DOCKETED

Docket Number:	06-AFC-09C
Project Title:	Colusa Generating Station - Compliance
TN #:	203762
Document Title:	Colusa Generating Station Condition of Certification Soil and Water 10 - ZLD Management Plan
Description:	Revised Zero Liquid Discharge (ZLD) Management Plan
Filer:	Charles Robert Price
Organization:	Pacific Gas & Electric Co.
Submitter Role:	Applicant
Submission Date:	3/3/2015 1:55:43 PM
Docketed Date:	3/3/2015

Ed Warner
Senior Plant Manager

Mailing Address
Pacific Gas and Electric Company
Colusa Generating Station
P.O. Box 398
Maxwell, CA 95955

530.934.9061
Fax: 530.934.9024

CGS15-L-010
March 3, 2015

Eric Veerkamp
California Energy Commission
1516 Ninth Street, MS-2000
Sacramento, CA 95814

Reference: Colusa Generating Station

Subject: Colusa Generating Station (06-AFC-9)
Condition of Certification Soil and Water 10 – ZLD Management Plan

Dear Eric:

As a result of a routine audit of our Zero Liquid Discharge (ZLD) Management Plan, changes were made to adequately reflect the current operations and maintenance of the facility. This updated plan is being submitted as required by Soil and Water-10 of our Final Commission Decision.

Should you have any questions or comments please contact me at (530) 934-9007.

Regards,

Charles Price
Senior Environmental Consultant

cc: File No. 3.6.3.22
Ed Warner, PG&E
Sarah Gassner, PG&E

Pacific Gas and Electric

Colusa Generating Station

Zero Liquid Discharge (ZLD) Management Plan

Prepared by

Pacific Gas & Electric Company

4780 Dirks Road
Maxwell, CA 95955

March 2015

Introduction

The Colusa Generating Station was designed and built to have no process wastewater discharge. The system is designed as a Zero Liquid Discharge (ZLD) system, such that most process water will be recycled within the plant, with a small amount evaporated or concentrated within the dryer. The plant process wastewater system will collect wastewater from the CTG evaporative coolers, Heat Recovery Steam Generators (HRSG's), water treatment system, chemical feed area drains, and general plant drains.

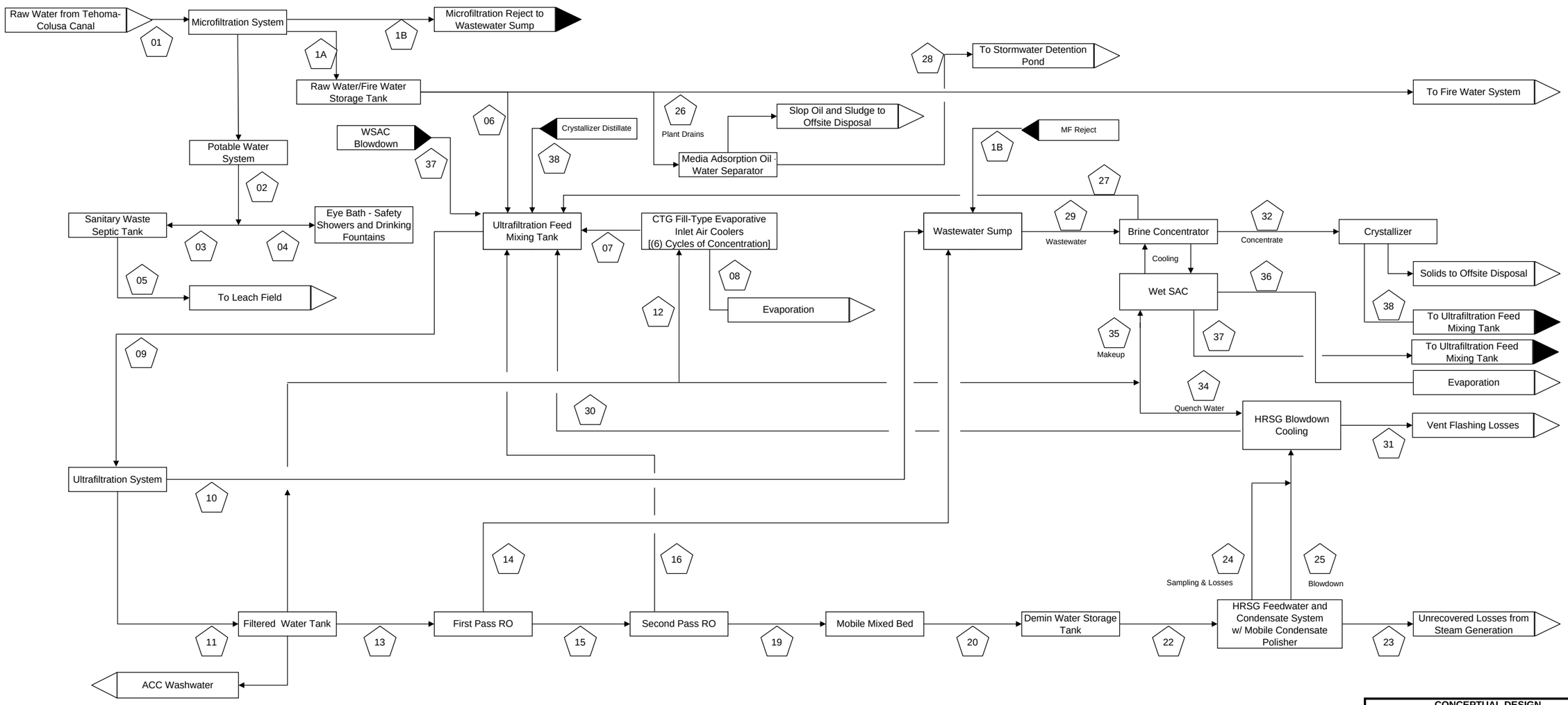
Evaporative Cooler Blowdown and HRSG Blowdown water is sent to the demineralization water treatment system for reuse. Reject water from the demineralizer is routed to the Crystallizer and press of the zero liquid discharge system. Chemical feed area drainage consists of spillage, chemical tank overflows, and maintenance operations, and is collected in corrosion-resistant piping separate from the general plant drainage system. The chemical feed area drainage is routed to ZLD Feed Tank, adjusted to neutral pH, and then routed to the Crystallizer and press of the ZLD.

General Plant Drainage consists of wastewater collected by sample drains, equipment drains, equipment leakage, and area wash downs. Wastewater collected in the general plant drainage is routed through an oily water separator with the effluent routed into the raw water tank for reuse.

The process wastewater streams treated with the ZLD system are processed into a residual solid waste. The solid waste will be disposed of in the appropriate class of landfill suitable for the constituent concentrations in the waste. The ZLD system will be operated in accordance with the ZLD management plan. The ZLD management plan includes the following elements as required by Condition of Certification Soil & Water – 10, of the Colusa Generating Station Final Commission Decision:

- A Flow Diagram showing all water sources and wastewater disposal methods at the Colusa Generating Station.
- A narrative of expected operation and maintenance of the ZLD system
- A narrative of the redundant or back-up wastewater disposal method to be implemented during periods of ZLD system shutdown or maintenance.
- A maintenance schedule.
- A description of on-site storage facilities and containment measures.
- A table identifying influent water quality
- A table characterizing the constituent concentrations of the solid waste or brine and specifying the permit limits of the selected landfill.

Flow Diagram



CONCEPTUAL DESIGN

WorleyParsons resources & energy

Colusa Generating Station Combined Cycle Project

Water Balance
Page 1 of 5

SK No:	Rev:	Date:
COLS-1-SK-021-305-001	B	7-Apr-08

Rev	Date	By	Checked	Rev	Date	By	Checked	Rev
A	1/25/2008	S.O'Neill	M.Casey	B	4/7/2008	M.Casey	S. Ruzze	

	Case (Heat Balance Case)	Duct Burning Status	Evaporative Cooler Status	Temperature °F	Relative Humidity (%)	Wet Bulb Temperature °F	Main Steam Flow at HRSG (pph)	% Occurrence
	A (1155)	Off	Off	**59**	**60.0**	**51.56**	**912018**	20%
	B (1189)	On	On	**94**	**25.4**	**67.96**	**1752568**	30%
	C (1159)	On	Off	**59**	**60.0**	**51.46**	**1765002**	20%
	E (1195)	Off	On	**114**	**20.0**	**77.81**	**903160**	
	(1199)	On	On	**114**	**20.0**	**77.81**	**1178258**	30%

Values are daily average values in gpm unless otherwise noted

Stream No.	Stream Description	Case A @ 2% HRSG blowdown	Case C @ 2% HRSG blowdown	Case B Full Wet SAC	Case E Full Wet SAC	1199 Full Wet SAC	**Startup** Case A
1	Influent from Canal	35	52	190	198	203	126
1A	Microfiltration Product	34	51	184	192	197	122
1B	Microfiltration Reject	1	2	6	6	6	4
2	Potable Water	5	5	5	5	5	5
3	Sanitary Waste	4	4	4	4	4	4
4	Eye Wash/Safety Shower Flow	1	1	1	1	1	1
5	Septic Waste to Leach Field	4	4	4	4	4	4
6	Ultrafiltration Feed Holding Tank	19	36	169	177	182	107
7	Evap. Cooler Blowdown	0	0	14	19	19	0
8	Evap. Cooler Evaporation	0	0	72	97	96	0
9	Ultrafiltration Feed	180	341	518	388	440	627
10	Ultrafiltration Reject	4	7	10	8	9	13
11	MF Filtrate	176	334	507	381	431	614
12	Evap Cooler Makeup	0	0	86	116	116	0
12a	NOT USED						
13	1st Pass RO Feed	67	122	121	66	84	199
14	1st Pass RO Reject	17	31	30	17	21	50
15	1st Pass RO Permeate	50	92	91	50	63	149
16	2nd Pass RO Reject	5	9	9	5	6	15
17	NOT USED						
18	NOT USED						
19	EDI Feed	45	83	82	45	57	134
20	EDI Effluent to Storage Tank	45	83	82	45	57	134
21	NOT USED						
21a	NOT USED						
22	Cycle Makeup	45	83	82	45	57	134
23	Unrecovered Losses	4	7	7	4	5	12
24	Sampling Losses	5	5	5	5	5	5
25	HRSG Blowdown	36	70	70	36	47	118
26	Plant Washwater	10	10	10	10	10	10
27	ZD Distillate	20	37	44	29	34	63
28	Oil/Water Separator Effluent	10	10	10	10	10	10
29	Evaporator Feed	21	39	46	30	36	66
30	Cooled HRSG Blowdown	134	257	255	133	172	427
31	Vent Flashing Losses	17	30	30	16	21	49
32	Crystallizer Feed	1	2	2	2	2	3
	Total Make Up to ZLDS	42	76	91	59	70	129
34	HRSG Blowdown Quench Water	109	211	210	108	141	353
35	Makeup to Wet SAC			90	90	90	62
36	Evaporation from Wet SAC			66	66	66	50
37	Blowdown from Wet SAC			24	24	24	12
38	Crystallizer Distillate	1	2	2	2	2	3
39	Yearly Average Total Make-up (acre-ft/year)	43	56	167	174	178	116

Operating Conditions:

16 hrs/day
6 days/week
2 hrs/startup/day

OVERALL AVERAGE YEARLY TOTAL MAKE UP:

123 acre-ft/year

Determined using full WSAC for Cases B and 1199 for 30% of the year respectively.
The remainder was determined with Cases A and C for 20% of the year respectively with no wet cooling.

