

**OCEAN SPRAY CRANBERRIES, INC.  
KENOSHA, WI**

**2 x 14/5 SPIRAL WOUND RO SYSTEM  
OPERATING MANUAL**

**KOCH Order Number: KM907372**

**Engineering Index: 7302**

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## **1.0 GENERAL**

### **1.1 FORWARD**

This operating manual provides instructions for proper installation, operation and maintenance of the 2 x 14/5 RO system provided by KOCH Membrane Systems, Inc. All system operators must read and understand the information contained in this operating manual, prior to operating the KOCH RO system.

The RO system is part of a larger juice extraction process, which includes extensive ancillary equipment. The RO system operators must know if the ancillary equipment is operating properly in order to successfully operate the KOCH RO system.

The RO system contains polymeric type membrane filter elements. These filters must be operated within specified limits of exposure to temperature, pressure, chemicals and process feed composition. The RO system operator is responsible for assuring the system is operated within the guidelines set forth in this manual.

KOCH provides training to assure all users understand proper RO system operation. Operators are required to understand and follow the operating guidelines in this manual for the Koch system hardware and membrane warranties to be honored. Operators are also required to monitor the system regularly and keep an accurate log of all operating parameters and any RO system upsets. KOCH provides logsheets for this purpose.

Trained operators will be prepared to operate the system efficiently and to solve problems quickly, which will result in safe and efficient operation of the RO system.

### **1.2 REFERENCE DOCUMENTATION**

The following documentation details the 2 x 14/5 RO system.

D7302-5001	RO System Outline Drawing
D7302-5002	RO System Flow Schematic
D7302-5003	Feed/CIP/Booster Outline Drawing
B7302-6001	Electrical/Pneumatic Schematic
A7302-8001	System Equipment Specification

### 1.3 GENERAL SYSTEM DESCRIPTION

The design basis for this system is a three stage RO system operating on red cranberry juice at OSC's Tomah, WI facility. The Kenosha RO system consists of two stages operating in series. Each stage is comprised of twelve housings with five membrane elements per housing for a total of 60 membrane elements. Since clear cranberry juice has not been piloted, or run on the system in Tomah, expansion capacity has been built into this new system should it be needed or desired. Each stage has been provided with expansion capacity of 16.7%, from twelve to fourteen housings. Each additional housing, with 5 elements, would add approximately 4 percent additional productivity.

Clarified decolorized cranberry juice is fed into the RO from a diatomaceous earth vacuum filter supplied by OSC at a flow rate of 40 gpm. The RO system will concentrate the cranberry juice from 4° to 18° Brix. Processing temperature is expected to be 70° to 80°F. The RO system delivers RO concentrate product and RO permeate to common downstream tanks supplied by OSC.

The RO system is designed to operate up to 20 hours per day in the Process mode with the remaining 4 hours per day for CIP and maintenance.

## 1.4 GLOSSARY

All operators must understand the following terms and definitions.

**°Brix:** Degrees Brix. A hydrometer scale for sugar solutions so graduated that its readings at a specified temperature represent percentages by weight of sugar in the solution

**CIP:** Abbreviation for Clean-In-Place.

**Concentrate:** Process fluid components retained by the membrane process. Same as retentate.

**Concentration Factor (CF):** Feed flow divided by Concentrate flow.  $CF = \text{Feed flow}/\text{Concentrate flow}$ .

**Conductivity:** The readiness with which a material transmits an electric current. Used as a measure of the RO permeate quality. Low RO permeate conductivity indicates good RO membrane quality.

**Crossflow Filtration:** A process where a single feed stream flows parallel to the membrane filter surface under pressure. Two outlet streams result; the permeate which consists of the fluid components which pass through the membrane pores and the concentrate which consists of the fluid components which are unable to pass through the membrane pores due to their size.

**Feed:** The fluid entering a membrane process.

**Flux:** The rate of permeation of the fluid through the membrane pores. Flux is usually expressed in "gfd", where gfd = gallons per square foot of membrane area per day.

**Fouling:** A condition that occurs due to the accumulation of material at the membrane surface. Flux is reduced as a result of fouling.

**Membrane Processing:** The separation of a process fluid, at the molecular level, by a semi-permeable membrane. Depending on the design of the membrane, certain smaller molecules will pass through the membrane, while larger molecules are retained and concentrated.

**Membrane Module:** The product containing the membrane surface used in the processing system.

**Osmotic Pressure:** The pressure required to separate two solutions of different concentrations using a semi-permeable membrane. In the RO system, the osmotic pressure required to separate water out of the juice stream increases with increasing juice concentration. (High solution concentration results in high osmotic pressure).

**Permeate:** The fluid containing water, dissolved material, etc. That passes through the membrane.

**Permeable:** Having pores or openings that permit liquids or gases to pass through.

**P Inlet:** Inlet Pressure. Measured where the fluid enters the membrane modules.

**P Outlet:** Outlet Pressure. Measured where the fluid exits the membrane modules.

**Pressure Differential:** Pressure Drop or Delta-P (DP). DP is the difference between inlet and outlet pressure. The DP is critical to membrane system operation since it is an indirect measure of the feed flow through the modules.

## 1.4 GLOSSARY

**Process Fluid:** Another name for the feed fluid.

**Retentate:** Those components of the process fluid that do not pass through, but are retained by the membrane process. Another name for concentrate.

**RO:** Reverse Osmosis. A pressure driven, crossflow filtration process used in conjunction with semi-permeable membranes. Filtration occurs through very small pores, which allow small molecules, such as water, to pass through the membrane, but holds back larger molecules, such as salts.

**RO Water:** Another name for Permeate from a reverse osmosis system.

**Salt Rejection(%):** 1 - the ratio of the salt concentration in the RO permeate to the salt concentration in the RO feed.

**Semi-permeable:** Permeable to some, usually small molecules or particles, but not to other, usually larger molecules or particles.

**Soft Water:** Deionized water or RO water produced by an RO system.

**TDS:** Total Dissolved Solids

**TSS:** Total Suspended Solids

**Turbidity:** The cloudiness (haziness) of a fluid as measured by the amount of light that can pass through it. The turbidity of the permeate is inversely proportional to the quality of the separation process. Low permeate turbidity indicates high membrane quality.

**Water Flux:** The rate of permeation measured when water is passed through the membrane filter. This permeation rate (flux) is converted to gallons per square foot per day (gfd), at standard pressure and temperature. The water flux is the basis by which the success of a cleaning cycle is determined.

## 1.5 PRECAUTIONS

### GENERAL RO SYSTEM PRECAUTIONS

All operators must understand the following precautions. Personal injury and/or premature membrane failure could result if these precautions are not followed.

1. DANGER - HIGH PRESSURE DEVICE. The pressure vessels and piping provided with this system may cause loss of life, severe bodily injury and/or property damage if not properly installed, operated and maintained. Read and understand all equipment guidelines given before attempting to open, operate or service the pressure vessels supplied with the system. Failure to follow these instructions and observe every precaution may result in malfunction and could result in catastrophic failure. Misuse, incorrect assembly or use of damaged or corroded components can result in high velocity release of the housing end closures.
2. Do not operate the RO pressure vessels at greater than 100 psig without the modules installed.
3. Do not perform any system or pressure vessel maintenance unless the system control power is OFF, the pump starters are OFF and locked-out and all internal pressure has been relieved from the system. Failure to do so may result in serious injury or death.
4. The RO membranes must not be allowed to dry out. The membranes must remain wet any time the system is shutdown for any reason, including maintenance. Membrane dry out is irreversible.
5. The RO membranes must not be allowed to freeze. The membranes must be operated and stored in a heated area at all times. Freezing will permanently damage the membranes.
6. RO membrane exposure to free chlorine, in any amount, degrades the membranes and will shorten their useful life. Always ensure the RO system is not exposed to ANY free chlorine.
7. If the system is to be shutdown for a period exceeding one week, arrangements must be made to clean the membranes to eliminate possible biological fouling. See Membrane Protection section.
8. No anti-foam agents of any kind are to be introduced into the Koch RO system, without prior review and written approval from Koch.
9. No silicone based materials, including any waterproofing sprays, lubricating or cutting fluids or greases, etc. are to be used in or around the Koch RO system. Using these materials in the Koch systems, in any amount, will cause complete and irreversible membrane fouling.
10. NEVER operate the Koch RO system with the permeate stream deadheaded. Permeate flow must always be unrestricted. Deadheading the permeate will cause membrane failure.
11. The maximum permeate side pressure that both the RO systems can be exposed to is 5 psig. If permeate is routed to a location that will result in more than 5 psig of back pressure on the permeate manifold, a separate permeate balance tank and transfer pump must be provided. It is the responsibility of Ocean Spray to determine if this is required for the RO system.
12. The retentate during process piping, from the RO system, must not have more than 50 psig of back pressure, including friction and static losses. The retentate during CIP piping, from the RO system, must not have more than 20 psig of back pressure, including friction and static losses.
13. Read, understand and follow the Operating Parameters and Limitations section for both systems.

## 1.6 CLEANING CHEMICALS

This section provides cleaning chemical specifications. All cleaning chemicals used in the RO system must be approved by Koch.

Only pure, food grade chemicals are to be used.

**DO NOT use cleaning chemicals with added surfactants, chelating agents, defoamers or colors.**

**Be sure to follow the chemical manufacturers safety recommendations. Wear goggles, gloves, dust mask and an apron when handling these chemicals.**

**Always ensure cleaning solutions are within the specified limits of concentration!**

### KOCH APPROVED RO SYSTEM CLEANING CHEMICALS:

KOCHKLEEN® 120  
KOCHKLEEN® 150  
KOCHKLEEN® 221  
KOCHKLEEN® KLD III  
KOCHKLEEN® ENZ 10  
KOCHKLEEN® PA  
KOCHKLEEN® LP

**MAXIMUM RO MEMBRANE KOCHKLEEN® PA EXPOSURE IS TWICE PER WEEK FOR 10 MINUTES. DO NOT EXCEED 75°F SYSTEM TEMPERATURE WHEN USING KOCHKLEEN® PA.**

## 1.7 CIP WATER QUALITY REQUIREMENTS

Proper CIP water quality is essential for maximizing membrane life, cleaning cycle effectiveness and production efficiency. The RO system is designed to use RO permeate for CIP water with the final rinse using potable water. Any water used for RO CIP must meet the following water quality guidelines.

If production efficiency drops off, verify the cleaning water quality. This is often the cause for poor performance.

### RO System CIP Water Quality Requirements

At all times free chlorine shall be zero

Turbidity less than 1.0 NTU

Iron less than 0.05 PPM

Manganese less than 0.05 PPM

Aluminum less than 0.5 PPM

No particulate matters such as rust, scale, flake material, sandy granular material, scum, or algae, etc.

