Tenergy Christ Water

Job Number: 04U202

Demineralized Water System

OPERATING INSTRUCTIONS and ENGINEERING MANUAL

Built for:

SCHWEITZER / MAUDUIT

RECORD of REVISION

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I. OVERVIEW

A. LIST OF MAJOR EQUIPMENT

The Tenergy Water Demineralized Purification System built for SCHWEITZER-MAUDUIT, Lee, Massachusetts consists of the following equipment:

1) Duplex Multimedia Filters: Unit A & Unit B
2) Single Pass Reverse Osmosis Skid with Anti Scalant Chemical Injection System:
   a) 5 Micron Prefilter F-R1
   b) RO High-Pressure Pump, P-R1
   c) Single Pass RO Unit
3) Anti-Scalant Chemical Injection System:
   a) Anti-Scalant Chemical Tank TK-R1
   b) Anti-Scalant Chemical Pump P-R2
4) Brine Chemical Injection System:
   a) Brine Chemical Tank TK-E1
   b) Brine Chemical Pump P-E1
5) RO / EDI Cleaning Skid consisting of:
   a) 500 Gallon Cleaning Tank, T-C1
   b) Cleaning Pump, P-C1
   c) 5 Micron Cleaning Solution Cartridge Filter F-C1
6) 30 ft^3 Service Exchange Vessels
7) Electrodeionization Skid:
   a) EDI Unit

B. MAJOR EQUIPMENT DESCRIPTION

1) Duplex Multimedia Filters: Unit A & Unit B

   Multimedia filtration is used to remove suspended solids from industrial and municipal water supplies. The filters are very effective in reducing the turbidity of raw water by removing suspended solids, from coarse sediment down to 10 micrometer (μm). Raw water filtration protects the softener ion exchange resin downstream from particulate fouling.

   The normal mode of operation of the Duplex Multimedia Filters is in the parallel mode such that the inlet flow is split between both filters.

2) Single-Pass Reverse Osmosis Assembly:

   Reverse osmosis (RO) removes total dissolved solids (TDS) including ions from water using polyamide (PA) thin-film composite (TFC) membranes at high pressure (>100 psig. The reject water contains most of the dissolved solids (> 98% rejection) and all the suspended solids in the feed water.

   The RO system provided is a Single-pass, two-stage unit. A high-pressure, multi-stage centrifugal pump, P-R1 transfers pre-treated feed water through the RO membrane elements housed in 8" diameter pressure vessels. Each pressure vessel contains four elements connected in series.

3) Dual $30ft^3$ Service Water Softeners

4) Electrodeionization System

Refer to the EDI Operations and Maintenance manual.

5) Cleaning / Sanitization Skid

   Employed to Clean and Sanitize the RO and EDI Units when the need arises.

6) Main Control Panel

   The Main Control Panel (MCP) houses the Allen-Bradley Micrologix 1200 programmable logic controller (PLC). The panel serves as a control center for the entire System including the pumps, the manual/automatic operation of the equipment and process alarms. The MCP is also inter-connected with the Controller / Stagers, which control the operation of all the automatic valves on the equipment. The Service, Backwash, Regeneration, and Sanitization modes are controlled from the MCP.

   The status of each unit including Service, Washing, RO pump inlet and outlet pressure, RO feed water pH, chlorine, temperature and conductivity, product water pressure and conductivity, product water and reject flow rates, % rejection, and common alarms are displayed on the ROTroll RO Controller screen. In addition, control power and equipment start-up switches are provided on the MCP.

II. SPECIFICATIONS

A. DUPLEX MULTIMEDIA FILTERS UNIT A & UNIT B

Model Number	FM60072DES
Catalog Number	50040-01
Dimensions (inches)	
Column Diameter	60"
Column Straightside	72"
Overall Height	107-1/4"
Overall Width	135"
Overall Depth	84-1/8"
Pressure Rating (psig)	
Design Pressure (Hydraulic)	100
Test Pressure (Hydrostatic)	150
Flow Rate (gpm) per column	
Service	209
Backwash	290
Rinse	190
Connection Size	
Inlet	6" PVC 150 lb. Ansi Flg.
Effluent	4" PVC 150 lb. Ansi Flg.
Drain	4" PVC 150 lb. Ansi Flg.
Column Drain	2" NPT Plug PVC
Top Manway	12" x 16"
Media Removal	2" NPT
Media (lbs.) per column	
Media Anthracite # 1.5	1,560 lbs. (30 bags)
Media Filter No. .45 Sand	1,500 lbs. (30 bags)
Media Filter Garnet Fine Silica # 50W	1,100 lbs. (55 lb container)
Media Filter Garnet Coarse Silica # 12W	800 lbs. (55 lb. Bag)
Media Filter Gravel Medium 3/8" x 3/16"	700 lbs. (50 lb. Bag)
Media Filter Gravel Coarse 5/8” x 3/8”	1,800 lbs. (50 lb. Bag)
Weights (estimated – pounds)	
Dry (no media)	20,200
Operating	30,680
Air Requirement	
Plant Air to Multimedia Solenoid Panel	2 scfm clean air @ Minimum 10 psig greater than operating pressure
Electrical Requirement	
From MCP to Controller / Stager Panels	120 VAC/ 1 phase/ 60 hertz, 2 amps
Electrical Drawings	
Electrical Schematic	58200-01

C. RO ASSEMBLY

Catalog Number	55027-01
Model Number	RG8167SPS
Dimensions (inches)	
Overall Height	100" (for maintenance)
Overall Length	271"
Overall Width	64-3/8"
Operating Pressure (psig)	
Feed Supply	20
Membrane Feed	231
Product Water	90
Reject	20
Pressure Vessel (FRP) Rating	450
Flow Rates Normal (gpm)	
Feed	209
Reject to Drain	42
Reject Recycle	5
Product	167
Connection Sizes	
RO Inlet	4" PVC 150# ANSI Flg.
RO Product to Drain	4" PVC 150# ANSI Flg.
RO Product	4" PVC 150# ANSI Flg.
Anti-Scalant Inlet from Pump P-R2	½" T
RO Reject	2" PVC 150# ANSI Flg.
RO Pump P-R1	
Manufacturer	Grundfos
Model	CRN-45-6
Rating	214 GPM @ 268 psi
Electrical	460 VAC/ 3 phase/ 60 hertz/ 50HP
Weights (estimated – pounds)	
Dry	4,254
Operating	9,054
Air Requirement	
Plant Air to Main Control Panel	2 scfm air @ at 85 psi
Electrical Requirement	
From Main Control Panel to RO Control Panel	120 VAC/ 1 phase/ 60 hertz 15 amps
From Plant Power supply to VFD Panel VFD-R1	460 VAC/ 3 phase/ 60 hertz 65 amps
Electrical Drawings	
Electrical Schematic	58200-01
Main Control Panel	58201-01

D. DUAL 30 FT^3 SERVICE WATER SOFTENERS

Catalog Number	
Dimensions (inches)	
Height	78"
Diameter	36"
Operating Pressure (psig)	
Design Pressure (hydraulic)	100
Test Pressure (hydraulic)	150
Flow Rates Normal (gpm)	
Service	180
Connection Sizes	
Softener Inlet	3" SST Female Quick Disconnect (Flex Hose)
Softener Outlet	3" SST Male Quick Disconnect (Flex Hose)
Weights (estimated – pounds)	
Operating	3,900

E. EDI SYSTEM

Model Number	EG10150BPS
Catalog Number	59005-01
Dimensions (inches)	
Overall Height	93-5/8"
Overall Length	136"
Overall Depth	44-3/4"
Operating Pressure (psig)	
Design Pressure (hydraulic)	100
Test Pressure (hydraulic)	100
Flow Rates Normal (gpm)	
Feed	167
Product	150
Recovery	150 GPM @ 90%
Connection Sizes	
Inlet	3" PVC 150# ANSI Flg.
Concentrate Outlet	1" PVC 150# ANSI Flg.
Electrolyte Outlet	1/2" PVC 150# ANSI Flg.
Outlet to Drain	3" PVC 150# ANSI Flg.
Brine Inlet to P-E1	¼" PP Tube
Weights (estimated – pounds)	
Shipping	4,217
Operating	5,017
Air Requirement	
	N/A
Electrical Requirement	
From Plant Power Supply to EDI Rectifier Panel	460VAC/ 3 phase/ 60 hertz 60 amp
From Plant power supply to Main Control Panel	120VAC/ 1 phase/ 60 hertz, 20 amps

F. RO / EDI CLEANING SKID 200 GPM

Model Number	CSR500-200M
Catalog Number	60134-01
Dimensions (inches)	
Overall Height	106” (for Maintenance)
Overall Width	73-5/8"
Overall Depth	72-7/8"
Pressure Rating (psig) piping only	
Design Pressure (Hydraulic)	75
Test Pressure (Hydrostatic)	100
Connection Sizes (Inches)	
Outlet	4” PVC 150# ANSI Flg.
Product Return	3” PVC 150# ANSI Flg.
RO Concentrate Return	3” PVC 150# ANSI Flg.
CIP Drain	1-1/2” PVC 150# ANSI Flg.
Cleaning Pump P-1	
Manufacturer	GRUNFOS
Model	CRN32-3-2
Rating	200 GPM @ 54 PSI
Electrical	460VAC/ 3phase /60 hertz/ 10 HP
Cleaning Tank & Solution Volumes	
Cleaning Tank Nominal Capacity	500 gallons
Tank Diameter	50"
Tank Straight Side	60"
Weights (estimated - Pounds)	
Dry	1,300
Operating	7,500
Electrical Requirements	
From Plant Power supply to Motor Starter MS-C1	460VAC/ 3phase /60 hertz/ 20 amps
Electrical Drawings	
Electrical Schematic	58200-01

III. INSTALLATION & INITIAL START-UP

A. INSTALLATION

1) Receiving

Upon receiving the equipment, a thorough inspection should be made for damage that may have occurred during transit. All damage should be reported to the carrier immediately.

CAUTION:

Equipment handlers should be informed not to lift or pull any of the System columns or components by their piping assemblies. The Multimedia Filters, RO unit, EDI unit and Service Water Softeners must be protected from temperatures above 120 °f. Failure to comply with this caution statement will result in serious damage to these components.

2) Erecting

The System Skids and Components should be located, erected, positioned and leveled conveniently to open type waste drains capable of handling flow rates 20% greater than the backwash flow rate of the Multimedia Filter. The drain must also be capable of handling the following:

- Chemical waste from RO membrane flushing and Chemical Injections.
- RO reject water.
- RO / EDI cleaning and sanitizing chemicals.

3) Plumbing Requirements

Follow the following guidelines:

- It is strongly recommended that manual isolation valves be installed in all interconnecting and drain lines (provided by others) to aid in the installation and maintenance procedures.
- The system feed water supply pressure must be within the Design range of the equipment (See Specification section).
- If the pressure is excessive (or fluctuating), install a pressure regulator in the feed water supply line.
- Each component of the system must be protected from water hammer that may occur.
- If there is excessive water hammer, install a properly sized accumulator in the feed water supply line.
- Customer must supply compressed air, inter-connecting piping and supply services.
- All plumbing connections should be made in accordance with state and local codes.

- Refer to the P&ID and Assembly Drawings for component location and identification.

a) Install a pipeline from the Water supply to be treated to the Inlet connection located on Multimedia Filter FM.

b) Install a pipeline from the Drain connection located on Multimedia Filter FM to an open type waste drain.

c) Install a pipeline from the Outlet connection located on Multimedia Filter FM to the Inlet connection located on the RO Skid.

d) Install a pipeline from the Reject connection located on the RO Skid to an open type waste drain.

e) Install flex hoses (supplied by others) from the Product connection located on the RO Skid to the Dual 30 ft^3 Service Water Softener columns Inlet connections.

f) Install a pipeline from the Product to Drain connection located on the RO Skid to an open type waste drain.

g) Install flex hoses (supplied by others) from the outlet connections of the Dual 30 ft^3 Service Water Softener columns to the Inlet connection located on the EDI Skid.

h) Install a pipeline from the Electrolyte Outlet connection located on the EDI Skid to an open type waste drain.

i) Install a pipeline from the Concentrate Outlet connection located on the EDI Skid to an open type waste drain.

j) Install a pipeline from the Outlet connection located on the EDI Skid to the To Boiler Feed connection (by others).

k) Install a pipeline from the Outlet To Drain connection located on the EDI Skid to an open type waste drain.

4) Electrical Requirements

- All electrical connections must be made in accordance with state and local codes.
- Refer to the P&ID and Assembly drawings for component location and identification.
- Refer to the Electrical Schematic drawing and the Specifications section of this manual for the wiring connections to be made.

G. INITIAL START-UP

1) Check List

a) All water used during Initial Start-up must be diverted to the waste collection system or drain.

b) These procedures are written with the assumption that manual isolation valves were installed in the connecting pipelines as advised in the installation section of this manual.

c) Prior to the system being placed in service, the Duplex Multimedia Filters, Ant-Scalant and Bisulfite Injection Systems, Reverse Osmosis (RO) Assembly, and Electrodeionization unit, along with the system piping must be made ready for operation.

d) Refer to the assembly drawing for each major component.

NOTE:

Prior to proceeding with Initial Start-up, the operator should read and follow the instructions described below.

2) Initial Preparation

a) Install the appropriate cartridge filter in 5 micron Filter Housing F-R1 located on the RO Unit.

b) Install the appropriate cartridge filter in Filter Housing F-C1 located on the RO / EDI Cleaning Skid.

c) Open the manual isolation valves supplying clean, compressed instrument air to the ROTROL Control Panel.

d) Set the Air Pressure Regulator on the cabinet to maintain the air pressure required for the operation of the automatic valves in the piping assemblies. (Refer to Specification Section II of this manual).

NOTE:

The solenoid valves and the automatic valves, they control in the piping assemblies, are match-marked. For example, solenoid valve SV-R1 on the ROTROL Control Panel controls the operation of the automatic RO Feed Inlet valve, V-R1 on the RO Skid.

C. DUPLEX MULTIMEDIA FILTERS UNIT A AND UNIT B

1) Hydrotest Multimedia Filter Unit A

Ready Duplex Multimedia Filters FM for Service

(1) Close all manual process valves.

(2) Make sure that the manual isolation valve in the air supply line to the Stager Controller Panel is open and the Air Pressure regulator is adjusted to maintain the required pressure to operate the valves in the Carbon Filter piping assembly. Refer to the Specifications section of this manual.

(3) Apply power to the Carbon Filter Stager Controller Panel and make sure the Stager Controller is in the service mode of operation. Refer to the instructions provided in the Manufacturer's Data section of this manual for detailed information on the use of the stager controller.

(4) Open manual vent valve H-M1A (H-M1B Multimedia Filter B).

(5) Slowly open manual inlet isolation valve to begin filling the vessel and piping. Make certain that automatic outlet valves are closed.

WARNING:

DO NOT EXCEED DESIGN PRESSURE. FAILURE TO FOLLOW THIS WARNING CAN RESULT IN SERIOUS INJURY TO PERSONNEL AND DAMAGE TO THE EQUIPMENT.

(6) Water will begin to fill the filter column. When water begins to flow to the waste drain from the Multimedia Filter Unit A, close manual vent valve H-M1A. Monitor pressure indicator PI-M2A until the Design Pressure is attained (refer to the Specifications section) and then close manual inlet isolation valve.

(7) Allow the filter column to remain pressurized for approximately 30 minutes and then check the column and piping for leaks. If leaks occur, relieve pressure, drain the column if necessary, and make repairs. Once repairs are made, refill the filter column, repressurize and check for leaks again.

The same procedure applies to Multimedia Filter B.

(8) When no leaks are found, drain the column as follows:

a. Leave manual inlet and outlet valves closed.

b. Leave power applied to the Stager Controller Panel.

c. Open manual vent valve V to relieve pressure in the column.

d. At the Multimedia Filter Stager Controller Panel, place the Stager Controller in the Backwash mode of operation. Refer to the instructions provided in the Manufacturer's Data section of this manual for detailed information on the use of the stager controller.

e. This will drain the column to approximately 1½ feet from the bottom. Leave the remainder of the water in the filter column to aid in the loading of the media.

f. Return the Stager Controller is in the service mode of operation (by cycling through the washing steps). Refer to the instructions provided in the Manufacturer's Data section of this manual for detailed information on the use of the stager controller.

Media Loading

CAUTION:

Do not load media until the assembly is anchored into place and supported. **When loading media, be careful not to damage the internal lining and distributors of the filter column. Do not allow any foreign objects to fall into the filter column. The presence of foreign objects may damage the internal lining and affect the outlet water quality.**

(1) Remove the top manway cover from the filter column and load the media. Level the lower levels of media as best possible and then load the remainder of the media into the column. After loading all of the media, replace the top manway cover.

The media must be loaded into each filter column in the order shown below.

TOP

Media Anthracite # 1.5	30 bags (1,560 lbs.)
Media Filter Sand	30 bags (1,500 lbs.)
Garnett fine silicate # 50W	1,100 lbs.
Garnett coarse silicate # 12W	800 lbs.
Gravel Medium 3/8 x 3/16	700 lbs.
Gravel Coarse 5/8 x 3/8	1,800 lbs.

BOTTOM

NOTE:

When replacing top manway covers, it is recommended that the gaskets be replaced.

(2) Once all of the filter media has been loaded into the filter columns the media must be Backwashed and Rinsed prior to initiating the service run.

Pre-Service Backwash and Rinse

(3) Fill the filter column with water by following the steps in the Hydrotest section.

(4) After the Multimedia Filter has been filled, place the Stager Controller in the Rinse mode of operation (by passing through the Backwash mode). Refer to the instructions provided in the Manufacturer's Data section of this manual for detailed information on the use of the stager controller. This will open automatic valves V-M1A and V-M4A (V-M1B and V-M4B Multimedia Filter B).

(5) Continue Rinsing the filter media for 20 minutes after the water flowing to the waste drain becomes clear. This can be accomplished by either disconnecting the power to the Stager Controller, or extending the time for Rinse.

(6) After initial Rinsing is complete (re-apply power if it was disconnected), place the Multimedia Filter in the Backwash mode at the Stager Controller (by passing through the Service mode and re-initiating Backwash). This will open automatic Backwash inlet and outlet valves V-M2A and V-M3A (V-M2B and V-M3B Multimedia Filter B).

(7) Continue backwashing the filter media for 20 minutes after the water flowing to the waste drain becomes clear. This can be accomplished by either disconnecting the power to the Stager Controller, or extending the time for Backwash.

(8) After Backwash is complete, place the Multimedia Filter in the Rinse mode at the Stager Controller by re-applying power (if disconnected) and allowing the Stager Controller to time-out, or by manually placing it in the Rinse mode. This will open automatic Rinse inlet and outlet valves V-M1A and V-M4A (V-M1B and V-M4B Multimedia Filter B) and close automatic

Backwash inlet and outlet valves V-M2A and V-M3A (V-M2B and V-M3B Multimedia Filter B).

(9) Continue rinsing the filter media for 20 minutes after the water flowing to the waste drain becomes clear. This can be accomplished by either disconnecting the power to the Stager Controller, or extending the time for Rinse.

(10) After Rinsing is complete, place the Multimedia Filter in the Service mode at the Stager Controller by re-applying power (if disconnected) and allowing the Stager Controller to time-out, or by manually placing it in the Service mode. This will open automatic outlet valve V-M5A (V-M5B Multimedia Filter B) and close automatic Rinse outlet valve V-M4A (V-M4B Multimedia Filter B). Automatic Service inlet valve V-M1A (V-M1B Multimedia Filter B) remains open.

Once the Rinse phase is complete on both Multimedia Filters, the units are ready for service.

NOTES:

Be sure to return the time settings to their proper positions at the Stager Controller. Refer to the Specifications section of this manual.

This procedure is the same for both Multimedia Filters.

Proceed to ready the Anti-Scalant and Brine Chemical Injection Systems for Service.

H. ANTI-SCALANT INJECTION SYSTEM

Chemical Precautions:

When handling the Anti-Scalant chemicals used in this system, the following protective clothing should be worn: goggles which cover the eyes completely and are equipped with impact resistant glass or plastic lenses, a face shield, rubber gloves, apron and boots.

First Aid:

Contact with eyes or skin requires immediate rinsing of contacted areas with large quantities of water. See a physician immediately.

Contact with Eyes:

Even minute quantities of these chemicals (in either liquid or solid, strong or dilute form) require immediate cleansing with copious quantities of running water for a minimum period of 15 minutes. The eyelids should be held apart during the cleansing to ensure that all tissues of the eyes and lids will receive thorough contact with the water. See a physician immediately. No oils or oily ointments should be used unless prescribed by a physician.