Assumptions:

Evap Cooler COC	6
UF Reject (% influent)	2%
1st Pass RO Reject (% influent)	25%
2nd Pass RO Reject (% influent)	10%
EDI Bleed Stream (% influent)	10%
Unrecovered losses (% HRSG B	10%
Blowdown flash (% Sampling + HRSG BD)	40%
ZLD Steam requirement (% Evaporator influent flow)	65%
Sanitary Waste (gpm)	4
Eye Wash/Safety Shower Flow (	1
Sampling Losses (gpm)	5
Plant Washwater (gpm)	10
Full WSAC Makeup (gpm)	90
Partial WSAC Makeup (gpm)	35
Percent HRSG BD	2%
MF Reject	3%
Startup BD	5%

Notes:

1.) **Values in BOLD text are from Heat Balance, COLS-1-LI-021-0001 Rev D, 3/13/2008**

Colusa Raw Water/Fire Water Storage Tank Size:

Per the scope book, the tank must store enough water for a 12 hour outage of makeup water.
The maximum flow is defined by the calculation to be

203 gpm
12 hours

The mimimum volume of raw water which must be stored is

150000 gallons

If the storage time is increased to 16 hours, the volume of raw water which must be stored is

16 hours
200000 gallons

Adding Fire Water, Raw water Fire Water Storage tank must be:

800,000 gallons

Filtered Water Storage Tank Size:

The maximum flow is defined by the calculation to be

122 gpm
48 hours

The mimimum volume of filtered water which must be stored is:

360,000 gallons

Demineralized Water Storage Tank Size:

The maximum flow is defined by the calculation to be

83 gpm
48 hours

The mimimum volume of Demin water which must be stored is:

240,000 gallons

Expected Operation and Maintenance of the ZLD System

The ZLD system Operations and Maintenance will be conducted as specified in Aquatech's Operation and Maintenance manuals. These manuals have been included as Attachment 1 and 2 of this plan.

Back-up Wastewater Disposal Plan

The ZLD system is designed with two redundant systems. In the event of a complete system breakdown or scheduled shut down the Colusa Generating Station has on-site holding sumps that can be employed for water storage. Once the ZLD system is up and running that water will be processed accordingly. If the limits of water storage are reached an outage would be scheduled until the system could be brought back on-line. Under no circumstances will processed wastewater be discharged to ground, the sanitary, or stormwater systems.

Maintenance Schedule

Daily Maintenance
Daily rounds will be conducted on all components of the water treatment and ZLD systems. These rounds will include verifying appropriate fluid levels, temperatures, and pressures. Rounds will also include listening for abnormal sounds, vibrations, and leaks. Chemistry is also verified on rounds. Should any abnormal conditions be identified during daily rounds, it will either be adjusted at that time or a notification shall be written to resolve the condition.

Flash Tank

Annually

- Drain, flush and chemically or mechanically clean the Flash Tank
- Retain labeled and dated samples of mist eliminator scale and sump scale for analysis.
- After cleaning, inspect the interior for structural integrity of welds, signs of corrosion or erosion.
- Examine the condition of sealing surfaces at the manway opening. Repair surfaces and replace gasketing as necessary.
- Clean and inspect the mist eliminator for integrity.

Forced Circulation Heat Exchanger (FCHX)

Annually

- Drain, flush and chemically or mechanically clean the tubeside of the FCHX.
- After cleaning, inspect the interior for structural integrity of welds, signs of corrosion or erosion.
- Inspect each tube hole for pluggage.
- Examine the sealing surfaces of in/out channel and return channel. Repair surfaces and replace gasket as necessary.

Vapor Compressor

1.

Annualy

- Change compressor lube unit oil (or analyze). Use only recommended oil type.
- Change compressor lube unit oil filters
- Clean shaft seal air filter and clean strainer dewatering unit.
- Clean compressor motor air filter and recharge with correct adhesive before reinstalling.

- Inspect the rotary lobes for signs of wear, corrosion, rubbing and cracking.
- Turn the rotary lobes by hand and verify that the rotary loves rotate freely without any unusual noises.
- Clean off any scale on the impeller with brass brush and steel wool.
- Check and tighten all wiring connections.
- Check and tighten all air connections and valves.
- Inspect couplings for wear and alignment.
- Check vapor compressor bearing seals for signs of wear, replace as required.
- Inspect and clean compressor motor stator windings.
- Check and record compressor motor insulation resistance.
- Inspect couplings and check alignment.
- Inspect shaft seal.
- Re-grease pump motor bearings.
- Drain the oil sumps, thoroughly clean, and inspect condition of interior paint finish.
- Inspect and clean lube oil coolers.
- Check operation and calibration of all gauges, indicators, switches, and monitoring devices.

Long Term (greater than 30 days) Shut Down

- Operate compressor once per month for a period of at least 10 minutes to thoroughly coat all parts with oil.
- Rotate compressor shafts at least once per month.
- Bearing journals and all bare metal parts should be flushed with rust inhibiting oil.
- Motor windings should be inspected periodically by checking insulation resistance.
- Check manufacturer literature for any addition recommendations.
- Before reactivating the compressor it should be thoroughly cleaned, inspected for rust and corrosion. Oil and grease should be renewed.

Forced Draft Decarbonator

Annually

- Drain, flush and chemically or mechanically clean the tank to rempve any scales that may have deposited with use.
- Inspect structural integrity.
- Inspect for wear.

Centrifugal Pumps

Semi-Annual

- Replace pump bearing lube oil after 2000 operating hours. Use only recommended oil type.
- Check baseplate bolting for tightness.

- Inspect couplings for wear and alignment.
- Check pump mechanical seals, adjust or replace as necessary. Check shaft of sleeve for scoring.
- Verify tightness of piping connections, equipment connections, flanged joints and threaded joints.

-

Miscellaneous Tanks & Vessels

Annually

- Inspect structural integrity.
- Inspect for corrosion or erosion.
- Clean scale and sludge deposits.

On-site Storage/Containment

Solid Waste Generated by the ZLD system will be stored in roll off binsand dumped periodically. The containers will either have covers or be tarped prior to any forecasts of precipitation. Based on process knowledge, lab analytical and the constituent concentrations estimated by Aquatech, there is no reason to believe that the solid waste will be hazardous and therefore will not have secondary containment.

Influent Water Quality

Table 8.14-7
Tehama-Colusa Canal Water Analyses

Water Quality Parameter	Tehama-Colusa (3/5/01)[a]	Tehama-Colusa (4/11/01)[b]
Turbidity	–	3.8 NTU
Color	–	10
pH	8.3	–
Total Suspended Solids	35 mg/L	12 mg/L
Total Dissolved Solids	94 mg/L	92 mg/L
Hardness as $CaCO_3$	62 mg/L	69 (75) mg/L
Calcium	20 mg/L	15 mg/L
Magnesium	2.9 mg/L	7.6 mg/L
Sodium	8.0 mg/L	8.8 mg/L
Potassium	–	1.2 mg/L
Barium	28 µg/L	<0.1 mg/L
Beryllium	2.3 µg/L	–
Total Alkalinity	78 mg/L	60 mg/L
Bicarbonate	78 mg/L	60 mg/L
Sulfate	7.4 mg/L	8.1 mg/L
Chloride	5.4 mg/L	4.5 mg/L
Nitrate	–	1.2 mg/L
Fluoride	–	<0.1 mg/L
Arsenic	< 0.005 mg/L	<0.01 mg/L
Iron	–	<0.1 mg/L
Boron	–	<0.1 mg/L
Silica	–	8.8 mg/L

Notes:

µg/L	micrograms per liter
mg/L	milligrams per liter
NTU	nephelometric turbidity units
–	not analyzed

[a]Water Analysis by Curtis & Tompkins, Ltd.
[b]Water Analysis by STL Chromalab

Constituent Concentrations

Aquatech calculated the dry solid composition of the cake to be the following:

Calcium:	12.2%
Magnesium:	3.5%
Sodium:	10.8%
Potassium:	1.5%
Bicarbonate:	1.3%
Sulfate:	44.8%
Chloride:	15.4%
Fluoride:	<0.1%
Nitrate:	1.0%
Silica (as SiO2):	9.5%

The material will be disposed of at Ostrom Road Landfill owned and Operated by Recology. I have included the permit limits for the disposal facility.

Attachment 1 Operations Plan

OPERATING PROCEDURES

PG&E Colusa Generating Station
Maxwell Ca.

Crystallizer System
2 x 50% Crystallizers
AQUATECH PROJECT NO. P-30032

DOCUMENT NO: P-30032-PD-PE-ICD006006-H

P-30032...4.6

INDEX

SECTION 1
GENERAL INSTRUCTIONS

NOTE

The personnel who operate and maintain the evaporator unit should follow the general instructions below.

1. Pay careful attention to temperatures, levels, pressures, flows, and concentrations. Become familiar with normal operating conditions (i.e. operator interface indicators and local gauge readings).

2. Study the drawings listed below for the locations of all equipment, vents, drains, valves, gauges, and controls.

   REFERENCES

   Piping & Instrumentation Diagram
   P-30032-DW-AE-ICD001P31-H thru P43-H

3. Review and become familiar with the System Description, Control Philosophy and Cause & Effect Diagram provided in Volume 1 of this manual.

4. The manufacturer's instructions on equipment supplied but not manufactured by Aquatech are provided in Volume 2 of this manual. Plant operators and maintenance personnel should be thoroughly familiar with all of the manufacturer's literature. The cautions furnished in this literature must be observed during start-up and operation of the crystallizer.

5. Prior to start-up, check carefully for loosened, broken, or damaged components, controls, fittings, wiring, or piping. Any damaged or loose fittings should be repaired, replaced, or tightened to prevent future problems.

6. The crystallizer assembly is supplied with all necessary sight glasses, manholes, instruments, etc., each sealed with a gasket. Due to normal gasket compression, bolt torque loss, and temperature changes, small gasket leaks may be observed during initial start-up. Such leaks are normal and should be fixed by tightening each bolt equally with equal torque in a criss-cross pattern so as to evenly distribute the load on the gasket.

SECTION 2
WARNINGS

1. This unit is designed to concentrate mixed salt wastewater streams according to the projected analysis shown in the Process and System Description of this manual. Attempts to concentrate other materials could result in damage to the equipment. Contact Aquatech for assistance if the feedwater varies from these guidelines.

