. The visual alarm will light and the audible alarm will sound. You can mute the audible alarm using the mute button. The visible alarm will stay on. After a few minutes of operation the product conductivity will come down to some value and be steady. The product conductivity should be typically about one to two percent that of the feed water. Now return the disinfection toggle switch to the normal position.

Check for any visible leaks then proceed with a disinfection cycle.

DISINFECTION

NECESSITY: Unless water contains some chemical to prevent it, the water can be expected to degrade in quality from the growth of bacteria and viruses. Although the membrane in the RO is an effective filter even for viruses, it is not considered a perfect filter. Bacterial growths on the feed side of the membrane can foul the module. Bacterial growths on the product side of the membrane release bacteria and pathogens into the product water. The only way to affirmatively have biologically pure water is to perform periodic disinfection and take samples for incubation and analysis. Water samples should be taken just prior to disinfection.

The PA2000 RO system is designed to facilitate easy disinfection. The system connects to a 10 liter bottle with supply and reject hoses attached to quick disconnects. The RO systems also have a mode selection switch underneath the top lid to switch between either

"Disinfection" or "Service and Rinse" modes.

Disinfection of the RO should be performed prior to disinfection of the dialysis machine. When the RO is disinfected, the membrane and all fluid paths downstream of the prefilters are exposed to the disinfectant. *It is imperative that the product water hose from the RO to the dialysis machine also be exposed to the disinfectant.*

BACTERIA MONITORING: Assurance that the disinfection procedure is performed sufficiently frequently to remain below the recommended 100 colony forming units per milliliter is achieved by a program of bacteria sampling and analysis.

Product water bacteria samples should be taken just prior to disinfection. Samples can be taken from the product sample hose. The discharge end should be placed in Minncare™ or bleach for a few seconds to kill bacteria there that can give false results. Then allow about a liter of water flow out before collecting a sample in a sterile container.

When a new RO system is installed, samples should be taken each week. If the counts are consistently low for two months, then disinfection and sampling frequency can be reduced to every other week or monthly. A subsequent high count (say more than 100 cfu/ml) would be reason to return to more frequent disinfection and sampling.

An alternative to monitoring bacteria by plate count is by performing the LAL test for pyrogens. This test gives results in hours and is a more sensitive indicator of biological activity. Typically bacteria colonies are attached to surfaces and the plate count sample only measures any bacteria that have sloughed off. The LAL test, on the other hand, is sensitive to the byproducts of bacterial activity.

CHEMICAL DISINFECTANTS: The recommended disinfectant is Minncare™ (also marketed as Renalin™), a mixture of hydrogen peroxide and peracetic acid. The same formula is now available under the name Peracidin™ from HDC Medical. Research has shown that a 1% Minncare™ solution provides a 6 log reduction in bacterial count in just 36 minutes of soaking time. Formaldehyde (formalin) at a 2% strength can also be used but it is less effective, requires a 12 hour soak, and takes longer to rinse out. To make a 1% Minncare™ solution add 120 ml to the pitcher. To make a 2% solution, add 550 ml of 37% formaldehyde concentrate to the pitcher. Do not use Actril® in place of Renalin®. It is too dilute for the purpose.

WARNING: Do not use bleach with RO system. Bleach will ruin the TFC membrane.

If iron is present in the feed water used, Renalin® can damage the membrane unless the iron is first removed. To remove the iron, perform a citric acid cleaning first. See Page 26.

NOTES ON DISINFECTION PROCEDURE:

The concept of chemical disinfection is simple. Proper execution of the procedure is important and is easily learned when the rationale behind the steps is understood.

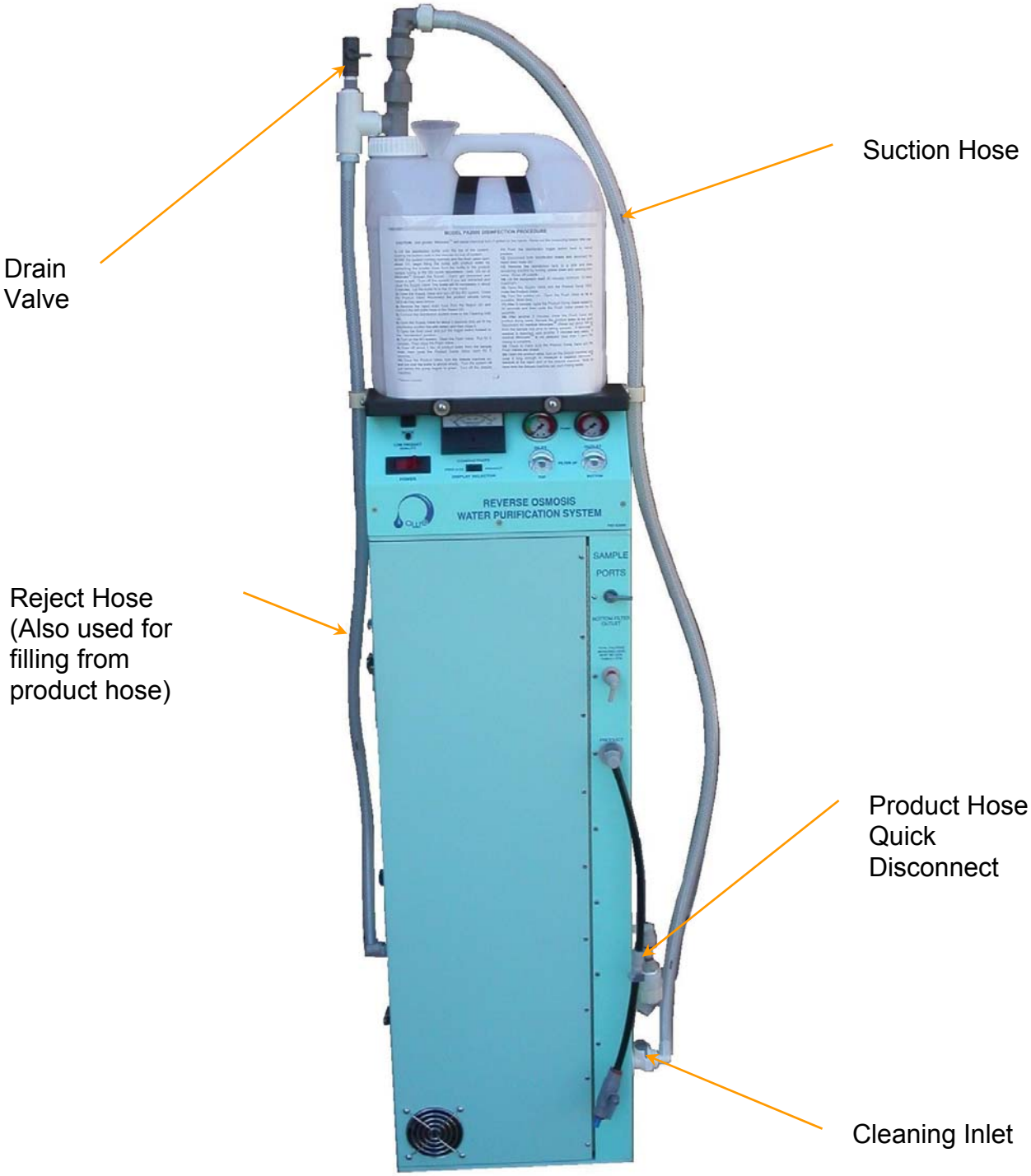
The concept of chemical disinfection is to contact every portion of every surface in the defined water path with a sterilizing chemical of a specific strength for a given length of time and then to rinse out all traces of the chemical. The actual process is made more complex by valves in the water path that must be cycled for full chemical exposure and for rinsing.