Solution Preparation:

When mixing chemical solutions, always add solid or liquid chemicals in small portions to water to avoid reactive hazards. Mix the solutions with slow agitation. If heat build-up occurs, or unusual reactions appear to take place, stop Chemical addition

immediately. Always maintain an abundant supply of water for emergency use and flushing away spilled chemicals.

a. Safety Precautions:

(1) Refer to the relevant Material Safety Data Sheets as supplied by the manufacturer of the chemicals used.

(2) When preparing chemical solutions, make sure that all cleaning chemical compounds are dissolved and well mixed prior to system start-up.

b. Start-up Preparation:

(1) Fill the Anti-Scalant Chemical Solution Tank TK-R1 with water for the Initial Start-Up of the Anti-Scalant Injection System.

(2) Then place the Anti-Scalant Pump P-R2 selector switch, located on the Main Panel Assembly, in the AUTO position, and check the operation of the pump.

(3) Check the piping for leaks.

(4) Shut off pump and repair and any leaks

(5) Provide the Anti-Scalant Chemical Tank (100 % Anti-Scalant concentration). Approximately 3 ½ gallons Avista Vitec 3000.

(6) Refer to the Manufacturer's Data section of this manual for detailed instructions and set the pump stroke to 60 % and the frequency to 100 %. Place the Anti-Scalant Pump P-R2 selector switch on the Main Control Panel in the OFF position. .

NOTE:

The pump stroke and frequency parameters will require some adjustment during startup of the system (when Anti-Scalant is added).

The Anti-Scalant injection system is now ready for Service.

I. BRINE INJECTION SYSTEM

Chemical Precautions:

When handling the Brine chemicals used in this system, the following protective clothing should be worn: goggles which cover the eyes completely and are equipped with impact resistant glass or plastic lenses, a face shield, rubber gloves, apron and boots.

First Aid:

Contact with eyes or skin requires immediate rinsing of contacted areas with large quantities of water. See a physician immediately.

Contact with Eyes:

Even minute quantities of these chemicals (in either liquid or solid, strong or dilute form) require immediate cleansing with copious quantities of running water for a minimum period of 15 minutes. The eyelids should be held apart during the cleansing

to ensure that all tissues of the eyes and lids will receive thorough contact with the water. See a physician immediately. No oils or oily ointments should be used unless prescribed by a physician.

Solution Preparation:

When mixing chemical solutions, always add solid or liquid chemicals in small portions to water to avoid reactive hazards. Mix the solutions with slow agitation. If heat build-up occurs, or unusual reactions appear to take place, stop Chemical addition immediately. Always maintain an abundant supply of water for emergency use and flushing away spilled chemicals.

a. Safety Precautions:

(1) Refer to the relevant Material Safety Data Sheets as supplied by the manufacturer of the chemicals used.

(2) When preparing chemical solutions, make sure that all cleaning chemical compounds are dissolved and well mixed prior to system start-up.

b. Start-up Preparation:

(1) Fill the Brine Chemical Solution Tank TK-E1 with water for the Initial Start-Up of the Brine Injection System.

(2) Then place the Brine Pump P-E1 selector switch, located on the Main Panel Assembly, in the AUTO position, and check the operation of the pump.

(3) Check the piping for leaks.

(4) Shut off pump and repair and any leaks

(5) Provide the Brine Chemical.

13% Brine concentration:

Set the Brine Pump stroke to 47%

Set the Brine Pump Frequency to 100%

(3) Refer to the Manufacturer's Data section of this manual for detailed instructions and set the pump stroke and frequency. Place the Brine Pump P-E1 Selector Switch on the Main Control Panel in the OFF position.

NOTE:

The pump stroke parameters will require some adjustment during startup of the system (when Anti-Scalant is added).

The Brine Injection System is now ready for Service.

J. REVERSE OSMOSIS SYSTEM

Installation/ Replacement of RO Membrane Elements

a. Familiarize yourself with the components of the RO pressure vessels and membrane assemblies as shown on the enclosed drawings and the manufacturer's data.

WARNING:

PRIOR TO INSTALLATION OR REPLACEMENT, BE SURE THAT PRESSURE IS RELIEVED FROM THE PIPING AND RO PRESSURE VESSELS. FAILURE TO COMPLY WITH THIS WARNING CAN RESULT IN SERIOUS INJURY TO PERSONNEL AND DAMAGE TO EQUIPMENT.

b. Remove all piping/tubing connected to the end caps of the RO pressure vessels. This is most easily accomplished by removing the header assemblies as a unit, breaking at common points on each vessel.

c. Once the piping/tubing has been removed, loosen the retaining rings on each cap-end.

d. Remove the retaining rings and end caps from both ends of the housing.

Steps 5 to 10 describe the procedure for removing the membrane elements from the pressure vessels. If the elements are to be installed in empty pressure vessels, go directly to Step #11.

e. Inspect the end-closure O-ring and discard if there is any sign of damage.

f. Remove the end adapter from each membrane end, and inspect all O-rings for damage. Also check the end adapters for cracks and scored surfaces. Replace the damaged components.

g. From the tube side marked with letter "F" on the vessels final assembly drawings, push the “feed” side membrane down toward the opposite end of the pressure vessel.

NOTE:

A pipe of i.d. large enough to pass over the membrane connection may be used to push the membrane once it moves beyond easy reach. Make sure to support each membrane as it protrudes from the opposite end of the vessel so as not to crack the inter-connectors or damage the membrane elements by dropping them on the ground.

h. As the first membrane protrudes from the opposite end of the vessel, use a gentle twisting motion to disconnect the membrane from the inter-connector.

i. Remove the inter-connector from the end of the membrane remaining in the vessel and continue to push the membrane elements through the vessel until the vessel is empty.

j. Inspect all inter-connectors for cracks, interior scoring, or any other damage. Inspect the inter-connector O-rings for damage. Replace the damaged components.

k. Start loading the membrane elements by locating the "U-Cup" brine seal on the "feed" end of the membrane.

NOTE:

If loose wrapped membranes are used and a brine seal is provided discard the brine seal. Note the direction in which the seal rolls. All membranes are loaded with the open end of the brine seal facing the "feed" side of the vessel. Lubricate each brine seal with glycerin.

l. From the "feed" side (marked with letter "F" on some membrane elements), push the first element into the pressure vessel making sure that the brine seal is oriented as indicated in Step #11. Leave about 6 in. of the element exposed beyond the end of the vessel.

m. Apply glycerin to the O-rings inside both ends of the membrane element inter-connectors, and slide one end of the inter-connector over the element end fitting extending out of the housing.

n. Lubricate and orient the second membrane element to be loaded as indicated above. Align the element with the one previously installed, and slide the exposed end of the membrane inter-connector over the end fitting on the "downstream" side of the second element. Push both membrane elements until the second element is exposed about 6 in. beyond the vessel.

o. Repeat the steps described above until all the membrane elements have been loaded in the pressure vessel (in this case it is 4 elements/vessel).

p. Push the last membrane element into the vessel until the space left between the end of the first and last elements, and their respective vessel ends is uniform.

q. Lubricate the interior O-rings of each end connector and slide them into the remaining end fittings of the first and last elements.

r. Install the thrust rings.

s. Lubricate the exterior O-ring of the exposed ends of each end connector and the end cap O-rings. Re-install the end cap O-rings into the grooves of the end cap inner faces.

t. Align the extended tube end of the end cap over the end connector on the membrane at either end of the pressure vessel. While making sure that the elements do not move within the vessel, push the end cap onto the end connector until the cap is flush with the vessel-end. Replace the ring over the end cap and vessel-end, tightening the retaining nut, "hand tight".

u. Use the same procedure to install the opposite end cap, and then tighten the retaining ring screws with an Allen wrench. DO NOT OVER-TIGHTEN.

v. Use the procedure described above for each pressure vessel, and replace the piping/tubing headers removed in Step #2.

w. Once the unit has been assembled, hydro-test the RO unit with water at 100 psig. Turn the RO pump, P-R1 Hand-Off-Auto selector switch to the Hand position on the Main Control panel to start the pump. Adjust the pressure to 100 psig.

x. Check for leaks after the unit has been placed in Service.

y. Relieve the pressure and tighten leaks as they are noted. If leaks persist, inspect the surfaces of the leaking components for damage. Replace components as necessary.

IMPORTANT NOTE:

The Anti-Scalant injection pump must be manually operated in order to prevent scaling of the RO Membranes during the initial RO unit filling.

RO Membrane Pre-Service Flushing

(6) Remove the covers from the Cleaning connections and install hoses supplied with the RO / EDI Cleaning Skid, in the product water and reject lines from the cleaning connection CIP-R4 (Product) and CIP-R3 (Reject) to the drain. Secure each hose so that it will not whip around when pressurized.

CAUTION:

Membrane elements are flushed to remove the membrane preservatives. Water containing the preservative can be harmful if consumed by humans or animals. Hence, during flushing the RO unit, product water and reject stream must be diverted to drain.

NOTE:

Make certain all equipment upstream of the RO Unit is in the Service mode of operation, supplying water to the RO Unit.

(1) Open Sample valves S-R4, S-R5, S-R6, S-R7, S-R8, S-R8, S-R9, S-R10.

NOTE:

The sample valves are opened to purge the air from the RO pressure vessels and piping during the filling of the RO vessels.

(2) Make sure that the RO Pump P-R1 selector switch is in the OFF position.

(3) Use the manual override button of Solenoid Valve SV-R1 on the ROTROL Control panel to open automatic inlet valve V-R1 then open manual Cartridge Filer F-R1 outlet valve H-R3. Also open manual pump inlet and discharge valves H-R7 and H-R4.

(4) Water will start flowing through the RO pressure vessels. Slowly close the manual sample valves as water begins to flow from each one

(5) Flush the membranes until there are no traces of the preservative present in the water flowing to the drain (a good indicator is no foaming).

(6) Check the RO piping for leaks. If leaks occur shut down the water supply and make the repairs, before completing flushing.

(7) After all traces of the preservative have been flushed from the membrane elements, prepare the RO unit for Service as described in the next section.

(8) Do not remove the cleaning hoses that are attached to the cleaning connections.

RO Unit Service Preparation

Before proceeding further, review the procedure described above.

(9) Make sure that the RO Pump P-R1 selector switch is in the OFF position.

(10) Set the RO Pump discharge ball valve, H-R4 to 75% Open.

(11) Open the RO Reject needle valve H-R5 halfway.

NOTE:

Read the instruction manual prior to starting a particular pump (refer to the Manufacturer's Data section). Prior to the operation of each pump, check the alignment, lubrication and rotation per instructions in the pump manual.

(12) Place the selector switch for the RO Pump, P-R1, in the HAND position to check the pump rotation (quick on/off jog of the RO Pump selector switch). If the rotation is incorrect, have the motor wiring corrected by authorized personnel.

CAUTION:

Do not run any pump with the automatic inlet and manual outlet valves closed. Otherwise, the pump seals may get damaged.

(13) Once RO Pump P-R1 rotation is checked, place the pump selector switch in the AUTO position.

(14) Once the RO Pump begins operation, adjust Reject needle valve H-R5 to obtain a 42 GPM Reject flow rate read on RO Reject Flow Indicator FI-R1.

(15) Adjust Reject Recirculation valve H-R6 to obtain a 5 GPM flow rate indicated on Reject Recirculation Flow Indicator FI-R2.

(16) Throttle manual RO Pump discharge valve H-R4 to obtain an RO product flow rate of 167 GPM as read on RO Product Flow Indicator FI-R3.

NOTE:

It is likely that flow alarms will occur during this setup. As a result, the RO may need to be restarted several times before the flow adjustments are finalized.

(17) Once the reject flow rates have been set, place the RO pump selector switch on the Main Control Panel in the OFF position.

(18) Check that all solenoid valve manual override buttons are in the normal position. Disconnect the cleaning hoses from the RO Unit and replace the Cleaning connection covers.

The RO System is now ready for normal service.

1) DUPLEX 30 FT^3 SERVICE WATER SOFTENERS

(a) Attach flex hoses (by others) from the RO Outlet connections to the Duplex 30 ft^3 Service Water Softeners inlet connections.

(b) Attach flex hoses (by others) from the Duplex 30 ft^3 Service Water Softeners outlet connections to the Inlet connection located on the EDI Skid.

The Duplex 30 ft^3 Service Water Softeners are now ready for normal service.

2) EDI UNIT START-UP

Ready EDI System for Service

NOTES:

Divert all Product, Electrode and Concentrate water to an open type waste drain during the Initial Start-Up of the System.

The E-Cell MK-2 Stacks™ may require regeneration. To regenerate the MK-2 Stacks, the system is started up and operated as normal, however, the product water is sent to drain until it is acceptable. During regeneration, the product water quality will rise from <1 Mohm.cm to +16 Mohm.cm.

The start up will be initially done in Manual, however, once all flow rates and pressures have been set, the system will be restarted in Automatic. It is important to have the system operating in Automatic as soon as possible as this allows the PLC to monitor the system and shut it down if the operating conditions are unsafe. For MK-2 Stacks that are regenerated, the same procedure will be followed, however the time required to reach +16 Mohm.cm will be significantly less.

The basic steps involved in the system start up are:

a) Fill the system with high quality water

b) Set dilute flow

c) Set concentrate flow

d) Set the concentrate inlet pressure

e) Set the electrode flow

f) Start the rectifier

A. EDI START UP

Once the E-Cell System™ is ready for start up, the Concentrate Loop must be filled. The initial filling is done with R.O. permeate (or other high quality water). The feed water must always meet all the quality requirements, this will require the R.O. to be rinsed to quality before being placed into Service and sending water to the E-Cell System™. The conductivity of the Concentrate loop will initially be the same as the Feed water conductivity. During regeneration, the conductivity may rise significantly to 1000-2000 μS/cm. This rise in conductivity is due to the salt (NaCl) solution that is present in the MK-2 Stacks from shipping. Systems with MK-2 Stacks shipped in the regenerated state, would not experience this rise in concentrate conductivity.

In order for the E-Cell System™ to function effectively, the Concentrate Loop should have an operating conductivity of 150-600 μS/cm. In some cases, it may be necessary to

inject concentrated brine into the Concentrate Loop in order to raise the conductivity once the system is operating.

Before you start, check:

a) MK-2 Stack dimensions checked

b) Installation check list is complete ("Installation Instructions" Section)

c) All Valves are closed

d) All pumps are in the "Off" position

e) Rectifier is in the "Off" position

f) Safety equipment is installed and operational.

(1) Fill Concentrate Loop

a) Open Concentrate Valve H-E2

b) Open the Concentrate outlet Valve H-E4

c) Slowly crack open the Dilute Feed Inlet Valve H-E1, maintain a low feed pressure (less than 40 psi) to the MK-2 Stacks to ensure a slow Concentrate Loop fill

d) Once water flows continuously through the Concentrate outlet (no bubbles), close all valves

The E-Cell System™ is now ready to flow water.

1) START UP PROCEDURE

Establish Dilute flow

a) Open the Dilute Rinse Outlet Valve H-E6 10-20%

b) Close the Dilute Product Outlet Valve H-E5

c) Slowly open the Dilute Feed Inlet Valve H-E1

d) Adjust the Dilute Rinse Outlet Valve to establish a 7.5-15.0 gpm/MK-2 Stack (1.70-3.41 m^3/h) flow rate.

Establish Concentrate and Electrode flow

a) Open Concentrate Inlet Valve H-E2

b) Open the Concentrate Outlet Valve H-E4. Adjust Concentrate Outlet valve H-E2 to attain 17 GPM. Approximately 10% of Product flow, 0.75 gpm/MK-2 Stack if Dilute flow is 7.5 gpm/MK-2 Stack (0.17 m3/h for 1.7 m3/h/MK-2 Stack)

c) Slowly adjust the Concentrate Inlet Valve H-E2 until the Concentrate Inlet is 5-10 psi (0.35-0.7 bar) less than the Dilute Feed pressure. If the Concentrate Inlet Valve is 100% open, and the pressure difference is still greater than10 psi (0.7 bar), throttle the Dilute Feed Inlet Valve H-E1 to decrease the Dilute Inlet pressure. The Dilute Rinse Outlet Valve will also require adjustment in order to maintain the required Dilute flow).

d) Open the Electrode Outlet Valve H-E3 to achieve 3.5 gpm. Approximately 0.25 - .35 gpm/MK-2 Stack (60 l/h)

e) Re-adjust Concentrate Inlet Valve H-E2 again if the pressure difference between Concentrate and Dilute Feed is not 5-10 psi (0.35-0.7 bar).

f) Set Concentrate Bleed Valve H-E2 to achieve the required recovery. The recovery rate is calculated by

$$\text{Recovery} = \frac{\text{Product Flow}}{\text{Product} + \text{Concentrate Bleed} + \text{Electrode Flow}} \text{ x } 100\%$$

The level of hardness in the feed water determines the Recovery rate.

Feed Hardness (ppm as $CaCO_3$)	E-Cell MK-2 Recovery[1]	NaCl Injection into C-loop [2] (uS/cm)
0.0 – 0.10	95%	- -
0.10 – 0.50	90%	+ 400 – 500
0.50 – 0.75	85%	+ 400 – 500
0.75 – 1.00	80%	+ 400 – 500

g) Lowering the recovery lowers the hardness level in the concentrate loop and hence decreases the scaling potential.

h) NaCl injection also reduces the electrical resistance of the stack, and hence the power consumption.

NOTE:

In conditions with very low Feed water pressures, it may be necessary to throttle the Concentrate Pump (OPTIONAL) Discharge Valve in order to achieve the required flows and pressures. This is the reason for the diaphragm valve on the pump discharge.

Confirm All Flows and Pressures

a) Electrode flow is 0.25 - .35 gpm/MK-2 Stack (60 l/h).

b) Dilute Flow is 7.5-15.0 gpm/MK-2 Stack (1.70-3.41 m^3/h).

c) Concentrate Bleed Flow is set for the appropriate recovery.

d) Dilute Feed pressure is 5-10 psi (0.35-0.7 bar) more than Concentrate Inlet pressure.

e) Dilute Product pressure is 5-10 psi (0.35-0.7 bar) more than Concentrate Outlet pressure.

Adjust flows and pressures where required.

Power up Rectifier

CAUTION

The Rectifier will be initially started in Manual mode, with the system operating in Manual mode. This is only a temporary arrangement to confirm the Rectifier operation. If the Rectifier is operating with no flow, the MK-2 Stacks will suffer irreparable damage. Once the Rectifier operation has been confirmed, the system must be shut down and restarted in Auto so that the PLC can monitor the system and shut it down if required.

a) Confirm Rectifier hand switch is in the OFF position

b) Set current to 0%, turn the knob counter clockwise (0 Amps)

c) Set voltage to 100%, turn the knob clockwise (the rectifier may not reach 600 Volts while in operation, but this configuration allows it to go up to 600 volts if required.)

d) Switch Rectifier hand switch to HAND

e) Press the FAULT RESET button

f) Press START button

g) Slowly increase current to 2 amps/MK-2 Stack. If the concentrate conductivity is low, the maximum current will also be low. As the concentrate conductivity increases, so will the current.

NOTE:

With this configuration, the Rectifier to be current limited, the Rectifier will adjust voltage 0-600 VDC in order to maintain the 2 amp/MK-2 Stack current.

NOTE:

If there is no current flow (but 600 VDC, and 150 μS/cm Concentrate conductivity), turn off the Rectifier and power supply and shut the down the system. Check that all E-Cell MK-2 Stack™ power cables are tightly connected and all fuses are good. If the problem persists, review the Electrical Submittal. Failing this, contact E-Cell Corporation.

Once the system is operating satisfactorily with respect to flows, pressure and current, the system must be switched from Manual operation to Automatic operation.

2) AUTOMATIC OPERATION

Once the system has been started up in manual, and all flows and pressures set, it must be shut down and restarted in automatic.

a) Turn off Rectifier by pressing STOP, place the hand switch into AUTO

b) Turn off Concentrate pump (OPTIONAL) by selecting OFF with the hand switch then, place hand switch into AUTO

c) Place the hand switch on the Brine Pump (optional) to Off

d) Select “Service” from the operator interface

NOTE:

The Brine Pump is set in the “Off” position because the conductivity in the Concentrate loop may be high enough to allow sufficient current flow. If the Concentrate loop conductivity remains below 150 µS/cm after half an hour of operation, start the Brine Pump by selecting AUTO (Below 150 µS/cm, current flow may be too low). The brine injection should be ramped up very slowly to prevent a sudden conductivity increase and therefore a sudden current increase through the MK-2 Stacks which could blow a fuse.

Once the resistivity of the product water is sufficient, or above 16 Mohm.cm, the regeneration is complete. The Dilute Product Outlet valve may be opened and the Rinse Outlet valve closed.

CAUTION

This water treatment system contains dangerously high voltage, which is harmful to human health. Do not touch the system while the rectifier is charged. Make sure all appropriate safety equipment is in the area before continuing.