Microbiological - no living or dead material

Silt Density Index (SDI) less than 3.0

Reactive silica less than 2 PPM

Colloidal silica nil

Total silica less than 10 mg/l

Calcium Sulfate less than saturated at 50 °C (122 °F)

Calcium carbonate less than saturated

Supply Temperature and flow per Koch Flow Schematic

## 1.8 INSTALLATION CHECK LIST

Complete these checks prior to loading modules. Run the system on water as necessary.

1. Check the RO area is properly heated. Check for clear access to all equipment.
2. Check all membrane modules and internal parts are present and in the correct quantities.
3. Check that all interconnecting piping and ancillary equipment is properly installed per the system flow schematic and outline drawings.
4. Check that all interconnecting piping is properly supported and does not place stress on the Koch supplied piping assemblies.
5. Check that all drain lines are free flowing and adequately sized for flush flows during CIP.
6. Check that interconnecting electrical wiring and pneumatic tubing is installed and operating per the system electrical and pneumatic drawings.
7. Check the compressed air supply is operating at the specified pressure and flow.
8. Check that motors, pumps and bed plates are properly leveled, secured and grouted. Disconnect pump and motor couplings first, then check that motor rotation is correct. Reassemble and align couplings to manufacturer's specifications.
9. Check the CIP water supply is operating at the specified quality, temperature and flow.
10. Check the seal water supply is installed and operating at the specified pressures and flow.
11. Check that CIP chemicals are available.
12. Check that piping joints, pressure vessels, connecting hoses, etc. are secure and free of leaks.
13. Check operation of all valves. Use air solenoid overrides to check pneumatic lines. Force valves from the PLC to check output to solenoid connections.
14. Flush all piping to remove debris.
15. Check operation and calibration of all instrumentation and controllers.
16. Check that cooling solution is installed and operational at the specified temperature and flow.

## 1.8 INSTALLATION CHECK LIST

Perform these checks after loading modules. Run the system on water, as necessary.

1. Check that piping joints, pressure vessels, connecting hoses, etc. are secure and free of leaks.
2. Check operation and calibration of all instrumentation.
3. Check that all alarm shutdowns are operational.
4. Check and debug all operating mode sequence steps and interlocks.
5. Check and confirm all timer settings, including CIP chemical dose pump timers.
6. Tune all control loops.
7. Correct any improperly supported piping, water hammer situations or other problems with system operation.
8. Perform a Salt Retention Test on the RO system. Fix any membrane or seal leaks.
9. Check that all upstream pretreatment and ancillary system equipment meets design specifications.
10. Check that the process feed is within design specifications.
11. Perform short Process Runs and CIP modes to complete sequence debugging.
12. Perform operator training.
13. Perform acceptance test.

## 1.9 KOCH MEMBRANE WARRANTY

Koch warranties all membranes to be free of manufacturing defects. Additional warranties may be honored depending on the product and process in which the membrane is employed and the individual agreement with each customer.

Koch Membrane Warrantees will not be honored where subsequent analysis reveals the customer employed excessive chlorine, caustic, acid, temperature, etc. and/or violated the normal operating parameters placed on the membrane.

It is the responsibility of the customer to monitor the operation (maintain accurate Process and CIP Logsheets and Module Maps) to assure they comply with the published parameters and limitations.

## **2.0 PROCESS AND SYSTEM DESCRIPTION**

### **2.1 REVERSE OSMOSIS**

Reverse Osmosis is a form of a fluid process generally referred to as cross flow filtration. The key to cross flow filtration is a thin, semi-permeable membrane designed to provide very fine levels of separation. During process operation a pressurized feed stream is pumped across the membrane surface. This circulation flow is used to sweep the retentate particles in the feed from accumulating or blinding off the membrane pores, as would happen in a dead-end type filter.

The RO membrane will allow passage of water and trace amounts of salts. The portion of the system feed that passes the membrane is called permeate. The retained portion of the feed is called retentate. Thus one feed stream is separated into two exit streams: the solution passing through the membrane surface, called permeate, and the retained stream, called concentrate or retentate.

The Reverse Osmosis system is designed to concentrate the diatomaceous earth filtered feed to a final 18 °Brix concentrate product and to produce RO permeate for plant reuse. During process operation, the RO system operates at pressures up to 650 psi. RO membranes are designed to achieve the finest level of filtration available. The RO membrane acts as a barrier to dissolved sugars, salts and molecules greater than approximately 100 molecular weight. Water molecules pass freely through the membrane.

## 2.3 SYSTEM DESCRIPTION

### MODULE DESCRIPTION

The RO system uses Koch Membrane Systems 3838-HR-N1 (3.8" OD x 38" long) spiral wound modules with minimum 99% salt rejection. The RO modules are made of numerous "leaves", made of flat sheets of membrane placed on both sides of a porous permeate carrier.

The leaves are separated by a flow spacer material resembling a plastic net. The flow spacer allows feed fluid to be pumped across the membrane surface under pressure. The leaves and flow spacers are wound around, and secured to, a central permeate collection tube. The permeate stream is removed through the central tube.

### HOUSING DESCRIPTION

RO modules are installed in pressure vessels made of 4" OD stainless steel tube, about 17 feet long. Each housing holds up to five RO modules connected in series. This is called an S-5 housing. Each housing is connected individually to feed and retentate manifolds using TriClover MHP clamps rated specifically for high pressure use.

Inside the housings, adjacent modules are connected together using plastic couplings and rubber seals. These seals keep the permeate and concentrate separated and prevent the modules from telescoping due to the flow forces. The combined permeate stream exits the downstream module through the housing end cap. A plastic hose connects the end cap to the permeate manifold.

### SYSTEM DESCRIPTION

The RO system has two stages in series. The stages in series design allows for continuous production of concentrated product. The stages are operated with 12 S-5 housings each and are expandable up to 14 S-5 housings each.

Each RO stage includes a recirculation pump designed to maintain the cross flow at 10 psi delta P per module, or a 50 psi delta P per housing.

#### **Each RO system is comprised of the following major sub-elements.**

**Feed/Booster/CIP Package:** Contains the RO system feed pump, two booster pumps, feed/CIP tank, feed filter, heat exchanger and associated valves, piping and instrumentation.

**Stage Package:** Contains the RO housings, stage pumps interconnecting piping, manifolds, valves and instrumentation.

## 2.4 **FEED PRETREATMENT REQUIREMENTS**

This section provides the Feed Pretreatment Requirements to be maintained by Ocean Spray. Note any variations in pretreatment in the system logs.

### **Feed**

DE Filtrate, < 2.0 NTU, No suspended solids, 1 - 4 °Brix.

### **Prefiltration**

1 micron by bag filter prior to RO Feed/CIP Tank. SUPPLIED BY OSC.  
140 micron by stainless steel mesh filter, after RO Feed Pump.

### **Temperature**

RO feed temperature will generally be in the range of 70 to 80 °F.

### **Zero Chlorine**

The RO feed must have **Zero Chlorine**. Chlorine in any concentration will destroy the RO Membranes.

## **2.5 VARIABLE FEED COMPOSITION**

This section describes the effects of variable feed composition on RO system operation.

### **General**

Membrane flux is directly related to operating temperature and pressure conditions. Increasing feed temperature and pressure will increase flux.

Membrane flux is inversely related to soluble and insoluble solids levels. Increasing soluble and insoluble solids will decrease flux.

### **RO System**

The RO system feed stream is DE filtrate. The DE filter will retain all suspended solids. Therefore, the RO system feed will vary in soluble solids (Brix) and temperature.

Increasing the sugar or soluble solids levels will generally decrease flux.

Increasing the temperature and feed pressure will generally increase flux.

The RO system operates at constant feed flow. If the feed sugar level increase, more pressure is required to overcome the higher osmotic pressure. In this case, the feed valve will open to allow higher pressure to overcome the decrease in flux.

**2.6 OPERATING PARAMETERS AND LIMITS**

Operators must understand the following design parameters and limits for the RO sub-system.

**OPERATING PARAMETER OR LIMIT**

Number Of Sub-Systems Or Stages-In-Series	2
Number Of Parallel Passes, At Start-up	12
Number Of Parallel Passes, Maximum Capacity	14
Number Of Modules In Series	5
Membrane Area (sq ft), At Start-up:	8400
Membrane Area (sq ft), Maximum Capacity	9800
Feed Flow (gpm)	40
Permeate Flow (gpm) @ 2 °Brix Feed	35.5
Retentate Flow (gpm) @ 2 °Brix Feed	4.5
Feed Temperature Range (°F)	70 - 80
Process Temperature Range (°F)	70 - 90
Process High Temperature Shutdown (°F)	113
CIP High Temperature Shutdown (°F)	113
Typical Inlet Pressure (psig)	400 - 650
Pressure Drop (psig)	50 - 60
Typical Outlet Pressure (psig)	450 - 600
High Pressure Shutdown (psig)	700
Low Pressure Shutdown (psig)	10
Membrane pH Limit Continuous	2.5-11
Typical Process pH	2.7
Chlorine Exposure Limit (ppm)	0.0

## 2.7 MONITORING AND DATA COLLECTION

**Improperly maintained logsheets will void the Koch Membrane Warranty.**

**OPERATION LOGSHEETS ARE INVALUABLE.** The information they provide is a record of system performance. The importance of maintaining proper logs cannot be overemphasized. The RO system should be recorded once per hour in Process operation and more frequently in CIP.

### Process Operating Variables

Date and Time  
Feed Tank Level  
Feed Pressure  
Stage Inlet Pressures  
Feed Temperature  
Stage Temperatures  
Feed Flow Rate and Total  
Retentate Flow Rate and Total  
Permeate Flow Rate and Total  
Stage Permeate Flows  
Retentate Total Solids  
Any comments

### CIP Operating Variables

During each CIP mode cycle, record the following CIP data.

Date and time  
Chemical Wash Type  
Chemical Amount Added  
Wash pH  
Feed Pressure  
Stage Inlet Pressures  
Feed Temperature  
Stage Temperatures  
Feed Flow rate  
Retentate Flow rate  
Permeate Flow rate  
Stage Permeate Flows  
Wash Duration in Minutes  
Water Flux data  
Any Comments

## 2.8 **MODULE IDENTIFICATION AND MODULE MAPS**

### **Module Identification Data**

All membrane module supplied with the Koch RO system are serial numbered to identify the membrane and module type, date of manufacture and production lot.

The following information must be recorded each time a membrane module is installed.

Date installed

Type of Membrane Module

Serial number

Position in the system using module map (see below)

### **Module Map Description**

**Improperly maintained module maps will void the Koch Membrane Warranty.**

Module Maps are used to maintain a log of the installation date, membrane type and serial number for each membrane module in the system. Refer to the Appendix for the module map form. An accurate module map copy must be maintained in the system Logsheet file.

Module map copies are to be sent to Koch, to the attention of the Technical Service Group at system commissioning and whenever modules are replaced.

## **2.8 MODULE IDENTIFICATION AND MODULE MAPS**

### **Procedure for Filling in the RO Module Location Map**

Also refer to the module loading instructions section.