The disinfection procedure contacts the pump inlet manifold, the pump, the RO module, the product water paths, and the reject water paths. The prefilters are upstream and are not contacted. Nor is any of the piping in the supply faucet or further upstream to the water treatment plant. The RO membrane is the primary filter for bacteriological matter.

The Flush Valve, the Supply Valve, the Product Dump Valve, the Product Sample Valve, and the Product Valve are all identified on the system. They all need cycling during both chemical contact and rinsing because when they are closed there is a dead flow area on both sides of the valve. The Flush Valve must be closed to force water through the Reject Pressure Regulating Valve.

The Disinfection Procedure is attached to the front of the disinfection bottle for convenience.

FIGURE 3
USE OF DISINFECTION TANK



MODEL PA2000 DISINFECTION PROCEDURE

CAUTION: Use gloves! Minncare™ will cause chemical burn if spilled on the hands. Wash off the measuring beaker after use.

1) Lift the disinfection bottle onto the top of the system, locating the bottom rods in the sleeves on rear of system.
2) With the system running normally, begin filling the bottle with product water by connecting the smaller hose from the bottle to the product sample tubing at the QD (quick disconnect). Add 120 ml of Minncare™ through the funnel. Don't get distracted and cause a spill. Turn off the system if you are distracted and close the Supply Valve. The bottle will fill completely in about 5 minutes. Let the bottle fill to the 10 liter mark.
3) Close the Supply Valve and turn off the RO system. Close the Product Valve. Reconnect the product sample tubing QD's as they were before.
4) Remove the reject drain hose from the Reject QD and connect the left bottle hose to the Reject QD.
5) Connect the disinfection suction hose to the Cleaning Inlet QD.
6) Open the Supply Valve for about 2 seconds (this will fill the disinfection suction line with water) and then close it.
7) Open the front cover and pull the toggle switch forward to the "disinfection" position.
8) Turn on the RO system. Open the Flush Valve. Run for 5 minutes. Then close the Flush Valve.
9) Draw off about 1 liter of product water from the sample hose, then cycle the Product Dump Valve open for 5 seconds.
10) Open the Product Valve, turn the dialysis machine on, and run until the bottle is almost empty. Turn the system off just before the pump begins to growl. Turn off the dialysis machine.
11) Push the disinfection toggle switch back to normal position.
12) Disconnect both disinfection hoses and reconnect the reject drain hose QD.
13) Remove the disinfection tank to a sink and drain remaining solution by turning upside down. Rinse off outside.
14) Let the equipment dwell 40 minutes minimum, 12 hours maximum.
15) Open the Supply Valve and the Product Dump Valve; close the Product Valve.
16) Turn the system on. Open the Flush Valve as far as possible. Note time.
17) After 5 minutes, cycle the Product Dump Valve closed for 30 seconds and then cycle the Flush Valve closed for 30 seconds.
18) After another 5 minutes, close the Flush Valve and product dump valve. Sample the product water from the product hose for residual Minncare™ (Rinse out about 100 ml from the sample line prior to taking sample). If Minncare™ residual is detected, wait another 5 minutes and retest. If residual Minncare™ is not detected (less than 1 ppm) the rinsing is complete.
19) Check to make sure the Product Dump Valve and the Flush Valves are closed.
20) Open the Product Valve, turn on the dialysis machine, and rinse it long enough to measure a negative Minncare™ residual at the reject port of the dialysis machine. Note: to save time the dialysis machine can start rinsing earlier.

NORMAL OPERATION

The Reverse Osmosis system should be turned on and run for 10 minutes prior to connecting a patient to the dialysis machine. It takes several minutes before the ionic quality of the product water stabilizes, and it is always a good idea to further rinse away any previously stagnant water paths for some additional time. So a minimum 10 minute run before beneficial use should be standard.

The machine will alarm on high product conductivity when first turned on and the conductivity needle will be pegged if the dialysis machine is using water or water is being drawn through the product sample hose. The alarm should cease and the conductivity should stabilize at a low value within a few minutes after starting.

Both pressure gauges and both differential pressure gauges should have the indicating needles within the green bands.

At the end of the treatment the RO can be run with the flush valve partially open for a couple of minutes before shutting the system off. This is not mandatory but will result in longer module life or longer time between membrane cleanings. Open the flush valve only so far that the pump inlet pressure gauge does not fall into the red zone.

When finished, turn off the supply valve and the RO system will shut off. If the unit is to be disconnected from the water supply, close the upstream valve first to relieve pressure. The power switch on the RO can then be turned off.

EXCESSIVE PRODUCT FLOW: The capillary on the system is sized so that the water recovery is about 35% when the dialysis machine is using about 800 ml/minute of purified water. The system actually produces a lot more product water than this. If product water is drawn at very high rates (as with filling a bicarbonate container with the product sample hose) the recovery will become excessive, the product conductivity will rise, and the RO module will scale and/or foul more quickly. To prevent this from happening, open the flush valve at least 30 degrees whenever using all the product water the system can produce.