Shut Down Procedures

A. E-CELL SYSTEM™ SHUT DOWN FROM MANUAL OPERATION

a) Press the STOP button on the Rectifier, and then turn Rectifier hand switch to OFF.

b) Turn off the Concentrate Pump (OPTIONAL) by turning hand switch to OFF.

c) Turn off the Brine Pump by turning the hand switch to OFF.

If the system is to be shut down for a period, and the piping configuration allows the system to drain, some of the manual valves must be closed. They include the following:

a) Close the Dilute Feed Inlet Valve.

b) Close the Dilute Product Outlet Valve.

c) Close the Dilute Product Rinse Valve.

d) Close the Concentrate Bleed Valve.

e) Close the Electrode Outlet Valve.

B. E-CELL SYSTEM™ SHUT DOWN FROM AUTOMATIC OPERATION

If the E-Cell System™ is in Service, in the Automatic mode, the following steps must be taken for its shut down.

a) Press **F1** on the operator interface, this will place the system into Standby.

If the system is to be shut down for a period of time, and the piping configuration allows the system to drain, some of the manual valves must be closed. They include the following

a) Close the Dilute Feed Inlet Valve.

b) Close the Dilute Product Outlet Valve.

c) Close the Dilute Product Rinse Valve.

d) Close the Concentrate Bleed Valve.

e) Close the Electrode Outlet Valve

PLC Interlock Shut Down Conditions

Automatic shut down of the E-Cell System™ will occur if:

a) The Concentrate Flow Switch, the Concentrate Bleed Flow Switch, the Electrode Flow Switch or the Dilute Product Flow Switch detects low flow.

b) No “run” confirmation is received for the Concentrate Pump (OPTIONAL), or the pump hand switch is not in Auto

c) No “run” confirmation is received from the Rectifier

C. E-CELL SYSTEM™ PROLONGED SHUT DOWN

If the E-Cell System™ is shut down for more than three days, it must be prepared for long-term shutdown and storage, to hinder the development of biogrowth.

NOTE:

Power to the E-Cell MK-2 Stacks™ must be off during all steps of the preparation for long-term shutdown!

NOTES:

Allow E-Cell System™ to drain such that no standing water remains in the Stacks™.

Close all E-Cell System™ inlet and outlet valves so that Stacks™ remain moist. Alternatively, disconnect hoses and cap all five Stack fittings with original caps supplied.

After long-term shutdown, the endplate distances of the E-Cell MK-2 Stacks™ will require inspection and possibly adjustment. See the Section 3.9 for Stack endplate distance adjustment procedures.

After long-term shutdown, E-Cell MK-2 Stacks™ may require regeneration. Regeneration will require approximately 8 to 16 hours.

1) SAFETY

a) Depressurize all process lines to avoid high-pressure chemical spray.

b) The E-Cell System™ operates at high voltage. Before performing any maintenance, ensure rectifier power is off and the rectifier properly tagged and/or locked out.

b) Place all equipment up-stream of the EDI Unit into the Service mode operation. Water will begin to flow through the EDI Unit.

c) Open manual EDI Outlet to Drain valve H-E6.

d) Open manual EDI Feed valve H-E1.

e) Adjust manual Needle valve H-E2 to obtain an EDI Concentrate Return flow rate of 4.3 GPM on Flow Indicator FI-E1 and manual Needle valve H-E4 to obtain an Electrode to Drain flow rate of 2.0 GPM on Flow Indicator FI-E4 then manual Needle valve H-E8 to obtain a Concentrate Bleed flow rate of 4.3 GPM on Flow Indicator FI-E3.

f) Check all equipment and piping for leaks. If leaks occur, disable the Service mode of operation of the equipment up-steam, and then make repairs. After repairs are made recheck for leaks again. If no leaks occur, the EDI System is ready for Service Use.

Read the EDI Manufacturer's O&M manual for installation, start-up and maintenance instructions and operating procedures.

IV. OPERATIONAL DESCRIPTION

A. NORMAL SERVICE OPERATIONAL OVERVIEW

NOTE:

Detail description of the system is included in Section B – System/Component Operation

RO feed water pre-treatment is essential for ensuring efficient membrane operation, and preventing scaling and fouling of RO membranes.

Raw water to be treated enters the Demineralized Water System and flows into and through the Duplex Multimedia Filters in the parallel mode of operation. The media filters are used to remove suspended solids down to 10 micrometer (μm) in size. The filter is operated *automatically* via Controller / Stager and undergoes periodic washing to remove the sediment collected in the column. Only one Multimedia Filter is in washing at a time.

Water enters Multimedia Filter Unit A through automatic valve V-M1A and flows downward through the media in the column and exits the column through automatic valve V-M5A to the RO Skid.

Water enters Multimedia Filter Unit B through automatic valve V-M1B, flows downward through the media in the column, and exits the column through automatic valve V-M5B to the RO Skid.

The Dual Multimedia Filters will remain in the Service mode of operation until either the preset Time set point in the Controller / Stager or the Operator manually initiates the Washing mode of operation.

Duplex Multimedia Filters effluent water flows to the inlet of the RO System.

The water enters the RO System through automatic valve V-R1, passes through 5-Micron RO Prefilter F-R1, which is employed to remove particulate matter from the RO Feed water down to the 5-micron level, and then passes through manual filter outlet valve H-R3.

The water is then chemically treated with an Anti-Scalant Chemical solution, which is stored in Anti-Scalant Chemical Tank TK-R1 via Anti-Scalant Chemical Pump P-R2, which is preset to a fixed stroke and frequency achieved during the Initial Start-Up of the System.

The Anti-Scalant is employed to prevent build-up of scale on the RO Membranes.

The Anti-Scalant Chemical solution enters the RO Feed water stream through a Backflow preventer valve.

The water then passes through a static mixer MX-R1 to thoroughly mix the water and chemical solution and then flows to the RO System skid.

Pressure Switch PS-R1 monitors the Feed water pressure to RO Pump P-R1. Should the Feed water pressure decrease to the preset minimum set point, an alarm condition, PAL-R1 RO UNIT LOW FEED PRESSURE ALARM, will occur.

The alarm light on the RO Controller panel will illuminate and the alarm horn will sound. The RO FEED LOW PRESSURE alarm will be displayed on the display. The Feed Pump P-F1 (by others), RO and EDI units will shutdown.

The Feed water passes through manual Pump inlet valve H-7, Pump P-R1, which is employed to pump the water through the Single-Pass, two-stage (5:2 array) RO unit and then passes through manual pump discharge valve H-R4.

A Variable Speed Drive VFD-R1 controls RO Feed Pump P-R1.

Conductivity Element AE-R1 and AE-R2 monitor the Conductivity of the RO Feed Water.

Should the percent rejection across the RO unit decrease to the preset minimum set point, an alarm condition, AAL-R1, RO LOW PERCENT REJECTION will occur. The alarm horn will sound.

RO Pressure vessels PV-R1, PV-R2, PV-R3, PV-R4 and PV-R5, constitute Stage I. Reject water from Stage I flows into Pressure Vessel PV-R6 and PV-R7 as Feed water, which make up Stage II. The reject water from Stage II Pressure Vessels is then split into two distinct streams.

The first stream, Reject Recycle is diverted back to the inlet of the RO Skid through manual needle valve H-R6.

The second stream, Reject to Drain is diverted to the waste drain through manual needle valve H-R5

Flow Element FE-R1 monitors the Reject water flow rate. Should the Reject water flow rate decrease to the preset minimum set point, an alarm condition, FAL-R1 RO REJECT LOW FLOW ALARM, will occur. The alarm light on the RO Controller panel will illuminate and the alarm horn will also sound. The RO REJECT LOW FLOW alarm will be displayed on the display.

Flow Element FE-R3 monitors the Product water flow rate. Should the Product water flow rate increase to the preset maximum set point, an alarm condition, FAH-R2 RO PRODUCT HIGH FLOW ALARM, will occur. The alarm light on the RO Controller panel will illuminate and the alarm horn will also sound. The RO REJECT LOW FLOW alarm will be displayed on the display.

Pressure Switch PS-R2 monitors the RO Product water pressure. Should the RO Product water pressure increase to the preset maximum set point, an alarm condition, PAH-R2 RO PRODUCT HIGH PRESSURE ALARM, will occur. The alarm light on the RO Controller panel will illuminate and the alarm horn will also sound. The RO PRODUCT HIGH PRESSURE alarm will be displayed on the display.

The product water from Stage I and Stage II is combined into a single header before it flows to the EDI skid through automatic valve V-R2.

Automatic valve V-R3 is only open during the Product Rinse mode of operation of the Reverse Osmosis System.

NOTES:

The RO and EDI Systems will remain in the Service (call for water) mode of operation until the DI Water Storage Tank (by others) reaches the preset maximum high-level set point shutting down the RO and EDI Systems.

When the DI Water Storage Tank (by others) sends a Call for Water signal, the RO will rinse to drain sequentially for two (2) minutes or until water quality set point is attained. (Product Rinse)

If the RO remains in the shut down mode for more than four hours, it will automatically flush to drain for two- (2) minutes.

The RO unit is inter-locked with the EDI unit.

The process water exits the RO skid and is diverted to the inlet of the Dual 30 ft^3 Service Water Softeners.

The water flows downward through the Dual 30 ft^3 Service Water Softener resins and is then diverted to the inlet of the EDI Skid.

The Softened water enters the Electrodeionization Skid through manual valves H-E1 and splits into two (2) streams. One feeding the ten (10) EDI modules in the parallel mode of operation and the second stream (Concentrate), flows through manual valve H-E2.

Flow Switch FSL-E2 monitors the Concentrate inlet flow rate. Should the Concentrate inlet water flow rate decrease to the preset minimum set point, an alarm condition, FAL-E2 EDI CONCENTRATE LOW FLOW ALARM, will occur. The alarm horn will sound, the red, EDI CONCENTRATE LOW FLOW alarm light on the Main Panel will illuminate and flash, Feed Pump P-F1 (by others), Reverse Osmosis and EDI Systems will shut down.

The first stream becomes Electrolyte and is diverted to the waste drain through manual valve H-E3. Flow Switch FSL-E3 monitors the Electrolyte to Drain flow rate. Should the Electrolyte water flow rate decrease to the preset minimum set point, an alarm condition, FAL-E3 EDI ELECTROLYTE LOW FLOW ALARM, will occur. The alarm horn will sound, the red, EDI ELECTROLYTE OUTLET LOW FLOW alarm light on the Main Panel will illuminate and flash, Feed Pump P-F1 (by others), Reverse Osmosis and EDI Systems will shut down.

Flow Element FE-E1 monitors the EDI Product water flow rate. Should the EDI Product water flow rate decrease to the preset minimum set point, an alarm condition, FAL-E1 EDI PRODUCT LOW FLOW ALARM, will occur. The alarm horn will sound, the red, EDI PRODUCT LOW FLOW alarm light on the Main Panel will illuminate and flash.

The EDI Product Resistivity is monitored by Resistivity Element AE-E1. Should the EDI Product water Resistivity decrease to the preset minimum set point, an alarm condition, AAL-E1 EDI PRODUCT LOW RESISTIVITY ALARM, will occur. The alarm horn will sound, the red, EDI PRODUCT LOW RESISTIVITY alarm light on the Main Panel will illuminate and flash, Feed Pump P-F1 (by others), Reverse Osmosis and EDI Systems will shut down.

The EDI Power Supply monitors the EDI Current. Should the EDI Current increase / decrease to the preset maximum / minimum set point, an alarm condition, AAHL-E2 EDI CURRENT HIGH ALARM / AAL-E2 EDI CURRENT LOW ALARM, will occur. The alarm horn will sound, the red, EDI POWER SUPPLY CURRENT HIGH ALARM / EDI CURRENT LOW alarm light on the Main Panel will illuminate and flash, Feed Pump P-F1 (by others), Reverse Osmosis and EDI Systems will shut down.

Conductivity Element AE-E2 monitors the EDI Concentrate conductivity. Should the EDI Concentrate conductivity decrease to the preset minimum set point, an alarm condition, AAL-E2 EDI CONCENTRATE LOW CONDUCTIVITY ALARM, will occur. The alarm horn will sound, the red, EDI CONCENTRATE LOW CONDUCTIVITY alarm light on the Main Panel will illuminate.

1) Duplex Multimedia Filter – Unit A & Unit B

Normal Service Operation

The normal mode of operation for the duplex filters is in parallel with both units in service.

During normal service operation, the water passes through automatic valve V-M1A. Water flows down through the layers of media and out Multimedia Filter Unit A through automatic valve V-M5A. Similarly, water passes automatic valve V-M1B. Water flows down through the layers of media and out Multimedia Filter Unit B through automatic valve V-M5B to the RO System skid.

The normal Service run continues until the Controller / Stager starts the Washing mode of operation based on preset time set point. The operator may also manually initiate the Washing at any time. Once initiated, the Washing proceeds automatically through a Backwash and Rinse cycle and then returns back to service mode. Note that only one Multimedia Filter can be in the Washing mode at a time.

2) SINGLE PASS REVERSE OSMOSIS UNIT WITH ANTI-SCALANT INJECTION

Reverse Osmosis

Reverse osmosis is a membrane process, whereby; the natural phenomenon of osmosis is reversed by the application of pressure to a concentrated solution in contact with a semi-permeable membrane.

If the applied pressure is in *excess* of the solution's natural osmotic pressure, the solvent will flow through the membrane to form a dilute solution on the opposite side and a more concentrated solution on the side to which pressure is applied. If the applied pressure is *equal* to the solution's natural osmotic pressure, no flow will occur, and if the applied pressure is *less* than its natural osmotic pressure, there will be flow from the dilute solution to the concentrated solution.

Osmotic pressure is proportional to the solution concentration and temperature, and depends on the type of ionic species present. For solutions of predominantly sodium chloride at ambient temperatures, a *rule of thumb* is that the osmotic pressure is 10 psi per 1000 mg/l concentration.

The rate of water transport across the membrane depends on the membrane properties, the solution temperature, and the difference in applied pressure across the membrane, less the difference in osmotic pressure between the concentrated and dilute solutions. The rate of salt transport across the membrane is proportional to the concentration difference across the membrane and is independent of the applied pressure.

Two parameters that quantitatively describe RO performance are product water recovery (PWR) and salt rejection (SR).

These are defined below:

$$PWR = \frac{\text{Product water flow rate}}{\text{Feed water flow rate}} \times 100$$

$$SR = \frac{\text{Salt concentration in feed - Salt concentration in product}}{\text{Salt concentration in feed}} \times 100$$

Cellulose acetate (CA) membranes were the first commercial membranes to be developed. These membranes marketed today are actually blends of cellulose acetate and cellulose triacetate. Cellulose acetate membranes are not as expensive as polyamide membranes and are more tolerant to chlorine. Because of this, CA is often preferred in wastewater applications where the SDI is high (> 5), and in potable water purification where residual chlorine is required.

The most commonly used RO membrane is a thin-film composite (TFC) polyamide membrane. Because of a very thin rejecting layer or skin, TFC membranes have a higher flux and at a lower pressure than CA membranes. These membranes are also not biodegradable, have a higher salt rejection than CA membranes; reject silica, nitrates and organic compounds much better than other types of membranes. TFC membranes are, however, susceptible to damage by chlorine.

The high rejection of TFC membranes is due to co-ion repulsion since the polyamide membrane has a net negative charge at a pH > 5.0. Below pH=4.0, the membrane has a net positive charge. Hence, at low pH values, e.g. due to the presence of carbon dioxide (carbonic acid), the rejection decreases as is often the case in second-pass RO. Carbon dioxide is converted to bicarbonate (HCO_3^-) and carbonate (CO_3^{--}) ions by raising the pH to > 7.5. These ions are well rejected by the polyamide RO membrane whereas CO_2 is not.

A typical RO system consists of either spiral-wound (SW) or hollow-fiber (HF) membrane elements housed in fiberglass-reinforced epoxy pressure vessels having burst strength approximately four to six times normal operating pressures, and containing the appropriate seals to prevent leakage. In the case of SW elements, the recovery is 8 to 10% per element.

Four to seven elements (*modules*) are connected in series in a single pressure vessel up to 20 ft. long to achieve a 50% recovery. The desired system capacity and recovery are achieved by connecting pressure vessels in parallel, and by staging the reject stream in an array of decreasing number of modules.

The recovery in each element is controlled by the concentration of rejected species, especially sparingly soluble salts of calcium and magnesium, and silica in the brine stream. Thus, when the PWR is 50%, the salt concentration in the reject stream is doubled whereas when the PWR is 75%, the salt concentration increases four-fold.

Feed water is introduced into the membrane module by a high pressure pump at pressures in the range of 150 to 450 psig for brackish water, and from 800 to 1,000 psig for sea water. The desalted product (permeate) is removed from the opposite side of the membrane at low pressure, and a flow-regulating valve on the brine side is used to create backpressure and control system recovery.

The pressure drop on the brine side is minimal, which allows the high-pressure brine (reject) to be fed to successive RO units (stages) to increase recovery (productivity). The brine volume gets reduced in each stage, so that the number of modules in successive stages is reduced (called *"tapered"* design) to maintain brine flow velocities specified by membrane manufacturers. Minimum brine flow velocity is essential in order to reduce the salt build-up (scaling) on the membrane surface, i.e. *concentration polarization.*

RO System Operating Conditions

The RO system operating conditions are given in Section II. Use the RO projections given in Section VI as a guide when selecting the operating conditions.

The RO unit consists of five pressure vessels arranged in a 5:2 staged-array. Each pressure vessel contains elements in series. *The RO unit design is based on the RO performance projections provided within this manual.*

RO system operating specifications are based on the following conditions:

- Feed water temperature remains within the specified temperature range.
- Feed water constituents remain within the 10% of the sample analysis.
- All feed water pretreatment is maintained.
- Product water flow rates are calculated at 50-psig backpressure.

NOTES:

Exceeding the maximum operating limits will damage the RO Pump and void the warranty. It is recommended that the RO Pump be operated within the design operating limits for maximum service life.

Product water backpressure exceeding the system pressure at any time will damage the RO membranes.

Always operate the RO Unit at the lowest system pressure that produces the design flow rate and percent rejection.

The initial minimum rejection percentage is salt-rejection based on chloride ions, and applies to each membrane element. The overall RO rejection may be lower depending on the array. In addition, changes in the polymer properties of the membrane may cause salt passage to double during the life of the membrane (3 years).

3) DUAL 30 FT^3 SERVICE WATER SOFTENERS

Normal Service Operation

The normal mode of operation for the Dual 30 Ft^3 Service Water Softeners is in parallel with both units in service.

During normal service operation, the water passes through the manual inlet valves of both units and flows downward through the resin in the columns then exits the columns through manual outlet valves where it is diverted to the inlet of the Electrodeionization Unit.

The normal Service run continues until the PLC starts the Washing mode of operation based on preset time set point. The operator may also manually initiate the Washing at any time. Once initiated, the Washing proceeds automatically through a Backwash and Rinse cycle and then returns back to service mode. Note that only one Multimedia Filter can be in the Washing mode at a time.

4) ELECTRODEIONIZATION SKID

EDI System Operation

When the EDI unit is in the normal Service mode of operation, the Softened Service water flows to the EDI skid through manual valve H-E1 and H-E2.

The Softened Service water enters the EDI Unit and splits into two streams. One portion is directed to the Feed section of the EDI as Dilute In and passes through the Unit where the deionization process occurs.

The second portion of the Softened Service water is directed to the Concentrate section of the EDI as Concentrate Inlet and passes through the EDI Unit where the deionization process occurs.

The Concentrate Inlet water is injected with a 13% Brine solution.

This Brine Injection is employed to raise the Concentrate Conductivity.

The Product water exits the EDI Unit and passes through automatic valve V-E2.

As the water exits the EDI Unit, Resistivity Indicating Transmitter AIT-E1 monitors the Resistivity of the EDI Product water.

A. WASHING/CLEANING

1) MULTIMEDIA FILTERS UNIT A and UNIT B

Washing Operation

The normal Service run continues until the preset time setpoint is attained then the Controller Stager starts the Washing mode of operation automatically or the Operator manually initiates the Washing mode of operation.

(1) Backwash Phase

When the Backwash phase starts, the amber MULTIMEDIA FILTER A WASHING status indicator light will illuminate.

During the Backwash phase, water enters the Multimedia Filter Unit A through automatic valve V-M2A (V-M2B for Multimedia Filter Unit B) and flows upward through the media bed @ 290 GPM. This upward flow of water through the media bed loosens any foreign matter that has collected on the media during the Service run and washes it out of the filter column, to the waste drain, through automatic valve V-M3A (V-M3B for Multimedia Filter Unit B).

This phase of regeneration will continue for 15 minutes and then the Controller Stager will initiate the Rinse phase.