1. Make copies of the module map supplied by Koch.
2. Orient yourself at the low pressure end of the RO stages. RO modules are loaded from this end.
3. Housings on each stage are numbered from left to right. The left housing is #1, and the right housing is #2.
4. The housings on each stage are arranged in rows. The top row is the "1st" row and the next row below is the "2nd" row, and so forth down to the "7th", or bottom row. For example, the 1-1 housing position is the housing on the top row on the left.
5. For each housing, the module installed at the highest pressure position is the #1 module, the next module downstream is the #2 module, etc.
6. Log the full module serial number on the module map, as accurately and neatly as possible, as each module is installed, following the procedure in section 2.10.
7. When complete, make copies of the completed module map and send to Koch. Place the originals in the RO system file for future reference.

## **2.9 INSTALLATION AND REMOVAL OF RO MEMBRANE MODULES**

### **Installation of RO Modules**

Install Modules from the Low Pressure end of the housings. Use water to ease installation of the ATD seals into the module permeate tubes. Always carefully insert the ATD's into the permeate tubes to avoid rolling or pinching the seals which could result in leaks.

1. Install an ATD/End Plug into the upstream end of the permeate tube of the first module.
2. Log this as the #1 module for the housing and push it about half-way into the housing.
3. Install an ATD/Interconnector into the upstream end of the second module.
4. Carefully install the #2 module/ATD/Interconnector into the #1 module permeate tube.
5. Log the #2 module and push it about half-way into the housing.
6. Repeat steps 3 thru 5 for the remaining modules.
7. Leave about 12 inches of the last module outside the housing and install the last ATD/Interconnector to the downstream permeate tube end.
8. Place a 4" OD gasket over the cap shaft and carefully insert the end cap shaft onto the ATD/Interconnector on the #5 module.
9. Grasping both sides of the end cap disk while holding the cap gasket in place, push the module stack into the housing until the cap disk and gasket are seated against the housing ferrule. Be careful to assure the gasket is properly seated.
10. Install the high-pressure clamp. Tighten bolts and nuts until the clamp halves touch, then torque to 20 ft-lb.
11. Install the permeate hose, gasket and clamps.
12. Install the upstream end cap, gasket and clamp. Be careful to properly seat the end cap gasket.
13. Double-check that all closures and hardware are in place and tightened.
14. Manually refill the stages with water using a hose.
15. Perform a CIP to remove preservative from the membranes. Check and repair any leaks. Measure and record water flux.

### **Removal of RO Membrane Modules**

1. Push the module stack from the high-pressure end towards the low-pressure end. A fair effort may be required to break the modules free.
2. Once free, push the module stack so the person at the low-pressure end can pull the module out of the housing and disconnect it at the ATD/Interconnector.
3. Repeat steps 1 and 2 for the remaining modules in the housing.

**2.10 MEMBRANE PROTECTION, SHORT AND LONG TERM SHUTDOWN**

This section describes the requirements for RO membrane protection and long term shutdown.

**MEMBRANE PROTECTION**

All RO membrane modules are supplied in a membrane preservative and anti-freeze solution. At start-up, this solution will be rinsed from the modules using the CIP mode.

- 1. Always store membranes in a tightly sealed plastic bag. Do not allow membranes to dry-out!**
- 2. Always store membranes in a heated area. Do not allow membranes to freeze!**

**SHORT TERM SHUTDOWN**

If the RO system is shutdown for 30 minutes or less at low concentration, the process fluid may be left in the system while maintenance, alarm correction, etc. is being performed. However, flux may be lower when restarted.

If the system is shutdown for more than 30 minutes, it is recommended that the modules be flushed with water, by performing shutdown.

**LONG TERM SHUTDOWN**

If the RO system is to be idle, Koch requires it be cleaned and sanitized. Then add preservative as detailed in the following schedule to prevent biological growth and membrane fouling or degradation.

<b><u>Idle Period</u></b>	<b><u>Recommended Operation</u></b>
Less than 1 hour	Leave system full of RO rinse water
Greater than 1 hour, but less than 3 months	Soak membranes in KOCHKLEEN® LP as per the Koch procedure enclosed
Greater than 3 months	Soak in a 75% Glycerin, 25% water solution (tolerance +/- 5%)

When performing maintenance, care must be taken to ensure the membranes are kept wet at all times.

If membranes are removed from the system for storage, drain them thoroughly, totally submerge them in a KOCHKLEEN® LP at ambient temperature. Drain excess KOCHKLEEN® LP and cap all openings. Store membranes in a cool area. Do not store modules in direct sun light.

**3.0 SYSTEM COMPONENTS**

The following is a list of the tagged components for each RO system train.  
Refer to the reference documentation for more details.

**3.1 RO SYSTEM COMPONENTS****RO PUMPS**

P-1	Feed/CIP Pump	15 HP 3500 RPM
P-2	Booster Pump	40 HP 3500 RPM Soft Start/Stop
P-3	Booster Pump	40 HP 3500 RPM Soft Start/Stop
P-101	Stage 100 Recirculation Pump	20 HP 3500 RPM
P-201	Stage 200 Recirculation Pump	20 HP 3500 RPM

**RO VALVES**

V-2A	Concentrate Control Valve	1/2" Ball Control ATC-STO
V-2B	Concentrate Control Valve	1/2" Ball Control ATC-STO
V-3	Concentrate By-Pass Valve	1" Ball ATO-STC
V-4	Concentrate Recycle Divert Valve	2" OD AT Recycle - ST Conc Forward
V-5	Concentrate Sprayball Divert Valve	2" OD AT Sprayball - ST Conc Forward
V-6	Feed/Conc Divert Valve	2" OD AT Conc Drain - ST Feed Forward
V-7	Permeate Recycle Divert Valve	3" OD AT Recycle - ST Permeate Forward
V-8	CIP Water Supply Valve	3" ATO-STC
V-9	Cooling Water Supply Valve	1" Solenoid NC
V-10	Feed/CIP Tank Drain Valve	3" ATO-STC
V-11	Cooling Water Return Valve	1" Gate
V-12	P-2 Seal Water Trim Valve	1/4" Gate Valve
V-13	P-3 Seal Water Trim Valve	1/4" Gate Valve
V-14	Feed Sample Valve	1/2" Sample Valve
V-15	Concentrate Sample Valve	1/2" Sample Valve
V-16	Feed Check Valve	2" Sanitary Check
V-17	Chemical Block Valve	1/2" Ball ATO-STC
V-18	Chemical Block Valve	1/2" Ball ATO-STC
V-19	Chemical Bleed Valve	1/2" Ball ATO-STC
V-101/V-201	Stage Recirc Pump Seal Water Trim Valve	1/4" Gate Valve
V-102/V-202	Stage Permeate Sample Valve	1/2" Sample Valve

**3.2 RO SYSTEM COMPONENTS****RO INSTRUMENTATION**

AT-1	Retentate Sonic Concentration Analyzer	0 - 25 °Brix
FT-1	Feed Flow Transmitter	0 - 264 gpm
FT-2	Retentate Flow Transmitter	0 - 264 gpm
FT-101	Stage 100 Permeate Flow Transmitter	0 - 264 gpm
FT-201	Stage 200 Permeate Flow Transmitter	0 - 264 gpm
LT-1	Feed/CIP Tank Level Transmitter	0 - 100%
PI-1	Feed Pressure Gauge	0 - 1000 psig
PI-2	Feed Filter Inlet Pressure Gauge	0 - 160 psig
PI-3	Feed Filter Outlet Pressure Gauge	0 - 160 psig
PI-4	Permeate Pressure Gauge	0 - 30 psig
PI-101	Stage 100 Inlet Pressure Gauge	0 - 1000 psig
PI-201	Stage 200 Inlet Pressure Gauge	0 - 1000 psig
PSH-2	Retentate High Pressure Switch	SP = 50 psig, increasing
PSH-3	Permeate High Pressure Switch	SP = 50 psig, increasing
PSL-2	Low Feed Pressure Switch	SP = 20 psig, decreasing
PT-1	Feed Pressure Transmitter	0 - 1000 psig
PT-101	Stage 100 Inlet Pressure Transmitter	0 - 1000 psig <b>By Ocean Spray</b>
PT-201	Stage 200 Inlet Pressure Transmitter	0 - 1000 psig <b>By Ocean Spray</b>
TT-1	Feed Temperature Transmitter	0 - 200 °F
TT-101	Stage 100 Temperature Transmitter	0 - 200 °F
TT-201	Stage 200 Temperature Transmitter	0 - 200 °F

**RO ANCILLARY**

F-X	Feed Prefilter	10 micron <b>By Ocean Spray</b>
F-1	Feed Filter	149 micron (100 mesh)
HE-1	Feed Heat Exchanger	Tube in Shell
TK-1	Feed/CIP Tank	300 gallon capacity

## **4.0 CONTROLS**

### **4.1 GENERAL CONTROLS DESCRIPTION**

The overall RO system is comprised of two RO stages operating in series. The stages are controlled through a PLC, Software Program and Operator Interface Device(s) supplied by Ocean Spray. The process goal is to run a 18 to 20 hr/day operation averaging 40 gpm of RO Feed and creating an 18 °Brix RO concentrate product.

#### **KOCH SUPPLIED CONTROL INTERFACE HARDWARE**

The RO system has a field interface panel mounted on the RO system frame. This panel includes pneumatic solenoids, I/P's, electrical terminal strip, etc. for field interconnection to the RO system components. All of the RO instrumentation and air operated valves require field interconnection.

#### **TO BE SUPPLIED BY OCEAN SPRAY**

The RO system operator interface device(s) designed to select, initiate and indicate RO system operating mode, pump, valve, process variable, alarm and fault status, etc., as described below.

The RO system programmable logic controller (PLC) and control program to monitors and control the sequence steps and operating variables of each operating mode as described below.

The RO controls include alarms that activate if process conditions are outside the design limits. If an alarm is sensed, the program will initiate action to prevent damage to the product, membrane modules and hardware.

The RO controls include a data acquisition system. The RO process variables are recorded by the Data Acquisition system eliminating the need for written operating logsheets.

The RO Motor Control Center (starters) for all RO system pumps supplied by OSC. The RO Booster Pumps require soft start-stop motor controllers designed to ramp up to speed and down to idle.

## 4.2 **PUSH BUTTONS**

This section describes push button functions required for each of the three RO sub-system trains.

### **Power On**

Power On the System controls.

### **Power Off/Emergency Stop**

Power Off the system control outputs.

### **Alarm Silence**

Silences the alarm horn

### **Alarm Reset**

Resets individual alarm circuit after correcting a fault.

### **Cycle Start**

Starts the selected system operating "Mode".

### **Cycle Hold**

Holds the control program at the present sequence step.

### **Cycle Pause**

Holds the control program at the present sequence step. (Stops timers, except chemical dose pumps. See Interlocks section). Pumps stop.