CHLORINE REMOVAL

Free chlorine in the water attacks the membrane and combined chlorine (chloramine) is very toxic to the dialysis patient. Total chlorine is defined as the sum of the free and combined chlorine. Replaceable activated carbon cartridges are used in the system to absorb both forms of chlorine. Over time the carbon loses its absorption ability and stops dechlorinating the water sufficiently.

The carbon cartridges could be replaced before every treatment but this is not economical. How often the cartridges will require replacement is dependent upon the particular water characteristics. To insure that the cartridges are replaced in sufficient time, it is important that the water after the carbon prefilter(s) be sampled frequently and checked for the breakthrough of chlorine. The water should be sampled at least before every treatment. The carbon

cartridge should be replaced immediately if breakthrough is detected. The number of treatments or hours of use till breakthrough occurs can then help establish an economic replacement schedule that is sufficiently frequent to mostly prevent future detection of breakthrough.

Free chlorine is more easily removed than chloramine, so testing for breakthrough should be made with a test for total chlorine. Colorimetric test reagents such as those sold by Hach have been commonly used to measure residual total chlorine but the procedure has plenty of room for operator error. Today a number of manufacturers make easier to use test strips. Only test kits or strips that can indicate total chlorine is less than 0.1 ppm should be used.

If free chlorine is present in the tap water but chloramine is undetectable, and if the water utility verifies that chloramine is not added to the water, then a 5 micron sediment cartridge in the first prefilter housing and an activated carbon cartridge in the second prefilter housing are recommended.

If chloramine is present in the tap water than activated carbon cartridges are recommended in both prefilter housings. Chlorine will breakthrough the first (top) filter before the second (bottom) filter. If the water is quite turbid in addition, a separate 5 micron prefilter should be considered for use upstream of the RO system.

The chlorine absorption of a carbon filter is affected by the flowrate of water through it. The chlorine sample should thus be taken under the same flow conditions as normal use. This means the dialysis machine should be using water at the normal rate and the flush valve should be in whatever position that it will be used during the treatment. Open the filter test valve just enough to establish a stream and let if flow about 10 seconds before taking the sample.

High Conductivity after Carbon Filter Change: Carbon filters often have soluble impurities that must be rinsed out when first installed. This raises the feed conductivity and the product conductivity. If this happens, run the system for an extended rinse with the flush valve open as much as possible.

MONITORING PERFORMANCE

The RO system has two pressure gauges, two differential pressure gauges and a conductivity monitor for tracking system performance. The pressure gauges are liquid (glycerin) filled for long life.

The pump inlet pressure gauge measures the feed water pressure at the pump inlet. This gauge reads the remaining feed water pressure after the water has passed through the prefilters and the feed pressure regulator. This pressure regulator is factory set so that the pump inlet pressure will not exceed 15 PSIG when the product water is all recirculated and the flush valve is closed.

Low pump inlet pressure indicates either a weak water supply and/or clogged prefilter elements. Operation at a low pump inlet pressure, as long as the system continues to run, is not harmful. If the system starts oscillating on and off however, corrective action must be taken.

The pump outlet gauge measures the pressure at the discharge port of the vane pump. This pressure should be 170 to 180 PSIG. The reject pressure control valve limits the pressure. If the pressure exceeds 180 PSIG, or goes up slowly with use, plugging of the module with turbidity is indicated. If the pressure is low, it could indicate that the pump needs replacement.

The differential pressure gauges monitor how clogged the prefilters have become. If there is sufficient tap water pressure available, the system can be operated with a filter element until the differential pressure is in the red zone of the gauges. Earlier replacement of the filter element is necessary where tap water pressures are low. Please note, typically a carbon filter element may need replacement due to chloramine breakthrough before its differential pressure is excessive. For a given filter element condition, the amount of differential pressure also increases with flow. So the gauge reading will increase when the flush valve is open and the RO is using the most water.

The conductivity monitor measures the electrical conductivity of the water adjusted for water temperature. The meter has a dual scale reading in both microSiemens/centimeter (micromhos/centimeter) as well as parts per million (ppm) total dissolved solids (TDS). The meter can be switched to read both the feed water conductivity or the product water conductivity. The reduction in conductivity between the feed and product water is a measure of the ionic reduction of the RO membrane and is called rejection. Rejection is the parameter which best defines RO membrane performance quality.

The monitor also includes an adjustable audible and visual alarm that activates on high product water conductivity. The audible alarm can be silenced by a mute pushbutton. The alarm is initially adjusted to activate at 20 ppm of product water TDS (total dissolved solids).

When the RO module is new, the system should produce water with conductivity less than 4%, typically 1 to 2% that of the feed water. This is usually expressed as a rejection of 96% minimum, typically 98% to 99%. Module cleaning/replacement is indicated when the rejection

falls to some critical value. This critical value is dependent upon the feed water chemistry. However, any decrease in rejection over time indicates that the RO module is being fouled or chemically attacked. Monitoring the rejection on a daily basis and charting it on a monthly basis is recommended.

REJECTION

Mathematically rejection is defined by:

$$\text{Rejection (\%)} = \frac{\text{Feed Conductivity} - \text{Product Conductivity}}{\text{Feed Conductivity}}$$

Since the system conductivity monitor displays the two in a 10 to 1 ratio, the approximate rejection is available at a glance. If the needle on the meter does not move when the display is shifted from feed to product it indicates the rejection is 90%. If the needle when indicating product is only half the value of the feed, then rejection is 95%. If the needle when indicating product is only one fourth of the value of the feed, then rejection is 97.5%. This is illustrated below for several different feed waters.