(2) Rinse Phase

When the Rinse phase starts the amber MULTIMEDIA FILTER A WASHING status indicator light will still be illuminated.

During the Rinse phase, water enters the Multimedia Filter Unit A through automatic valve V-M1A (V-M1B for Multimedia Filter Unit B) and flows downward through the media bed @ 190 GPM. This downward flow of water through the media bed rinses any foreign matter that was loosened during Backwash and washes it out of the filter column, to the waste drain, through automatic valve V-M4A (V-M4B for Multimedia Filter Unit B).

This phase of regeneration will continue for 9 minutes and then the Controller Stager will place the Multimedia Filter Unit A or B back in the Service mode.

2) RO / EDI MEMBRANE/SYSTEM CLEANING

This section contains the following information:

- **Safety Precautions -** Overview of safety precautions to be exercised while cleaning or sanitizing RO systems.
- **Recommended Cleaning Equipment -** Additional equipment required for RO system cleaning and sanitizing operations.
- **Cleaning Chemicals** - Overview of recommended cleaning and sanitizing chemicals and handling guidelines
- **Cleaning Procedures -** Procedures for cleaning and sanitizing RO systems.

WARNING:

PRIOR TO EITHER CLEANING OR SANITIZATION THE RO SYSTEM, THE PERSONNEL RESPONSIBLE FOR CONDUCTING THESE PROCEDURES, MUST READ THE ENTIRE CLEANING SECTION. THEY SHOULD HAVE A FULL COMPREHENSION OF ITS CONTENTS. FAILURE TO DO SO CAN RESULT IN SERIOUS INJURY TO PERSONNEL AND DAMAGE TO THE EQUIPMENT.

RO MEMBRANE/SYSTEM CLEANING

Review the cleaning instructions recommended by the membrane manufacturer.

(3) Membrane Fouling

Particulates, organic and biological compounds, and colloids easily foul the RO membranes. The membranes are also prone to *scaling* by metal oxides and hardness compounds.

Fouling of the membranes is often the result of:

- Pre-treatment upset conditions.
- Failure of chemical injection systems.
- Inadequate flushing following shut down.
- Improper operation control.
- Slow build-up of salt precipitates over extended periods.
- Changes in the feed water composition.
- Biological contamination of feed water. Biological fouling is often slimy gelatinous and irreversible.

Fouling affects the performance adversely, resulting in reduced flux (gallons/ft^2/ day) [**Note,** flux is not the same as rate (gallons/min) and there is no such thing as flux rate], and higher salt passage. Increased pressure drop between the feed and concentrate side is usually an indicator of fouling.

Membrane Cleaning

Cleaning is accomplished very effectively because TFC polyamide membranes are quite stable in the pH range of 3-11, and can withstand temperatures of up to 85 ^{o} F. This project utilizes high temperature RO membranes, which can withstand temperatures up to 180^{o} F. If the time of cleaning is delayed for too long, however, it can be difficult to remove the foulants completely from the membrane surface.

Cleaning is tailored to the specific fouling problem. Sometimes the wrong cleaning chemicals can even worsen the situation. Therefore, the type of foulant should be determined prior to cleaning.

The following methods can be used to determine the type of foulant:

- Analyze the plant performance data. (See the section on Troubleshooting).
- Analyze the feed water.
- Check the results of previous cleanings.
- Analyze the foulants on the 0.45 μm membrane filter used for measuring SDI.
- Analyze the deposits on the cartridge filter.
- Inspect the inner surface of the feed line tubing and the feed scroll of the membrane element. If it is reddish-brown, fouling by iron materials may be considered.

a. If bacteria or mold has infected the RO membranes, **Sanitization** must be performed after cleaning as described below.

b. Upsets in feed water characteristics can also affect productivity and quality of membrane permeates. Changes in pre-treatment equipment performance should be considered prior to establishing that the membranes have fouled.

Water Quality. Water utilized to dilute chemical cleaning solution should be of RO permeate quality.

(4) Cleaning Frequency

The RO membranes should be cleaned when:

- The normalized permeate flow rate drops by 10%.
- The salt content of the permeate increases by 10%.
- The differential pressure (feed pressure - concentrate pressure) increases by 15% from the reference conditions (the initial performance established during the first 24 to 48 hours of operation).

For additional guidelines, see the Membrane Manufacturer's guidelines.

(5) RO Daily Log Sheets

The information recorded on the Daily Log Sheets should be used as the basis for determining an RO cleaning and disinfecting schedule. This information should also be used to measure the effectiveness of cleaning and disinfecting procedures. A sample of the Daily Log Sheet is located in the Engineering Data section of this manual. Details regarding the use of the Daily Log Sheet are located Process / Operation section of this manual.

Performance parameters recorded in the Data Log Sheet that is provided in the RO section of this manual must be scrutinized frequently to determine when cleaning is to be done. Note, only those sections of the form applicable to your unit need to be utilized. For the single-pass unit provided for this plant, use only the first-pass (primary RO) section.

It should be noted that the feed water temperature affects membrane productivity. A *rule of thumb* is that permeate flow rate increases 3% per ^{o} C.

Safety/Chemical Handling

WARNING:

PRIOR TO PREPARING ANY CLEANING CHEMICAL COMPOUNDS, THE PERSONNEL SHOULD READ THIS SECTION CAREFULLY. ALSO READ THE MATERIAL SAFETY DATA SHEETS PRIOR TO HANDLING A CHEMICAL.

Safety Equipment Requirements - When handling cleaning chemicals, the following protective clothing should be worn: goggles which cover the eyes completely and are equipped with impact resistant glass or plastic lenses, a face shield, rubber gloves, apron and boots.

First Aid - Contact with eyes or skin requires immediate rinsing of contacted areas with large quantities of water. See a physician immediately.

Contact With Eyes - Even minute quantities of cleaning chemicals (in either liquid or solid, strong or dilute form) require immediate cleansing with copious quantities of running water for a minimum period of 15 minutes. The eyelids should be held apart during the cleansing to ensure that all tissues of the eyes and lids will receive

thorough contact with the water. See a physician immediately. No oils or oily ointments should be used unless prescribed by a physician.

Solution Preparation – When making cleaning solutions, always add solid or liquid chemicals in small portions to water to avoid reactive hazards. Mix the solutions with slow agitation. If heat build-up occurs, or unusual reactions appear to take place, stop the addition immediately. Always maintain an abundant supply of water for emergency use and flushing away spilled chemicals.

Storage of Chemicals - Acid containers should be stored, preferably under cover, on a floor of acid resistant brick or concrete treated with Sodium Silicate. Suitable drainage facilities should be provided. If it is necessary to store acid outdoors, containers should be protected from direct sunlight provided with suitable drainage at the bottom tier, and stored in a properly drained site. Ample, natural ventilation should also be provided. Spilled acid should be removed immediately by flushing the contaminated area with large quantities of water. Soda Ash or Lime should be available for immediate neutralizing of spilled acid on concrete or wood floors. Again, allow ample ventilation when Soda Ash or Lime is used.

Safety Precautions – Follow the guidelines given below:

(1) When using cleaning chemicals, follow accepted safety practices as well as those recommendations set forth under the 'CHEMICAL HANDLING' portion of this section.

(2) Refer to the relevant Material Safety Data Sheets as supplied by the manufacturer of the chemicals used.

(3) When preparing cleaning solutions, make sure that all cleaning chemical compounds are dissolved and well mixed prior to circulating to the membranes.

(4) After cleaning, the permeate must be diverted to the waste drain for a minimum period of 10 minutes or until water purity is regained.

(5) Do not exceed operating temperatures specified within these procedures.

(6) Cleaning flow rates should not exceed the recommended cleaning flow rate (See Specifications).

(7) Operating pressure during Cleaning must not exceed 60 psig.

(8) Cleaning solutions should only be circulated in the normal flow direction of a membrane pressure vessel.

(9) Prior to operating the RO Cleaning Skid Pump, be sure to read the instruction manual for that particular pump, located in the Manufacturer's Data section of this manual. Do not run the pump dry since mechanical seal failure may result. Prior to operating the pump, check for proper shaft alignment and rotation. Lubricate per Manufacturer's instruction.

(10) Make sure that the materials that were used to build the cleaning skid and the cleaning chemicals to be used are compatible. Never use aluminum where it may contact the cleaning solution.

CAUTION:

All the components used in the RO cleaning system must be compatible with the cleaning chemicals to be utilized.

Cleaning System Requirements

Cleaning Skid

Cleaning Tank - The cleaning tank should be capable of holding a cleaning fluid volume in excess of the volume required to fill the maximum number of RO pressure vessels which will be cleaned at one time, and associated piping.

Cleaning Pump - The cleaning pump recirculates the cleaning fluid through the membrane pressure vessel. The recommended cleaning flowrates are given in the table below (based on the RO membrane diameter). *If more than one membrane vessel is to be cleaned at one time, multiply the flow by the appropriate number of vessels to be cleaned in parallel.*

Membranes may be cleaned in series, as long as each component of the series contains the same number of vessels in parallel.

Membrane Diameter (in)	Flow (gpm)	Pressure (psig)
2-1/2"	3-5	60
4"	8-10	60
8"	30-40	60

RO Pre-filter - The cleaning filter is sized to handle the full cleaning flow. The pore size rating is 5.0 μm (nominal).

Heater/Temperature Controller (Optional) - Cleaning is more effective when performed at an elevated temperature (85-90 ^{o} F).

Instrumentation - The cleaning system instrumentation typically includes pressure, temperature and flow rate measurement for monitoring and control.

Water Quality – Water utilized to dilute chemical cleaning should be of RO permeate quality.

Cleaning Chemicals

A relatively wide variety of chemicals are available to clean and sanitize RO membranes. In general, the compounds available are formulated to address specific membrane foulants. *Use the chemicals recommended by the membrane manufacturer*. Follow the recommended procedures for cleaning thin-film composite (TFC) membranes.

Harsh and frequent cleaning will shorten membrane life resulting in increased salt passage. Acid cleaners and alkaline cleaners are the standard cleaning chemicals. The acid cleaners are used to remove inorganic compounds such as iron and hardness salts, while the alkaline cleaners are used to remove organic compounds including biological matter.

CAUTION:

Sulfuric acid should not be used during cleaning because of the risk of calcium sulfate precipitation.

Preferably, RO permeate water should be used in the preparation of the cleaning solution although pre-filtered raw water will also work in most cases. The raw water is usually highly buffered; hence, more acid or hydroxide may be needed to reach the desired pH. The pH for acid cleaning must be > 2.0 and the pH level for alkaline cleaning must be < 12.0.

During cleaning, the pH range and maximum temperatures given in the table below must not be exceeded.

Max Temp 50 °C pH Range	Max Temp 35 °C pH Range	Max Temp 30 °C pH Range	Continuous Operation
2 - 10	1 - 11	1 - 12	2 - 11

Some cleaning chemicals may worsen the performance of the membrane after cleaning (e.g. by fouling and subsequent flux loss). The cleaning chemical must be compatible with the RO membrane to be cleaned.

CAUTION:

Follow the membrane manufacturer's instructions and observe the temperature and pH limits of the membrane being cleaned.

Inorganic Foulants – For inorganic salts or metal oxide foulants, an *acid* based cleaner is recommended. This compound contains organic acids, detergent builders and chelating agents, specifically designed to remove metal hydroxides, calcium carbonate and other similar scales.

The chemical is supplied in a dry powder form (40 lb. container), and should be mixed with RO permeate grade water**:** 2 lb. chemical/10 gal. water. This dosage makes a cleaning solution with a weight concentration of 3 % and a pH of ~ 3.0.

Organic Foulants - When foulants are suspected to be organic in nature, an *alkaline*-based cleaner is recommended. This compound contains detergent builders, chelating agents and a pH buffer, specifically designed to remove organics, silt and other particulate deposits.

The chemical is supplied in a dry powder form (40 lb. container), and should be mixed with RO permeate grade water**:** 2 lb. chemical/ 10 gal. water. This dosage makes a cleaning solution with a weight concentration of 3 % and a pH of ~10.0.

NOTE:

If both inorganic and organic cleaners are to be used, the inorganic cleaner should be utilized first, followed by a thorough rinsing of the membranes prior to cleaning with the organic cleaner.

Biofoulants - If bacteria or mold has infected the RO membranes, a *disinfecting* chemical must be used after the cleaning chemicals. Refer to the section "RO Sanitizing" below.

Cleaning Operations

(1) Installation

Receiving - Equipment handlers should not lift or pull the cleaning skid by its piping assembly. The piping assembly will be seriously damaged if subjected to temperatures above 120 °F.

Inspection - Upon receiving the cleaning system skid, a thorough inspection should be made for damage that may have occurred during transit. All damages should be reported to the carrier immediately.

Location - For cleaning systems, which are to be permanently connected to electrical, and water supplies, a location should be chosen adjacent to the RO unit (without impinging upon maintenance space requirements for the RO) so that the cleaning hoses can reach their appropriate cleaning connections on the RO unit.

Electrical Requirements - See the Specifications and Manufacturer's Data sections of this manual for pump and heater (if supplied) characteristics. Provide local "plug-in" type power source with a disconnect switch for mobile cleaning skids if one is not provided on the RO control panel.

Plumbing Connections - Connect a line from a deionized or reverse osmosis permeate water supply source for filling the cleaning tank.

Connect a pipe from the tank drain outlet to an open type waste drain. This pipe and drain must be capable of handling the disposed cleaning chemical.

OPERATIONAL CONSIDERATIONS

Prior to beginning the cleaning operation, a number of considerations must be made regarding your facilities operating practices. The cleaning process described in this section will produce wastewater, which may be high or low in pH.

See the section "Safety Precautions" discussed above.

If the floor drains in the area of the Reverse Osmosis unit cannot handle non-neutralized or hazardous wastewater, special flushing will be required each time cleaning hoses must be moved to clean a new stage, to avoid chemical spillage. This can be accomplished by flushing the cleaned stage with RO feed water.

pH Adjustment - If pH adjustment is required prior to draining the cleaning solution, mix the solution before draining. Use the cleaning skid pump to circulate the cleaning solution tank contents for mixing, and adjust the pH accordingly.

Cleaning Procedure

3) Pre-cleaning Preparation

a) Install new filter cartridge(s) in the RO / EDI Cleaning Skid Filter F-C1.

b) Turn OFF power to the RO unit.

c) Close the feed and effluent isolation valves to the RO unit.

d) Drain the RO unit as completely as possible.

e) Once unit is drained, close all vent and drain valves and cap any other openings.

f) Close all other manual isolation valves.

g) When preparing the cleaning solution make sure that all of the valves on the cleaning skid are closed.

4) Cleaning Connections

The cleaning procedures detailed below are identical for each RO stage to be cleaned. The cleaning connection locations on the RO unit, however, will change depending on which stage is being cleaned. The first stage is comprised of RO Vessels PV-R1 thru PV-R5. The second stage is comprised of RO Vessels PV-R6 and PV-R7.

The following table will indicate the cleaning connections to be used for the cleaning of each stage. The connections at the cleaning skid end do not change. It is important to note that the use for the cleaning connection may change. For example, the Reject cleaning connection CIP-R2 is the Feed connection during the cleaning of the second stage and the Reject Return connection during the cleaning of the first stage.

RO vessels	Feed Connection	Reject Connection	Product Connection	Cleaning Flowrate
PV-R1 thru PV-R5	CIP-R1	CIP-R2	CIP-R4	150-200 GPM
PV-R6 and PV-R7	CIP-R2	CIP-R3	CIP-R4	60-80 GPM

(2) Slow Flow Step

a) Prepare enough solution to 'Slow Flow' clean the stage(s) of the RO unit, which will be cleaned, by filling the cleaning tank deionized or RO permeate grade and then adding the required chemical quantities for the cleaning compound to be utilized.

b) Place the OFF / ON Selector Switch located on the RO Pump Motor Starter in the OFF position then place the Main Disconnect Switch to the ON position.

g) Recirculate the contents of the tank for 10 minutes by opening the manual pump suction and discharge valves H-C1 and recirculation valve H-C2, and then turn the RO Cleaning Pump P-C1 selector switch to the ON position.

NOTES:

There are three (3)-cleaning hoses provided with the RO / EDI Cleaning Skid.

Refer to the Cleaning Connections Table above for the appropriate connections to be used for the cleaning of each RO stage/pressure vessel.

Refer to P&ID drawing for component and connection locations.

h) Attach a cleaning hose between the Feed connection on the RO / EDI Cleaning Skid and Cleaning connection on the Feed side of the vessel(s) to be cleaned.

i) Attach a cleaning hose between the Product Return connection on the RO / EDI Cleaning Skid and Product Return Connection of the vessel(s) to be cleaned.

j) Finally, attach a cleaning hose between the Concentrate Return connection on the RO / EDI Cleaning Skid and the Reject Connection of the vessel(s) to be cleaned.

k) Open manual inlet valve H-C3 of the 5 micron Cleaning Solution Cartridge Filter F-C1.

l) Open the cleaning filter housing vent valve H-C6 slightly to remove entrapped air from the filter.

m) Slowly open the cleaning skid discharge valves H-C4 and close 5-Micron Cleaning Solution Cartridge Filter F-C1 vent valve H-C6.

n) Slowly close the cleaning skid recirculation valve H-C2 until the flow to the RO unit is 1/2 the cleaning flow rate per vessel. Refer to the Specifications section of this manual. The pressure should be low enough that essentially no product is produced.

o) Recirculate until one tank volume of solution has passed through the array and temperature has stabilized.

p) Turn the RO Cleaning Pump P-C1 selector switch to the OFF position and close the cleaning skid discharge valve H-C4. Do not drain the unit. Go on to the Soak step.

(3) Soak Step

a) Allow the solution from the slow flow steps to remain in the unit for at least one hour. Soak may continue overnight for highly fouled membranes.

b) Flush the membranes by allowing RO feed water into the unit (without starting the pump). Flush with a volume equal to two times that prepared for the Slow Flow step.

q) Drain the cleaning tank and Reverse Osmosis unit before beginning the High Flow step.

(4) High Flow Step

NOTE:

When preparing the cleaning solution make sure that all of the valves on the cleaning skid are closed.

a) Prepare enough solution to 'High Flow' clean the stage(s) previously soaked by filling the cleaning tank with a volume of deionized or reverse osmosis permeate grade water greater than the volume of the stage(s) to be cleaned, and any associated piping between the cleaning connections and the vessels and then adding chemical quantities required for the cleaning compound to be utilized.

b) Place the OFF / ON Selector Switch located on the RO Pump Motor Starter in the OFF position then place the Main Disconnect Switch to the ON position.

c) Recirculate the contents of the tank for 10 minutes by opening the manual pump suction and discharge valves H-C1 and recirculation valve H-C2, and then turn the RO Cleaning Pump P-C1 selector switch to the ON position.

d) Make sure the cleaning hoses are still connected to the proper cleaning connections from the Slow Flow step.

e) Open the cleaning filter housing vent valve H-C6 slightly to remove entrapped air from the filter.

f) Slowly open the cleaning skid discharge valve H-C4 and close 5 Micron Cleaning Solution Cartridge Filter F-C1 vent valve H-C6.and close the cleaning recirculation valve H-C2 until the flow to the RO unit is at the full cleaning flow rate per vessel. Refer to the Specifications section of this manual. The pressure should be low enough that essentially no product is produced.

g) Recirculate for 30 - 60 minutes.

h) Turn OFF the RO Cleaning Pump and close the cleaning skid discharge valves H-C4.

i) Flush the membrane elements by allowing RO feed water into the reverse osmosis unit without starting the pump(s)). Flush with a volume equal to two times that prepared for the High Flow step.

j) Drain the cleaning tank and prepare new cleaning solutions prior to cleaning subsequent stages or passes.

k) When the last pressure vessel is cleaned, refer to the "Post Cleaning Procedure".

Post Cleaning Procedure

When starting up the RO System after cleaning, the product water must be flushed to drain for a minimum of 10 minutes to ensure that all of the cleaning solution has been purged from the system.

Refer to the Start-up procedures described in Section III. Adjust the Reject to Drain and Product Water flow rates as necessary after restarting the RO System.

CAUTION:

If a second cleaning procedure with another chemical solution, or Sanitization is to be performed after the first cleaning procedure, ensure that there is no residual solution from the first cleaning solution in the RO system. Otherwise, a chemical reaction between the two solutions is likely, which may damage the membranes and/or associated parts.