### **Cycle Reset**

Resets the control program to the initial step of the selected System "Mode".

## 4.2 PUSH BUTTONS

### **KOCHKLEEN® PA Dose Pump Jog**

KOCHKLEEN® PA Dose Pump on when pressed. (non-latching). Only active in the KOCHKLEEN® PA Wash cycle.

### **Cycle Advance**

Allows the operator to manually advance the sequence to achieve more flexibility in system operation.

1. During Shutdown Mode, to end the displacement prior to reaching the Low Solids Setpoint.
2. During any CIP Wash or Flush cycle, to end the current cycle step and advance to the next step.

### **Feed Pump P-1 Start/Stop**

Starts and Stops the Feed Pump P-1.

### **Booster Pump P-2 Start/Stop**

Starts and Stops the Booster Pump P-2.

### **Booster Pump P-3 Start/Stop**

Starts and Stops the Booster Pump P-3.

### **Stage 100 Circulation Pump P-100 Start/Stop**

Starts and Stops the Stage 100 Circulation Pump P-101.

### **Stage 200 Circulation Pump P-200 Start/Stop**

Starts and Stops the Stage 200 Circulation Pump P-201.

### 4.3 **SELECTOR SWITCHES**

This section describes selector switch type functions required for each of the three RO sub-system trains.

#### **Mode Selector**

The Mode selector sets the system operating mode.

#### **OFF**

Set to this position when the RO system is not in use. Prevents operation by powering off control outputs.

#### **PROCESS**

Set to this position when the RO system train is to process juice. Once the RO Process mode is started, the Process sequence automatically steps through the Process operating cycles (Modified Batch, Batchdown, Pump Out, RO Shutdown) described in the Sequence of Operation section below.

#### **CIP**

Set the RO Mode selector to CIP. Then press the Cycle Advance Push Button to display the RO CIP cycles. Select the CIP cycle to start at and press accept. The system will run the CIP Mode starting at the selected cycle. If the first flush cycle is selected the CIP mode will complete all RO CIP cycles described in the Sequence of Operation section below.

#### **Valve Force Feature**

All air operated valves in the RO system may be forced Open or closed using this feature. Select the valve and use the Force On, Force Off or Cancel buttons to set the desired valve position.

### 4.3 **SELECTOR SWITCHES**

#### **Recycle Selector**

A three position selector switch, positions are Manual, Off and Automatic.  
The switch is normally set to Automatic. Active only when the RO is in the Process Mode.  
In Automatic, the RO will be set into Recycle if low RO Feed tank level is sensed. The RO will automatically Reset Off Recycle if the tank level rises above a low level setpoint.

#### **Manual**

Set to this position to manually initiate RO Recycle. See sequence below.

#### **Off**

Set to this position to manually prevent the automatic initiation of RO Recycle.

If the RO is already in Recycle, set to Off to manually reset off the recycle operation.

1. RO Cycle Start push button flashes
2. Operator presses RO Cycle Start push button
3. The Reset Off Recycle sequence below occurs.

#### **Automatic**

In Auto, the RO system will be set to Recycle, if the following input is sensed.

##### A. Recycle on RO Low Feed Tank Level

Active during the RO Process mode only.

1. RO Feed tank level drops to 30% level
2. RO Recycle On per sequence described below.
3. RO Recycle will be reset Off, if RO Feed tank level rises to 75% level.

#### **The Recycle sequence is as follows:**

1. RO Recycle indicator On flashing (No Alarm)
2. Booster Pumps P-2, P-3 off
3. 15 second delay
4. V-1, V-2A, V-2B override open, V-3 open
5. Divert Valves V-4 and V-7 energized to Divert Concentrate and Permeate to Feed Tank.

#### **The Reset Off Recycle sequence is as follows:**

1. V-1, V-2A, V-2B to auto, V-3 closed
2. Divert Valves V-4 and V-7 to normally open position Concentrate and Permeate Forward.
3. 15 second delay
4. Booster Pumps P-2, P-3 On
5. Recycle Indicator Off

### 4.3 **SELECTOR SWITCHES**

#### **Shutdown Selector**

The RO Shutdown selector is used during the Process mode only to select the type of input that will initiate the RO Shutdown operation. During RO shutdown, water is substituted for DE filtrate feed to recover juice from the RO system prior to CIP.

A two position selector switch. Switch positions are Automatic and Manual.  
The switch is normally set to Automatic.

#### **Automatic**

Set to this position to have the RO Shutdown start automatically.

#### **The automatic RO Shutdown sequence is as follows:**

1. RO Shutdown indicator On flashing. Disable RO Recycle on Low Tank Level.
2. Delay for RO Tank level to drop to 30% level
3. 30% RO Feed Tank level sensed
4. Booster Pumps P-2, P-3 stop
5. 15 second delay
6. V-1, V-2A, V-2B off auto
7. V-1, V-2A, V-2B override open, V-3 open
8. V-8 to auto. Add water and maintain tank between 30 and 50% level
9. RO Retentate solids drop to 1 °Brix
10. P-1, P-101, P-201 off
11. V-8 closed
10. RO Shutdown Completed message on

#### **Manual**

Set to this position to manually initiate RO Shutdown, the sequence is the same as described above.

1. Cycle Start Flashes.
2. Press Cycle Start to initiate the RO Shutdown mode.
3. RO Shutdown mode operates as described above.

#### **4.4 MESSAGES, TIMERS, PROCESS VARIABLE AND FAULT INDICATORS**

The following Messages, Timers, Process Variable and Fault indicators are displayed for operator information.

##### **MESSAGES**

Check Swings  
Process Mode  
Recycle  
Shutdown  
CIP Mode  
Flush  
Wash  
Check Chemicals  
Check Water Flux

##### **TIMERS**

RO Wash Timers  
RO Shutdown Displacement Timer

##### **PROCESS VARIABLE INDICATORS**

Feed/CIP Tank Level  
Feed Flow rate  
Feed Total Flow  
Concentrate Flow rate  
Concentrate Total Flow  
Permeate Flow Stage 100  
Permeate Flow Stage 200  
Feed Temperature  
Stage 100 Temperature  
Stage 200 Temperature  
Feed Pressure  
Retentate °Brix

##### **FAULT INDICATORS**

High Feed Temperature (TSH-1)  
High Stage 100 Temperature (TSH-100)  
High Stage 200 Temperature (TSH-200)  
High Stage 300 Temperature (TSH-300)  
RO High Feed Pressure (PSH-1)  
RO Low Feed Pressure (PSL-1)  
RO Low Booster Pump Feed Pressure (PSL-2)  
RO High Feed Tank Level (LSH-1)  
RO Low Feed Tank Level (LSL-1)  
RO High Retentate Pressure (PSH-2)  
RO High Permeate Pressure (PSH-3)  
Low Air Pressure (PSL-2)

#### 4.5 SYSTEM CONTROLLERS AND ALARMS

This section details the RO system controllers and alarms.

##### Feed Flow Controller (FIC-1)

Provides RO Feed Flow Indication and controls Feed Pump P-1 VFD during the Process mode.

**Input Signal:** 4-20 mA from FT-1 (0-200 gpm)  
**Control Type:** Proportional (direct acting)  
**Output Signal:** 4-20 mA to VFD  
**Control Element:** P-1 VFD  
**Setpoint:** The default process setpoint is 2 gpm less than the DE filtrate rate.  
The setpoint may be changed to be from 2 to 15 gpm less than DE filtrate rate.  
The feed rate may not be greater than 60 gpm and not be less than 30 gpm

##### Temperature Controller (TIC-1)

Provides indication and control of the RO system temperature during all modes of operation

**Input Signal:** 4-20 mA from TT-300 (0-200 °F)  
**Control Type:** On-Off  
**Output Signal:** 110 VAC to V-9  
**Control Element:** V-9 solenoid valve. Feed Pump P-1 must be running for V-9 to open.  
**Setpoints:** Process Mode: Open if > 70 °F, Closed if < 68 °F  
CIP Mode: open if >115 °F, Closed if < 113 °F

##### Retentate Solids Controller (AIC-1)

Provides indication and control of the RO system final Retentate solids during the process mode.

**Input Signal:** 4-20 mA from AIT-1 (0-25 °Brix)  
**Control Type:** Proportional (reverse acting)  
**Output Signal:** 4-20 mA to V-2A/V-2B  
**Control Element:** V-2A, V-2B, 4 mA = 100% open, 20 mA = 0% open  
**Setpoint:** 18 °Brix during Process Mode

## 4.5 RO SYSTEM CONTROLLERS AND ALARMS

### Inlet High Pressure Alarm (PAH-1)

Protects RO membranes from damage.

Sensor: PT-1

Active whenever RO Booster pumps P-2, P-3 should be running.

Alarm point: Pressure > 650 psig for 2 seconds.

If sensed, alarm indication and horn on, All RO pumps Off

### Inlet Low Pressure Alarm (PAL-1)

Protects RO membranes and pumps from damage.

Sensor: PT-1

Active whenever RO Feed pump P-1 should be running.

Disabled for 30 seconds whenever RO Feed P-1 or Booster pump P-2, P-3 start.

Alarm point: Pressure < 10 psig for 2 seconds.

If sensed, alarm indication and horn on, All RO pumps off.

### Booster Pumps Low Feed Pressure Alarm (PAL-2)

Protects RO membranes and pumps from damage.

Sensor: PSL-2

Active whenever RO Feed Pump P-1 and either Booster Pump P-2 or P-3 are running.

Disabled for 10 seconds during RO Feed Pump P-1 start.

Alarm point: Pressure < 10 psig for 2 seconds.

If sensed, alarm indication and horn on, All RO pumps off.

### Feed/CIP Tank Low Level Alarm (LAL-1)

Used to initiate RO Recycle if the feed is interrupted.

Sensor: LT-1

Active during the RO Process mode only. Only if P-1 should be running.

Alarm point: Level drops to 30%

If sensed, alarm indication and horn on

If the RO Recycle selector switch is set to Automatic, RO Recycle on.

Alarm will reset off if RO Feed Tank level rises to 75% level

### Feed/CIP Tank High Level Alarm (LAH-1)

Indicates excessive RO Feed/CIP tank level.

Sensor: LT-1

Active during the RO Process mode only.

Alarm point: Level > 95%

If sensed, RO High Level Indicator On, No Alarm horn

Will reset Off if level < 95%.

### Process Feed High Temperature Alarm (TAH-1)

Protects Juice from damage.

Sensor: TT-1

Active during the RO Process mode only. only if P-1 should be running.

Disabled for 10 minutes after P-1 starts in the RO Process Start-up sequence.

Disabled during the RO Shutdown mode.

Alarm point: Temperature > 95 °F

If sensed, alarm indication and horn on, all RO pumps off.

Will reset Off if Temp < 95°F.