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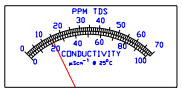
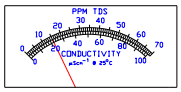
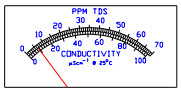
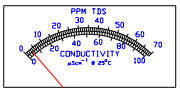
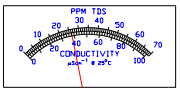
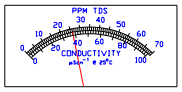
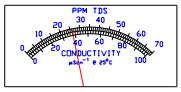
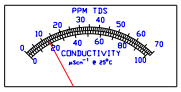
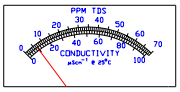
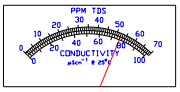
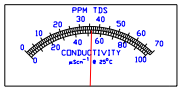
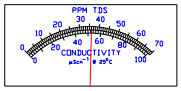
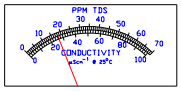
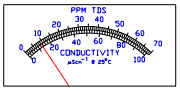
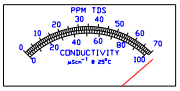
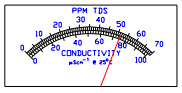
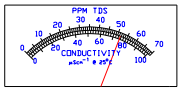
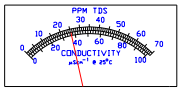
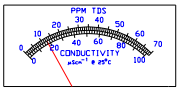
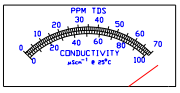
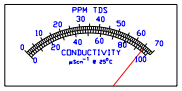
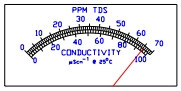
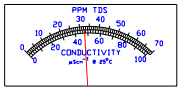
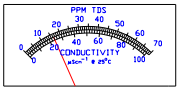
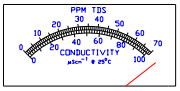
		90%	95%	97.5%	80%
SAMPLE 1					
SAMPLE 2					
SAMPLE 3					
SAMPLE 4					
SAMPLE 5					

According to current ANSI/AAMI standards (RD62-2001) the maximum allowable chemical containment levels are as follows:

Contaminant	Suggested Maximum Level (mg/l)
Calcium	2 (0.1 mEq/l)
Magnesium	4 (0.3 mEq/l)
Sodium	70 (3.0 mEq/l)
Potassium	8 (0.2 mEq/l)
Fluoride	0.20
Chlorine (free)	0.50
Chloramine	0.10
Nitrate	2.0
Sulfate	100
Copper, barium, zinc	each 0.1
Aluminum	0.01
Arsenic, lead, silver	each 0.005
Antimony	0.006
Beryllium	0.0004
Thallium	0.002
Cadmium	0.00
Chromium	0.01
Selenium	0.09
Mercury	0.0002

IONIC LIMITS AND CRITICAL REJECTION:
The actual minimum ionic rejection and/or maximum product conductivity needed to meet AAMI ionic standards will depend on the chemical analysis of the feed water. It is the user's responsibility to have such an analysis conducted. Chemical analysis of a sample of the product water will confirm that the maximum ionic levels are not exceeded. Measurement of the system rejection at the same time that both product and feed samples are taken is important.

Most tap water supplies have hardness levels that exceed the calcium and magnesium ion limits. If the water is softened by ion exchange first, then usually whatever other ions still exceed the limits can be removed by a relatively low rejection.

However if a softener is not used to pretreat the tap water, then the RO membrane must do all the softening itself. Thus a high rejection is necessary to meet the calcium and magnesium

limits.

The total hardness is related to the ionic levels by

Total Hardness (mg/l as $CaC0_3$) = 2.497 x Ca (mg/l) = 4.118 x (mg/l)

If the hardness were assumed to be all calcium with no magnesium present, then we can solve the formula above to get

Ca (mg/L) = 0.400 x Total Hardness (mg/l as $CaC0_3$)

Hardness is usually reported in grains per gallon. There are 7000 grains per pound and the conversion is 1 grain per gallon equals 17.1 mg/l as $CaCO_3$.

Water that measures 10 grains per gallon of total hardness has 171 mg/l of hardness expressed as $CaC0_3$. Assuming no magnesium, then by the formula above the calcium level is 68 mg/l. To achieve a calcium level of 2 mg/l (the AAMI limit) we must have a 97% reduction through the RO.

The conductivity-measured rejection is a surrogate for the reduction in all the ions in the feed water. Since calcium and magnesium are actually removed somewhat better than ions like sodium, the reduction of these ions is somewhat underestimated by rejection. So equating reduction with rejection in considering hardness is conservative.

Some water supplies are so hard that a softener will have to be used to treat the feed water to the RO.

AUTOMATIC SYSTEM SHUTDOWNS: If there is sufficient pressure to start the system, but just after the pump starts it stops and then oscillates on and off, it indicates that there is a restriction in the feed line. This could be due to clogged prefilter elements. An inadequate or clogged tap or excessive demand on the water supply (such as a toilet being flushed) could also cause it. It is not good for the motor to go on and off repeatedly.

The RO system can also shut off if the motor draws excessive current and trips the circuit breaker. The circuit breaker is integral with the power switch. If the circuit breaker trips, the rocker handle will occupy a middle position between on and off. After allowing the breaker to cool down several minutes, it can be reset by turning the power switch completely off and then on again.

If there are no indicators of problems and the pump motor is excessively hot, the pump motor has shut itself off. The pump motor has its own internal thermal overload which, resets automatically after several minutes of cool down. Open the front cover and use a fan if necessary to cool the motor faster.

An oscillating on and off condition caused by a poor water supply or clogged prefilters will draw excessive starting current for an abnormal length of time and can cause either the circuit breaker or pump motor shutdowns to occur.

NORMAL MAINTENANCE

All water treatment equipment requires timely and adequate maintenance to insure against costly and unexpected breakdowns. A timely log of operating conditions and service performed is very useful. A log helps insure that everything is checked and also aids in pinpointing the cause of any problems that might develop.

FLUSHING:
Flushing the system can help to limit turbidity accumulation and scaling in the module. Opening the green flush valve lets the reject water flow freely to drain, increasing the reject flow and decreasing the pump outlet pressure. Since flushing causes more feed water to flow than normally through the prefilters, the pressure drop may be excessive and prevent fully opening the flush valve without kicking off the system on low feed pressure. So only open the flush valve until the pump inlet pressure is in the yellow zone. If you can, flush for a few minutes after each use.

PREFILTERS:
The frequency of replacement of the 5 micron sediment element is entirely dependent upon the characteristics of the feed water and the usage of the system. The differential pressure indicator helps determine when replacement is needed. The element should be replaced when the differential gauge needle is in the red zone. It may need replacement sooner if there is so little feed pressure that the system otherwise will not run. The sediment element should be replaced with a 9.75" long cartridge rated at 5 microns or less. The AWE part number of the element required is F94B1 which is a 5 micron rated spun polypropylene type.