B. MAINTENANCE / TROUBLESHOOTING

(1) General Guidelines

Maintenance is essentially a matter of good housekeeping. The following list should serve as a guide for maintenance:

a) Cartridge filters should be checked and serviced regularly.

b) RO membranes are to be cleaned based on the data recorded. Refer to the RO unit instructions.

c) Service all pumps as recommended by the manufacturer. Refer to the Manufacturer's Data section.

d) Routinely check the calibration of the instrumentation.

e) Valve diaphragms should be checked for defects at least once a year and replaced as necessary.

f) Keep the equipment clean. Exposed metal surfaces, except for stainless steel, should be given a protective coating of paint.

g) The customer must determine the Sanitization schedule and then follow that schedule to prohibit organic growth.

h) Multimedia Filter Media Replacement

Initial Preparation

Close the Filter vessel inlet and outlet valves. Shut down all downstream equipment, which is dependent upon the water supply from the filter.

Equipment - Provide the following equipment:

a) An industrial vacuum cleaner if available.

b) A hose with an adapter that can be connected to the vessel drain plug in the main piping assembly located at the bottom of the filter column.

c) Containers for taking away used media.

Drain the Vessels:

a) Turn OFF power to the solenoid panel, and close the manual influent and effluent isolation valves.

b) Open the manual vent valves, H-M1A and H-M1B to relieve pressure then close them.

c) Remove the vessel drain plugs located in the piping assembly at the bottom of the filter vessels. Refer to the Assembly Drawing 50040-01 for components and locations.

d) After removing the column drain plug, attach the hose with an adapter to it and run the hose to an open type waste drain. Open the vent valve, H-M1A and H-M1B.

e) Once the filter vessels are completely empty, replace the vessel drain plugs.

f) Remove the Media

g) Remove the manway covers at the top of the filter vessels.

CAUTION:

Be careful so as not to damage the internal lining of the vessel.

(2) The media may be removed by the following procedure:

<u>METHOD #1</u>: Remove the media through the top opening of the filter vessels with an industrial vacuum cleaner. In addition, METHOD #2 is required to remove the sub-fill if necessary.

<u>METHOD #2</u>: Remove the Side Manway on the bottom side of the vessel. Then, remove the remainder of the filter media by hand.

(3) Install New Media:

h) Refer to the media loading procedure described in Section III.

i) After loading the filter media, replace the manway covers and backwash/rinse the media as described in Section III.

NOTE:

Install new manway gaskets before replacing the manway covers, if necessary.

1) RO MAINTENANCE

Maintenance Schedule

PROCEDURE	FREQUENCY
Check system for leaks and failures	Daily
Collect operational data and adjust valves to achieve proper flow rates	Daily
Change prefilter cartridge elements	monthly or when the pressure differential reaches 10-15 PSIG, which ever occurs first
Test GFCI	monthly
Lubricate pump motor bearings	2 times a year
Calibrate instrumentation	2 times a year
Clean RO membrane elements	When normalized productivity rate drops by more than 15% of the clean membrane normalized productivity rate, when the RO feed pressure increases by 25 psig over the clean feed pressure, or when the RO rejection rate drops by more than 3%
Replace RO membrane elements	When cleaning the membranes fails to restore the proper performance *

* Contact Tenergy Christ Water for replacement.

C. MEMBRANE ELEMENT REPLACEMENT

Required down time: 2 - 6 hours

You will need the following:

- Safety equipment (glasses, boots, etc.)
- Lock-Out / Tag-Out equipment
- Rubber mallet
- 24 liquid ounces of glycerin
- Set of new membrane elements

a) Secure the unit for a short-term shutdown as described in Section 4.3

b) Remove the product pipe connection from the end of the pressure vessel by un-screwing the fittings in the product lines. Some water will inevitably drain from the broken plumbing connections so be prepared for a wet floor.

NOTE:

The <u>flow arrowhead sticker</u> located on one end of the pressure vessel indicates the direction of flow through the pressure vessel. You should unload and reload the new RO membrane elements in the direction of flow. This greatly reduces the chance of rolling or damaging the brine seals.

c) To determine the correct procedure for pressure vessel end cap disassembly, consult the pressure vessel manufacturer literature in the Appendix.

d) Remove the retaining rings that hold the end caps.

e) Carefully remove the end caps by applying even steady pulling force on them.

NOTE:

Be sure to make note of which end cap came out of which end of the pressure vessel so they may be reinstalled in the same vessels.

f) Push the old membrane elements out of the pressure vessel in the direction of the flow arrowhead sticker on the outside of the vessel.

g) Remove the membrane product tube adapters from the old membrane elements if they did not remain on the vessel end caps and keep them. Dispose of the old membrane elements.

h) Check the o-rings on the inter-connectors for damage and replace any that show signs of wear or damage. (It is a good idea to replace all the o-rings at the same time you replace the RO membrane elements). Apply a liberal coating of glycerin to the o-rings and brine seals before they are inserted back into the pressure vessel.

i) Remove enough new RO membrane elements from the protective packaging to fill one pressure vessel.

j) Install the inter-connectors between the RO membrane elements as you load them into the vessel.

k) Load the new membrane elements in the pressure vessel in the same direction as the flow arrowhead sticker. Make sure that the membrane brine seal is on the end to enter the pressure vessel last.

NOTE:

The flow arrow on the new RO membrane element should match the flow arrowhead sticker on the pressure vessel.

l) Carefully reinstall the product tube adapters on the ends of the membrane element product tubes. Apply a liberal amount of glycerin on the o-rings to make installation easier.

m) Carefully reinstall the end caps back in the ends of the pressure vessel, *taking care to put them in the same ends that they came out of.* Use a small amount of glycerin on the o-rings to make installation easier.

n) Carefully tap the end caps into place, using the rubber mallet. Re-assemble the end cap assembly per manufacture instructions.

o) Carefully reinstall the retaining rings in both ends of the pressure vessel.

p) Once all the membranes are replaced, reinstall the product piping connections.

q) Check all connections and vessels carefully.

F. RO TROUBLESHOOTING

Problem: Control Power Is Off

CAUSE	ACTION
Power source disconnect is opened or fuses have blown.	Check the power source and fuses.
RO unit Control Panel disconnect switch may be *open.*	Verify that the RO unit Control Panel disconnect switch is *closed*.
RO unit Control Panel fuses may be blown.	Check the fuses and replace them if necessary.
RO unit Control Panel low voltage circuit breaker may be tripped.	Check the Control Panel low voltage circuit breaker and reset it if necessary.

Problem: Ro Unit Will Not Start In The Hand Mode

CAUSE	ACTION
The RO unit pre-treatment interlock may be engaged because of a filter backwash or a softener regeneration cycle.	Check the operational status of the pre-treatment system. Check out the Control Panel circuitry to ensure the proper jumpers have been installed.
Low feed pressure fault may have caused the RO unit to drop out of service.	Turn the RO unit H-O-A switch to the OFF position and then to the AUTO position. Allow the RO unit to restart, and check that the feed pressure is at least 10 PSIG.
The RO unit Control Panel motor overload may have tripped.	Reset the motor overload and observe the operation of the RO unit to determine if this was a transient trip or if there is a more serious electrical problem.
The RO unit Control Panel may have an electrical component failure.	Inspect all components of the Control Panel.

Problem: Ro Unit Will Not Start In The Auto Mode

CAUSE	ACTION
The RO unit pretreatment interlock may be engaged because of a filter backwash or a softener regeneration cycle.	Check the operational status of the pretreatment system. Check out the Control Panel circuitry to ensure the proper jumpers have been installed.
The RO water storage tank may be full.	No action is required. unit is in standby mode, storage tank full indicator should be on.
The RO water storage tank level sensing device may be broken or require adjustment.	Inspect the electrical functioning of the RO water storage tank level sensing device. Inspect the settings of the RO water storage tank level sensing device.

Problem: Automatic Feed Water Valve Will Not Open

CAUSE	ACTION
Solenoid valve may have failed.	Replace the solenoid valve.
Feed water valve actuator may have failed.	Repair or replace the actuator.

Problem: Ro Unit Productivity Is Low

CAUSE	ACTION
RO unit operating pressure is too low.	Readjust the RO unit operating pressure.
RO unit product backpressure is excessive.	Check the pressure of the RO unit product plumbing, it should not exceed 90 psig. If it does, determine what is causing the pressure drop and reduce it.
RO unit feed water temperature is colder then usual. (Lower feed water temperatures require a higher operating pressure.)	Check the RO unit feed temperature. If it has decreased, increase the operating pressure to compensate for this low temperature operation.
RO unit membrane elements may be fouled.	Determine the nature of the foulant and clean the membrane elements.
Flow Indicator readings not accurate.	Verify correct operation of flow indicators. Clean out or replace if necessary.
RO pretreatment failure.	Inspect all pretreatment systems for problems.

Problem: Ro Unit Rejection Is Low

CAUSE	ACTION
Inadequate operating pressure.	Increase RO unit operating pressure by further opening the pump discharge valve.
RO unit recovery is too high.	Reduce RO unit recovery to match values listed in RO operating spec sheet in Appendix.
Shift in feed water chemistry (oxidants in feed water).	Check feed water chemistry. If substantially different from the original design feed water chemistry, have a new performance projection run to determine what the rejection rate characteristic should be.
Mechanical leak in the membrane element system.	Inspect all RO element product tube adapter o-ring seals.
RO feed water temperature increase.	Check feed water temperature. Install or adjust temperature controls, if necessary.
RO units concentrate to waste flow out of adjustment.	Check flow parameters and adjust system.
RO unit membrane elements may be fouled.	Determine the nature of the foulant and clean the membrane elements.

Problem: Can Not Achieve Proper Flow Readings

CAUSE	ACTION
Flow indicators not operating correctly.	Check for obstruction in piping, clean out flow indicator bore and replace if necessary.
Control valves not properly adjusted.	Reset the control valves.
Control valve may have failed.	Check that there are no obstructions or damage to the control valves. Check seats on ball valves for excessive wear.

The RO unit is now ready to be put back into service.

G. EDI MAINTENANCE

Preventative Maintenance

a) PRESSURE GAUGES

Every twelve months check calibration. Adjust as necessary.

b) CENTRIFUGAL PUMPS (IF SUPPLIED)

Every month check bearing lubrication and inspect pump gaskets and mechanical seals for leakage.

Regularly check motor temperature

c) CONDUCTIVITY SENSORS

Every three months clean sensors and check calibration.

d) FLOW INSTRUMENTS

Every three months check calibration.

e) DIVERT VALVES (Optional equipment)

Every four months lubricate and check for air leakage at actuator.

f) FLOW SWITCHES

Every six months check calibration (location on Rotameter) and operation.

g) HARDNESS ANALYZER

Change reagent cartridges, as they are exhausted.

h) E-CELL SYSTEM™

Check for proper recovery ratio once per week (minimum).

Check feed water quality on a regular basis. See the “Operating Instructions” section for more information on testing the feed water.

Monitor all E-Cell flow rates and pressures. See the “Operation Instructions” section for more information on trending the operating data.

Check for leaks on a regular basis. Attend to leaks immediately.

Maintenance personnel must exercise extreme caution as any leaking water may be electrically charged.

WARNING

TRAINED, CERTIFIED, SERVICE PERSONNEL MUST CARRY OUT ALL ELECTRICAL WORK.

CHECK GROUNDING WIRES ON MK-2 STACK, (GREEN / YELLOW WIRES BETWEEN SIDE PLATES AND END PLATES) AND ENSURE THEY ARE TIGHT. CHECK CONNECTIONS ONCE A QUARTER.

WARNING

CHECK HIGH VOLTAGE CONNECTION AT THE MK-2 STACK AND ENSURE THAT IT IS TIGHT. THE RECTIFIER MUST BE OFF WHEN WORKING ON THE HIGH VOLTAGE CABLES. CHECK CONNECTIONS ONCE A QUARTER.

DUE TO THE ELECTRICAL NATURE OF THE EQUIPMENT, IT MUST NOT BE CLEANED USING HIGH PRESSURE WATER.

H.E-CELL MK-2 STACK™ CLEANING AND SANITIZING

Overview

Over time cleaning and/or sanitization of the E-Cell MK-2 Stack™ may be necessary, due to:

- Hardness scaling, mainly in the concentrate and cathode chambers
- Fouling of the ion exchange medium or membranes with inorganic material
- Fouling of the ion exchange medium or membranes with organic material
- Biological fouling of the E-Cell MK-2 Stack™ and system piping and components
- Combinations of the above

Scaling in the concentrate and cathode chambers is a result of feed water minerals exceeding design limits or recovery exceeding design limits. Since the scaling effect is additive over time this can be the result even of cumulative, small, short duration excursions. Silica scaling can be very difficult to remove but hardness scaling can usually be dissolved with an acid cleaning. Circulating a low pH solution in the C-loop as discussed in Procedure 1 below is the recommended procedure for removing scaling in the concentrate and cathode chambers.

Inorganic fouling of the ion exchange material in the dilute chambers occurs when iron or manganese levels in the feed water exceed design limits or when very high TDS water is accidentally fed to the E-Cell MK-2 Stack™. Since scaling in the concentrate chambers can also occur in these conditions it is advisable to clean all chambers of the MK-2 Stack. Procedure 2 provides an acid cleaning of the dilute chambers and the concentrate and cathode chambers.

Organic fouling of the ion exchange material in the dilute chambers occurs when organic material in the feed water exceeds the design limits. Circulating a high pH brine solution through the dilute chambers squeezes organic molecules out of the ion exchange material. Circulating the same solution through the concentrate loop assists with the removal of any organic material that might have accumulated in the concentrate chambers. Procedure 3 accomplishes this. If there is a chance that inorganic fouling or scaling may also be present an acid recirculation step is performed first as indicated in Procedure 4.

Biological fouling of the E-Cell MK-2 Stacks™ and system components occurs when conditions for biological growth are conducive and any bacteria or algae are present. Regular sanitization before fouling becomes extensive is preferred to trying to clean and

sanitize a badly fouled MK-2 Stack. The high pH brine solution used in Procedures 3 and 4 are useful for routine, scheduled sanitization where the fouling has not had an opportunity to become heavy.

For installations where the biological fouling is heavy one of the stronger sanitizing agents discussed in Procedure 5 can be applied. Again, where inorganic fouling or scaling is suspected in addition to the biological fouling an acid recirculation step can be introduced as indicated in Procedure 6.

For severe biological fouling one of the steps in Procedures 5 or 6 can be performed at a high pH to further increase the effectiveness of the sanitization. These are discussed in Procedures 7 and 8.

For procedures 5 through 8 there is a choice of two different sanitizing agents.

The chart below summarizes the scaling and fouling conditions and the cleaning/sanitizing procedures best suited to correct the condition.

Procedure / Problem	1	2	3	4	5	6	7	8
C chamber scaling	Yes							
D chamber scaling		Yes						
Organic fouling			Yes					
Organic fouling and scaling				Yes				
Biological fouling			Yes					
Biological fouling and scaling				Yes				
Heavy biological fouling					Yes			
Heavy biological fouling and scaling						Yes		
Sever biological fouling							Yes	
Sever biological fouling and scaling								Yes

The table below summarizes the main steps that are performed for each procedure. These steps are provided in detail in subsections, which follow.

Proc.	1	2	3	4	5	6	7	8
Step 1	C Acid	Acid	Caustic	Acid	Brine	Acid	Brine	Acid
Step 2	Rinse	Rinse	Rinse	Caustic	Rinse	Brine	Rinse	Brine
Step 3	-	Regen	Regen	Rinse	Sanitize A or B	Rinse	Sanitize A or B	Rinse
Step 4	-	-	-	Regen	Brine	Sanitize A or B	Caustic	Sanitize A or B
Step 5	-	-	-	-	Rinse	Brine	Rinse	Caustic

Step 6	-	-	-	-	Regen	Rinse	Regen	Rinse
Step 7	-	-	-	-	-	Regen	-	Regen

WARNING

READ CLEANING PROCEDURES COMPLETELY BEFORE ATTEMPTING ANY CLEANING.

NOTES:

The cleaning procedures are written for a 120 GPM (27.3 m^3/h) E-Cell System™. For larger or smaller systems scale up or down proportionally. For example on a 360 GPM (81.8 m^3/h) E-Cell System™, maintain chemical concentrations and multiply all water and chemical amounts by three.

Acid cleaning of the concentrate chambers (Procedure 1) takes the least amount of time since there are only two main steps and the ion exchange material in the dilute chambers is not exhausted as it is in all other procedures.

E-Cell System™ cleaning requires up to 8 hours per cleaning procedure.

After cleaning, the E-Cell MK-2 Stacks™ must be regenerated (except Procedure 1). Regeneration requires up to 16 hours.

A Long Term Shutdown procedure must be followed if the E-Cell System™ is to be down for more than three days. This procedure is located in section 5.3.

1) Safety

a) Avoid contact with Halane (1,3-Dichloro-5,5-dimethyl hydantoin), sodium hydroxide, peracetic acid, hydrogen peroxide and hydrochloric acid, as these are corrosive. Hydrogen peroxide is an oxidizer.

b) Depressurize all process lines to avoid high-pressure chemical spray.

c) The E-Cell System™ operates at high voltage. Before performing any maintenance, ensure rectifier power is off and the rectifier properly tagged and/or locked out.

WARNING:

MK-2 STACK™ POWER POLARITY MUST NOT BE REVERSED OR MK-2 STACK™ DAMAGE WILL OCCUR.

2) Cleaning Chemical Specifications

All chemicals must be of recommended grade or better.

Sodium Chloride (NaCl) Food Grade (≥99.80%), ACS or USP grade

Halane (1,3-Dichloro-5, 5-dimethyl hydantoin) USP or ACS grade

Peracetic Acid (CH_3COOOH) and Hydrogen Peroxide (H_2O_2) 30%: ACS grade, or commercial concentrate for water system cleaning (ex. MinnCare, Oxonia, Divosan, Flocide)

Hydrochloric Acid (HCl) ACS or Technical grade

Sodium Hydroxide (NaOH): Pellets, NF, ACS or Purified grade; or 50% w/w Solution

NOTE:

Specifications for NaCl for cleaning are different from those for brine injection.

3) Legend

The E-Cell System™ process streams will be referenced throughout the cleaning procedures as follows:

a) Dilute Feed Inlet: D_{in}

b) Dilute Product Outlet: D_{out}

c) Concentrate Inlet: C_{in}

d) Concentrate Outlet: C_{out}

e) Electrode Outlet: E_{out}

I. CLEANING PROCEDURE 1: ACID CLEANING OF CONCENTRATE CHAMBERS

Refer to section above for general comments and requirements for cleaning.

A cleaning tank and pump and three hoses to connect the tank and pump to the E-Cell System™ are required.

This procedure provides an acid cleaning of the concentrate and electrode (anode and cathode) chambers of the MK-2 Stacks. The steps involved are:

- Preparation of the system for cleaning
- Makeup and recirculation of an acid cleaning solution through the concentrate loop.
- Rinse of the concentrate loop and return to operation

This step prepares the system for cleaning.

NOTE:

During hydrochloric acid cleaning some gas will be produced.

a) Shutdown the E-Cell System™ according to the Shutdown Procedures in the Owner's Manual. Ensure that power to the E-Cell MK-2 Stacks™ is off by turning the rectifier hand switch to OFF.

WARNING:

THE E-CELL SYSTEM™ OPERATES AT HIGH VOLTAGE. BEFORE PERFORMING ANY CLEANING OR MAINTENANCE, ENSURE RECTIFIER POWER IS OFF.

j) Close the E-Cell System™ Dilute Feed Inlet (D_{in}) Valve.

WARNING:

BEFORE CLOSING THE VALVE, SHUT OFF OR REDIRECT FEED FLOW TO ENSURE THAT THE FEED LINE AND EQUIPMENT (EX. RO OR TRANSFER PUMP) CANNOT OVER PRESSURIZE.

k) Close the following E-Cell System™ valves:

- Dilute Product Outlet (D_{out})
- Dilute Rinse Outlet
- Electrode Outlet (E_{out})
- Concentrate Bleed
- Concentrate Pump (OPTIONAL) Discharge
- Concentrate Pump (OPTIONAL) Suction

WARNING:

DEPRESSURIZE ALL PROCESS LINES TO AVOID HIGH-PRESSURE CHEMICAL SPRAY.

1) Acid solution Recirculation in the C-loop: 1.8% Hydrochloric Acid

Acid is recirculated by the cleaning pump, through the concentrate loop, to the MK-2 Stacks and back to the tank. Hydrochloric acid is not pumped through the concentrate loop pump as this might damage the stainless steel pump components.

a) Connect Concentrate Outlet (C_{out}) and E_{out} cleaning lines and direct them to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Connect the Concentrate Inlet (C_{in}) cleaning line to the (C_{in}) cleaning connection.

l) Fill the cleaning tank with 400 L of RO (or better) quality water

m) Make up 400 L (106 US gal) of HCl 1.8% solution in the cleaning tank:

- to 400 L of water, add **slowly** while mixing well 16.8 L/19.8 kg (4.4 US gal/43.6 lb) of HCl 37%.