2. The vessels in this system are designed to operate at and below the stamped pressure ratings on the vessels. Pressure relief devices are provided to protect the equipment and must be periodically maintained and inspected. Operation at higher pressures is not acceptable and will damage the equipment.

3. Cleaning chemicals must be compatible with the wetted materials of construction.

4. The Crystallizer and associated piping must be rinsed with low chloride water upon any extended shutdown to prevent corrosion from occurring upon opening the unit to atmospheric oxygen.

5. Foaming in the Crystallizers must be monitored and controlled. If foaming occurs, it must be addressed and eliminated. An anti-foam system has been provided. Failure to do so can damage the Vapor Compressors.

6. The pH in the Crystallizer must be maintained between 5.5 and 10.0 pH units to prevent corrosion of the wetted materials of construction.

7. Do not operate the system with a Forced Draft Decarbonator Feed Inlet pH of less than 5.0.

8. The Crystallizer System is designed to concentrate the feedwater to approximately 50% total solids (30% suspended solids). Operating above this level will reduce operating capacity and can cause premature scaling/fouling conditions. Significantly higher concentration factors can reduce the operating capacity and lead to corrosion of the wetted materials of construction.

9. Do not operate the Crystallizer system for an extended period of time with a slurry boiling point elevation of greater than 25°F and never operate the system with a slurry boiling point elevation of greater than 26°F. High boiling point elevations are indicative of high chloride concentrations, which can reduce the corrosion resistance of the wetted materials of construction.

10. The Crystallizer Distillate Pump must always be running when the compressor is running to desuperheat the steam in order to prevent scaling of the tubes and damage to the FCHX.

11. Always complete the Vapor Compressor prestart-up checks as specified in the compressor start-up section.

12. Always make sure the Vapor Compressor suction and casing has been completely drained of any water prior to starting the compressor. The associated valves should be slightly open with steam and condensate flowing out. Failure to do so can damage the compressor.

13. The Recirculation Pump must be running anytime there are suspended solids in the system. Stopping the Recirculation Pumps will cause these solids to quickly settle. Over time the solids compact and will eventually plug the Recirculation Pump, preventing it from restarting.

14. Conditions differing from design should be reported to Aquatech. Operating the evaporator at conditions differing from design could cause scaling and/or equipment damage.

IMPORTANT

Delay in responding to alarms, shutdowns, or conditions that are outside of the design of the evaporation system can have serious consequences and can void all warranties and guaranties. If unusual operating conditions or unexplained anomalies are observed, the safe course of action is to shut off the Vapor Compressor immediately. The majority of harmful effects of improper conditions will occur only when the Compressor is running.

SECTION 3
OPERATING PROCEDURES

3.1 PRE-OPERATION CHECKS

Before starting up any equipment, make sure the following steps are complete:

1. Verify that instrument air is available to the plant for control valves and equipment.
2. Verify that there is power available to the control system and equipment to be operated.
3. Verify that there is feedwater available and that the upstream supply pump is operational.
4. Verify that there is an adequate supply of chemicals in the chemical feed totes. Fill the totes as required.
5. Obtain a sample of the feedwater and determine the concentration of major ions. Record these values.

3.2 CHEMICAL DOSING SYSTEM START-UP

3.2.1 Anti-Foam Dosing

The foaming tendency of an evaporator is primarily dependent on the feed composition. Foaming can occur at any time: during initial start-up, with dilute slurry concentration, or with concentrated slurry. The most effective way to control foam is to maintain a steady, consistent composition of feed. If the feed has foaming characteristics, it can be controlled by anti-foam dosing.

Severe foaming in the Crystallizer can damage the compressors since foam is mostly liquid and the compressors are not designed to pump liquid. Therefore, the foaming tendency of the Crystallizer must be monitored. In addition to visual observation, spikes in crystallizer level, fluctuations in compressor amps, fluctuations in recirculation pump amps, and a reduction in distillate purity are also indicators that foaming is occurring.

CAUTION

Aquatech recommends that the contents of the sump be monitored frequently. During initial start-up it is very important to monitor the sump for foam.

Four Anti-Foam dosing pumps are provided. Two Anti-foam dosing pumps (2 x 100%) 1-529-P-6740-1 / 1-529-P-6740-2 are dedicated to train A. Two Anti-foam dosing pumps (2 x 100%) 1-529-P-6740-3 / 1-529-P-6740-4 are dedicated to train B.

Follow the procedure below for the Anti-Foam Dosing Pumps.

1. Verify that there is an adequate level of chemical dosing agent in the chemical tote.
2. Open the suction and discharge manual isolation valves for the chosen Anti-Foam Dosing Pumps.
3. Open the common pump suction isolation valve and the chemical tote isolation valve.
4. Open the inlet manual isolation valve for the appropriate Recirculation Pump suction pipeline and adjust the Anti-Foam Supply Back Pressure Valve to the proper setpoint.
5. Select the appropriate Anti-Foam Dosing Pumps for MANUAL with 0% output from the operator interface.
6. Set the Anti-Foam dosing concentration setpoint in ppm at the Anti-Foam Dosing Pump controller screen. An initial dosing concentration of 10 ppm of the 50% anti-foam solution is recommended for initial start-up. An initial dosing feed rate of 0.00023 gpm is recommended for initial start-up. The stroke rate should be increased or decreased based on operating experience and the foaming characteristics of the feedwater. (Refer to section 2.2 of the Control Philosophy for further details.)

NOTE

When selected for AUTO, the dosing pump will start automatically and add Anti-Foam if the appropriate Feed Pump is running.

3.2.2 Acid Dosing

Sulfuric acid is dosed to the Feed Line before entering the Forced Draft Decarbonator to convert feedwater bicarbonate ions to carbon dioxide which reduces the carbonate scaling potential in the Feed/Distillate Heat Exchangers.

Two (2 x 100%) Acid Dosing Pumps 1-529-P-6738-1/2 are provided. One Acid dosing pump should be operating when either one or both trains are in operation. The other dosing pump is an in-line spare that can be used for either crystallizer train.

Follow the procedure below for the Acid Dosing Pumps.

1. Verify that there is an adequate level of sulfuric acid in the Sulfuric Acid Drum.
2. Open the suction and discharge manual isolation valves for the chosen Acid Dosing Pump.
3. Open the inlet manual isolation valve for acid dosing pipeline into the feed and adjust the Acid Supply Back Pressure Valve to the proper setpoint.
4. Open the common pump suction isolation valve and the tote isolation valve.
5. Select Acid Dosing Pump 1-529-P-6738-1 or 1-529-P-6738-2 for MANUAL with 0% output from the operator interface.

6. Verify that there is a flow of feedwater into the system. (See section 3.3.1 of this document.)
7. Set the pH of the Forced Draft Decarbonator according to Section 1.2 of the Control Philosophy at the operator interface.
8. Select the chosen Acid Dosing Pump for AUTO.

NOTE

When selected for AUTO the Acid dosing pumps will start automatically when a Feed Pump is running and the Forced Draft Decarbonator Low pH Alarm 1-529-AAL-6001 is not active.

3.3 FEED SYSTEM START-UP/OPERATION

3.3.1 Crystallizer Feed System

1. Verify that all drain, vent and sample valves are closed.
2. Complete Chemical Dosing start-up.
3. Verify that the Forced Draft Decarbonator Recirculation Pipeline manual valve 1-529-BV-6003 is in the open position.
4. Place the Crystallizer Feed Flow Controller 1-529-FIC-6001/6002 in MANUAL and fully close both of the flow control valves 1-529-FCV-6002/6004 to 0%.
5. Place Forced Draft Decarbonator Level Controller 1-529-LIC-6703-1 in MANUAL and fully close the level control valve 1-529-LCV-6001 to 0%.
6. Open manual valve BV-6011.
7. Select AUTO for the Forced Draft Decarbonator Level Controller 1-529-LIC-6703-1. Level control valve 1-529-LCV-6001 will open. Feedwater from the ZLD Crystallization Feed Tank will then fill the Forced Draft Decarbonator until the level controller setpoint is reached. The level controller will modulate the level control valve to maintain level in the tank.
8. When the Forced Draft Decarbonator Level nears setpoint, activate the acid dosing system. Place the Forced Draft Decarbonator pH Controller 1-529-AIC-6001 in AUTO with a setpoint per Section 1.2 of the Control Philosophy when the feed flowrate reaches a stable flow. A stable liquid level in the Forced Draft Decarbonator would indicate a stable feed flowrate.
    A. Verify that the Acid Dosing Pumps 1-529-P-6738-1/2 are in AUTO at the operator interface. For both single and dual train operation ONLY one dosing pump should be in operation.
    B. Verify that the pH of the Forced Draft Decarbonator as indicated by 1-529-AI-6002 is being properly controlled to maintain the setpoint.

9. Open the manual suction and discharge valves for the appropriate Feed Pump 1-529-P-6005/6006. Feed Pump 1-529-P-6005 is dedicated to both train A and B. Feed Pump 1-529-P-6006 is an on-line spare.
10. Start the appropriate Feed Pump when the Forced Draft Decarbonator Level Low Alarm 1-529-LAL-6703 becomes non-active.
11. Verify that the pump is operating without any unusual noise emitting from the pump or motor.
12. The Feed Pump can run continuously without providing flow to the crystallizers. The recirculation pipeline provides minimum flow requirements for the pump.
13. The Feed Pump can be started and stopped as needed. During extended shutdowns, the pump can be stopped.

NOTE

The Forced Draft Decarbonator Recirculation Pipeline should be open anytime a Feed Pump is running and when there is no fluid flow to the Crystallizer, or when the pH control of the Forced Draft Decarbonator is active.

3.3.2 Seal Water Start-up / Operation

1. Verify that all drain, vent and sample valves are closed on the seal water piping.
2. Verify that Seal Water supply is available and that the Seal Water Pressure Low Alarm 1-529-PAL-6001 is not active.
3. Seal water supply must be available and remain available anytime the following pumps with mechanical seals are running.

   - Train A Recirculation Pump 1-529-P-6009
   - Train B Recirculation Pump 1-529-P-6022

CAUTION

These pumps are not allowed to start if Seal Water Pressure Low Alarm 1-529-PAL-6001 is active. However, the pumps will not stop on Seal Water Pressure Low Alarm. The pumps will ONLY stop on Seal Water Pressure Low-Low Alarm 1-529-PALL-6001. When 1-529-PAL-6001 is active the cause of low seal water pressure must be immediately identified and corrected to prevent damage to the mechanical seals. If seal water pressure cannot be restored, then the Crystallizer will need to be shutdown and drained. Continued operation will result in damage to the mechanical seals.

4. Open the manual valve at the inlet side of each pump. Set the seal water flowrate and pressure according to the information below. The flowrate is adjusted by throttling the flow meter needle valve and the pressure is adjusted by setting the back pressure control valve.

   - Train A Recirculation Pump 1-529-P-6009 2 gpm, 30 psig
   - Train B Recirculation Pump 1-529-P-6022 2 gpm, 30 psig

3.4 CRYSTALLIZER FILL AND HEAT-UP FROM COLD CONDITION

The Crystallizer system is filled, heated to boiling and placed in a Hot Stand-by condition.