## **4.5 SYSTEM CONTROLLERS AND ALARMS**

### **CIP Feed High Temperature Alarm (TAH-2)**

Protects membranes from damage due to High CIP temperature

Sensor: TT-1

Active during the RO CIP mode and RO Shutdown modes.

Alarm point: temperature > 113°F

If sensed, alarm indication and horn on, all RO pumps off.

Will reset Off if Temp < 113°F.

### **Stage Process High Temperature Alarm (TAH-101, TAH-201)**

Protects Juice from damage.

Two separate alarms, one for each stage

Sensors: Stage Temperature Transmitters: TT-101, TT-201

Active during Process mode only.

Disabled during the RO Shutdown mode.

Disabled for 10 minutes after P-1 starts in the RO Process Start-up sequence.

Alarm point: Temperature > 95°F

If sensed, alarm indication and horn on. All RO pumps off.

Will reset off if Temp < 95°F.

### **Stage CIP High Temperature Alarm (TAH-102, TAH-202)**

Protects membranes from damage.

Three separate alarms (one for each stage)

Sensors: Stage Temperature Transmitters: TT-101, TT-201

Active during RO CIP mode and RO Shutdown Mode.

Alarm point: Temperature > 113 F

If sensed, alarm indication and horn on, all RO pumps off.

Will reset off if temperature < 113 °F.

### **Retentate High Pressure Alarm (PAH-2)**

Protects RO system from damage due to dead headed retentate outlet.

Sensor: PSH-2

Active during All RO Modes. Disabled whenever V-5 is set to the sprayball position.

Alarm point: 50 psig increasing pressure for 3 seconds

If sensed, alarm indication and horn on, all RO pumps off.

### **Permeate High Pressure Alarm (PAH-3)**

Protects RO system from damage due to dead headed permeate outlet.

Sensor: PSH-3

Active during All RO Modes.

Alarm point: 50 psig increasing pressure for 3 seconds

If sensed, alarm indication and horn on, all RO pumps off.

### **Compressed Air Low Pressure Alarm (PAL-2)**

Protects the RO system from damage.

Sensor: PSL-2 (located in Air/Electrical Terminal Box)

Active in all RO modes.

Alarm point: 50 psig decreasing pressure

If sensed, alarm indication and horn on, all RO pumps off.

#### 4.6 CLEARING FAULT ALARMS

If an alarm is sensed and/or pump shutdown occurs, use the following steps to clear the fault and restart pumps.

1. Press the Alarm Silence push button.
2. Identify the fault
3. Correct the fault condition. If high temperature, allow system to cool.
4. Press the Alarm Reset push button.
5. Restart individual pumps using the start push buttons.
6. Press the Cycle Start push button to restart the automatic sequence steps and timers.
7. Set controllers to manual, as needed, to return to, or change, operating conditions.

## 4.7 INTERLOCKS

### System Flow Totalizers and Recycle Function

Flow totalization will stop whenever the respective system Recycle function is On.  
Flow totalization will start if the Recycle function is Off.

### System Pumps and Alarms

Pumps that stop due to an alarm condition will not restart once an alarm is acknowledged and reset.  
The pumps must be restarted manually using the pump start push buttons on the panel.  
Pump start button backgrounds are colored light blue to show if the pump should be running.

### Timers and System Alarms

Timers that were counting will stop if any alarm occurs which stops the system pumps.  
The operator must acknowledge and reset the alarm, then manually press the Cycle Start push button for the respective system to restart the timers.

### Chemical Dose Pump Timers and System Alarms

Any chemical dose pump timer that was running will continue to time out regardless of alarm activation.  
This interlock is to prevent overdosing of chemicals, if an alarm occurs during the dose step.

### Booster Pumps Soft Start/Stop Feature

The Booster Pumps use customer supplied soft start type motor starters.  
These devices protect the systems from damage due to water hammer.  
Always ensure the starters are set to a 30-second ramp up time and are operating properly.

### Booster Pumps Start and V-3 Open Position

The booster pumps P-2, P-3 are interlocked to not run if the RO retentate by-pass valve, V-3, is open.  
V-3 is open during RO CIP Flush and Wash modes and RO Process Recycle and Shutdown modes.

### Concentrate High Pressure Alarm and Divert Valve V-5

The RO Concentrate High Pressure Alarm PSH-2 is inactive whenever Divert Valve V-5 is set to the spray ball position.

### Cooling Water Valves and Feed Pump

Cooling water Valve V-9 will not open unless the RO Feed Pump P-1 is On.

## 5.0 CIP MODE SEQUENCE OF OPERATION AND CONTROL

The RO system has two modes of operation: Process and CIP. This section provides detailed operating instructions for the RO system CIP Mode sequence of operation and control. General descriptions of the operating modes are given first, followed by detailed operating steps, for software program development.

### 5.1 CIP MODE GENERAL DESCRIPTION

The CIP mode is designed to clean and sanitize the RO membranes and process piping.

The CIP mode is required to be performed after each process run, or, prior to a new process run if the RO system has been off for more than 24 hours.

The CIP mode contains 11 cycles which operate automatically. They are listed below along with the water temperature needed. Note that the **KOCHKLEEN® PA** Sanitize Wash temperature must not exceed 77 °F or membrane damage will occur. In a typical operating week, the **KOCHKLEEN® 150** Sanitize Wash is performed 5 times and the **KOCHKLEEN® PA** Sanitize Wash is performed twice. The type of Sanitize Wash to be performed can be preset and the CIP Auto mode sequence will adjust the water temperature as needed.

CIP AUTO MODE CYCLES		Sanitize Wash Type	
		KOCHKLEEN® 150	KOCHKLEEN® PA
		Water Temp Required	
FLUSH #1		HOT (105 °F)	HOT (105 °F)
WASH #1	KOCHKLEEN® 221, KLD III & SP Wash	HOT	HOT
FLUSH #2		HOT	HOT
WASH #2	KOCHKLEEN® ENZ 10 Wash	HOT	HOT
FLUSH #3		HOT	HOT
WASH #3	KOCHKLEEN® 221, KLD III & SP Wash	HOT	HOT
FLUSH #4		HOT	HOT
WASH #4	KOCHKLEEN® ENZ 10 Wash	HOT	HOT
FLUSH #5		HOT	COLD (65 °F)
	Check Water Flux Cycle and Sanitize Wash	HOT	COLD
FLUSH #6		HOT	COLD

All Flush cycles displace system hold-up volume to drain. All Flush cycles are similar, except that the last Flush uses Potable Water, while the other Flushes can use RO permeate or Potable water

All wash cycles circulate chemicals to clean and sanitize the membranes and system piping. Only the **KOCHKLEEN® PA** Wash uses the chemical addition valves. All other washes require manual chemical addition. The control program includes the necessary pauses and prompts to alert the operator to manually add chemicals or check wash solution strength prior to chemical addition.

The Check Water Flux Cycle is used to determine if the preceding CIP sequence was effective in restoring membrane performance.

## 5.2 CIP MODE DETAILED SEQUENCE OF OPERATION

This section describes the detailed operating instructions, both manual and automatic, for the CIP mode.

### CIP MODE PRELIMINARY MANUAL OPERATIONS

Prior to starting the CIP Mode, complete the following tasks.

1. Set all Flowplate and swing elbow connections to the CIP positions.
2. Check that sufficient chemical and water supplies are available.
3. Remove Clean and Reinstall the Feed Filter.
4. Set System Mode selector switch to CIP. Select either **KOCHKLEEN® 150** or **KOCHKLEEN® PA** Sanitize Wash.
5. Press the Cycle Reset push button. The “Cycle will start at Flush #1” message will be displayed.
6. Press the Start push button.
7. The Alarm Horn will sound and the "Check Swings" message will be displayed.
8. Press the Alarm Silence push button.
9. Press to confirm that all preliminary tasks are complete.
10. If the preliminary steps have been completed as listed above, then press the Proceed push button.

### CIP Mode Operating Steps

The CIP mode now operates under control of the PLC. The operator is required to be present to assure CIP effectiveness. Duties include checking CIP flush conditions, chemical addition (solution pH), wash duration and temperature and to monitor, confirm and record.

The CIP Mode cycles are described in the sections that follow.

## **5.2 CIP MODE DETAILED SEQUENCE OF OPERATION**

### **5.2.1 RO Flush #1 Cycle**

#### **Step 1: Set System Components**

"Flush #1" message on  
Pumps Off  
P-1 VFD to Auto, Control Flow at 100 GPM  
V-2A, V-2B forced open  
V-3, V-19 open  
V-10, V-17, V-18 closed  
V-4, V-5 to Concentrate forward  
V-6, V-7 to Drain  
V-9/TIC-1 setpoint = 105 °F.

#### **Step 2: Fill CIP Tank**

V-8 to automatic. Control RO CIP tank between 70 and 80% level  
Delay for CIP tank to reach high level  
At 80% level

#### **Step 3: Feed Pump On**

P-1 on  
PT-1 senses 20 psig  
5 second delay

#### **Step 4: Stage Pumps On**

P-101 on  
5 second delay  
P-201 on

#### **Step 5: Flush RO Concentrate and Permeate to Drain**

8 minute delay for RO system displacement (Log Flush Data)

#### **Step 6: Flush Permeate and Concentrate Recycle Lines**

V-6, V-7 to CIP tank  
15 second delay

#### **Step 7: Flush Tank Via Sprayball**

V-5 to CIP tank, override PSH-2  
30 second delay

#### **Step 8: Flush Retentate Recycle**

V-4 to CIP Tank  
15 second delay

#### **Step 9 End RO Flush Cycle**

All RO Pumps off  
V-8 closed (Off Auto)  
"Flush #1 Complete" message on

#### **Flush #1 Cycle complete**

The CIP sequence proceeds to the Wash #1 Cycle

## 5.2 CIP MODE DETAILED SEQUENCE OF OPERATION

### 5.2.2 Wash #1: KOCHKLEEN® 221, KLD III & SP Wash Cycle

The RO Wash #1 requires manual addition of several **KOCHKLEEN®** products and has a 10-minute wash step.

#### Step 1: Set System Components

"Wash #1: **KOCHKLEEN® 221, KLD III & SP Wash**" message on

Pumps off

V-1,V-2A, V-2B forced open,

V-3,V-19 open

V-10,V-17,V-18 closed

V-4,V-5,V-6,V-7 to CIP tank

V-9 to automatic, TIC-1 setpoint = 105°F

#### Step 2: Fill CIP Tank

V-8 to automatic. Control RO CIP tank level between 70 and 80% level

Delay for CIP tank to reach high level

At 80% level

#### Step 3: Feed Pump On

Start P-1

When PT-1 senses 20 psig

5 second delay

#### Step 4: Stage Pumps On

P-101 on

5 second delay

P-201 on

#### Step 5: MANUAL OPERATION - ADD CHEMICALS TO CIP TANK

Cycle Hold

Alarm horn flashes on and off

"Add 5# **KOCHKLEEN® 221**, 48 oz. **KOCHKLEEN® KLD III**, 5# **KOCHKLEEN® SP**" message on

Cycle Start push button On Flashing

Operator presses Silence push button to silence horn.