The activated carbon filter will also require periodic replacement either due to chlorine breakthrough or excessive pressure drop. The standard element used is a cartridge of granular Centaur™ catalytic activated carbon (AWE P/N F94CC) which has very high dechlorination capability. The water after the filter should be tested before each treatment for the presence of free and combined chlorine.

To replace a prefilter element, turn off the system and close the Supply valve. Open the Filter Bleed Valve to relieve pressure. The blue sump of the filter is held onto the top cap with threads. The sump must be turned counterclockwise when looking up to remove it. A filter wrench is included with the system to facilitate removal. The inside of the sump should be rinsed thoroughly when the element is changed.

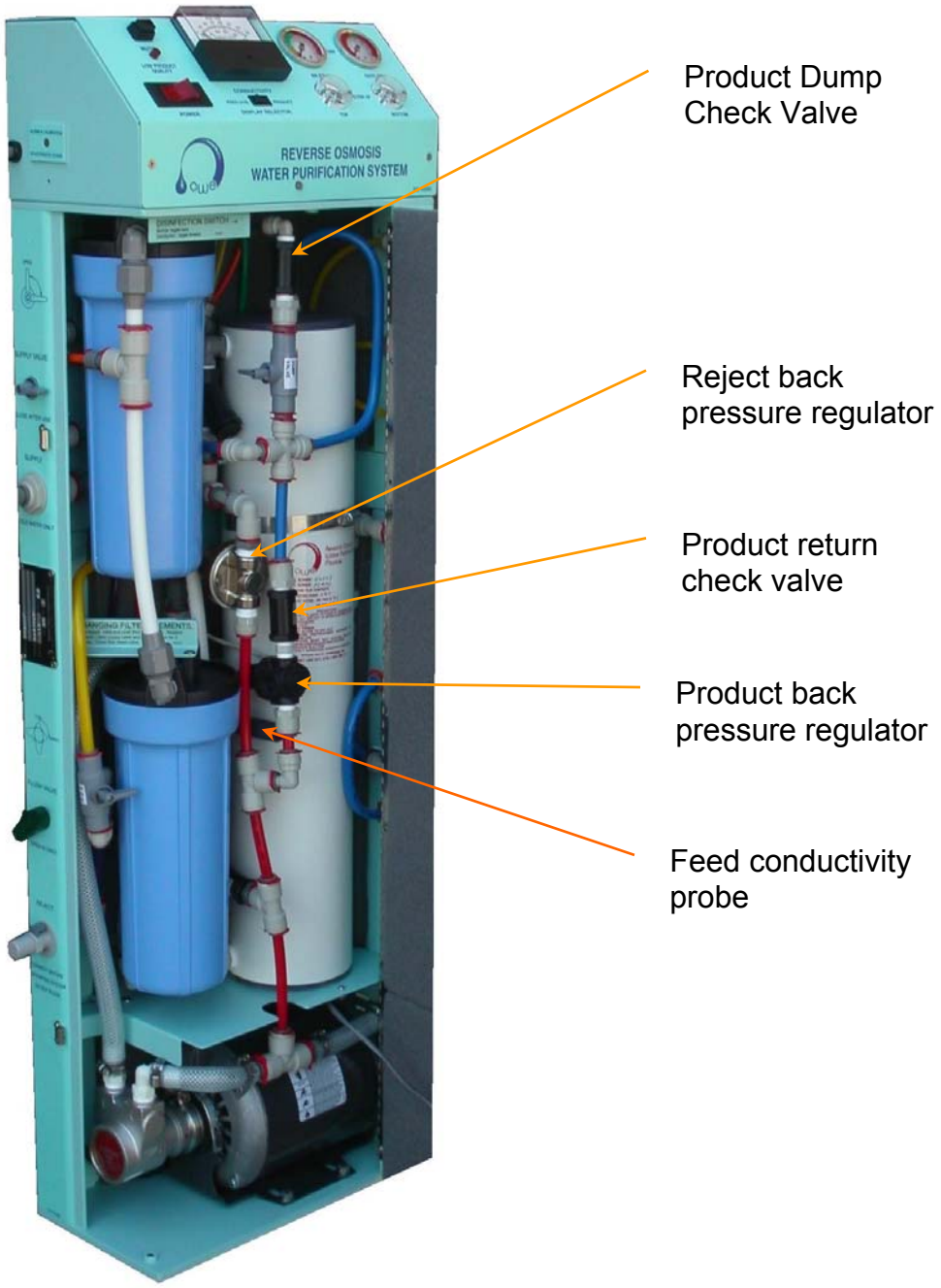
Buna N rubber “O” rings seal the prefilter housings. The "O" ring must be seated in its groove to make the seal. Occasionally the "O" ring should be lubricated with Vaseline or equivalent petroleum jelly. The housing should be leak tight with only hand tightening. Do not use a wrench to tighten the filter! If hand tightening is not sufficient, a new "O" ring may be needed.

Note that the some activated carbon elements must be installed in the proper orientation (there is a distinct top and bottom).

After changing the filter elements, open the Supply Valve and open the Filter Bleed Valve for 2

minutes. This will purge air and carbon fines from the filters.

FIGURE 4
ITEM IDENTIFICATION



SERVICE NOTES

WATER FLOW IN SYSTEM: Refer to the flow schematic attached. The flows are colored to match the tubing colors in the system.

When the supply valve is opened water flows through the two prefilters, through a feed pressure regulator, through a check valve and then proceeds into the pump inlet. A feed pressure switch, which is connected to the pump inlet manifold, senses the water pressure there and closes after the water pressure rises to about 3 PSIG. The switch closure energizes the pump motor.

Water from the vane pump enters the bottom side of the RO module at 175 PSIG. Most of the water exits the module from the topside at almost the same pressure and continues through a SS strainer element. After the strainer, the flow splits with a portion going through a length of 1/8" OD capillary tubing to drain (this sets the amount of water flow to drain); and the remainder enters the reject pressure control valve where the pressure is lowered to about 15 PSIG. This water then enters into the pump inlet tubing assembly. The pressure control valve has a spring controlled diaphragm and it automatically adjusts its orifice to maintain the upstream pressure.

A portion of the water entering the module passes through the semi-permeable membrane and exits the module through the top center port. This water then splits and either flows past the product conductivity probe to use, or goes back into the pump inlet assembly after passing through the product check valve and the product pressure regulator. The Product Dump Valve, when opened, bypasses the product water to drain. If no product water is being used, all of the water is recirculated back into the pump inlet. The product pressure control valve is factory set to limit the maximum product water pressure to 25 PSIG.