1. Complete Chemical Feed System and Feed System start-up operations.
2. Verify that all drain and sample valves associated with the Flash Tank are closed. Check Flash Tank drain valve located on the suction of the Recirculation Pump.
3. Open Flash Tank Vent Valve 1-529-BV-6020 and compressor suction and casing drain valves. These valves must be open during system heat-up to displace air from the system with steam.

IMPORTANT

It is important that as much air as possible be vented from the system prior to start-up of the compressor. Any air in the system will be pushed by the compressor into the FCHX shell and blanket the tubes. This will result in a high discharge temperature.

4. Verify that pump seal water is available at a pressure of greater than 40 psig. Verify the seal water supply pressure and seal water flowrate for the Recirculation Pump 1-529-P-6009/6022 is 2 gpm @ 30 psig.
5. Place distillate heater controller 1-529-PIC-6001 in MANUAL with 0% output to keep distillate heaters de-energized.
6. Place distillate level controller 1-529-LIC-6716-1 in MANUAL with 0% output to close distillate level control valve 1-529-LCV-6003.
7. Select AUTO for Flash Tank mesh pad wash automated valves 1-529-SV-6001 / 6002.
8. Select Flash Tank level controller 1-529-LIC-6708 for AUTO with a level setpoint per the Setpoint Table provided in the Control Philosophy Section 1.2 of this manual.
9. Set feed flow controller 1-529-FIC-6001 in AUTO with a REMOTE setpoint. Feedwater from the Forced Draft Decarbonator will begin to fill the Flash Tank.
10. Start Recirculation Pump 1-529-P-6009 when Flash Tank low level alarm 1-529-LAL-6708 clears. The level in the Flash Tank will fall after the Recirculation Pump is started.

11. Verify that the Recirculation Pump is operating without any unusual noise emitting from the pump or motor.

CAUTION

These pumps are not allowed to start if Seal Water Pressure Low Alarm 1-529-PAL-6001 is active. However, the pumps will not stop on Seal Water Pressure Low Alarm. The pumps will ONLY stop on Seal Water Pressure Low-Low Alarm 1-529-PALL-6001. When 1-529-PAL-6001 is active the cause of low seal water pressure must be immediately identified and corrected to prevent damage to the mechanical seals. If seal water pressure cannot be restored, then the Crystallizer will need to be shutdown and drained. Continued operation will result in damage to the mechanical seals.

12. Verify that the manual isolation valve between the distillate pump and desuperheater is open.
13. Verify that the manual isolation valve between the feed stream and filter wash is open.
14. Open Distillate Pump 1-529-P-6019 suction and discharge manual valve.
15. Select distillate make-up level valve 1-525-ABV-6001 for AUTO. Add make-up water to the distillate tank until the distillate tank low level alarm 1-529-LAL-6716-1 has cleared. Then, place the distillate make-up level valve into MANUAL and fully close the valve.
16. Select vent steam controller 1-529-PIC-6001 for AUTO with a setpoint per the Setpoint Table provided in the Control Philosophy Section of this manual.
17. Start Distillate Pump 1-529-P-6019.
18. Verify that the distillate pump is operating without any unusual noise emitting from the pump or motor.
19. Select HOT STAND-BY from the operator interface.
20. Select distillate heater controller 1-529-PIC-6001 for MANUAL and select distillate heater 1-529-HT-6017/6018 for ON to begin heating the system. Monitor the temperature rise of the recirculating slurry at 1-529-TI-6002. Limit the temperature rise to less than 15°F per hour.
21. When the recirculating temperature reaches 210°F place distillate heater controller 1-529-PIC-6001 in AUTO and select distillate heater 1-529-HT-6017/6018 for OFF.
22. Select CASCADE setpoint for feed flow controller 1-529-FIC-6001. Verify that the controller has been previously selected for AUTO.
23. Select AUTO for distillate tank level controller 1-529-LIC-6716-1.

Allow the system to vent non-condensables for at least 2 hours after the temperature of the Flash Tank has reached the boiling point **and** steam is venting at a high rate from the Flash Tank vent and compressor suction and casing drain vents.

Crystallizer system fill and heat-up is complete. The system is in Hot Stand-by. Proceed to Crystallizer Start-up from Hot Stand-by procedure.

3.5 CRYSTALLIZER START-UP FROM HOT STAND-BY

This procedure takes the system from Hot Stand-by into normal operation. Starting the compressor starts the evaporation and distillate production process.

NOTE

The Crystallizer should be recirculating at the boiling point prior to starting the Vapor Compressor. The system should be under pressure control with the distillate heater and vent steam controller 1-529-PIC-6001 in AUTO. Vent steam should be flowing from the Vapor Compressor suction ducting and casing drains as well as the Flash Tank vents.

IMPORTANT

Operations personnel must review and be familiar with the compressor manufacturer's start-up and operating instructions.

3.5.1 Vapor Compressor Prestart-up

1. Start the auxiliary oil pump 1-529-P-6713-1 / 6726-1 by selecting AUTO from the PLC operator interface. The pump will start when the compressor is started. The pump will stop 30 minutes after the compressor is stopped.
2. Select the Sound Enclosure Cooling Fan 1-529-FAN-6713-2 / 6726-2 for AUTO.
3. Verify that the compressor casing does not have a liquid level. The compressor casing drain valve must be cracked open to allow condensate to drain prior to start-up.

NOTE

The suction casing drain and suction ducting drain valves must be opened to allow accumulated condensate to drain from the compressor casing and suction ducting. These drain valves are then throttled slightly open during compressor start-up to allow condensate to drain while preventing excessive amounts of steam from venting. After the compressor has been started, the compressor casing drain can be closed, however, the suction ducting drain must remain throttled slightly open.

4. For initial compressor start-up and commissioning, adjust the vapor compressor suction recycle valve 1-529-BV-6023 / 6046 to 100% open.
5. Verify that water injection valve for compressor wash 1-529-SV-6713-2 / 6726-2 is set to AUTO and that water is available for injection.

IMPORTANT

The vapor compressor is a positive displacement type and requires continuous water injection to prevent the rotary elements from becoming superheated, which leads to thermal expansion of the lobes and mechanical damage.

6. Verify that all compressor start permissives have been satisfied.

3.5.2 Vapor Compressor Start-up

1. Close the Flash Tank vent valve 1-529-BV-6020 / 6043.
2. Select the Crystallizer Anti-foam dosing pumps 1-529-P-6740-1 or 2 and 1-529-P-6740-3 or 4 for MANUAL from the PLC operator interface to batch dose the Crystallizer with Anti-foam prior to start-up. Allow the Anti-foam dosing pumps to dose the Anti-foam to the Crystallizers for 10 minutes before the compressor is started. After 10 minutes, set the manual speed control for 0% and switch the pumps to AUTO.
3. Verify that Flash Tank A and B level indicators 1-529-LIT-6708-1/2 and 1-529-LIT-6721-1/2 do not deviate by more than 3%. Investigate the cause if the deviation is greater. Do not start-up until the problem is resolved.
4. The Flash Tank level should be between 40% and 60% with the Recirculation Pump running.
   - If the level is above 60%, open Flash Tank drain valve to drain some of the system contents. Close the valve after 2 minutes and recheck the Flash Tank level. Repeat as necessary and then complete the following step.
   - If the level is less than 40%, add feedwater to the Flash Tank.
5. Verify that Flash Tank A and B level controller 1-529-LIC-6708 / 6721 is set for AUTO with a setpoint per the Setpoint Table provided in the Control Philosophy Section 1.2 of this manual. Set the Flash Tank level controller remote setpoint selector to CASCADE.
6. Verify that feed flow controllers 1-529-FIC-6001 / 6002 are set to AUTO with REMOTE setpoint selected. Distillate tank level control valves 1-529-LCV-6003 / 6005 will remain closed since there is no distillate flow out of the system.
7. Verify that vent steam controller 1-529-PIC-6001-1 / 6002-1 and distillate heater controller 1-529-PIC-6001-2 / 6002-2 are both selected for AUTO.
8. Vapor recycle manual valve BV-6023 / 6046 is 100% open.
9. Verify that the Crystallizer recirculating temperature is at least 210°F. If not, select distillate heater controller for MANUAL and energize the distillate heaters to heat-up the slurry. When the recirculation temperature reaches 210°F, place the controller back in AUTO.
10. Reset Hot Stand-by from the operator interface to release feed flow control valves 1-529-FV-6002 / 6004 and distillate tank level control valves 1-529-LCV-6003 / 6005 from the closed position.

11. Start the compressor from the Crystallizer PLC operator interface. When start is selected the operator must acknowledge at the Crystallizer PLC operator interface that the following manual tasks have been completed before the compressor will be allowed to start.

    - The suction casing has been drained and the casing drain valve is throttled open.
    - The suction ducting has been drained and the drain valve is throttled open.
    - Anti-Foam Batch Dose has been initiated (if needed).

12. Listen to the compressor for unusual vibration and noises. If something unusual is detected, stop the compressor.

    - The compressor will draw very high in-rush current as the motor begins to speed up. Within 15 to 20 seconds the current draw will fall.
    - After the compressor impeller has come up to the operating speed, the vapor recycle valve 1-529-BV-6023 / 6046 will be manually close gradually to begin loading the compressor.
    - Immediately after the compressor starts, a large amount of distillate will be produced. Feed flow controller 1-529-FIC-6001 / 6002 and distillate tank level controller 1-529-LIC-6716-1 / 6729-1 outputs will change rapidly at first. Within 1 minute after the compressor is started the feed and distillate flows should stabilize.

13. Following the start-up of the compressor, vapor recycle manual valve BV-6023 / 6046 should be closed slowly to avoid system pressure swings and initiation of a foaming event.

Vapor recycle manual valve BV-6023 / 6046 shall be opened 100%, unloading the vapor compressor, under any of the following conditions:

- Flash Tank Level Rate of Change Alarm 1-529-LAR-6708 / 6721 is active.
- Compressor Current Rate of Change Alarm 1-529-IAR-6013 / 6026 is active.

IMPORTANT

Do not operate compressor at a speed between 896-1130 RPM during initial operation. To lock out the specific speed around the natural frequency, the frequency of the compressor shall be determined from field results.

The Crystallizer is now processing feedwater and discharging distillate. The contents of the Flash Tank will begin concentrating.

- **If starting-up from a cold and drained condition, proceed to Filter Press Start-up.**
- **If starting up from a normal Hot Stand-by Shutdown, proceed to Normal Operation (Filter Press will already be operating).**

3.5.3 ZLD Filter Press Feed Tank and Filter Press Start-up

The ZLD Filter Press Feed Tank and Filter Press are provided for batch operation mode. The Filter Press can be started immediately upon starting the Vapor Compressor, or after the Flash Tank has concentrated and the Flash Tank high density setpoint is approached. The high density setpoint is set at a specific gravity of 1.43.