Operator adds chemicals manually to the CIP Tank.

Press the message box after chemical addition is correct

#### Step 6: Wash Circulation

Wash timer starts

10-minute delay (Log Wash Data)

## **5.2 CIP MODE DETAILED SEQUENCE OF OPERATION**

### **5.2.2 Wash #1: KOCHKLEEN® 221, KLD III & SP Wash Cycle**

#### **Step 7: Wash Concentrate to Drain Line**

V-6 to drain

15 second delay

#### **Step 8: Wash Tank and Permeate to Drain Line**

V-5 to Tank

V-7 to Drain

30 second delay

#### **Step 9: Concentrate Recycle**

V-4 to tank

15 second delay

#### **Step 10: Stop Pumps**

Stop all pumps

#### **Step 11: Drain CIP Tank**

V-10 open

At 0% level

45 second delay

V-10 closed

#### **Step 12: End Wash #1 Cycle**

"Wash #1: KOCHKLEEN® 221, KLD III, SP Wash Complete" message on

The CIP sequence proceeds to the Flush #2 Cycle

### **5.2.3 Flush #2 Cycle**

Repeat RO Flush #1 cycle per section 5.2.1 above.

"Flush #2" message on.

When complete,

"Flush #2" Complete message on.

The CIP sequence proceeds to the Wash #2.

## 5.2 CIP MODE DETAILED SEQUENCE OF OPERATION

### 5.2.4 Wash #2: KOCHKLEEN® ENZ 10 Wash Cycle

The Wash #2 requires manual addition of enzyme and has a 45-minute wash step.

Repeat Wash #1 cycle per section 5.2.2 above, except change the following:

“Wash #2: **KOCHKLEEN® ENZ 10** Wash” message on

In Step 5 Manually add 20 lb. of **KOCHKLEEN® ENZ 10** only.

In Step 6 Wash timer duration is 45-minutes

When complete,

“Wash #2: **KOCHKLEEN® ENZ 10** Wash Complete” message on

The CIP sequence proceeds to the Flush #3 Step.

### 5.2.5 Flush #3 Cycle

Repeat Flush #1 cycle per section 5.2.1 above.

"Flush #3" message on.

When complete,

“Flush #3” message off.

The CIP sequence proceeds to the Wash #3

### 5.2.6 Wash #3: KOCHKLEEN® 221, KLD III & SP Wash

The RO Wash #3 is the same as RO Wash #1. It requires manual addition of three **KOCHKLEEN®** products and has a 30-minute wash step.

Repeat Wash #1 cycle per section 5.2.2 above.

The CIP sequence proceeds to the Flush #4 Step.

### 5.2.7 Flush #4 Cycle

Repeat Flush #1 cycle per section 5.2.1 above.

"Flush #4" message on.

When complete,

“Flush #4 Complete” message on

The CIP sequence proceeds to the Wash #4 Cycle.

## 5.2 CIP MODE DETAILED SEQUENCE OF OPERATION

### 5.2.8 Wash #4: KOCHKLEEN® ENZ 10 Wash

Repeat Wash #2 cycle per section 5.2.4 above, except change the following:

“Wash #4: **KOCHKLEEN® ENZ 10 Wash**” message on

In Step 5 Manually add 20 lb. of **KOCHKLEEN® ENZ 10** only.

In Step 6 Wash timer duration is 30 minutes

When complete,

“Wash #4: **KOCHKLEEN® ENZ 10 Wash Complete**” message on

The CIP sequence proceeds to the Flush #5 Step.

### 5.2.9 Flush #5 Cycle

Repeat Flush #1 cycle per section 5.2.1 above, except:

Use Hot Water if the **KOCHKLEEN® 150** Sanitize is to be selected, use Cold water if the **KOCHKLEEN® PA** Sanitize is to be selected.

"Flush #5" message on.

When complete,

“Flush #5 Completed” message on

The CIP sequence proceeds to the Check Water Flux/Sanitize Cycle.

## 5.2 CIP MODE DETAILED SEQUENCE OF OPERATION

### 5.2.10 Check Water Flux/Sanitize Cycle

The Check Water Flux cycle is run at the completion of the above cycles. During this cycle, the System Water Flux is calculated and displayed. The operator must verify the Water Flux meets the minimum criteria. If it does the RO system finishes the cycle by performing a Sanitize wash. The type of sanitize wash determines the water temperature used in the previous flush cycle and this cycle. The **KOCHKLEEN® 150** wash is run Hot (water supply 105 °F), the **KOCHKLEEN® PA** wash is run cold (water supply 65 °F).

#### Step 1: Set System Components

"Check Water Flux" message on

All Pumps off

P-1 VFD to Auto Setpoint = 70 gpm

V-2A, V-2B forced closed

V-3, V-8, V-10, V-17, V-18 closed

V-19 open

V-4, V-5, V-6, V-7 to CIP Tank

V-9/TIC-1 to Auto, setpoint = 105 °F if **KOCHKLEEN® 150** Wash is selected, setpoint = 65 °F if **KOCHKLEEN® PA** Wash is selected.

#### Step 2: Fill CIP Tank

V-8 to automatic. Control CIP tank between 70 and 80% level

Delay for CIP tank to reach high level

At 80% level

#### Step 3: Feed Pump On

P-1 on

When PT-1 senses 20 psig

5 second delay

#### Step 4: Booster Pump On

P-2 on (P-3 remains off)

5 second delay

#### Step 5: Stage Pumps On

P-101 on

5 second delay

P-201 on

#### Step 6: Prompt for Operator to Check Water Flux

Cycle Hold, Calculated Water Flux is displayed.

Alarm Horn on flashing

#### Step 7: MANUAL OPERATION - READ AND RECORD RO WATER FLUX DATA

Press Alarm Silence push button to silence Alarm Horn

The PLC logs the following data.

RO Feed Pressure PI-1

RO Stage Inlet Pressures PI-101 and PI-201

RO Stage Temperatures TI-101 and TI-201

RO Stage Permeate Flows FI-101 and FI-201

The PLC/HMI displays the Calculated Water Flux

**5.2 CIP MODE DETAILED SEQUENCE OF OPERATION****5.2.10 Check Water Flux/Sanitize Cycle****Step 8: MANUAL OPERATION - VERIFY CALCULATED RO WATER FLUX**

The RO Water Flux is NOT Acceptable if below 12 GFD

Stop all RO Pumps using the Pump Stop push buttons.

Set the mode selector to repeat the RO CIP sequence or individual wash steps.

The RO Water Flux is Acceptable if at or above 12 GFD

Press “Accept Data”.

The pre-selected sanitize wash begins

RO “KOCHKLEEN® 150 Wash” or “KOCHKLEEN® PA Wash” message On

**Step 9: Chemical Addition**

If the if KOCHKLEEN® 150 Wash is selected, the operator must manually add KOCHKLEEN® 150 to the RO CIP tank. If the KOCHKLEEN® PA Wash is selected, the KOCHKLEEN® PA will be added using the Dose Pump and chemical Addition valves.

**KOCHKLEEN® 150 WASH**

Manually Add 15 lb. of KOCHKLEEN® 150

**KOCHKLEEN® PA WASH**

V-17, V-18 Open

V-19 closed

KOCHKLEEN® PA Dose Pump On

XX second dose

KOCHKLEEN® PA Dose Pump Off

**Step 10: Sanitize Wash Duration****KOCHKLEEN® 150 WASH**

15-minute wash timer starts (Log Wash Data)

When the timer times out

**KOCHKLEEN® PA WASH**

10-minute wash timer starts (Log Wash Data)

When the timer times out

**Step 11: End Check Water Flux/Sanitize Wash**

All pumps stop

V-8 closed (off auto)

V-10 open

At 0% level

**Step 12: End Check Water Flux/Sanitize Wash**

Wait 45 seconds

Close all valves

"Sanitize Wash Completed" message on

**5.2.11 Flush #6 Cycle**

Repeat Flush #1 cycle per section 5.2.1 above, except:

Use Hot Water if the KOCHKLEEN® 150 Sanitize was selected, use Cold water if the KOCHKLEEN® PA Sanitize was selected.

"Flush #5" message on.

When complete,

“Flush #5 Completed” message on

“ CIP Mode Complete” message on.

**CIP Sequence Complete**

## **6.0 PROCESS MODE SEQUENCE OF OPERATION AND CONTROL**

This section provides detailed operating instructions for the RO system PROCESS Mode sequence of operation and control.

### **6.1 PROCESS MODE GENERAL DESCRIPTION**

During the Process mode, RO system operates as two stages in series. The DE filter clarifies the raw juice and DE filtrate feeds to the RO system. The RO system concentrates the DE filtrate to a final 18 °Brix concentrate. RO permeate is reused in the plant.

### **6.1 PROCESS MODE GENERAL DESCRIPTION**

The RO system has the following operations in PROCESS mode.

#### **Start-Up**

At the beginning of the PROCESS Mode, DE filtrate is pumped into the RO Feed/CIP tank. When a high level is sensed, the RO Feed and Booster pumps, P-1, P-2 and P-3 start. Once the Feed and Booster pumps start, the Stage Pumps are all started.

The RO feed control valve, V-1, maintains a feed rate to the RO system to match the DE filtrate rate (but not greater than 60 gpm or less than 30 gpm). As low °Brix juice is fed into the RO, and permeate is removed, the juice becomes concentrated.

A Sonic Velocity Concentration analyzer (AT-1) is located in the Stage 200 final concentrate piping. This device monitors the final concentrate °Brix level. As the solids increase to the 18 °Brix setpoint, the retentate solids controller opens control valves V-2A and V-2B to maintain the final 18 °Brix concentration setpoint.

#### **Recycle**

If the Recycle selector switch is in Automatic, the system will be set into Recycle if the RO Feed tank level drops below 30%. This condition could occur if the DE Filtrate rate is less than the minimum 30 gpm RO Feed Rate. Refer to the RO Recycle selector switch section for details.

#### **Shutdown**

The Shutdown mode is used to recover the final volumes of juice at the end of the Process Run and prior to CIP. During Shutdown, the Booster Pumps stop and the Concentrate By-Pass valve opens. Water is added to the Feed tank and displaces the remaining juice from the system. The displacement continues until the RO concentrate solids drops to 1 °Brix. At this point, the RO shutdown is complete and the RO pumps stop.

Once the RO Shutdown is complete, system must be cleaned and sanitized using the CIP Mode.

## **6.2 PROCESS MODE DETAILED SEQUENCE OF OPERATION**

This section describes the operating steps, both manual and automatic, for the Process Mode.

### **MANUAL OPERATION - PROCESS MODE PRELIMINARY OPERATIONS**

Complete the following tasks, prior to starting Process operation.