When the power switch is turned off, the pump motor will stop. Some water flow will continue until the supply valve is closed. The reject capillary will slowly drain and reduce all residual pressure within the system.

The green handled flush valve is piped in parallel across the reject capillary. When the flush valve is opened it increases the water flow to drain from a nominal 1400 ml/minute to a maximum of about 5000 ml/minute.

Normally the RO system produces much more product water than is needed by the dialysis machine. The excess product water is combined with the tap water with the result that the membrane actually is fed a lower conductivity and less fouling water than the raw feed water.

If all the product water flow is drawn, as in filling a container or when the Product Dump Valve is open, there is no product recirculation so the membrane receives a saltier than normal feed and this increases the product conductivity too.

The pressure drop through the prefilter elements increases with flow. With the product valve closed, and all the product water recirculated, the system uses a minimum amount of tap water

and the prefilter pressure drop is at a minimum (depending upon the filter condition and type). When the product flow is dumped, the tap water flow through the elements increases, as do the pressure drops. The flow of tap water increases much more if the flush valve is opened and this also increases the pressure drops. The flush valve has a restrictor to limit flow to 1.2 to 1.4 GPM. This restrictor is a section of 1/8" OD polypropylene tubing inside the 1/4" tubing attached to the flush valve discharge.

VANE PUMP REPLACEMENT: The vane pump on the Awesmosis system has an expected life of 8000 hours or about one year of continuous duty. Abrasive turbidity or hardness in the feed water will shorten pump life. Pumps are quickly worn if they are allowed to cavitate and growl. The pump needs replacement when it is unable to develop the normal 175 PSIG operating pressure, when it cannot develop normal flow of 100 gph, if it has an external leak, or if it is very noisy. Replace the pump with an exact replacement (AWE P/N F01C1). Save the old pump for factory rebuilding. Do not attempt to rebuild the pump or disassemble it - special tools are required.

Reinforced vinyl hose rather than tubing is used for the pump inlet and outlet to reduce noise. Since it is difficult to remove hose from the barbs without damage, it is recommended that the hoses not be disconnected. Instead disconnect the pump from the motor, undo the inlet hose piece at the push-in tee, and unthread the outlet fitting by rotating the pump. Then the inlet elbow hose fitting can be unscrewed with the hose attached. The pipe threads of the hose fittings should be cleaned of old thread tape, retaped with TFE thread sealant tape, and installed on the replacement pump in the reverse order of removal. The pump is coupled to the carbonator-type motor with a V band clamp. When reinstalling the pump it is very important to make certain the pump tang is firmly aligned with the motor slot and that the V band clamp is tight.

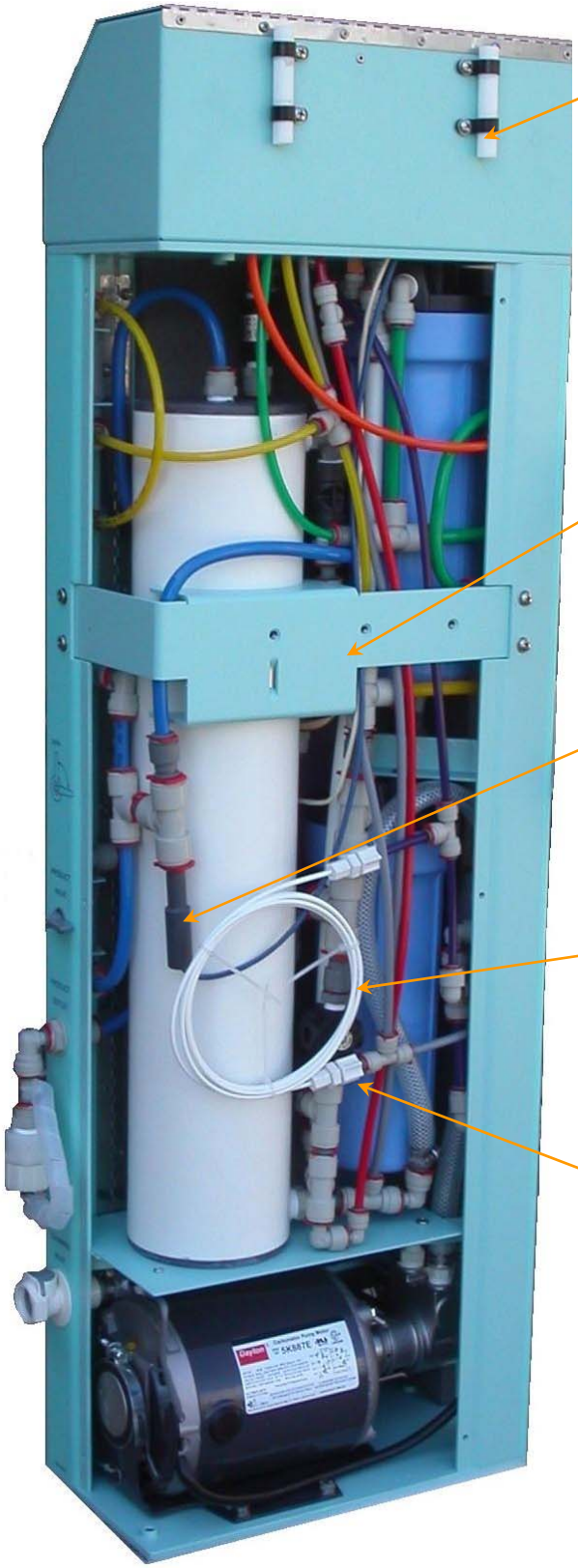
MODULE FOULING: The TFC membrane module has an indefinitely long life if not operated with chlorine in the feed water, but typically will require chemical cleaning to regain lost output or declining rejection. Changes in feed water characteristics, insufficient pretreatment, and inadequate service can all cause premature failure.

Poor system performance is not necessarily due to a fouled or failed membrane module. Before indicting the module, check to see that the pump outlet pressure is 150 PSIG or more and that the reject water flow is at least 1.4 liters per minute. Subnormal pressure or reject flow will result in low product water flow and/or low ionic rejection even if the module is new.