The Filter Feed Tank Feed Water Inlet Valve 1-529-ABV-6009 is provided to cool the slurry in the Filter Press Feed Tank to a lower temperature if needed, before feeding it to the Filter Press. A Filter Press Feed Tank temperature setpoint should be entered and displayed at the operator interface.

IMPORTANT

Operators should review and be familiar with the filter press manufacturers start-up and operating instructions and the Filter Press P&ID.

1. Initiate Filter Press operation by closing the filter press.

2. At this point, manual valves 1-529-BV-6087, 1-529-BV-6088 and 1-529-BV-6736-2 should be in CLOSE position. The manual air valves 1-529-BV-6053, 1-529-BV-6054, 1-529-BV-6736-7 and 1-529-BV-6736-8 should also be in CLOSE position.

3. Once the Filter Press is closed, open feed inlet manual valve 1-529-BV-6086 and 1-529-BV-6736-1.

4. Open manual air valve 1-529-BV-6054. To initiate a filtration cycle, start the Filter Press Feed Pump by opening the Filter Feed Pump to Filter Air Valve 1-529-SV-6736-2 using the local hand switch.

5. Open Filter Press Filtrate Valves 1-529-BV-6736-3 and 1-529-BV-6736-4 to allow sludge filtrate to return to the Filter Press Feed Tank during filtration.

6. This starts the filtration cycle. The slurry will begin to transfer to the Filter Press and filtrate will gravity drain to the Filter Press Feed Tank. No salt cake will be produced if the brine has not yet been concentrated.

7. During normal operation, the filter press feed supply will be at a low pressure initially and gradually increase over time. High Pressure Alarm 1-529-PAH-6713-1 will be active once the feed supply pressure increases to the setpoint value.

8. Upon receiving the pressure switch High Pressure Alarm 1-529-PAH-6713-1 signal, stop the Filter Press Feed Pump by closing the Filter Feed Pump to Filter Air Valve 1-529-SV-6736-2 using the local hand switch and the Filter Press Feed Inlet Valve 1-529-BV-6736-1.

9. Core blow is a step to allow the utility air to blow off the remaining liquid collected in the center core of the filter plates and associated piping into the Filter Press Feed Tank. Start the core blow step by closing manual valves 1-529-BV-6736-3 and 1-529-BV-6736-4. Open valve 1-529-BV-6736-2 and follow by 1-529-BV-6736-8.

10. Filtrate blow is a step to allow air to blow off the remaining liquid collected in the filtrate piping into the Filter Press Feed Tank. Start the filtrate blow step by closing valve 1-529-BV-6736-8 and 1-529-BV-6736-2 after completion of the core blow step. Then, open valve 1-529-BV-6736-3 and follow by 1-529-BV-6736-7.

11. Close valves 1-529-BV-6736-7 and 1-529-BV-6736-3 after completion of the filtrate blow step.

12. At the end of the cycle, open the Filter Press using the Press Plate Shifter and allow the cake to drop into the self-dumping hopper. Clean the filter press plates with water as necessary to remove any remaining solids before the next filtration cycle.

CAUTION

Caution should be taken during removal of filter cake as it may be HOT. Appropriate Personal Protective Equipment (PPE) should be used by operators during operation of the Filter Press.

An automated filtrate pump-out procedure is provided to transfer the liquid from the Filter Press Feed Tank to the Flash Tanks. The low solids content liquid should be returned to each of the Flash Tanks in equal proportions. The following steps should be taken before initiating the automated filtrate return procedure as described in section 1.9 of the Control Philosophy.

1. Ensure valves 1-529-BV-6087, 1-529-BV-6736-1 and 1-529-BV-6089 are closed.

2. Open valves 1-529-BV-6086, 1-529-BV-6088 and 1-529-BV-6053.

3. Select the START Pushbutton at the operator interface to initiate the filtrate return procedure.

4. Return all open valves above to CLOSE position after completion of the procedure.

3.5.4 Crystallizer Post Start-up Checks

The following steps should be performed immediately after system start-up. The items are listed in order of priority, with the first item the most important:

1. Check the Compressor discharge pressure, power consumption, and vibration. Check against the baseline numbers. Cycling discharge pressure and power consumption may indicate compressor surge.
2. Monitor the Flash Tank for foaming. If foaming is observed, increase the dosing rate of the Crystallizer Anti-foam Dosing Pumps. If foaming does not subside with higher dosing of anti-foam, select HOT STAND-BY to stop the compressor. Investigate the cause of foaming. An alternative anti-foam agent may be required. Consult with the anti-foam chemical supplier.
3. Check the Compressor Bearing Lube Oil System. Check pressures, flowrates, temperatures, and oil levels against baseline numbers.
4. Be alert to unusual noises that could indicate problems.
5. Check the Flash Tank level, make sure it is stable. If the level is not stable, and the level is well above or below the controller setpoint, then adjust the setpoint of Flash Tank level controller 1-529-LIC-6708 / 6721 equal to the existing level. In 2% increments, slowly adjust the setpoint to the normal setpoint.
6. Verify that the feed and distillate flows are stable. Verify that the FCHX Distillate Tank Level is stable.
7. Verify that the Forced Draft Decarbonator and Flash Tanks pH are stable at least once per shift. Make sure that the Flash Tanks pH are operating in the allowable range of 5.5 – 10.0.
8. Monitor the conductivity (1-529-AI-6003/6004) of the distillate produced by the Crystallizer System. If the conductivity remains above 40 µS/cm for 15 minutes, investigate the cause of high conductivity (See Troubleshooting Guide).
9. Monitor the Crystallizer pressure at 1-529-PIT-6001 / 6002. Note the system pressure may drop at start-up due to a transient energy imbalance. This is acceptable. The system pressure should increase and stabilize once all the flows become steady.
10. Check that the Desuperheater is functioning by comparing the distillate temperature (1-529-TI-6716-1 / 6729-1) to the desuperheated vapor temperature (1-529-TI-6004 / 6010). The distillate temperature should approximately equal the desuperheated vapor temperature. A temperature difference greater than 10°F should be corrected. Ensure that block valves in the desuperheater line are open. If these valves are open, the blowdown Y-strainer may have accumulated solids which are restricting flow. If the desuperheated temperature does not decrease, shutdown and check for a plugged desuperheater nozzle.

NOTE

Superheated steam tends to bake fouling deposits onto the tubes at the tube bundle entrance. The problem is compounded by the fact that fouled tubes do not easily transfer heat. Thus, the superheated vapor advances further down the tube bundle resulting in more baked on deposits. The end result is reduced capacity and difficulty in cleaning.

11. Check the Anti-Foam Dosing Pumps to make sure they are operating correctly.
12. Check that all controllers are set in automatic at the normal setpoint as specified per the Section 1.2 of the Control Philosophy of this manual.
13. Periodically check the seal water pressure and flowrate to all pumps with mechanical seals and adjust as required.
14. Start-up is complete.

3.6 NORMAL OPERATION

1. *Plate exchanger operation.* As the Feed/Distillate Heat Exchanger fouls, the distillate heater 1-529-HTR-6018 / 6031 will be required to use greater quantities of power. When the distillate heater power usage becomes excessive, the heat exchangers will need to be cleaned. The following are potential causes of the heater scaling.
   - *Calcium carbonate scaling:* Feedwater alkalinity is neutralized in the Forced Draft Decarbonator by acid addition to eliminate this scale mechanism. Steady Forced Draft Decarbonator pH control and level control are important for this neutralization reaction to proceed to completion.
   - *Calcium sulfate scaling:* Anti-scale dosing is not required based on the design feed chemistry. If the preheaters are scaling with calcium sulfate then anti-scale dosing may be required. Contact Aquatech for assistance.
2. *Carbon Dioxide Removal.* The Forced Draft Decarbonator is designed to remove CO_2. The following parameters are important for efficient CO_2 removal:
   - Efficient CO_2 removal is dependent on good Forced Draft Decarbonator pH control and steady Feed Flow to the Crystallizer.
3. *Flash Tank Sampling:* The Flash Tank is sampled once per shift at the discharge of the Recirculation Pump using sample valve 1-529-BV-6066 / 6076. The sump contents are normally very hot (approximately 230°F-235°F). Use protective equipment when obtaining hot samples. Use good sampling practice such as purging the sample point prior to obtaining a sample.
4. *Maximum Capacity and Maximum Temperature Difference.* A low temperature difference (ΔT) has been designed into the Forced Circulation Heat Exchanger. The temperature difference referred to above is the difference between condensing steam temperature in the shell (1-529-TI-6004 / 6010) and the recirculating slurry temperature (1-529-TI-6002 / 6008). For a given evaporation rate, this difference will increase as the surface area becomes scaled or fouled.
5. *Feed pH.* The pH of the feed entering the Feed/Distillate heat Exchanger must be controlled. Feed with a pH that is too low may damage the equipment. Feed with a pH too high will not allow removal of the bicarbonate from the feed and may cause scaling of the heat exchanger.
6. *Flash Tank pH.* It is necessary to monitor the pH of the recirculating slurry in the Flash Tank

Sump. A pH between 5.5 and 7.0 in the Flash Tank Sump is normal. The maximum pH range is 5.5 to 10.0. Operation outside of these limits can damage the equipment.

- If the pH is low, troubleshoot the Forced Draft Decarbonator pH control loop.

7. *Flash Tank Level:* The Flash Tank level is controlled by modulating Feed Flow Control Valve 1-529-LCV-6002 / 6004. The level in the Flash Tank is measured by 1-529-LIT-6708-1/2 and 1-529-LIT-6721-1/2. The level transmitters are calibrated such that 0% corresponds to the feed inlet nozzle elevation and 100% is at the top diaphragm seal nozzle elevation. The following should be noted about Crystallizer level control.

   - ***Overfilling the Flash Tank while the vapor compressor is running could cause substantial damage to the compressor.***
   - 1-529-LIT-6708-1/2 and 1-529-LIT-6721-1/2 should be compared frequently. If the transmitters deviate by a large quantity, determination of which transmitter (or both) is in error should be made by utilizing the respective Flash Tank sightglass. The correct level transmitter should be selected for control, and the system should be scheduled for a shutdown to repair the faulty transmitter.
   - If an Emergency Stop, or Flash Tank low low low level interlock shuts down the Recirculation Pump, the Recirculation Pump should be restarted ASAP. The Recirculation Pump must be running anytime there are suspended solids in the system. Stopping the Recirculation Pump will cause these solids to quickly settle. Over time the solids compact and will eventually plug the Recirculation Pump, preventing it from restarting.

8. *Foaming.* Foaming in the Crystallizer must be frequently monitored. Failure to do so can damage the Vapor Compressor. Increase the dosing speed of the Anti-foam Dosing Pump from the operator interface for emergency foam control. If foaming is a frequent problem, try higher concentrations of continuous Anti-foam dosing and/or alternative Anti-foam agents. Consult with the Anti-foam chemical supplier.