WARNING:

AVOID CONTACT WITH HYDROCHLORIC ACID, AS THIS IS CORROSIVE.

n) Start the cleaning pump and run for 30 minutes at a flow rate of 8-24 GPM for a 120 GPM E-Cell System™ (1-3 GPM per MK-2 Stack). Crack open the Concentrate Bypass valve slightly to allow a small flow of cleaning solution through this arm of the Concentrate loop

o) Turn the cleaning pump off.

p) Drain the cleaning tank and pump.

2) Rinse system

This step removes the cleaning chemical from the system and prepares for a return to service.

a) Redirect the return cleaning lines from the cleaning tank to drain. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water.

c) Start the cleaning pump.

d) Run approximately 180 L of water through the E-Cell System™ in a range of nominal flows (and pressures), to half flows. Do not run the pump dry.

e) Turn the cleaning pump off.

f) Repeat the previous four steps once.

g) Drain the cleaning tank and pump.

h) Set up the E-Cell System™ to run as under operating conditions, except for power. Rectifier power must remain off.

i) Open Dilute Rinse Outlet Valve.

j) Disconnect cleaning lines.

k) Plug or cap cleaning connections.

l) Open E_{out} valve.

m) Open Concentrate Bleed valve.

n) Open Concentrate Pump (OPTIONAL) discharge and suction valves.

o) Open the E-Cell System™ Din Valve and run E-Cell System™ feed water through the system until Dout and Cout conductivities are no more than 50 uS/cm greater than feed water conductivity. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

J. CLEANING PROCEDURE 2: ACID CLEANING OF ALL CHAMBERS

Refer to section above for general comments and requirements for cleaning.

A cleaning tank and pump and five hoses to connect the tank and pump to the E-Cell System™ are required.

This procedure provides an acid cleaning of all chambers of the MK-2 Stacks. The steps involved are:

- Preparation of the system for cleaning
- Makeup and recirculation of an acid cleaning solution through all chambers of the MK-2 Stacks.
- Rinse of the system
- Regeneration of the MK-2 Stacks

1) Preparation

This step prepares the system for cleaning.

NOTE:

During hydrochloric acid cleaning some gas will be produced.

a) Shutdown the E-Cell System™ according to the Shutdown Procedures in the Owner's Manual. Ensure that power to the E-Cell MK-2 Stacks™ is off by turning the rectifier hand switch to OFF.

WARNING:

THE E-CELL SYSTEM™ OPERATES AT HIGH VOLTAGE. BEFORE PERFORMING ANY CLEANING OR MAINTENANCE, ENSURE RECTIFIER POWER IS OFF.

b) Close the E-Cell System™ Dilute Feed Inlet (D_{in}) Valve.

WARNING:

BEFORE CLOSING THE VALVE, SHUT OFF OR REDIRECT FEED FLOW TO ENSURE THAT THE FEED LINE AND EQUIPMENT (EX. RO OR TRANSFER PUMP) CANNOT OVER PRESSURIZE.

c) Close the following E-Cell System™ valves:

- Dilute Product Outlet (D_{out})
- Dilute Rinse Outlet
- Electrode Outlet (E_{out})
- Concentrate Bleed
- Concentrate Pump (OPTIONAL) Discharge
- Concentrate Pump (OPTIONAL) Suction

WARNING:

DEPRESSURIZE ALL PROCESS LINES TO AVOID HIGH-PRESSURE CHEMICAL SPRAY.

d) Acid solution Recirculation: 1.8% Hydrochloric Acid

e) Connect D_{out}, Concentrate Outlet (C_{out}) and E_{out} cleaning lines and direct them to the cleaning tank. **Cleaning lines must be secured so that no splashing or spraying of solution can occur.**

f) Connect the Din and Concentrate Inlet (Cin) cleaning lines to the Din and Cin cleaning connections, respectively.

g) Fill the cleaning tank with 400 L of RO quality (or better) water. Make up 400 L (106 US gal) of HCl 1.8% solution in the cleaning tank:

- in 400 L of water, add **slowly** while mixing well 16.8L/19.8kg (4.4 US gal/43.6 lb) of HCl 37%.

WARNING:

AVOID CONTACT WITH HYDROCHLORIC ACID, AS THIS IS CORROSIVE.

h) Start the cleaning pump and run for 30 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

i) Turn the cleaning pump off.

j) Drain the cleaning tank and pump.

2) Water Rinse

a) Redirect D_{out}, C_{out} and E_{out} cleaning lines from the cleaning tank to drain.

b) Cleaning lines must be secured so that no splashing or spraying of solution can occur.

c) Fill the cleaning tank with 200 L of RO quality (or better) water.

d) Start the cleaning pump.

e) Run approximately 180 L of water through the E-Cell System™ in a range of

f) Nominal flows (and pressures), to half flows. **Do not run the pump dry.**

g) Turn the cleaning pump off.

h) Repeat steps (ii) through (v) once.

i) Drain the cleaning tank and pump.

j) Set up the E-Cell System™ to run as under operating conditions, except for power. **Rectifier power must remain off.**

k) Open Dilute Rinse Outlet Valve.

l) Disconnect D_{out}, D_{in}, C_{out}, C_{in} and E_{out} cleaning lines.

m) Plug or cap D_{out}, D_{in}, C_{out}, C_{in} and E_{out} cleaning connections.

n) Open E_{out} valve.

o) Open Concentrate Bleed valve.

p) Open Concentrate Pump (OPTIONAL) discharge and suction valves.

q) Open the E-Cell System™ Din Valve and run E-Cell System™ feed water through the system until Dout and Cout conductivities are no more than 50 uS/cm greater than feed water conductivity. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

3) Regeneration

a) Regenerate the E-Cell MK-2 Stacks™. (Refer to “Start Up” in section 3)

K. CLEANING PROCEDURE 3: SODIUM CHLORIDE / SODIUM HYDROXIDE CLEANING/SANITIZING

Sodium chloride 5% / sodium hydroxide 1% is useful for cleaning fouling due to organics and for sanitization.

Refer to section above for general comments and requirements for cleaning.

A cleaning tank and pump and three hoses to connect the tank and pump to the E-Cell System™ are required.

This procedure provides a high pH cleaning/sanitizing of all chambers of the MK-2 Stacks. The steps involved are:

- Preparation of the system for cleaning
- Makeup and recirculation of a brine/caustic cleaning solution through all chambers of the MK-2 Stacks.
- Rinse of the system
- Regeneration of the MK-2 Stacks

1) Preparation

This step prepares the system for cleaning.

a) Shutdown the E-Cell System™ according to the Shutdown Procedures in the Owner's Manual. Ensure that power to the E-Cell MK-2 Stacks™ is off by turning the rectifier hand switch to OFF.

WARNING:

THE E-CELL SYSTEM™ OPERATES AT HIGH VOLTAGE. BEFORE PERFORMING ANY CLEANING OR MAINTENANCE, ENSURE RECTIFIER POWER IS OFF.

b) Close the E-Cell System™ Dilute Feed Inlet (D_{in}) Valve.

WARNING:

BEFORE CLOSING THE VALVE, SHUT OFF OR REDIRECT FEED FLOW TO ENSURE THAT THE FEED LINE AND EQUIPMENT (EX. RO OR TRANSFER PUMP) CANNOT OVER PRESSURIZE.

c) Close the following E-Cell System™ valves:

- Dilute Product Outlet (D_{out})
- Dilute Rinse Outlet
- Electrode Outlet (E_{out})
- Concentrate Bleed

WARNING:

DEPRESSURIZE ALL PROCESS LINES TO AVOID HIGH-PRESSURE CHEMICAL SPRAY.

WARNING:

POWER TO THE E-CELL MK-2 STACKS™ MUST BE OFF DURING ALL STEPS OF CLEANING!

2) Sodium Chloride / Sodium Hydroxide Solution Recirculation

a) Connect D_{out} and E_{out} cleaning lines and direct them to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Connect the D_{in} cleaning line.

c) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of NaCl 5% / NaOH 1% solution in the cleaning tank:

- In 200 L of water, dissolve 10 kg sodium chloride (NaCl) while mixing well

d) Dissolve slowly while mixing well 2 kg (4.4 lb) of sodium hydroxide pellets, or 4 kg / 3.1 L (8.8 lb / 0.81 US gal) 50% w/w sodium hydroxide solution.

WARNING:

AVOID CONTACT WITH SODIUM HYDROXIDE SOLID AND SOLUTION, AS THESE ARE CORROSIVE.

e) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 30 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

f) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

g) Drain the cleaning tank and pump.

3) Water Rinse

a) Redirect D_{out} and E_{out} cleaning lines from the cleaning tank to drain. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode).

d) Run approximately 180 L of water through the E-Cell System™ in a range of nominal flows (and pressures), to half flows. Do not run the pump dry.

e) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

f) Repeat steps (b) through (e) once.

g) Drain the cleaning tank and pump.

h) Set up the E-Cell System™ to run as under operating conditions, except for power. Rectifier power must remain off.

i) Open Dilute Rinse Outlet Valve.

j) Disconnect D_{out}, D_{in}, and E_{out} cleaning lines.

k) Plug or cap D_{out}, D_{in}, and E_{out} cleaning connections.

l) Open E_{out} valve.

m) Open Concentrate Bleed valve.

n) Open the E-Cell System™ Din Valve and run E-Cell System™ feed water through the system until Dout and Cout conductivities are no more than 50 uS/cm greater than feed water conductivity. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

4) Regeneration

a) Regenerate the E-Cell MK-2 Stacks™. (Refer to “Start Up” in section 4.)

L. CLEANING PROCEDURE 4: ACID AND SODIUM CHLORIDE / SODIUM HYDROXIDE CLEANING/SANITIZING

Sodium chloride 5% / sodium hydroxide 1% is useful for cleaning fouling due to organics and for sanitization. Where inorganic scale is also present it is removed first with an acid recirculation step.

Refer to section above for general comments and requirements for cleaning.

A cleaning tank and pump and five hoses to connect the tank and pump to the E-Cell System™ are required. Five hoses are required for the acid cleaning. Three hoses are required for the sodium chloride/sodium hydroxide cleaning.

This procedure provides an acid cleaning followed by a high pH cleaning/sanitizing of all chambers of the MK-2 Stacks.

The steps involved are:

- Preparation of the system for cleaning
- Makeup and recirculation of an acid cleaning solution through all chambers of the MK-2 Stacks.
- Makeup and recirculation of a brine/caustic cleaning solution through all chambers of the MK-2 Stacks.
- Rinse of the system
- Regeneration of the MK-2 Stacks

1) Preparation

This step prepares the system for cleaning.

a) Shutdown the E-Cell System™ according to the Shutdown Procedures in the Owner's Manual. Ensure that power to the E-Cell MK-2 Stacks™ is off by turning the rectifier hand switch to OFF.

WARNING:

THE E-CELL SYSTEM™ OPERATES AT HIGH VOLTAGE. BEFORE PERFORMING ANY CLEANING OR MAINTENANCE, ENSURE RECTIFIER POWER IS OFF.

b) Close the E-Cell System™ Dilute Feed Inlet (D_{in}) Valve.

WARNING:

BEFORE CLOSING THE VALVE, SHUT OFF OR REDIRECT FEED FLOW TO ENSURE THAT THE FEED LINE AND EQUIPMENT (EX. RO OR TRANSFER PUMP) CANNOT OVER PRESSURIZE.

c) Close the following E-Cell System™ valves:

- Dilute Product Outlet (D_{out})
- Dilute Rinse Outlet
- Electrode Outlet (E_{out})

- Concentrate Bleed
- Concentrate Pump (OPTIONAL) Discharge
- Concentrate Pump (OPTIONAL) Suction

WARNING:

DEPRESSURIZE ALL PROCESS LINES TO AVOID HIGH-PRESSURE CHEMICAL SPRAY.

WARNING:

POWER TO THE E-CELL MK-2 STACKS™ MUST BE OFF DURING ALL STEPS OF CLEANING!

2) Acid solution Recirculation: 1.8% Hydrochloric Acid

a) Connect D_{out}, Concentrate Outlet (C_{out}) and E_{out} cleaning lines and direct them to the cleaning tank. **Cleaning lines must be secured so that no splashing or spraying of solution can occur.**

b) Connect the D_{in} and Concentrate Inlet (C_{in}) cleaning lines to the D_{in} and C_{in} cleaning connections, respectively.

c) Fill the cleaning tank with 400 L of RO quality (or better) water. Make up 400 L (106 US gal) of HCl 1.8% solution in the cleaning tank:

- in 400 L of water, add **slowly** while mixing well 16.8L/19.8kg (4.4 US gal/43.6 lb) of HCl 37%.

WARNING:

AVOID CONTACT WITH HYDROCHLORIC ACID, AS THIS IS CORROSIVE.

d) Start the cleaning pump and run for 30 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

e) Turn the cleaning pump off.

f) Drain the cleaning tank and pump.

3) Water Rinse

a) Redirect D_{out}, C_{out} and E_{out} cleaning lines form the cleaning tank to drain. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water.

c) Start the cleaning pump.

d) Run approximately 180 L of water through the E-Cell System™ in a range of nominal flows (and pressures), to half flows. Do not run the pump dry.

e) Turn the cleaning pump off.

f) Repeat steps (ii) through (v) once.

g) Drain the cleaning tank and pump.

h) Disconnect C_{out} and C_{in} cleaning lines.

i) Plug or cap the C_{out} and C_{in} cleaning connections.

j) Open Concentrate Pump (OPTIONAL) discharge and suction valves.

k) Sodium Chloride / Sodium Hydroxide Solution Recirculation

l) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of NaCl 5% / NaOH 1% solution in the cleaning tank:

- In 200 L of water, dissolve 10 kg sodium chloride (NaCl) while mixing well
- Dissolve **slowly** while mixing well 2 kg (4.4 lb) of sodium hydroxide pellets, or 4 kg / 3.1 L (8.8 lb / 0.81 US gal) 50% w/w sodium hydroxide solution.

WARNING:

AVOID CONTACT WITH SODIUM HYDROXIDE SOLID AND SOLUTION, AS THESE ARE CORROSIVE.

m) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 30 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

n) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

o) Drain the cleaning tank and pump.

4) Water Rinse

a) Redirect D_{out} and E_{out} cleaning lines from the cleaning tank to drain. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode).

d) Run approximately 180 L of water through the E-Cell System™ in a range of nominal flows (and pressures), to half flows. Do not run the pump dry.

e) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

f) Repeat steps (b) through (e) once.

g) Drain the cleaning tank and pump.

h) Disconnect C_{out} and C_{in} cleaning lines

i) Plug or cap the C_{out} and C_{in} cleaning connections

j) Open Concentrate Pump (OPTIONAL) discharge and suction valves

k) Set up the E-Cell System™ to run as under operating conditions, except for power. Rectifier power must remain off.

l) Open Dilute Rinse Outlet Valve.

m) Disconnect D_{out}, D_{in}, and E_{out} cleaning lines.

n) Plug or cap D_{out}, D_{in}, and E_{out} cleaning connections.

o) Open E_{out} valve.

p) Open Concentrate Bleed valve.

q) Open the E-Cell System™ Din Valve and run E-Cell System™ feed water through the system until Dout and Cout conductivities are no more than 50 uS/cm greater than feed water conductivity. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

5) Regeneration

a) Regenerate the E-Cell MK-2 Stacks™. (Refer to “Start Up” in section 4.)

M. CLEANING PROCEDURE 5: HALANE OR PERACETIC ACID SANITIZING

Halane, a widely used source of chlorine, is useful for cleaning and sanitizing high-purity water treatment equipment. This is an oxidizing cleaning solution, which is effective primarily as a biocide against biofouling and secondarily a cleaner against organic fouling. Due to its oxidizing power, this cleaning solution should be used infrequently and the following directions for its use followed closely.

Peracetic acid 0.04% / hydrogen peroxide 0.2% performs similarly using a different chemical species. It should also be used only when necessary.

Refer to section above for general comments and requirements for cleaning.

A cleaning tank and pump and three hoses to connect the tank and pump to the E-Cell System™ are required.

This procedure provides a sanitizing of all chambers of the MK-2 Stacks. The steps involved are:

- Preparation of the system for cleaning
- Makeup and recirculation of a brine solution through all chambers of the MK-2 Stacks.
- Rinse of the MK-2 Stack to remove excess brine
- Makeup and recirculation of a Halane sanitizing solution through all chambers of the MK-2 Stacks OR
- Makeup and recirculation of a peracetic acid sanitizing solution through all chambers of the MK-2 Stacks
- Makeup and recirculation of a brine solution through all chambers of the MK-2 Stacks
- Rinse of the system
- Regeneration of the MK-2 Stacks

1) Preparation

This step prepares the system for cleaning.

a) Shutdown the E-Cell System™ according to the Shutdown Procedures in the Owner's Manual. Ensure that power to the E-Cell MK-2 Stacks™ is off by turning the rectifier hand switch to OFF.

WARNING:

THE E-CELL SYSTEM™ OPERATES AT HIGH VOLTAGE. BEFORE PERFORMING ANY CLEANING OR MAINTENANCE, ENSURE RECTIFIER POWER IS OFF.

b) Close the E-Cell System™ Dilute Feed Inlet (D_{in}) Valve.

WARNING:

BEFORE CLOSING THE VALVE, SHUT OFF OR REDIRECT FEED FLOW TO ENSURE THAT THE FEED LINE AND EQUIPMENT (EX. RO OR TRANSFER PUMP) CANNOT OVER-PRESSURIZE.

c) Close the following E-Cell System™ valves:

- Dilute Product Outlet (D_{out})
- Dilute Rinse Outlet
- Electrode Outlet (E_{out})
- Concentrate Bleed

WARNING:

DEPRESSURIZE ALL PROCESS LINES TO AVOID HIGH-PRESSURE CHEMICAL SPRAY.

WARNING:

POWER TO THE E-CELL MK-2 STACKS™ MUST BE OFF DURING ALL STEPS OF CLEANING!

2) Salt Solution Recirculation: 5% NaCl

a) Connect D_{out} and E_{out} cleaning lines and direct them to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Connect the D_{in} cleaning line.

c) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of 5% NaCl solution (10 kg (22 lb) NaCl in 200 L of water).

d) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 10 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

e) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

f) Drain the cleaning tank and pump.

3) Water Rinse

a) Redirect D_{out} and E_{out} cleaning lines from the cleaning tank to drain. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode).

d) Run approximately 180 L of water through the E-Cell System™ in a range of nominal flows (and pressures), to half flows. Do not run the pump dry.

e) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

f) Repeat steps (ii) through (v) once.

g) Drain the cleaning tank and pump.

4) Halane (1,3-Dichloro-5, 5-dimethyl hydantoin) recirculation

a) Redirect D_{out} and E_{out} cleaning lines from drain to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of Halane 500 ppm solution in the cleaning tank:

- in 200 L of water, dissolve 100 g Halane while mixing well (Halane is sparingly soluble)
- **Completely dissolve the Halane before proceeding to recirculate the cleaning solution.**

WARNING:

AVOID CONTACT WITH HALANE (1,3-DICHLORO-5,5-DIMETHYL HYDANTOIN) AS IT IS CORROSIVE AND AN OXIDIZER. DO NOT MIX HALANE OR ITS SOLUTIONS WITH ACID.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 30 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

d) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

e) Drain the cleaning tank and pump.

5) Peracetic Acid / Hydrogen Peroxide Solution Sanitization

NOTE:

During peracetic acid / hydrogen peroxide sanitizing, some gas may be produced and pressure drops across the E-Cell MK-2 Stacks™ may increase.

a) Redirect D_{out} and E_{out} cleaning lines from drain to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water. Makeup 200L of peracetic acid 0.04% / hydrogen peroxide 0.2%:

- In 200L of water, dilute **slowly** 2L of a commercial solution of peracetic acid 4% / hydrogen peroxide 20% (such as Minntec's MinnCare) while mixing well.

WARNING:

AVOID CONTACT WITH PERACETIC ACID / HYDROGEN PEROXIDE SOLUTION, AS THIS IS CORROSIVE.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 2 hours. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

d) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

e) Drain the cleaning tank and pump.

6) Salt Solution Recirculation: 5% NaCl

a) Ensure that D_{out} and E_{out} cleaning lines are directed to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of 5% NaCl solution (10 kg (22 lb) NaCl in 200 L of water).

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 10 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows

d) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

e) Drain the cleaning tank and pump.