A membrane is failing by fouling when ionic rejection, product water flow and pressure, or both diminish significantly. The tolerable drop in either parameter depends upon the application. For dialysis use, in general, the module needs cleaning or replacement when the salt passage (1 – rejection %) doubles in value. Of course if the module does not make enough water to maintain sufficient product pressure to the dialysis machines, it has failed.

In addition to fouling, modules can also fail from chemical attack. The membrane of the thin film composite (TFC) modules can be permanently destroyed by low levels of chlorine or other oxidizing chemicals. Module failure by chemical attack necessitates replacement and is usually indicated by a fall in ionic rejection and an increase in product water flow.

FIGURE 5
ITEM IDENTIFICATION
Rear view with cover removed



CHEMICAL CLEANING OF MODULE: Often the foulant deposits on the membrane can be removed by circulating chemical solutions. Chemical cleaning is most effective with high flows and low pressures such as a dedicated cleaning skid can provide. Nevertheless, usually cleaning the membrane module in the system using the disinfection apparatus is effective on moderate scaling. Acid cleaning is most effective on common carbonate hardness scale. Citric acid is recommended due to its relative safety, effectiveness and availability.

CITRIC ACID CLEANING PROCEDURE:

1) Initial Performance: The first step is to measure the rejection and the output of the RO module before cleaning.
2) Add about 425 grams of citric acid powder (about 1 & 2/3 cup measure) to a plastic container and fill with about a liter of purified water. Stir the solution until all the powder is dissolved. Add the solution to the disinfection bottle.
3) Use the sample tubing connected to the product sample bulkhead to fill the bottle with product water (as in disinfection).
4) Close the supply valve and the product valve and turn off the RO system.
5) Remove the drain hose from the reject QD. Attach the two hoses from the bottle to the cleaning inlet and reject bulkhead quick disconnects.
6) Open the front cover and pull the toggle switch forward to the "Disinfection" position.
7) Turn on the RO system. It should quiet down after a few seconds and then run smoothly. Then open the flush valve. Run for 15 - 25 minutes and turn off the system.

Warning: Do not let the solution recirculate too long and get too hot. The solution should not exceed 38 degrees Celsius (100 degrees Fahrenheit).

8) Let the equipment dwell 40 minutes.
9) Disconnect the disinfection bottle hose from the reject bulkhead and reconnect the regular drain hose.
10) Turn the system back on and run until the disinfection container is emptied.
11) Push the disinfection toggle switch back to normal position.
12) Open the supply valve and the product dump valve (inside the hinged cover). After a few seconds close the supply valve again. (While the supply valve is open, water is flowing backwards through the cleaning inlet into the bottle, rinsing out the line).
13) Disconnect the suction hose from the cleaning inlet quick disconnect.
14) Open the supply valve again.
15) Turn the system on and check the time.
16) Open the flush valve as far as possible.
17) After 5 minutes, cycle the product dump valve closed for 30 seconds and then cycle the flush valve closed for 30 seconds.
18) Water must be drawn from the product sample tubing or from the product outlet to monitor the product conductivity. So close the product dump valve and open the sample valve.
19) Rinsing is complete when the product conductivity stops dropping.
20) After 30-60 minutes of running, test the output and rejection. Compare with the initial values.

Note: Acid rinsing is only effective at removing hardness and metal oxide scale. Fouling by other contaminants in the water will eventually require a caustic cleaning of the module as well.

Organic fouling can be partially removed by using a 0.5% caustic (sodium hydroxide, NaOH) solution instead of acid. If performed, follow with an acid cleaning.

MODULE REPLACEMENT: The RO module is pretty easy to replace. It is held in place with a SS band clamp that can be loosened with a screwdriver or nut driver. Remove the gray tubing from the bottom module inlet, the gray tubing from the topside outlet after the strainer, and the blue product tubing from the top port. In addition, the blue tubing at the right side of the cross must be undone. Then the module can be lifted up and out the front, top side first. Remove the fittings from the old module and install into the ports of the new module. Installation of a new module is the same procedure in reverse.

LEAKS: There are many plumbing connections where leaks are possible. Every system is tested for several hours before shipment to help insure the system will operate without leaks when installed. Even so, vibration in transit, temperature changes, etc. may allow a leak to develop. The “O” rings on some of the fittings are also susceptible to chemical attack during disinfectant exposure and aging.

The pipe thread connections are sealed with Teflon (TFE) tape type thread sealant. Sometimes a leak at a pipe thread connection can be fixed by tightening the fitting one full turn. If the leak remains then the fitting must be removed, the old tape cleaned from both the female and male threads, and the male fitting wrapped with new tape.

To retape a fitting: The tape should be wrapped around the threads in a clockwise direction as viewed from the insertion end. It is best to start the tape edge one or two threads from the end of the fitting. The fittings require 4 to 6 wraps of tape. After wrapping the fitting run a fingernail around the thread to lock it in position.

NOTE: When installing a threaded joint it is very important to not cross thread. The fitting must be held in firm alignment to the mating fitting the first turn or two of thread engagement.

Several of the fittings are of the gray acetal compression type. The compression nut is threaded the same as 1/2" pipe thread but this part of the connection does not use any TFE tape. If further tightening of the nut can not prevent the leaking then replacement of the tubing piece, ferrule, and/or fitting may be required. Scratches on the outside diameter of the tubing are usually responsible for a leak in these fittings.

Most of the connections are made with instant push in fittings. These fittings have an interior "O" ring seal and a plastic collar with stainless steel teeth that grab the tubing. We now also use red retainer clips to prevent movement of the tubing. First remove this red retainer by pulling on it with needle nose pliers or your fingers. Tubing can be removed from the fitting by pulling on the tubing after pushing in on the collar. However the tubing often gets scratched by the grab ring during removal. The "O" rings can be replaced if necessary by pulling out the collar cage and then the "O" ring. Usually a leak is caused by scratches on the tubing itself and a replacement section of tubing should be installed.

It is recommended that an open end wrench with an opening the same size as the

tubing be used to depress the collar on the push in fittings.

When reinstalling the retaining clips notice that one side of the clip is flat. This side should face the body of the fitting.

PRESSURE CONTROL VALVES: The feed, product and reject pressure control valves do not require periodic adjustment.

The product pressure control valve can be adjusted to maintain a higher or lower maximum product pressure if required. The product pressure cannot be limited to any value less than the setting of the feed pressure regulator.

If the valves are defective and replaced, the following procedure should be used to set the pressures.