9. *Boiling Point Elevation:* Monitor the Flash Tanks BPE (1-529-TDI-6001 / 6002). The BPE of the recirculating slurry will increase as the total dissolved solids concentration (TDS) increases. A high boiling point elevation reduces the evaporation capacity of the Crystallizer System, increases the slurry temperature and increases the chloride ion concentration of the recirculating slurry.

   - High BPE's limit the capacity of the vapor compressor by requiring a higher discharge pressure at a given evaporation rate.
   - High chloride concentrations can cause corrosion of the crystallizer materials.

CAUTION

The Crystallizer should not be operated for extended periods of time with high BPE alarm 1-529-TDAH-6001 / 6002 active. When this alarm is active, operations personnel must troubleshoot the root cause.

If the boiling point elevation cannot be controlled by the filter press, the pump-out drain system is used to remove highly soluble salts.

The purge will be taken batch-wise only as necessary. When the boiling point elevation of the flash tank slurry increases above the boiling point elevation high setpoint, the inlet valve to the Pump-out Drain System opens and the concentrated solution is pumped into the tank and held for removal (by others).

10. *Mist Eliminator.* The Mist Eliminator will periodically be washed with distillate. Depending on the amount of solids build-up on the chevron faces, the frequency and duration of this automated wash may need to be adjusted. Typically, frequent short washes are more effective than long infrequent washes.

11. *Crystallizer Vapor Compressor Drains:* The compressor suction drain should remain cracked open during operation to allow water to drain before entering the compressor. The compressor casing drain should be closed during normal operation.

12. *Compressor Vapor Recycle:* The vapor recycle valve 1-529-BV-6023 / 6046 must be 100% open during compressor start-up and is slowly ramped closed after start-up. The vapor recycle valve is also used to unload the compressor if foaming is detected.

13. *Heat Transfer Coefficient:* Monitor the Heat Transfer Coefficient. A decreasing heat transfer coefficient over time is an indication of forced circulation heat exchanger scaling. When the required operating capacity can no longer be obtained, shut the system down, drain, inspect and clean (mechanically or chemically) the Crystallizer to restore the heat transfer rate.

14. *Specific Gravity:* Monitor the Flash Tank specific gravity (1-529-DI-6708-1 / 6721-1).

    - The specific gravity at start-up with feedwater will be near 1.0. After the compressor is started, the Flash Tank contents will begin to concentrate and the specific gravity will begin to increase.
    - At a specific gravity of approximately 1.347, the solution will begin crystallizing salts and the solution total suspended solids (TSS) will begin increasing.
    - At a specific gravity of approximately 1.43, the Crystallizer control system will open the Filter Feed Tank slurry inlet valves and fill the tank. The filter press will be started up and operated manually to begin batch processing and discharging salt cake. The specific gravity will decrease as crystallized salt is removed from the Flash Tank.
    - The filter press run permissive will remain until the Flash Tank specific gravity decreases to less than 1.347. The filter press will stop batch processing and remain ready until the specific gravity of the Flash Tank increases back to 1.43 (See Control Philosophy Section 1.9 Crystallizer Filter Press System for additional information).

15. *Trends:* Monitor the Crystallizer system performance, temperature and analyzer trends on a frequent basis.

3.7 CRYSTALLIZER BOIL-OUT

NOTE

Prior to adding the feed/dilution water, the plate filter press should be run at least once to remove as many suspended solids as possible from the crystallizer slurry.

1. Change the Flash Tank A / B Low Low Level Alarm 1-529-LALL-6708 / 6721 to 25% for this procedure.

2. While the vapor compressor is still running, place feed flow controller 1-529-FIC-6001 / 6002 in manual and close the corresponding feed flow control valve. The level in the flash tank will decrease.

3. When the Low Low Level Alarm in the flash tank becomes active, open the vapor compressor recycle manual valve 1-529-BV-6023 / 6046 for the vapor compressor to unload.

4. Place the crystallizer in hot stand-by; this should stop the vapor compressor and close the distillate level control valve 1-529-LCV-6003 / 6005. The recirculation pump should still be running.

5. Reset the crystallizer from hot stand-by but do not start the compressor. This will allow you to open the Feed Flow Control Valve 1-529-FCV-6002 / 6004. Open this valve and fill the flash tank until the flash tank level is just below the High High Level Alarm (65%). (Note: If the LAHH is active, some of the flash tank contents will need to be drained before restarting the compressor). Close the Feed Flow Control Valve.

6. Allow the system to circulate and scrub for 4 hours.

7. When the circulation period has been completed, the crystallizer valves can be placed in AUTO and the vapor compressor restarted.

8. Reset the Flash Tank A / B Low Low Level Alarm to 45% when finished.

3.8 SHUTDOWNS

There are two different shutdown phases: (1) Hot Stand-By (short duration shutdown) and (2) Long Term Shutdown.

Hot Standby: This is the most common type of shutdown. This shutdown requires the least amount of manpower to execute. Re-start from Hot-Standby is executed more quickly than start-up from the other shutdown modes. For a Hot Stand-by Shutdown the evaporation process is stopped by stopping the compressor. Concentrated slurry remains in the Crystallizer and is

maintained at or near boiling while the recirculation pump remains running. The system can stay in Hot Stand-by for several days.

Evaporator Long Term Shutdown: This shutdown is preceded by Hot Stand-by. Long Term Shutdown is initiated when major maintenance of the Crystallizer System is required, or for other reasons where the Crystallizer must be shutdown and drained. The Crystallizer System is drained and rinsed.

3.8.1 Hot Stand-by Shutdown

Activation of a Hot Stand-by stops the evaporation process; the Vapor Compressor, feed flow and distillate flow is stopped. All other equipment and control loops continue to function as normal. The system remains circulating and hot.

Each of two Crystallizer Systems is placed into Hot Stand-by independently of the other system.

1. Select Hot Stand-by from the operator interface. The Vapor Compressor will stop running, and the mist eliminator in the Flash Tank will be washed. The Feed Flow Control Valve and the Distillate Tank Level Control Valve will close. See Section 1.3 of the Control Philosophy for additional detail.
2. (Optional) Stop the Feed Pump.
3. Verify that the chemical dosing systems have stopped.

The Recirculation Pump will continue to recirculate the brine slurry. The energy input to the pump motor is converted into heat, and a small amount of continuous evaporation occurs. This evaporated vapor is condensed and accumulates in the Distillate Tank. To avoid further concentration of the recirculating slurry, and to maintain the Distillate Tank level, the following actions are automatically initiated during activation of Hot Stand-by.

- Mist Eliminator Wash Valve is opened on high Distillate Tank level and closed when the Distillate Tank level setpoint is reached.

3.8.2 Long Term Shutdown

This shutdown is preceded by Hot Stand-by. The Crystallizer System is drained and rinsed with feed.

1. Verify that Hot Stand-by has been selected.
2. Set the Distillate Heater to OFF and the Vapor Compressor Suction Pressure to MANUAL with a 0% output.
3. Stop the chemical dosing pumps (only for the appropriate train).
   - Place the Acid Dosing Pump in MANUAL with a 0% output.
   - Set the Anti-Foam Dosing Pumps for MANUAL with 0% output.

4. Start the Feed Pump (if previously stopped).
5. Activate the Crystallizer Low Levels Interlock Bypass.
6. Set Flash Tank Level Controller remote setpoint selector to LEVEL.
7. Set the Distillate Tank Level Controller 1-529-LIC-6716-1 / 6729-1 for MANUAL with an output of 0% and close level control valve 1-529-LCV-6003 / 6005.
8. Stop the Distillate Pump.
9. Drain the Distillate Tank (optional).
   - Open the drain valve located on the heater side of the Distillate Tank.
   - Open the distillate drain valve located at the suction of the Distillate Pump to drain the discharge side of the Distillate tank.
10. Open the Vapor Compressor suction and casing drain valves.
11. Set the Flash Tank Density high and low setpoints to 1.165 and 1.160 respectively. Then, start the Filter Press to begin a filtration cycle to remove solids in the Flash Tank.
12. The Flash Tank specific gravity will begin to decrease from the dilution by feedwater and the removal of suspended solids by the filter press. When the specific gravity decreases to 1.165 **and** the recirculating temperature (1-529-TI-6002 / 6008) is less than 150 °F, reset the Flash Tank Density setpoint to the normal value.

NOTE

The Flash Tank suspended solids concentration should be very low due to removal by the filter press and dissolution by feedwater. The feedwater also cools the Crystallizer contents.

13. Recirculate for a minimum of 2 hours (longer is better) to dissolve soluble solids inside the Crystallizer.
14. Set the crystallizer feed flow controller 1-529-FIC-6001 / 6002 for MANUAL and close level control valve 1-529-LCV-6002 / 6004.
15. Drain the Flash Tank.
    a) Open Flash Tank drain valve to drain the Flash Tank. Stop the Recirculation when the Flash Tank reaches low low low level.
    b) Close the Flash Tank drain valve when the Flash Tank stops draining.
16. Refill and flush the Flash Tank, Filter Press and ZLD Filter Press Feed Tank.
    a) Set the Forced Draft Decarbonator level controller 1-529-LCV-6001 for AUTO to control the level in the Forced Draft Decarbonator.
    b) Set feed flow controller 1-529-LCV-6001 / 6002 to AUTO to begin filling the Flash Tank. Start the Recirculation Pump, set the crystallizer feed flow controller 1-529-LCV-6001 / 6002 for MANUAL and close flow control valve 1-529-LCV-6001 / 6002 when the low level alarm clears.

c) While recirculating, manually initiate a filter press cycle by selecting AUTO START locally at the filter press control panel. Start the Filter Press Feed Pump when the Filter Press Feed Tank low level alarm clears.

d) Open the inlet valve to System Pump-out Drain 1-529-BV-6006 / 6007. This will flush the disposal line.

e) Recirculate the Crystallizer for a minimum of 1 hour.

f) Sample the Flash Tank and determine the conductivity, or total solids.

g) Open Flash Tank drain valve to drain the Flash Tank. The Recirculation Pump will stop when the Flash Tank reaches low low low level.

h) Close the Flash Tank drain valve when the tank stops draining.

i) Open the Crystallizer Feed Tank drain valve to drain the tank. The Crystallizer Feed Pump will stop on low low level.

j) Close Crystallizer Feed Tank drain valve when the tank stops draining.

k) Repeat if the conductivity of the sample was greater than 15,000 µS/cm or the total solids was greater than 10,000 ppm.

17. Piping associated with these equipment and vessels should be flushed and rinsed accordingly with low chloride water.

18. Stop the seal water supply to the Recirculation Pump.

19. Completely drain the contents of the Crystallizer Forced Draft Decarbonator.

20. Stop the Crystallizer Feed Pump if running.

The Crystallizer system has been drained and flushed and is ready for long-term shutdown.

NOTE

Refer to the Maintenance Procedures Document No. P-30032-PD-PE-ICD006009-H for intermittent operations during long-term shutdown.

Attachment 2 Maintenance Plan

MAINTENANCE PROCEDURES

PG&E Colusa Generating Station
Maxwell Ca.