7) Water Rinse

a) Redirect D_{out} and E_{out} cleaning lines from the cleaning tank to drain. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode).

d) Run approximately 180 L of water through the E-Cell System™ in a range of nominal flows (and pressures), to half flows. Do not run the pump dry.

e) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

f) Repeat steps (ii) through (v) once.

g) Drain the cleaning tank and pump.

h) Set up the E-Cell System™ to run as under operating conditions, except for power. Rectifier power must remain off.

i) Open Dilute Rinse Outlet Valve.

j) Disconnect D_{out}, D_{in}, and E_{out} cleaning lines.

k) Plug or cap D_{out}, D_{in}, and E_{out} cleaning connections.

l) Open E_{out} valve.

m) Open Concentrate Bleed valve.

n) Open the E-Cell System™ Din Valve and run E-Cell System™ feed water through the system until Dout and Cout conductivities are no more than 50 uS/cm greater than feed water conductivity. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

8) Regeneration

a) Regenerate the E-Cell MK-2 Stacks™. (Refer to “Start Up” in section 4.)

N. CLEANING PROCEDURE 6: ACID AND HALANE OR PERACETIC ACID SANITIZING

Where inorganic scale is present along with heavy biological fouling an acid cleaning step is added to the beginning of the procedure.

Halane, a widely used source of chlorine, is useful for cleaning and sanitizing high-purity water treatment equipment. This is an oxidizing cleaning solution which is effective primarily as a biocide against biofouling and secondarily a cleaner against organic fouling. Due to its oxidizing power, this cleaning solution should be used infrequently and the following directions for its use followed closely.

Peracetic acid 0.04% / hydrogen peroxide 0.2% performs similarly using a different chemical species. It should also be used only when necessary.

Refer to section above for general comments and requirements for cleaning.

A cleaning tank and pump and five hoses to connect the tank and pump to the E-Cell System™ are required. Five hoses are required for the acid cleaning. Three hoses are required for the Halane or peracetic acid sanitizing.

This procedure provides a sanitizing of all chambers of the MK-2 Stacks. The steps involved are:

- Preparation of the system for cleaning
- Makeup and recirculation of an acid solution through all chambers of the MK-2 Stacks.
- Makeup and recirculation of a brine solution through all chambers of the MK-2 Stacks.
- Rinse of the MK-2 Stack to remove excess brine
- Makeup and recirculation of a Halane sanitizing solution through all chambers of the MK-2 Stacks OR
- Makeup and recirculation of a peracetic acid sanitizing solution through all chambers of the MK-2 Stacks
- Makeup and recirculation of a brine solution through all chambers of the MK-2 Stacks
- Rinse of the system
- Regeneration of the MK-2 Stacks

1) Preparation

This step prepares the system for cleaning.

NOTE:

During hydrochloric acid cleaning some gas will be produced.

a) Shutdown the E-Cell System™ according to the Shutdown Procedures in the Owner's Manual. Ensure that power to the E-Cell MK-2 Stacks™ is off by turning the rectifier hand switch to OFF.

WARNING:

THE E-CELL SYSTEM™ OPERATES AT HIGH VOLTAGE. BEFORE PERFORMING ANY CLEANING OR MAINTENANCE, ENSURE RECTIFIER POWER IS OFF.

b) Close the E-Cell System™ Dilute Feed Inlet (D_{in}) Valve.

WARNING:

BEFORE CLOSING THE VALVE, SHUT OFF OR REDIRECT FEED FLOW TO ENSURE THAT THE FEED LINE AND EQUIPMENT (EX. RO OR TRANSFER PUMP) CANNOT OVER-PRESSURIZE.

c) Close the following E-Cell System™ valves:

- Dilute Product Outlet (D_{out})
- Dilute Rinse Outlet
- Electrode Outlet (E_{out})
- Concentrate Bleed
- Concentrate Pump (OPTIONAL) Discharge
- Concentrate Pump (OPTIONAL) Suction

WARNING:

DEPRESSURIZE ALL PROCESS LINES TO AVOID HIGH-PRESSURE CHEMICAL SPRAY.

WARNING:

POWER TO THE E-CELL MK-2 STACKS™ MUST BE OFF DURING ALL STEPS OF CLEANING!

2) Acid solution Recirculation: 1.8% Hydrochloric Acid

NOTE:

During hydrochloric acid cleaning some gas will be produced.

a) Connect D_{out}, Concentrate Outlet (C_{out}) and E_{out} cleaning lines and direct them to the cleaning tank. **Cleaning lines must be secured so that no splashing or spraying of solution can occur.**

b) Connect the D_{in} and Concentrate Inlet (C_{in}) cleaning lines to the D_{in} and C_{in} cleaning connections, respectively.

c) Fill the cleaning tank with 400 L of RO quality (or better) water. Make up 400 L (106 US gal) of HCl 1.8% solution in the cleaning tank:

- In 400 L of water, add slowly while mixing well 16.8L/19.8kg (4.4 US gal/43.6 lb) of HCl 37%.

WARNING:

AVOID CONTACT WITH HYDROCHLORIC ACID, AS THIS IS CORROSIVE.

d) Start the cleaning pump and run for 30 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

e) Turn the cleaning pump off.

f) Drain the cleaning tank and pump.

3) Salt Solution Recirculation: 5% NaCl

a) Ensure the D_{out}, C_{out} and E_{out} cleaning lines are directed to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of 5% NaCl solution (10 kg (22 lb) NaCl in 200 L of water).

c) Start the cleaning pump and run for 10 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

d) Turn the cleaning pump off.

e) Drain the cleaning tank and pump.

4) Water Rinse

a) Disconnect the C_{out} and C_{in} cleaning lines.

b) Plug or cap the C_{out} and C_{in} cleaning connection.

c) Open concentrate pump (OPTIONAL) discharge and suction valves.

d) Redirect D_{out} and E_{out} cleaning lines from the cleaning tank to drain. **Cleaning lines must be secured so that no splashing or spraying of solution can occur.**

e) Fill the cleaning tank with 200 L of RO quality (or better) water.

f) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode).

g) Run approximately 180 L of water through the E-Cell System™ in a range of nominal flows (and pressures), to half flows. **Do not run the pump dry.**

h) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

i) Repeat steps (e) through (h) once.

j) Drain the cleaning tank and pump.

Use either of the following steps but not both

5) Halane (1,3-Dichloro-5, 5-dimethyl hydantoin) recirculation

a) Redirect D_{out} and E_{out} cleaning lines from drain to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of Halane 500 ppm solution in the cleaning tank:

- in 200 L of water, dissolve 100 g Halane while mixing well (Halane is sparingly soluble)
- **Completely dissolve the Halane before proceeding to recirculate the cleaning solution.**

WARNING:

AVOID CONTACT WITH HALANE (1,3-DICHLORO-5,5-DIMETHYL HYDANTOIN) AS IT IS CORROSIVE AND AN OXIDIZER. DO NOT MIX HALANE OR ITS SOLUTIONS WITH ACID.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 30 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

d) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

e) Drain the cleaning tank and pump.

6) Peracetic Acid / Hydrogen Peroxide Solution Sanitization

NOTE:

During peracetic acid / hydrogen peroxide sanitizing, some gas may be produced and pressure drops across the E-Cell MK-2 Stacks™ may increase.

a) Redirect D_{out} and E_{out} cleaning lines from drain to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water. Makeup 200L of peracetic acid 0.04% / hydrogen peroxide 0.2%:

- In 200L of water, dilute **slowly** 2L of a commercial solution of peracetic acid 4% / hydrogen peroxide 20% (such as Minntec's MinnCare) while mixing well.

WARNING:

AVOID CONTACT WITH PERACETIC ACID / HYDROGEN PEROXIDE SOLUTION, AS THIS IS CORROSIVE.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 2 hours. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

d) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

e) Drain the cleaning tank and pump.

7) Salt Solution Recirculation: 5% NaCl

a) Ensure that D_{out} and E_{out} cleaning lines are directed to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of 5% NaCl solution (10 kg (22 lb) NaCl in 200 L of water).

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 10 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows

d) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

e) Drain the cleaning tank and pump.

8) Water Rinse

a) Redirect D_{out} and E_{out} cleaning lines from the cleaning tank to drain. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode).

d) Run approximately 180 L of water through the E-Cell System™ in a range of nominal flows (and pressures), to half flows. Do not run the pump dry.

e) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

f) Repeat steps (b) through (e) once.

g) Drain the cleaning tank and pump.

h) Set up the E-Cell System™ to run as under operating conditions, except for power. Rectifier power must remain off.

i) Open Dilute Rinse Outlet Valve.

j) Disconnect D_{out}, D_{in}, and E_{out} cleaning lines.

k) Plug or cap D_{out}, D_{in}, and E_{out} cleaning connections.

l) Open E_{out} valve.

m) Open Concentrate Bleed valve.

n) Open the E-Cell System™ Din Valve and run E-Cell System™ feed water through the system until Dout and Cout conductivities are no more than 50 uS/cm greater than feed water conductivity. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

9) Regeneration

a) Regenerate the E-Cell MK-2 Stacks™. (Refer to “Start Up” in section 3.)

O. CLEANING PROCEDURE 7: HALANE OR PERACETIC ACID AND HIGH PH SANITIZING

Halane, a widely used source of chlorine, is useful for cleaning and sanitizing high-purity water treatment equipment. This is an oxidizing cleaning solution which is effective primarily as a biocide against biofouling and secondarily a cleaner against organic fouling. Due to its oxidizing power, this cleaning solution should be used infrequently and the following directions for its use followed closely.

Peracetic acid 0.04% / hydrogen peroxide 0.2% performs similarly using a different chemical species. It should also be used only when necessary.

For sever biological fouling a high pH step can be added to the procedure for improved efficiency.

Refer to section above for general comments and requirements for cleaning.

A cleaning tank and pump and three hoses to connect the tank and pump to the E-Cell System™ are required.

This procedure provides a sanitizing of all chambers of the MK-2 Stacks. The steps involved are:

- Preparation of the system for cleaning
- Makeup and recirculation of a brine solution through all chambers of the MK-2 Stacks.
- Rinse of the MK-2 Stack to remove excess brine
- Makeup and recirculation of a Halane sanitizing solution through all chambers of the MK-2 Stacks OR
- Makeup and recirculation of a peracetic acid sanitizing solution through all chambers of the MK-2 Stacks
- Makeup and recirculation of a brine solution through all chambers of the MK-2 Stacks
- Rinse of the system
- Regeneration of the MK-2 Stacks

1) Preparation

This step prepares the system for cleaning.

a) Shutdown the E-Cell System™ according to the Shutdown Procedures in the Owner's Manual. Ensure that power to the E-Cell MK-2 Stacks™ is off by turning the rectifier hand switch to OFF.

WARNING:

THE E-CELL SYSTEM™ OPERATES AT HIGH VOLTAGE. BEFORE PERFORMING ANY CLEANING OR MAINTENANCE, ENSURE RECTIFIER POWER IS OFF.

b) Close the E-Cell System™ Dilute Feed Inlet (D_{in}) Valve.

WARNING:

BEFORE CLOSING THE VALVE, SHUT OFF OR REDIRECT FEED FLOW TO ENSURE THAT THE FEED LINE AND EQUIPMENT (EX. RO OR TRANSFER PUMP) CANNOT OVER-PRESSURIZE.

c) Close the following E-Cell System™ valves:

- Dilute Product Outlet (D_{out})
- Dilute Rinse Outlet
- Electrode Outlet (E_{out})
- Concentrate Bleed

WARNING:

DEPRESSURIZE ALL PROCESS LINES TO AVOID HIGH-PRESSURE CHEMICAL SPRAY.

WARNING:

POWER TO THE E-CELL MK-2 STACKS™ MUST BE OFF DURING ALL STEPS OF CLEANING!

2) Salt Solution Recirculation: 5% NaCl

a) Connect D_{out} and E_{out} cleaning lines and direct them to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Connect the D_{in} cleaning line.

c) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of 5% NaCl solution (10 kg (22 lb) NaCl in 200 L of water).

d) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 10 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

e) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

f) Drain the cleaning tank and pump.

3) Water Rinse

a) Redirect D_{out} and E_{out} cleaning lines from the cleaning tank to drain. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode).

d) Run approximately 180 L of water through the E-Cell System™ in a range of nominal flows (and pressures), to half flows. Do not run the pump dry.

e) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

f) Repeat steps (ii) through (v) once.

g) Drain the cleaning tank and pump.

Use either of the following steps <u>but not both</u>

4) Halane (1,3-Dichloro-5, 5-dimethyl hydantoin) recirculation

a) Redirect D_{out} and E_{out} cleaning lines from drain to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of Halane 500 ppm solution in the cleaning tank:

- in 200 L of water, dissolve 100 g Halane while mixing well (Halane is sparingly soluble)
- **Completely dissolve the Halane before proceeding to recirculate the cleaning solution.**

WARNING:

AVOID CONTACT WITH HALANE (1,3-DICHLORO-5,5-DIMETHYL HYDANTOIN) AS IT IS CORROSIVE AND AN OXIDIZER. DO NOT MIX HALANE OR ITS SOLUTIONS WITH ACID.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 30 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

d) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

e) Drain the cleaning tank and pump.

5) Peracetic Acid / Hydrogen Peroxide Solution Sanitization

NOTE:

During peracetic acid / hydrogen peroxide sanitizing, some gas may be produced and pressure drops across the E-Cell MK-2 Stacks™ may increase.

a) Redirect D_{out} and E_{out} cleaning lines from drain to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water. Makeup 200L of peracetic acid 0.04% / hydrogen peroxide 0.2%:

- In 200L of water, dilute **slowly** 2L of a commercial solution of peracetic acid 4% / hydrogen peroxide 20% (such as Minntec's MinnCare) while mixing well.

WARNING:

AVOID CONTACT WITH PERACETIC ACID / HYDROGEN PEROXIDE SOLUTION, AS THIS IS CORROSIVE.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 2 hours. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

d) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

e) Drain the cleaning tank and pump.

6) Sodium Chloride / Sodium Hydroxide Solution Recirculation

a) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of NaCl 5% / NaOH 1% solution in the cleaning tank:

- In 200 L of water, dissolve 10 kg sodium chloride (NaCl) while mixing well
- Dissolve **slowly** while mixing well 2 kg (4.4 lb) of sodium hydroxide pellets, or 4 kg / 3.1 L (8.8 lb / 0.81 US gal) 50% w/w sodium hydroxide solution.

WARNING:

AVOID CONTACT WITH SODIUM HYDROXIDE SOLID AND SOLUTION, AS THESE ARE CORROSIVE.

b) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 30 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

c) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

d) Drain the cleaning tank and pump.

7) Water Rinse

a) Redirect D_{out} and E_{out} cleaning lines from the cleaning tank to drain. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode).

d) Run approximately 180 L of water through the E-Cell System™ in a range of nominal flows (and pressures), to half flows. Do not run the pump dry.

e) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

f) Repeat steps (ii) through (v) once.

g) Drain the cleaning tank and pump.

h) Set up the E-Cell System™ to run as under operating conditions, except for power. Rectifier power must remain off.

i) Open Dilute Rinse Outlet Valve.

j) Disconnect D_{out}, D_{in}, and E_{out} cleaning lines.

k) Plug or cap D_{out}, D_{in}, and E_{out} cleaning connections.

l) Open E_{out} valve.

m) Open Concentrate Bleed valve.

n) Open the E-Cell System™ Din Valve and run E-Cell System™ feed water through the system until Dout and Cout conductivities are no more than 50 uS/cm greater than feed water conductivity. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

8) Regeneration

a) Regenerate the E-Cell MK-2 Stacks™. (Refer to “Start Up” in section 3.)

A. CLEANING PROCEDURE 8: ACID AND HALANE OR PERACETIC ACID AND HIGH PH SANITIZING

Where inorganic scale is present along with heavy biological fouling an acid cleaning step is added to the beginning of the procedure.

Halane, a widely used source of chlorine, is useful for cleaning and sanitizing high-purity water treatment equipment. This is an oxidizing cleaning solution which is effective primarily as a biocide against biofouling and secondarily a cleaner against organic fouling. Due to its oxidizing power, this cleaning solution should be used infrequently and the following directions for its use followed closely.

Peracetic acid 0.04% / hydrogen peroxide 0.2% performs similarly using a different chemical species. It should also be used only when necessary.

For sever biological fouling a high pH step can be added to the procedure for improved efficiency.

Refer to section above for general comments and requirements for cleaning.

A cleaning tank and pump and five hoses to connect the tank and pump to the E-Cell System™ are required. Five hoses are required for the acid cleaning. Three hoses are required for the Halane, peracetic acid and high pH sanitizing.

This procedure provides a sanitizing of all chambers of the MK-2 Stacks. The steps involved are:

- Preparation of the system for cleaning
- Makeup and recirculation of an acid solution through all chambers of the MK-2 Stacks.
- Makeup and recirculation of a brine solution through all chambers of the MK-2 Stacks.
- Rinse of the MK-2 Stack to remove excess brine
- Makeup and recirculation of a Halane sanitizing solution through all chambers of the MK-2 Stacks OR
- Makeup and recirculation of a peracetic acid sanitizing solution through all chambers of the MK-2 Stacks
- Makeup and recirculation of a brine solution through all chambers of the MK-2 Stacks
- Rinse of the system
- Regeneration of the MK-2 Stacks

1) Preparation

This step prepares the system for cleaning.

NOTE:

During hydrochloric acid cleaning some gas will be produced.

a) Shutdown the E-Cell System™ according to the Shutdown Procedures in the Owner's Manual. Ensure that power to the E-Cell MK-2 Stacks™ is off by turning the rectifier hand switch to OFF.

WARNING:

THE E-CELL SYSTEM™ OPERATES AT HIGH VOLTAGE. BEFORE PERFORMING ANY CLEANING OR MAINTENANCE, ENSURE RECTIFIER POWER IS OFF.

b) Close the E-Cell System™ Dilute Feed Inlet (D_{in}) Valve.

WARNING:

BEFORE CLOSING THE VALVE, SHUT OFF OR REDIRECT FEED FLOW TO ENSURE THAT THE FEED LINE AND EQUIPMENT (EX. RO OR TRANSFER PUMP) CANNOT OVER-PRESSURIZE.

c) Close the following E-Cell System™ valves:

- Dilute Product Outlet (D_{out})
- Dilute Rinse Outlet
- Electrode Outlet (E_{out})
- Concentrate Bleed
- Concentrate Pump (OPTIONAL) Discharge
- Concentrate Pump (OPTIONAL) Suction

WARNING:

DEPRESSURIZE ALL PROCESS LINES TO AVOID HIGH-PRESSURE CHEMICAL SPRAY.

WARNING:

POWER TO THE E-CELL MK-2 STACKS™ MUST BE OFF DURING ALL STEPS OF CLEANING!

2) Acid solution Recirculation: 1.8% Hydrochloric Acid

a) Connect D_{out}, Concentrate Outlet (C_{out}) and E_{out} cleaning lines and direct them to the cleaning tank. **Cleaning lines must be secured so that no splashing or spraying of solution can occur.**

b) Connect the D_{in} and Concentrate Inlet (C_{in}) cleaning lines to the D_{in} and C_{in} cleaning connections, respectively.

c) Fill the cleaning tank with 400 L of RO quality (or better) water. Make up 400 L (106 US gal) of HCl 1.8% solution in the cleaning tank:

- in 400 L of water, add **slowly** while mixing well 16.8L/19.8kg (4.4 US gal/43.6 lb) of HCl 37%.

WARNING:

AVOID CONTACT WITH HYDROCHLORIC ACID, AS THIS IS CORROSIVE.

a) Start the cleaning pump and run for 30 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

b) Turn the cleaning pump off.

c) Drain the cleaning tank and pump.

3) Salt Solution Recirculation: 5% NaCl

a) Ensure the C_{out}, D_{out} and E_{out} cleaning lines are directed to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of 5% NaCl solution (10 kg (22 lb) NaCl in 200 L of water).

c) Start the cleaning pump and run for 10 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

d) Turn cleaning pump off.

e) Drain the cleaning tank and pump.

4) Water Rinse

a) Disconnect the Cout and Cin cleaning lines.

b) Plug or cap the Cout and Cin cleaning connections..

c) Open the Concentrate Pump (OPTIONAL) discharge and suction valves.

d) Redirect D_{out} and E_{out} cleaning lines from the cleaning tank to drain. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

e) Fill the cleaning tank with 200 L of RO quality (or better) water.

f) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode).

g) Run approximately 180 L of water through the E-Cell System™ in a range of nominal flows (and pressures), to half flows. **Do not run the pump dry.**

h) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

i) Repeat steps (e) through (h) once.

j) Drain the cleaning tank and pump.

Use either of the following steps (8.10.5 or 8.10.6) but not both

5) Halane (1,3-Dichloro-5, 5-dimethyl hydantoin) recirculation

a) Redirect D_{out} and E_{out} cleaning lines from drain to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of Halane 500 ppm solution in the cleaning tank:

- In 200 L of water, dissolve 100 g Halane while mixing well (Halane is sparingly soluble)
- **Completely dissolve the Halane before proceeding to recirculate the cleaning solution.**

WARNING:

AVOID CONTACT WITH HALANE (1, 3-DICHLORO-5, 5-DIM ETHYL HYDANTOIN) AS IT IS CORROSIVE AND AN OXIDIZER. DO NOT MIX HALANE OR ITS SOLUTIONS WITH ACID.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 30 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

d) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

e) Drain the cleaning tank and pump.