1. Change all Flowplate and swing elbows to the Process positions.
2. Check the RO feed filters are clean and intact.
3. Set all RO Process controllers and selector switches to AUTO
4. Reset all Flow Totalizers.

### **MANUAL OPERATION - STARTING THE PROCESS MODE**

1. Set the RO mode selector switches to Process
2. Press the Cycle Reset push button
3. Press the RO Cycle Start push button
4. The Alarm Horn will sound and the list of set-up steps will be displayed.
5. Press the Alarm Silence push button.
6. Press to acknowledge that all preliminary steps have been completed. Then press continue button.

The Process mode now operates automatically under control of the PLC.

The Operator must monitor the Process start-up sequence to assure all pumps start, DE Filtrate Turbidity is good and the RO achieves final concentration.

The RO Process mode cycles are described below.

## **6.2 PROCESS MODE DETAILED SEQUENCE OF OPERATION**

### **6.2.1 Recycle Operation**

This operation is used to prevent the RO system from shutdown due to interruption of the DE filtrate feed.

If the Recycle Selector is in Auto, the system will be set to Recycle, if the RO Feed Tank Level falls to 30% level. Also refer to the :Recycle selector switch section.

#### **Step: Low Feed Tank level Sensed**

RO Feed tank level falls to 30%

#### **Step 2: Stop Booster Pumps**

Recycle indicator On flashing

Booster Pumps P-2, P-3 off

15 second delay

#### **Step 3: Set Valves**

V-1, V-2A, V-2B override open, V-3 open

Divert Valves V-4 and V-7 to Normally closed position (Feed Tank)

The system will remain in Recycle until the Feed tank level rises or the recycle selector is set to Off.

### **Recycle Off Automatic Sequence**

#### **Step 1: High Feed Tank Level Sensed**

RO Feed tank level rises to 75% level, or,

Operator Manually sets Recycle Selector to Off (See RO Recycle selector switch section).

#### **Step 2: Set Valves**

V-1, V-2A and V-2B to Auto. V-3 closed

Divert Valves V-4 and V-7 to Normally Open position (Concentrate and Permeate Forward)

#### **Step 3: Start Booster Pumps**

Booster Pumps P-2, P-3 On

Recycle indicator Off

### **Recycle Off Manual Sequence**

The operator can manually set the RO Off of Recycle using the steps below.

#### **Step 1: MANUAL OPERATION - SET SELECTOR SWITCH**

Manually sets the Recycle Selector to Off

Cycle Start push button flashes

#### **Step 2: MANUAL OPERATION - CONFIRM SELECTION**

Operator presses cycle start push button

#### **Step 3: Automatic Steps**

Steps 2 and 3 of the Recycle Off Automatic sequence above are performed.

## **6.3 PROCESS MODE DETAILED SEQUENCE OF OPERATION**

### **6.3.3 Shutdown Operation**

The Shutdown operation is used to end the RO Process Run. During shutdown, water is substituted for DE filtrate feed to displace juice from the RO system prior to CIP.

If the Shutdown selector is set to Auto, the Shutdown sequence will occur automatically once initiated.

#### **Automatic Shutdown Sequence**

##### **Step 1: Input Sensed**

Operator selects Shutdown (See Shutdown selector switch section)

##### **Step 2: Tank Level Drops**

Shutdown indicator On flashing  
Disable Recycle on Low Tank Level  
Delay for RO Feed tank level to drop  
At 30% RO Feed Tank Level

##### **Step 3: Booster Pumps Off**

Booster Pumps P-2 and P-3 stop  
15 second delay

##### **Step 4: Set Valves**

V-1, V-2A and V-2B off auto, Force Full open, V-3 open  
V-8 to auto. Maintain RO Feed tank level between 60 and 90% level

##### **Step 5: Final Solids Level Reached**

Delay for RO Retentate solids drop  
AIC-1 senses 1 °Brix

##### **Step 6: End Shutdown**

P-1, P-101 and P-201off  
V-8 closed  
Shutdown Completed message on

#### **Process Mode Sequence Complete**

### **PROCESS MODE SEQUENCE OF OPERATIONS COMPLETE**

## 7.0 PERFORMANCE TESTS

### 7.1 CHECK WATER FLUX TEST

Check Water Flux is performed after every CIP mode to determine if the previous cleaning was effective. **The Water Flux test is the standard method used to determine if the membranes are in a clean condition.** The Water Flux data can track the effectiveness of the CIP mode and can spot trends that may indicate reduction in cleaning efficiency, water quality or membrane performance.

**Koch requires that the Check Water Flux test be performed and the data analyzed and recorded to ensure the Koch RO membrane warranty remains in effect.**

**Therefore, a requirement of the RO system OPERATOR training is:**

1. Understand how to perform the Check Water Flux sequence.
2. Understand how to calculate RO membrane water flux.
3. Understand what the water flux data tells us about the condition of the membranes.

**The Check Water Flux sequence is the only method for:**

1. Determining the effectiveness of the cleaning cycle.
2. Monitoring cleaning effectiveness from run to run.

**For the RO System:**

During the RO Check Water Flux, only Booster pump P-2 runs.

1. The minimum acceptable Corrected RO Water Flux is 13 gfd.
2. The Standard Conditions for the Corrected RO Water Flux are:
  - a. Average pressure = 250 psi
  - b. Water temperature = 77 °F

In practice, due to variations in water temperature and system design, it is impossible to perform the Water Flux test at the Standard Conditions. Instead, formulas are provided to correct water flux data taken at different conditions of pressure and temperature. The sections below describe how this is done.

**NOTE: THE RO CONTROLS INCLUDES A DATA ACQUISITION SYSTEM WHICH WILL RECORD THE NEEDED CHECK WATER FLUX DATA, CALCULATE THE CORRECTED WATER FLUX AND INDICATE IF THE CORRECTED WATER FLUX IS ACCEPTABLE OR NOT. THE FOLLOWING SECTIONS DESCRIBE THE METHOD USED TO CALCULATE THE CHECK WATER FLUX DATA.**

## 7.1 CHECK WATER FLUX TEST

The general formula used to calculate uncorrected water flux, for any fluid, measured at any pressure and temperature condition is:

### MEASURED WATER FLUX

$$J_m \text{ (gfd)} = \frac{\text{Permeate rate (gpm)} \times 1440 \text{ (min/day)}}{\text{Membrane area (square feet)}}$$

Where the pressure and temperature conditions are stated.

Where:

$J_m$  = Uncorrected Water Flux in gfd

gfd = gallons per square foot of membrane per day

### CORRECTED WATER FLUX

The measured water flux is changed to corrected water flux as follows:

#### For the RO System

$$J_c \text{ (gfd}_c\text{)} = J_m \text{ (gfd)} \times \text{TCF-RO} \times (250/P_{avg})$$

Where:

**TCF-RO** = RO Temperature Correction Factor, See table below.

**P<sub>avg</sub>** = The average of the stage inlet and outlet pressures. RO Inlet pressure are from PI-101 and PI-201 and the common RO Outlet pressure is from PI-1.

**7.1 CHECK WATER FLUX TEST****RO System Check Water Flux Test Example:**

The RO water flux check is done for each stage using the individual Stage inlet pressures, temperatures and permeate flows. The stage outlet pressure is the same as the RO system feed pressure.

Example: Calculate the RO Stage 100 Corrected Water Flux if the data was recorded as follows.

Inlet Pressure (PI-101)	75 psig
Outlet Pressure (PI-1)	25 psig
Stage Temperature (TI-101)	105 °F
Stage 100 Flux Rate (FI-101)	17 gpm

**Step 1: Look-up the RO Temperature Correction Factor (TCF-RO)**

From the table below. At 105 °F, Find TCF-RO is about equal to 0.623

**Step 2: Calculate the RO Stage 100 Average Pressure**

$$P_{avg} = (P_{in} + P_{out})/2 = (75 + 25)/2 = 100/2 = 50 \text{ psig}$$

**Step 3: Look-Up RO Membrane Area.**

Stage 100, as initially supplied with 12 each S-5 housings;

12 housings x 5 modules/housing x 70 sq. ft./module = 4200 square feet of membrane area.

**Step 4: Calculate the Uncorrected Water Flux**

$$J_m \text{ (gfd)} = \frac{\text{Permeate rate (gpm)} \times 1440 \text{ (min/day)}}{\text{Membrane area (square feet)}}$$

$$J_m \text{ (RO Stage 100)} = \frac{17 \text{ (gal/min)} \times 1440 \text{ (min/day)}}{4,200 \text{ (sq ft)}}$$

$$J_m \text{ (RO Stage 100)} = 5.8 \text{ gfd}$$

**Step 5: Calculate the Corrected Water Flux**

$$J_c \text{ (gfd}_c\text{)} = J_m \text{ (gfd)} \times \text{TCF-RO} \times (250/P_{avg})$$

$$J_c = 5.8 \times 0.623 \times (250/50)$$

$$J_c = 18.1 \text{ gfd}_c$$

**Step 6: Analyze the Data**

Since the Corrected Water Flux is greater than the minimum of 15 gfd<sub>c</sub>, the Water Flux Test data indicates that the RO membranes are clean.

If the Corrected Water Flux was less than the minimum:

First check the accuracy of the data and calculation.

If the calculation is correct, check that chemical supplies and water quality are adequate.

Then repeat individual CIP washes as needed to try to raise the Water Flux to an acceptable level.

**7.1 RO WATER FLUX TEMPERATURE CORRECTION FACTOR TCF-RO**

Temperature Centigrade °C	Temperature Fahrenheit °F	Temperature Correction Factor TCF-RO
5	41.0	2.083
6	42.8	1.976
7	44.6	1.880
8	46.4	1.792
9	48.5	1.712
10	50.0	1.639
11	51.8	1.572
12	53.6	1.511
13	55.4	1.453
14	57.2	1.401
15	59.0	1.351
16	60.8	1.305
17	62.6	1.263
18	64.4	1.222
19	66.2	1.185
20	68.0	1.149
21	69.8	1.126
22	71.6	1.093
23	73.4	1.061
24	75.2	1.030
25	77.0	1.000
26	78.8	0.971
27	80.6	0.943
28	82.4	0.915
29	84.2	0.888
30	86.0	0.863
31	87.8	0.837
32	89.6	0.813
33	91.4	0.789
34	93.5	0.766
35	95.0	0.744
36	96.8	0.722
37	98.6	0.701
38	100.4	0.681
39	102.2	0.661
40	104.0	0.642
41	105.8	0.623
42	107.6	0.605
43	109.4	0.587
44	111.2	0.570
45	113.0	0.554

## **7.2 RO SALT RETENTION TEST**

The RO Salt Retention Test is an integrity check to determine if o determine if the RO membranes or seals are leaking. The test is used, after module loading, and as needed, to determine if membrane or seal leaks are present.

**NOTE:** During Process Operation, the RO Permeate stream should appear clear, colorless and haze free at all times. Lower than 98% retention and/or turbid permeate, indicates a membrane or seal leak.