Crystallizer System
2 x 50% Crystallizers
AQUATECH PROJECT NO. P-30032

DOCUMENT NO: P-30032-PD-PE-ICD006009-H

1.0 GENERAL

The Crystallizer System has been designed for long periods of efficient uninterrupted operation. Careful attention to proper maintenance as described in this chapter will extend trouble-free operation of the unit. The objective of preventative maintenance is to anticipate and prevent operational difficulties before they require plant shutdown.

THE FOLLOWING PREVENTATIVE MAINTENANCE SUMMARY IS A GUIDE FOR ESTABLISHING A PLANT MAINTENANCE PROGRAM. CONSULT THE OEM O&M MANUALS FOR DETAILED PREVENTATIVE MAINTANCE AND REPAIR INSTRUCTIONS. FAILURE TO FOLLOW THE MANUFACTURER'S REQUIREMENTS CAN VOID ANY WARRANTY AND CAUSE PREMATURE EQUIPMENT FAILURE.

2.0 DATA ON COMPONENTS NOT MANUFACTURED BY AQUATECH

Maintenance personnel should be thoroughly familiar with the maintenance and servicing requirements of all components contained in the OEM O&M manuals provided in Volume 2 of this manual.

3.0 RECOMMENDED ROUTINE INSPECTIONS & PREVENTATIVE MAINTENANCE

The following are recommendations for routine inspections. These recommendations are not a comprehensive list of all the OEM's inspection recommendations. Consult the OEM O&M manual provided in Volume 2 of this manual for detailed periodic inspection requirements for each equipment component.

3.1 Flash Tank

3.1.1 Annually

- Drain, flush and chemically or mechanically clean the Flash Tank (including upper chamber, lower chamber and mist eliminator).
- Retain labeled and dated samples of mist eliminator scale and sump scale for analysis. Contact Aquatech for assistance.
- After cleaning, inspect the interior for structural integrity of welds, signs of corrosion or erosion.
- Examine the condition of sealing surfaces at the manway opening. Repair surfaces and replace gasketing as necessary.
- Mist Eliminator
  - Remove the chevron mist eliminators and soak in 5-10% EDTA cleaning solution to dissolve scale deposits or replace.
  - Inspect and clean the mist eliminator wash header nozzle.
  - Verify that all mist eliminator support, wash header support, and wash header

flange bolting is tight.

3.1.2 Monthly

- Perform Crystallizer boil-out procedure as described in the Operating Procedures Section 3.7.

3.2 Forced Circulation Heat Exchanger (FCHX)

3.2.1 Annually

- Drain, flush and chemically or mechanically clean the tubeside of the FCHX (in/out channel, return channel and tubes).
- After cleaning, inspect for structural integrity of welds, signs of corrosion or erosion.
- Inspect each tube hole for pluggage.
- Examine the sealing surfaces of in/out channel and the return channel. Repair surfaces and replace gasket as necessary.

3.3 Vapor Compressor

3.3.1 Daily

- Check oil levels and oil condition of gear box sump and lube oil system reservoir through sightglass on housings.
- Check for fluid leaks.
- Check for abnormal noises and vibration from all rotating equipment.
- Check for vapor leaks from underneath insulation and repair as necessary.
- Check the vapor compressor oil supply temperature, bearing temperature and vibration levels. Trending this data over time can identify problems before equipment failure.
- Check shaft seal pressure.
- Check for loose or defective components.
- Main Drive Motor:
  - Record bearing/stator temperature and vibration data
  - Clean off accumulated dirt
  - Check for erratic or noisy operation, frayed or worn electrical cables and loose mounting bolts.

3.3.2 Monthly

- Check for:
  - Water or acid in oil
  - Dirty or clogged oil filter
- Test auxiliary pump motor start-up
- Air Motor Cooler:

- Keep motor clean and ventilation openings clear

3.3.3 Annually

- Change compressor lube unit oil (or analyze). Use only recommended oil type (see Lubrication Schedule).
- Change compressor lube unit oil filter(s).
- Clean shaft seal air filter and clean strainer on dewatering unit.
- Clean compressor motor air filter and recharge with correct adhesive before reinstalling.
- Inspect the rotary lobes for signs of wear, corrosion, rubbing and cracking.
- Turn the rotary lobes by hand and verify that the rotary lobes rotate freely without any unusual noises.
- Clean off any scale on the impeller with brass brush and steel wool. (This may be required more frequently if high vibration levels occur during normal operation).
- Check and tighten all wiring connections.
- Check and tighten all air connections valves.
- Inspect couplings for wear and alignment.
- Check vapor compressor bearing seals for signs of wear, replace as required.
- Inspect and clean compressor motor stator windings.
- Check and record compressor motor insulation resistance.
- Inspect coupling(s) and check alignment, compare against initial alignment report (high vibration levels may require more frequent checking). Correct misalignment as necessary.
- Inspect shaft seal.
- Re-grease pump motor bearings.
- Drain the oil sump(s), thoroughly clean, and inspect condition of interior paint finish.
- Inspect and clean the lube oil cooler(s).
- Check operation and calibration of all gauges, indicators, switches and monitoring devices.
- Check calibration of positioners and actuators.
- Inspect regulators, solenoids and limit switches.
- Replace compressed air supply filters.
- Verify tightness of piping connections, equipment connections, flanged joints and threaded joints.

3.3.4 Long-term Shutdown

Compressor maintenance during long term shut down:

A) To reduce rust during this period the compressor should be operated once per month for a period of at least ten minutes to thoroughly coat all parts with oil.

B) The compressor shafts should be rotated at least once per month.

Note

If sections A or B can not be accomplished, motor shafts should be rotated by hand at least 25 revolutions.

C) Bearing journals and all bear metal parts should be flushed with rust inhibiting oil.

D) Motor windings should be inspected periodically by checking insulation resistance. (Compare to base line megger data)

E) Check manufacturer literature for any additional recommendations.

F) Before reactivating the compressor it should be thoroughly cleaned, inspected for rust and corrosion. Oil and grease should be renewed.

3.4 Forced Draft Decarbonator

3.4.1 Annually

- Drain, flush and chemically or mechanically clean the Tank to remove any scales that may have deposited with use.
- Inspect structural integrity.
- Inspect for wear.

3.5 Centrifugal Pumps

3.5.1 Daily

- Check discharge pressure of all pumps, compare against baseline data.
- Check pump bearing temperatures by hand.
- Check oil levels and oil condition of all pumps through sightglass on bearing housing.
- Check for abnormal leaks from pump seals.
- Check the seal water flowrate to pumps with double mechanical seals. Cloudy or "milky" water in the flow indicator is indicative of a failed inboard seal.

3.5.2 Monthly

- Check pump bearing temperature with a thermometer.

3.5.3 Quarterly

- Replace pump bearing lube oil after 200 hrs and then every 3 months or 2000 operating hours. Use only recommended oil type (see Lubrication Schedule).
- Check baseplate bolting for tightness.

3.5.4 Annually

- Inspect couplings for wear and alignment.
- Check pump mechanical seals, adjust or replace as necessary. Check shaft of sleeve for scoring.
- Verify tightness of piping connections, equipment connections, flanged joints and threaded joints.

3.6 Plate Heat Exchanger

3.6.1 Annually

- Disassemble, inspect and clean plate heat exchanger. Check plates for cracks and punctures, gaskets for rips, flattening, brittleness, or displacement from gasket groove. Replace gasket as needed.

3.7 Agitators

3.7.1 Daily

- Check for abnormal noises and vibration.
- Check for fluid leads.
- Check for vapor leaks from mechanical seal. Adjust seal or replace as necessary.

3.7.2 Annually

- Retighten shaft to mixer bolting and impeller to shaft bolting.

3.8 Instrumentation

3.8.1 Weekly

- Check pressure indicators downstream of pressure regulating valves against PRV setting.
- Standardize pH probe(s) against pH standards.
- Standardize conductivity probe(s).
- Standardize dissolved oxygen probe(s).
- Perform self diagnostic checks on all transmitters equipped with such capability.
- Inspect local indicators for cleanliness and readability.

3.8.2 Annually

- Check and tighten all wiring connections.
- Check operation and calibration of all gauges, indicators, switches and monitoring devices.

- Clean seal water rotameter flowtubes (may be required more frequently).

3.9 Control Valves

3.9.1 Daily

- Check for fluid leaks.

3.9.2 Semi-Annually

- Check control valve stroking for smooth full stroke operation.
- Clean dirt away from stem.
- Verify that positioner linkage and accessories are securely fastened.
- Check packing box bolting on all valves and tighten as necessary to stop leaks, or replace packing.

3.9.3 Annually

- Check and tighten all wiring connections.
- Check and tighten all air connections on valves.
- Check calibration of positioners and actuators.
- Inspect regulators, oil collectors and air filters (replace as necessary).

3.10 Automated On/Off Valves

3.10.1 Daily

- Check for fluid leaks.

3.10.2 Semi-Annually

- Check automated on/off valves and actuators for proper operation. Replace seats and seals if necessary.
- Clean dirt away from stem.
- Check packing box bolting on all valves and tighten as necessary to stop leaks, or replace packing.
- Verify limit switch operation at fully open and closed positions.
- Check the associated solenoid valve for proper operation.

3.10.3 Annually

- Check and tighten all wiring connections.
- Check and tighten all air connections on valves.
- Inspect regulators, oil collectors and air filters (replace as necessary).

3.11 Manual Valves

3.11.1 Daily

- Check for fluid leaks.

3.11.2 Semi-Annually

- Check condition, repair or replace as necessary.
- Check packing box bolting on all valves and tighten as necessary to stop leaks, or replace packing.

3.12 Miscellaneous Tanks & Vessels

3.12.1 Annually

- Inspect structural integrity.
- Inspect for corrosion or erosion.
- Clean scale and sludge deposits.

3.13 Miscellaneous

3.13.1 Daily

- Check for fluid leaks (water, water vapor, oil, and chemicals).
- Check for loose or defective components.

3.13.2 Semi-Annually

- Clean and inspect all wye strainers.
- Clean and inspect all steam traps and strainers.

3.13.3 Annually

- Check condition of chemical tanks and piping. Repair or replace as necessary.
- Check condition of back pressure valves and pressure relief valves on all chemical addition systems. Repair or replace as necessary.
- Check foundation bolting for tightness.

- Inspect air regulator oil collectors and filters.
- Inspect and replace compressed air supply filters as necessary.
- Check and tighten all wiring connections.
- Inspect structural steel, platforms, and supports for corrosion. Remove corrosion, prime and repaint as necessary.
- Inspect condition of piping and equipment paint. Remove corrosion, prime and repaint as necessary.
- Inspect condition of piping and equipment insulation. Repair and replace as necessary.

4.0 CALIBRATION OF INSTRUMENTS

It is difficult to monitor and troubleshoot the system performance if instruments are out of calibration. Instruments need to be calibrated prior to the initial start-up and on a periodic basis thereafter. To allow meaningful analysis, calibrate to the following tolerances.