6) Peracetic Acid / Hydrogen Peroxide Solution Sanitization

NOTE:

During peracetic acid / hydrogen peroxide sanitizing, some gas may be produced and pressure drops across the E-Cell MK-2 Stacks™ may increase.

a) Redirect D_{out} and E_{out} cleaning lines from drain to the cleaning tank. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water. Makeup 200L of peracetic acid 0.04% / hydrogen peroxide 0.2%:

- In 200L of water, dilute **slowly** 2L of a commercial solution of peracetic acid 4% / hydrogen peroxide 20% (such as Minntec's MinnCare) while mixing well.

WARNING:

AVOID CONTACT WITH PERACETIC ACID / HYDROGEN PEROXIDE SOLUTION, AS THIS IS CORROSIVE.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 2 hours. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

d) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

e) Drain the cleaning tank and pump.

7) Sodium Chloride / Sodium Hydroxide Solution Recirculation

a) Fill the cleaning tank with 200 L of RO quality (or better) water. Make up 200 L (53 US gal) of NaCl 5% / NaOH 1% solution in the cleaning tank:

- In 200 L of water, dissolve 10 kg sodium chloride (NaCl) while mixing well

- Dissolve **slowly** while mixing well 2 kg (4.4 lb) of sodium hydroxide pellets, or 4 kg / 3.1 L (8.8 lb / 0.81 US gal) 50% w/w sodium hydroxide solution.

WARNING:

AVOID CONTACT WITH SODIUM HYDROXIDE SOLID AND SOLUTION, AS THESE ARE CORROSIVE.

a) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode), and run for 30 minutes. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

b) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

c) Drain the cleaning tank and pump.

8) Water Rinse

a) Redirect D_{out} and E_{out} cleaning lines from the cleaning tank to drain. Cleaning lines must be secured so that no splashing or spraying of solution can occur.

b) Fill the cleaning tank with 200 L of RO quality (or better) water.

c) Start the cleaning pump, then the Concentrate Pump (OPTIONAL) (in Hand mode).

d) Run approximately 180 L of water through the E-Cell System™ in a range of nominal flows (and pressures), to half flows. Do not run the pump dry.

e) Turn the Concentrate Pump (OPTIONAL) off, then the cleaning pump off.

f) Repeat steps (b) through (e) once.

g) Drain the cleaning tank and pump.

h) Set up the E-Cell System™ to run as under operating conditions, except for power. Rectifier power must remain off.

i) Open Dilute Rinse Outlet Valve.

j) Disconnect D_{out}, D_{in}, and E_{out} cleaning lines.

k) Plug or cap D_{out}, D_{in}, and E_{out} cleaning connections.

l) Open E_{out} valve.

m) Open Concentrate Bleed valve.

n) Open the E-Cell System™ Din Valve and run E-Cell System™ feed water through the system until Dout and Cout conductivities are no more than 50 uS/cm greater than feed water conductivity. Run the E-Cell System™ in a range of nominal flows (and pressures), to half flows.

9) Regeneration

a) Regenerate the E-Cell MK-2 Stacks™. (Refer to “Start Up” in section 3.)

A. EDI TROUBLESHOOTING

Problem	Possible Cause	Corrective Action
High MK-2 Stack Pressure Drop	MK-2 Stack Fouled	Identify the foulant. Follow the appropriate cleaning procedure.
	Flow rate too high	Check "Operating Instructions" and adjust flows as required.
Low MK-2 Stack Pressure Drop	Flow rate too low	Check "Operating Instructions" and adjust flows as required.
Low Product Flow (Low Dilute Flow)	MK-2 Stack Fouled	Identify the foulant. Follow the appropriate cleaning procedure.
	Valve closed	Confirm all required valves are open
	Flow Switch	Check setting of switch, confirm it operates correctly
	Low feed water pressure	Identify and resolve the cause.
	Flows incorrectly set	Adjust the rate set valve.
Poor Quality Product	Feed water quality out of spec.	Check feed water. CO_2 is a frequent cause of poor product water quality
	Improperly wired electrodes	De-energize the system immediately and verify the wiring. Call an E-Cell™ representative.
	One or more MK-2 Stacks with no or low current	Check all fuses, wiring, rectifier output, confirm negative rectifier terminal grounded
	Current too low	Check Concentrate loop conductivity, it may be too low. Check rectifier setting, ensure it is set for current limiting operation (voltage set for 100%)
	Concentrate pressures higher than feed or product pressures.	Re-set the Concentrate pressures to obtain a 5 to 10 psid (0.34 to 0.68 bar) differential pressure. See the "Operating Instructions".
	Not all MK-2 Stacks are installed	Dead legs created where MK-2 Stacks are not installed. Low quality water is leaching from these dead legs into the product water. Flush the dead legs.
	Temperature Compensation	Ensure temperature compensation is enabled on conductivity/resistivity meter

Problem	Possible Cause	Corrective Action
Low Concentrate Conductivity	Low recovery	Check Concentrate Bleed flow rate, may be too high
	Feed water conductivity decreased	Use brine injection to increase Concentrate loop conductivity
	Brine Feeder	Confirm measuring tank contains brine, confirm pump is primed, confirm pump has power, confirm pump is in Auto for automatic operation
Concentrate Pump (OPTIONAL) will not Run in Auto	No power	Confirm all disconnects are closed. Check power with volt meter or "bump" pump in "Hand"
	PLC	PLC will not start Concentrate pump (OPTIONAL) if Dilute flow is low
Low Concentrate Flow	Concentrate Pump (OPTIONAL)	Concentrate pump (OPTIONAL) must be operating in order to have Concentrate flow
	MK-2 Stack Fouled	Identify the foulant. Follow the appropriate cleaning procedure.
	Flow switch	Check position of flow switch and wiring
Low Electrolyte Flow	Concentrate Pump (OPTIONAL)	Concentrate pump (OPTIONAL) must be operating in order to have Electrolyte flow
	Flow switch	Check position of flow switch and wiring
	MK-2 Stack Fouled	Identify the foulant. Follow the appropriate cleaning procedure.
	Valves	Check setting of Electrolyte outlet valve
Low Concentrate Bleed Flow	Concentrate Pump (OPTIONAL)	Concentrate pump (OPTIONAL) must be operating in order to have Concentrate Bleed flow
	Flow switch	Check position of flow switch and wiring
	Valves	Check setting of Concentrate Bleed outlet valve

Problem	Possible Cause	Corrective Action
System Will Not Start In Auto (Concentrate Pump (OPTIONAL) will not Start)	Remote E-Cell™ Start contact not closing	A dry contact (supplied by others) must close to start up the E-Cell™ and keep it running. The dry contact (relay) is landed on DC-TB-10 in the E-Cell™ local control panel
	Concentrate pump (OPTIONAL) not in Auto	Move pump hand switch to AUTO
	No power to pump	Confirm all disconnects are closed. Check power with volt meter or "bump" pump in "Hand"
	Dilute Flow Low	Dilute valves not set correctly, flow switch not set correctly or wiring problem. Check for light on PLC for I:00/04 a light indicates flow is good
System Will Not Start In Auto (Concentrate Pump (OPTIONAL) Does Start, Rectifier Does Not Start)	Rectifier not in AUTO	Move pump hand switch to AUTO
	Rectifier has no power	Confirm Rectifier disconnect is in the ON position. Try starting Rectifier in Hand to confirm its operation.
	Electrode Flow Low	Electrode valve not set correctly, flow switch not set correctly or wiring problem. Check for light on PLC for I:00/03 a light indicates flow is good (note, light may not come on until Concentrate Pump (OPTIONAL) starts)
	Concentrate Bleed Flow Low	Concentrate Bleed valve not set correctly, flow switch not set correctly or wiring problem. Check for light on PLC for I:00/07 a light indicates flow is good (note, light may not come on until Concentrate Pump (OPTIONAL) starts)
	Concentrate Flow Low	Concentrate valves not set correctly, flow switch not set correctly or wiring problem. Check for light on PLC for I:00/02 a light indicates flow is good (note, light may not come on until Concentrate Pump (OPTIONAL) starts)

Problem	Possible Cause	Corrective Action
Rectifier Trips Intermittently	High Temperature Inside the Rectifier	Poor air circulation in the rectifier. A fan may not be operating or the screen/filter before the fan may be blocked

V. SYSTEM CONTROLS & COMPONENTS

A. CONTROL SYSTEM

An Allen Bradley Micrologix 1200 programmable logic controller (PLC) mounted inside the Main Control Panel (MCP) on the EDI System skid controls the water purification system. The MCP is inter-wired with the Controller / Stagers on the Multimedia Filters and the RO Controller Panel.

Located on the Main Control Panel are the status indicating lights, selector and Push-Button switches, EDI Flow and Resistivity Meters, and an alarm horn and alarm status indicating lights.

A description of these items and their functions are given below.

EDI Product Low Resistivity PL-2	Red Light	Illuminates and flashes whenever the Product water Resistivity decreases to a preset minimum setpoint. The alarm horn will also sound.
EDI Product Low Flow PL-3	Red Light	Illuminates and flashes whenever the Product water flow rate decreases to a preset minimum setpoint. The alarm horn will also sound.
EDI Concentrate Inlet Low Resistivity PL-12	Red Light	Illuminates and flashes whenever the EDI Concentrate inlet water Resistivity decreases to a preset minimum setpoint. The alarm horn will also sound.
EDI Concentrate Inlet Low Flow PL-4	Red Light	Illuminates and flashes whenever the EDI Concentrate inlet water flow rate decreases to a preset minimum setpoint. The alarm horn will also sound.
EDI Electrolyte Outlet Low Flow PL-5	Red Light	Illuminates and flashes whenever the EDI Concentrate outlet water flow rate decreases to a preset minimum setpoint. The alarm horn will also sound.
EDI Power Supply High / Low Current PL-6	Red Light	Illuminates and flashes whenever the EDI Power supply current increases / decreases to a preset maximum / minimum setpoint. The alarm horn will also sound.
Emergency Stop PL-7	Red Light	Illuminates and flashes whenever the E-Stop pushbutton switch is depressed. The alarm horn will also sound.

EDI Resistivity AIT-E1	Resistivity Meter	Monitors and indicates the Resistivity of the EDI Product water and energizes an alarm circuit at preset low resistivity set point.
EDI Product Flow FIQT-E1	Flow Meter	Indicates and monitors the EDI Product water flow rate and energizes an alarm circuit at preset low EDI Product water flow rate.
Multimedia Filter A Washing Pl-13	Amber Light	Illuminates whenever Multimedia Filter A is in the Washing mode of operation.
Multimedia Filter B Washing Pl-14	Amber Light	Illuminates whenever Multimedia Filter B is in the Washing mode of operation.
Storage Tank Full Pl-15	Amber Light	Illuminates whenever Storage Tank (by others) reaches its preset maximum setpoint.
E-Stop PB-2	Pushbutton Switch	Depressing this pushbutton switch when an alarm condition occurs will stop the operation of the System. When the alarm condition is rectified, pulling out on this pushbutton switch allows the System to resume normal operation.
Control Power PL-1	Green Light	Illuminates whenever Control Power is applied to the Main Panel.
Control Power SW-1	Selector Switch OFF / ON	OFF Position: Disables control power to the Main Control Panel. ON Position: Enables control power to the Main Control Panel.
RO Pump P-R1 PL-8	Amber Light	Illuminates whenever RO Pump P-R1 is in operation.
RO Pump P-R1 SW-8	Selector Switch HAND/OFF/AUTO	HAND position: Allows RO Pump P-R1 to run at any time and should only be used during the Initial Start-Up of the System. OFF position: Disables power to RO Pump P-R1. AUTO position: Normal-operating position. Allows the PLC to control the operation of RO Pump P-R1.

Anti-Scalant Pump PL-9	Amber Light	Illuminates whenever Anti-Scalant Chemical Pump P-R2 is in operation.
Anti-Scalant SW-3	Selector Switch OFF/AUTO	OFF Position: Disables the operation of Anti-Scalant Chemical Pump P-R2. AUTO Position: Enables the operation of Anti-Scalant Chemical Pump P-R2.
Brine Pump P-E1 PL-10	Amber Light	Illuminates whenever Brine Pump P-E1 is in operation.
Brine Pump P-E1 SW-4	Selector Switch OFF/AUTO	OFF Position: Disables the operation of Brine Pump P-E1. AUTO Position: Enables the operation of Brine Pump P-E1.
EDI Power Supply PSP-EDI PL-11	Amber Light	Illuminates whenever EDI System Power Supply is in operation.
EDI Power Supply SW-5	Selector Switch OFF/AUTO	OFF Position: Disables the operation of the EDI System Power Supply. AUTO Position: Enables the operation of the EDI System Power Supply.
Alarm Acknowledge / Reset PB-1	Push-button Switch	Depressing this push-button switch when an alarm condition occurs will silence the alarm horn and stop the alarm status indicating light from flashing. Depressing this push-button switch and holding it for five seconds once the alarm condition has been rectified will turn OFF the alarm light and allow the System to resume normal operation if it was interrupted.
	Alarm Horn	Sounds when an alarm condition occurs.

NOTES

Other Alarm conditions will be displayed on the ROTrol II Graphic Display located on the RO / EDI System skid.

- The alarms are listed below
  - Low RO Percent Rejection Alarm – Alarm

- Low RO Pump Feed Pressure Alarm – Shutdown Alarm
- High RO Membrane Feed Pressure Alarm – Shutdown Alarm
- Low Reject Flow Alarm –Alarm
- High Product Flow Alarm – Shutdown Alarm

There are two types of alarms. They are Shutdown and Alert Only.

When a Shutdown alarm occurs, the RO / EDI System will shutdown or automatic valves will open or close. The alarm light and horn will also sound.

When an Alert Only alarm occurs, the operator will be notified of the condition by the alarm light and horn.

Refer to the Alarm/Condition Response Chart in Section 7.3, Alarm/Events Section located in this manual for detailed descriptions of the alarms.

The Solenoid valves that control the automatic valves on the RO Skid are also mounted on the ROTROL PANEL. They are described below.

SV-R1	Solenoid Valve	Controls the operation of automatic RO Feed valve V-R1.
SV-R2	Solenoid Valve	Controls the operation of automatic RO Product valve V-R2.
SV-R3	Solenoid Valve	Controls the operation of automatic RO Product to Drain valve V-R3.

B. SOFTWARE

VI. ENGINEERING DOCUMENTATION

A. VALVE/ PUMP SEQUENCE CHART

B. ALARM / CONDITION RESPONSE CHART

C. RO PROJECTIONS

D. RO DAILY LOG SHEET

E. EDI DAILY LOG SHEET

1) Valve/ Pump Sequence Chart

2) Alarm / Condition Response Chart

3) RO Projections

4) RO Daily Log Sheet

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RO Operating Data Log

	Date										
	Time										
	Operating hours										
Pressure (psig)	Membrane Feed										
	Product										
	Reject										
Pressure Difference (psid)	Cartridge Filter										
	Feed - Reject										
Flow (gpm)	Product										
	Reject										
	Recycle										
	% Recovery										
Conductivity (mS/m)	Feed										
	Product										
	% Rejection										
PH	Raw Water										
	Feed										
	Reject										
	Product										
Feed	Chlorine (ppm)										
	SDI										
	Turbidity (NTU)										
	Temperature (F)										
Comments:											

5) EDI Daily Log Sheet

EDI Daily Operating Data

SAMPLE LOG FORMS

The following operating data log forms may be used to record E-Cell System™ operating data. Data should be recorded at least once a day. For information on analyzing operating data, refer to the “Operating Instructions” section.

DATE/TIME							
RECTIFIER VOLTAGE (volts)							
SYSTEM CURRENT (amps)							
FEED PRESSURE (psi, bar)							
CONCENTRATE INLET PRESSURE (psi, bar)							
PRODUCT PRESSURE (psi, bar)							
CONCENTRATE OUT PRESSURE (psi, bar)							
PUMP DISCHARGE PRESSURE (psi, bar)							
CONCENTRATE FLOW (gpm, m^3/h)							
CONCENTRATE BLEED FLOW (gpm, m^3/h)							
ELECTRODE FLOW (gpm, m^3/h)							
PRODUCT FLOW (gpm, m^3/h)							
THROUGHPUT (gallons, Litres)							
PROD. RESISTIVITY (Mohm-cm)							
CONCENTRATE CONDUCTIVITY (μS/cm)							
FEED CONDUCTIVITY (µS/cm)							
PRODUCT TEMPERATURE (°F, °C)							
CONCENTRATE TEMPERATURE (°F, °C)							
OPERATOR INITIALS							
COMMENTS							

DATE/TIME	OPERATOR	FEED CO_2 (ppm)	FEED HARDNESS (ppm)	FEED SILICA (ppb)	COMMENTS

6) Equipment Drawings

DRAWING #	DESCRIPTION
73053	P & ID 150 GPM Demineralized Water System
50040-01	Assembly Duplex Multimedia FM60
55027-01	Assembly RO 167 GPM 8" –6M 5:2 Array
58200-01	Electrical Schematics
58201-01	Assembly Panel Main
59005-01	Assembly EDI 150 GPM
60134-01	Assembly RO/EDI Cleaning Skid 200 GPM

NOTE:

Refer to the 04U202 SCHWEITZER MAUDUIT DRAWINGS FOLDER on this CD and open the VoloView Software provided and then open the drawing.

Tenergy Christ Water is not responsible for any problems encountered with the VoloView Software. Refer to the VoloView website.

VII. BILLS OF MATERIALS AND SPARE PARTS LIST

ASSEMBLY #	ASSEMBLY
90128	System Bill 04U202 Schweitzer Mauduit
50040-01	Assembly Duplex Multimedia FM60072DES
55027-01	Assembly RO 167 GPM 5:2 Array
58201-01	Assembly Panel Main
59005-01	Assembly EDI 150 GPM PVC
60134-01	Assembly RO/EDI Cleaning Skid 200 GPM

VIII. MANUFACTURER'S DATA LIST

Component Description	Manufacturer	Manufacturer's Model #
PLC Controller Micrologix 12000	Allen Bradley	1762-L40AWA
Variable Frequency Drive Powerflex	Allen Bradley	PowerFlex 700
Controller / Stager Filter Time Initiate Homing	Aquamatic	A148-0111-SA17B NEMA1 INVERTED STAGER FOR SC VALVES
Pressure Switch 316/BUNA 0-30PSI	Ashcroft	B424B30PSI
Pressure Switch 316/BUNA 0-100PSI	Ashcroft	B424B100PSI
Flow Indicator PP/Viton .75 npt 1-10 gpm	Blue White	F-40750LN-12
Butterfly Valve	Bray	4 #30/124-91/925-FC
Butterfly Valve	Bray	3 #30/124-91/825-FC
RO Element 8 x 40	Filmtec	#BW30LE-440
Filter Cartridge PP5 NOM X 40 DOE	Filterite	CLR5-40
Cleaning Pump 316/EPDN 2.5 FLG. 3 Stage 10HP	Grundfos	CRN32-3-2
RO Pump 316 EPDM 3 FLG. 6 Stage 50HP	Grundfos	CRN45-6
Pump Metering	LMI	A171-1558
Pump Metering	LMI	P121-358SI
Tank Chemical 35 Gal	LMI	27400
EDI Rectifier	Primax	# P5500-3-600-45
Vessel RO FRP White 8X6M 450 PSI 1NPTX(3) 2.5VIC SP	Protec	PRO-8-450-3P
Controller ROTroll II % Rejection / Flow 120V Nema 4X	R & D	ROTROLL II
Filter Housing 304L 12 X 40 3 FLG.	Shelco	12FOS4
Flow Monitor Sensor Powered Analog	Signet	# 3-5090
Flow Transmitter Indicator 4-20MA	Signet	3-8550-2P
Sensor Flow PP/TIT .5-4	Signet	P51530-P0
Power Supply 115/230VAC – 24VDC 2.5AMP	Sola	SDP1-24-100
Pressure Indicator 0-160 PSI .25NPT	TEL TRU	LM 316 2533SS4L1E4AG
Pressure Indicator 0-400 PSI .25NPT	TEL TRU	LM 316 2533SS4L1F2AG
Pressure Indicator 0-160 PSI .25NPT	TEL TRU	CBM 316 2533SS4C1E4AG

Sensor Resistivity 0.1cm	Thornton	240-202
Sensor Resistivity 0.1cm	Thornton	240-201
Monitor Resistivity 200CR	Thornton	6222-1

NOTE:

Refer to the 04U202 SCHWEITZER MAUDUIT MANUFACTURERS DATA FOLDER provided on this CD.