Adjusting reject pressure regulator: With Flush Valve closed and Product Valve closed, adjust regulator so pump outlet pressure is at the upper end of the green band.

Adjusting feed pressure regulator: With Flush Valve closed and Product Valve closed, adjust regulator so that pump inlet pressure is at the upper end of the green band. This regulator only reduces the pressure so clearly the tap water pressure must be high enough to allow the adjustment.

Adjusting product pressure regulator: Connect a test pressure gauge to end of the bicarbonate fill hose. With Product Valve closed, adjust regulator to 25 PSI.

BALL VALVES: Five PVC ball valves are used in the system. If the valves leak to the outside at any time or from inlet to outlet when closed, then they must be replaced. Replacement of the Supply valve or the Product valve require that the handle be removed and the two brackets holding onto the fittings that screw into the valve be removed. Each bracket is held on with a 6-32 Nylok nut (5/16" hex).

MONITOR ADJUSTMENT: Remove the control panel cover with a Phillips screw to expose the holes for adjusting the monitor. Use a flash light to see into the holes. The alarm setting is displayed by moving the slide switch lever on the circuit board from the normal to the alarm position. The setting can then be adjusted by rotating the slot head in the adjacent potentiometer. Be sure to return the slide switch back to the normal position after adjustment.

There are two other potentiometers marked feed and product. These are used to calibrate the conductivity probes to an external standard such as a calibrated hand held meter. When using the hand held meter, remember to rinse the sample cup at least three times with the water to be measured.

EXTENDED STORAGE: Formaldehyde can be used for long term storage or, with most feedwaters, there is no problem in merely draining the module and then disinfecting when putting back in service. Do not use Minncare™ for long term storage. Do not let the membrane module dry out. Do not leave activated carbon elements in the prefilter housing.

Open the housing and discard the element. Leave the filter sump off so the next person to use the system will know to put in a new cartridge.

TROUBLESHOOTING

SYSTEM WILL NOT START:

1) No power. The light in the circuit breaker/power switch should come on when the switch is turned on if there is electrical power. If it doesn't, check cord, cord cap, and outlet. If these are OK, check to see if power switch is bad by checking for voltage between the red (switched hot) wire and the white (neutral) wire.

2) Feed switch failure. If the pump inlet pressure gauge shows there to be at least 10 PSI feedwater pressure, but the system doesn't start, then the feed switch may be bad. Check by seeing if the pump runs when the disinfection toggle switch is placed in the disinfect position.

7) Motor failure. If there is power to the motor and it does not run, it must be replaced.

8) No feed water.

LOW PUMP OUTLET PRESSURE:

1) Worn pump. When the vanes of the pump are sufficiently worn, the pump will either not develop normal pressure or flow.

2) Reject pressure control valve. Check to see if this valve is defective by tightly squeezing the 3/8" OD red tubing at the outlet of the valve with a pair of long nose pliers (the flush valve must be closed). If squeezing raises the pump outlet pressure the valve is defective or misadjusted. Try tightening the adjustment screw. Note: the red tubing piece should be replaced after the squeeze test.

3) Flush valve open. The operating pressure will be subnormal if the flush valve is open.

4) Module/element leak. If the module develops an internal leak or the membrane surface is destroyed, the module will make an excessive volume of product water of low quality. This reduces the reject flow so much that the operating pressure cannot be maintained.

HIGH PUMP OUTLET PRESSURE:

WARNING: The pump outlet pressure should never exceed 185 PSIG, and if it does, the system should be immediately turned off. High pressure is an abnormal condition and indicates something is drastically wrong.

1) Blockage. Any blockage in the reject pressure control valve inlet or upstream strainer could cause the pressure to be excessive. Check strainer element by unscrewing hex plug out of strainer body and visually inspecting it for blockage.

2) Fouled modules. This is unlikely to happen since output will be low and rejection poor before the fouling would become so severe as to cause the pressure to rise. The modules could become blocked by either turbidity from a filter element too long in service that bypasses or fails, or from severe precipitate (hardness scaling) or colloidal fouling. The module must be cleaned or replaced.

FREQUENT LOW PRESSURE SHUTDOWNS:

1) Poor water supply: If the RO runs with plenty of inlet pressure until a toilet is flushed (or other tap opened), an insufficient supply is indicated. The building plumbing is too small in size or has a severe restriction somewhere. A clogged aerator is a frequent cause.

2) Clogged prefilters: Replace prefilter elements.

3) Feed switch: If the pump inlet gauge shows there to be plenty of pressure just before cut out, the feed switch may be misadjusted or defective. The cover of the switch comes off with one screw. Adjustment instructions are inside the cover. The switch can be adjusted to open as low as 1 or 2 PSIG. If pump does not turn off when feed water supply valve is turned off when running, then the feed switch has been adjusted too low.

5) Pretreatment: Excessive pressure drop may be in pretreatment equipment. Check tempering (blending) valve, softener, iron filter or other pretreatment device for blockage.

LOW PRODUCT WATER OUTPUT:

1) Pump: Low pump outlet pressure will reduce product water flow.

2) Module: A fouled module may make much less water than it should.

3) Cold water: The output of an RO module is strongly affected by inlet water temperature.

4) Excess demand: The dialysis machine or other device using the product water may suffer internal wear or a malfunction that can cause it to use more water than normal. On dialysis machines, check the dialysate flow regulator.

5) Product pressure control valve: A misadjusted, defective, or clogged product pressure control valve could bleed an excessive amount of product water back into the pump inlet manifold. When product flow is blocked off completely, the valve should be adjusted so that the product pressure does not exceed 25 PSIG.

6) Valve failure: If the product dump valve leaks, it will bypass product water to drain when it is supposed to be closed.

HIGH CONDUCTIVITY:

1) Feed water change: The product water TDS or conductivity will track changes in the feed water TDS. Water agencies will sometimes switch between different supply sources having different characteristics.

2) Softener: If a softener is used for pretreatment or the building has a central softener, a defective rinse cycle after regeneration can cause excess salt to remain on the resin, which would increase the feed water conductivity.

3) Module: A module that is fouled, old, or has been chemically attacked will make poor quality water. Before indicting the module, check that the pump outlet pressure, feed TDS, and reject flow are all normal.

4) Defective monitor: Check the reading on the conductivity monitor with a hand held meter. Adjust or replace probe.