The RO Salt Retention Test also establishes a baseline for RO Membrane retention. It is recommended that the salt retention test be repeated every 3 months.

Canning or Kosher Salt is used as a marker to locate any leaks.

Conditions for checking the salt retention are 77 °F, 225 psi average pressure and feed conductivity of 2,000 micro ohms salt.

### **RO SALT RETENTION TEST PROCEDURE**

#### **Step 1: Check RO Condition**

Be sure the RO system has been cleaned.

#### **Step 2: Check Materials**

Materials required are:

5 - 10 pounds of Canning or Kosher Salt

A hand held conductivity monitor.

#### **Step 3: Prepare Salt Solution**

Dilute the salt in warm water in a bucket.

**Note: Do Not add granular salt to the RO system.**

#### **Step 4: Start-Up System**

Start an individual Check Water Flux operation. BUT USE COLD WATER.

Allow the system to start-up

#### **Step 5: Add Salt Solution**

Add the diluted salt solution to the CIP tank to attain about 2,000 micro ohms solution conductivity.

Check using conductivity meter at feed sample valve.

Allow the salt solution to circulate.

#### **Step 6: Sample and Record Data**

Record the Feed, Retentate and Stage conductivity's using the sample valves

#### **Step 7: Stop the RO System Pumps.**

Use the Pump stop push buttons to stop the RO pumps while salt retention is analyzed.

## 7.2 RO SALT RETENTION TEST

### Step 8 Calculate the RO Membrane Retention

Because the RO is a stages in series design, RO each stage has a different salt retention calculation.

#### For stage 100:

$$\text{Retention} = \frac{(\text{Feed conductivity} - \text{Permeate conductivity})}{\text{Feed conductivity}}$$

#### For stage 200:

$$\text{Retention} = \frac{((\text{Feed Conductivity} + \text{Concentrate conductivity})/2) - \text{Permeate conductivity}}{(\text{Feed conductivity} + \text{Concentrate conductivity})/2}$$

$$\% \text{ Retention} = \text{Retention} \times 100$$

### Step 9: Analyze the Data

The minimum salt retention should be 98% or greater.

If the stage salt retention is less than 98% restart the system pumps and sample again from individual housings.

To check the individual housings, loosen the permeate hose clamp at the end cap connection, to get a small stream to leak out.

Locate and mark any low retention housings.

### Step 10: Stop and Lock-out Pumps

Stop the system pumps and LOCK THEM OUT, prior to any disassembly.

### Step 11: Disassemble and Inspect

Disassemble and inspect seals for damage or improper assembly. Repair or replace seals.

### Step 12: Retest

Close-up the housings, restart the system pumps, and recheck the conductivity of the repaired housings.

### Step 13: Remodule

If retention is still below specification, repeat steps 10 and 11, but also replace all membranes in that housing with new ones. Then perform CIP, then repeat step 12.

### Step 14: CIP

If all leaks are repaired, stop the Check Water Flux step.

Initiate CIP, and clean the salt from the system using the normal CIP procedure.

## **8.0 MAINTENANCE AND TROUBLESHOOTING**

### **8.1 GENERAL**

An operator's duty is to monitor and maintain a process so that the desired output is achieved. To this end, the RO system operator is trained to monitor the system on a regular basis and to be on the look-out for anything unusual.

To assure proper system operation, Koch strongly recommends a preventative maintenance (PM) program be instituted, per the schedule shown below. Most problems start out small, are easily identified, scheduled for repair and fixed. It is too often the case that when a process is not regularly monitored and maintained, that problems arise affecting the process output, efficiency and down time.

Regular system upkeep includes lubrication of the pumps and motors, valve and air diaphragm pump maintenance, checking the accuracy of the process instruments and keeping the system clean and neat. Perform routine component maintenance per the individual manufacturers recommendations. Information is available in the vendor literature supplied by Koch.

### **8.2 PREVENTATIVE MAINTENANCE SCHEDULE**

**Daily** checks that should be performed include:

1. Check all system pressure connections for leaks.

**DO NOT TOLERATE ANY PIPING OR PRESSURE VESSEL LEAKS. REPAIR ALL LEAKS AND CORRODED OR DAMAGED CONNECTION HARDWARE IMMEDIATELY.**

2. Check pump and motor bearings for excessive heat, vibration or noise.
3. Check that pump and motor bed plates are securely fastened.
4. Check seal water flow and quality, where applicable.
5. Check for seal leakage at each pump, where applicable.

**Monthly** checks that should be performed include:

1. Check operation of air actuated valves.
2. Check for coupling deterioration on frame mounted pumps.
3. Blow down air filters and regulators.
4. Check amperage readings on motors.
5. Check all air supply connections and tubing for leaks.

**Every Six Months** the following checks should be performed:

1. Check alignment of all frame mounted pumps.
2. Check transmitter accuracy and calibrate, if needed.

### 8.3 TROUBLESHOOTING

This section is used to troubleshoot and correct the more common problems that can occur.

As each operator gains experience, they will be able to correct problems, as they occur, with little need to refer to this section.

It is also expected that the operators may run up against other problems, not specifically mentioned here. If technical assistance is required, call the Koch Technical Service Group at (978) 657-4250.

#### PROBLEM: LOW SYSTEM PRODUCTIVITY

<u>Probable Cause</u>	<u>Recommended Solution</u>
Incomplete depectinization	Assure correct enzyme addition pretreatment
Fouled membranes	Perform CIP
Low feed temperature	Check feed temperature pretreatment.
High feed solids	Check DE filtrate turbidity and solids
High concentration	Check Total solids controller setpoint is correct Check operation of concentrate valves V-2A/V-2B Check operation of solids analyzer AT-1

#### PROBLEM: LOW FEED PRESSURE

<u>Probable Cause</u>	<u>Recommended Solution</u>
Empty feed tank	Check FIC-1 setpoint and operation
Faulty pump	Check feed and booster pumps P-1,P-2,P-3
Fouled feed strainer	Check prefilter pressure drop Remove, inspect and clean screen
Faulty valve or control fault	Check FIC-1 and P-1 VFD operation

#### PROBLEM: HIGH FEED PRESSURE

<u>Probable Cause</u>	<u>Recommended Solution</u>
Fouled membranes	Perform CIP
Feed valve/control fault	Check FIC-1 and P-1 VFD operation

#### PROBLEM: HIGH FEED TEMPERATURE

<u>Probable Cause</u>	<u>Recommended Solution</u>
Inoperable Cooler	Check TIC-1 and V-9 operation. Check V-11 is open. Check cooling supply

**8.3 TROUBLESHOOTING****PROBLEM: HIGH RETENTATE SOLIDS**

<b><u>Probable Cause</u></b>	<b><u>Recommended Solution</u></b>
V-2A, V-2B not open	Check operation of V-2A, V-2B
Concentration Analyzer Fault	Check Concentration Analyzer AT-1 operation

**PROBLEM: AIR VALVE NOT OPERATING OR VALVE LEAKING**

<b><u>Probable Cause</u></b>	<b><u>Recommended Solution</u></b>
Low air pressure	Check air pressure is 60 psig minimum
Pneumatic Obstruction	Check air flow/pressure at valve actuator Check for obstructions in all lines and fittings.
Solenoid Fault	Check solenoid and replace, if needed
Valve Stuck	Turn off pumps and check valve strokes without line pressure. Check alignment of actuator and valve shaft for binding. Adjust bolts as needed. Remove actuator from valve and check that valve operates by hand.
Line Obstruction	Check valve seat for obstructions

**8.4 SPARE PARTS****RECOMMENDED SYSTEM SPARE PARTS**

Materials that are consumed during normal plant operations include:

CIP Chemicals:	See CIP Chemical Section.	
pH Paper Sticks:	Range: 0-14 pH units	KPN 0210391
Log Sheets and Module Maps:	See Appendix for Master Copies	

**RECOMMENDED SPARE PARTS**

The following Materials are recommends be on hand, to minimize downtime.

<u>Quantity</u>	<u>Description</u>	<u>KMS Part Number</u>
5 each	Fluid Systems 3838-HR-N1 RO Modules (99% min rejection)	
1 each	Koch Internals Kit for S-5 RO 4" SW Housing	0251009
1 each	Koch Common Parts Kit for RO 4" SW Housing	0251024

**OTHER SPARE PARTS**

Additional TriClamp gaskets, clamps (MHP and MHHM), component spare parts and maintenance materials should be ordered for the pumps, valves, instruments and ancillary items used on the RO system, per the individual Vendor recommendations. Vendor data is supplied by KMS with the system operating manual kit.

Koch recommends that sufficient component spares be on-hand to minimize downtime in the event of component failure. Refer to the system component specifications and vendor literature provided by Koch.

**APPENDIX 1**

**RO SYSTEM MODULE MAP**

<b>CUSTOMER:</b>	<b>LOCATION:</b>	
<b>MODULE TYPE:</b>	<b>DATE:</b>	
<b>Stage Number:</b>		
<b>Row # 1</b>	<b>Housing #1</b>	<b>Housing #2</b>
<b>Module #1 (High Pressure End)</b>		
<b>Module #2</b>		
<b>Module #3</b>		
<b>Module #4</b>		
<b>Module #5 (Low Pressure End)</b>		
<b>Row # 2</b>	<b>Housing #1</b>	<b>Housing #2</b>
<b>Module #1 (High Pressure End)</b>		
<b>Module #2</b>		
<b>Module #3</b>		
<b>Module #4</b>		
<b>Module #5 (Low Pressure End)</b>		
<b>Row # 3</b>	<b>Housing #1</b>	<b>Housing #2</b>
<b>Module #1 (High Pressure End)</b>		
<b>Module #2</b>		
<b>Module #3</b>		
<b>Module #4</b>		
<b>Module #5 (Low Pressure End)</b>		
<b>Row # 4</b>	<b>Housing #1</b>	<b>Housing #2</b>
<b>Module #1 (High Pressure End)</b>		
<b>Module #2</b>		
<b>Module #3</b>		
<b>Module #4</b>		
<b>Module #5 (Low Pressure End)</b>		
<b>Row # 5</b>	<b>Housing #1</b>	<b>Housing #2</b>
<b>Module #1 (High Pressure End)</b>		
<b>Module #2</b>		
<b>Module #3</b>		
<b>Module #4</b>		
<b>Module #5 (Low Pressure End)</b>		
<b>Row # 6</b>	<b>Housing #1</b>	<b>Housing #2</b>
<b>Module #1 (High Pressure End)</b>		
<b>Module #2</b>		
<b>Module #3</b>		
<b>Module #4</b>		
<b>Module #5 (Low Pressure End)</b>		
<b>Row # 7</b>	<b>Housing #1</b>	<b>Housing #2</b>
<b>Module #1 (High Pressure End)</b>		
<b>Module #2</b>		
<b>Module #3</b>		
<b>Module #4</b>		
<b>Module #5 (Low Pressure End)</b>		