Dial Type Local Thermometers:	$\pm$ 2°F
RTD's & Thermocouples:	$\pm$ 0.2°F

Calibrate temperature devices in boiling water against a glass laboratory thermometer. Note that the boiling point of water varies depending on barometric pressure. Be sure to calibrate all of the temperature devices at one time. Doing so avoids systematic erros and makes temperature difference calculations more meaningful.

Pressure Transmitters:	$\pm$ 0.2 psi
Pressure Gauges:	$\pm$ 1 psi

Use a deadweight type tester for pressure gauges. Be careful not to let any of the silicone fluid leak out of pressure gauges equipped with diaphragm seals. Gauges with diaphragm seals are carefully filled by the factory to ensure accuracy. Without proper vacuum filling equipment, it is difficult to recalibrate gauges with diaphragm seals to the same degree of accuracy. Once seal fluid leads out, have the factory recalibrate them.

5.0 CRYSTALLIZER CLEANING

Crystallizer cleaning should be initiated when:

1. Crystallizer design capacity can no longer be maintained without the addition of make-up steam.
2. The unit has been running for an extended period of time, the feed stocks are low, and the system will not be required for at least two days.
3. The balance of the plant will be shut down for at least one week annually.
5. The heat transfer coefficient drops to less than 50% of the initial clean value.

Cleaning is not only a time for cleaning the heat exchanger surfaces but also a time for inspection of equipment and repair of minor items to ensure availability of equipment. Cleaning prepares the equipment for disassembly, entry, inspection, and repair.

These steps are performed after the unit has been drained and rinsed, see Long Term Shutdown procedures. Cleaning chemicals are introduced to the flash tank, circulated and heated. The spent chemicals are then discharged.

The most effective and economical method of washing the flash tank is a combination of mechanical (hydro-blast) and chemical cleaning. The hydroblast cleaning should be done on all accessible portions of the evaporator that have substantial scale build-up. Chemical cleaning removes scale relatively slowly and should be used to clean the inaccessible portions of the flash tank only.

5.1 Mechanical (Hydroblast) Cleaning

The following procedures describe the recommended method for hydro-blast cleaning of the evaporator. Hydroblasting refers to a method of using a very high pressure water spray (10,000 to 20,000 PSIG) to clean equipment. Hydroblast cleaning is usually done by contracted service companies that supply both equipment and personnel qualified and trained to safely perform this hazardous work.

The following procedures are written in series fashion, when in reality much of the work can be scheduled concurrently. Depending on the allowable downtime for the system, multiple crews working around the clock may be required.

5.1.1 Crystallizer Mechanical Cleaning

Flash Tank

1. Ensure the flash tank has been thoroughly rinsed and drained.
2. Lock out motor starters for all pumps.
3. Open the manway. Do not enter at this time.
4. Test the air quality and check vessel internal temperatures. Plant vessel entry procedures must be satisfied before entering the vessel.
5. Enter the tank and inspect for scaling. Bars are provided to support planks for personnel to stand on. Personnel entering the vessel should be provided with fall protection gear.
6. Remove the mist eliminator chevrons for external chemical cleaning or replacement. Inspect the spray header nozzle and clean/replace as necessary.
7. Inspect the upper chamber for scaling.

8. Thoroughly clean the internal walls of the upper chamber.

9. Remove the recirculation pump suction line expansion joint. This will allow scale and water to drain from the Flash Tank during hydroblasting without entering the pump.

10. Remove the level transmitter diaphragm seals from the Flash Tank nozzles. Carefully hand clean the diaphragm seals as necessary. Be careful to not damage while cleaning.

11. Consult hydroblast personnel to determine if sightglasses will be damaged by hydro-blasting. Remove sightglasses if required and cover with blanks.

12. Hydroblast the Flash Tank walls.

13. All loose scale must be removed. Manually remove large scale pieces caught in the vortex breaker. Thoroughly flush all scale debris out the bottom of the Flash Tank. If left inside the flash tank it could damage the recirculation pump.

NOTE

It is extremely important to remove all loose scale. This will expedite chemical cleaning and reduce the amount of chemical required. Large scale pieces not removed could damage the recirculation pump.

14. Reinstall the mist eliminator chevrons.

15. Remove scaffolding from the Flash Tank. Reinstall sightglasses, instrumentation and the manway cover.

16. Reinstall the recirculation pump suction line expansion joint.

Mechanical cleaning of the flash tank is complete. The flash tank is now ready for service or chemical cleaning.

Forced Circulation Heat Exchanger

1. Ensure the FCHX has been thoroughly rinsed and drained.
2. Lock out motor starters for all pumps.
3. Remove the heads from both ends of the heat exchanger.
4. Inspect the heads and tubes for scaling.
5. Thoroughly clean the heads as necessary.
6. Thoroughly clean the tubes.

NOTE

It is extremely important to remove all loose scale. This will expedite chemical cleaning and reduce the amount of chemical required. Large scale pieces not removed could damage the recirculation pump.

Mechanical cleaning of the Forced Circulation Heat Exchanger is complete. The FCHX is now ready for service or chemical cleaning.

5.2 Chemical Cleaning

The following procedure describes chemical cleaning of the evaporator system. The steps below make the following assumptions:

- 38% Tetra Sodium EDTA is utilized as the cleaning chemical
- The scale on the tubes is calcium sulfate. Other scales are possible but unlikely based on the projected feed chemistry and assuming that the good operating procedures have been utilized in running the evaporator.
- If conditions are different than above the steps below may need to be modified to accommodate the change in conditions.

The steps below describe the process to dilute the cleaning chemical to wash strength, heat the cleaning chemical to increase the wash effectiveness, check the chemical strength, drain, and rinse the evaporator system.

Commercial EDTA chelating agent formulations are available from various suppliers. One such recommended formulation is Dow Chemical's Versene 100. Versene 100 is a 38 wt% solution of EDTA that has been pH adjusted with caustic soda. Versene Acid Powder is used to adjust the cleaning solution pH.

Approximately 800 gallons of 38% cleaning chemical (Versene 100 or equal) and 100 lbs or Versene Acid Powder (or equal) should be on hand for cleaning of the flash tank. This estimate is based on an average scale thickness on the evaporator tubes of 0.01 inch, with no scale on the sump walls or in the top head. The actual amount of scale present will determine the amount of cleaning chemical that is required.

Chelating agents dissolve scale by reacting with divalent cations such as calcium, removing these ions from calcium sulfate and calcium carbonate scale. This process of displacing calcium from the surface of the scale results in scale dissolution. The scale surface must be in contact with the EDTA solution, therefore, impervious hard scale surfaces will take longer for the scale to dissolve than porous or cracked surfaces. Similarly, thin scale will be dissolved faster than thick scale.

The following factors contribute to an effective scale removal.

- The cleaning solution optimum pH is in the range of 9.0 to 12.0 for calcium scale removal. In general, the rate of scale dissolution increases as the solution pH increases.

NOTE

At a pH greater than 12.0 the evaporator tubes are susceptible to corrosion at cleaning solution temperatures greater than 150°F. If the cleaning solution is heated above this temperature then the solution pH must be monitored and the pH of the cleaning solution may need to be adjusted down using Versene Acid Powder. Alternatively sulfuric acid can be used for pH adjustment, but is more hazardous to handle and consumes some of the active cleaning chemical.

- Higher solution strengths will increase the rate of scale dissolution.
- Circulation of the cleaning solution must be provided. The cleaning solution must make repeated contact with the scale to dissolve the scale.
- Adequate time must be provided to assure a thorough cleaning. Thin scale deposits require 48 to 72 hours of contact with circulating cleaning solution. Heavy scale deposits will require additional circulation with the cleaning solution. In general, the more time allowed for circulation of cleaning fluid the better the results that can be expected.
- The cleaning solution is more effective when heated, although heating is not essential.
- Approximately ten pounds of active chemical (EDTA) is required to dissolve one pound of scale.

5.2.1 Chemical Cleaning Procedure

1. Obtain a scale sample, preferably off the FCHX tubes. Place the scale in a 50% solution of cleaning solution and water. Heat the solution and boil for several hours. Replace evaporated water as solution boils. If more than 75% of the scale dissolves continue to the next step.

   If the scale dissolves the scale is likely Calcium Sulfate. If not, the scale composition must be determined. The EDTA cleaning solution may not be effective on different types of compounds. The cleaning procedure should be discontinued until the scale is identified and an effective wash solution is identified. Contact Aquatech for assistance with scale identification and wash solution recommendations.

2. Ensure that seal water is available to the Recirculation Pump.

3. Add filtered water to the Flash Tank via the ZLD Crystallization Feed Tank. Stop adding water when the Flash Tank low level alarm clears.
4. Start the Recirculation Pump. Monitor the pump for unusual noises. Large scale pieces may still be in the system that could damage the pump.
5. Add 230 gallons of EDTA cleaning solution (Versene 100 or equal) to the Flash Tank by adding to the ZLD Crystallization Feed Tank and transferring into the Flash Tank.
6. Check the pH of the recirculating cleaning solution and record. If the pH is greater than 12 then the cleaning solution pH must be adjusted down to between 10 and 11 by adding Versene Acid Powder to Feed Tank, mixing with water and transferring into the Flash Tank. Alternatively sulfuric acid can be used for pH adjustment, but is more hazardous to handle and consumes some of the active chemical.
7. The Crystallizer system will contain approximately 1,100 gallons of an 8% EDTA solution. Sample the Flash Tank and determine the EDTA concentration in the laboratory (see Laboratory Procedures). Record the concentration.
8. Heat the recirculating system to 150°F by using the heater in the distillate tank. Ensure that feed water is continuously being added to the distillate tank to maintain the liquid level and to keep the heaters submerged. Limit the system heat-up rate to 20°F per hour.

   The recirculation pump will provide sufficient energy to maintain a minimum temperature of 150°F.
9. The Crystallizer is being cleaned. Test the cleaning solution strength and pH every 2 hours.
   - Add additional EDTA solution (Versene 100) as the cleaning solution strength depletes. The minimum cleaning solution concentration is 3%. The higher the concentration, the faster that the scale will dissolve.
   - Add Versene Acid Powder (or sulfuric acid) as required to maintain the pH between 9.0 and 12.0.
10. Recirculate the wash solution for a minimum of 48 to 72 hours. If the wash solution strength has remained stable for 12 hours and the wash solution has been recirculated for a minimum of 48 hours the flash tank is probably clean.
11. Drain out the wash solution and dispose off-site. Follow the operating instructions for long term shutdown to drain and rinse the Crystallizer.

NOTE

The bulk of the wash solution should not be pumped back to the feed tank. The EDTA will interfere with crystal growth. However, a small amount, such as the amount that must be gravity drained from the unit, can be pumped to the feed tank.

6.0 REPAIR

Repair of the system is primarily limited to the repair/replacement of defective components. Refer to Volume 2 of this manual for repair procedures for all components not manufactured by Aquatech.

7.0 SAFETY

Always observe the following safety precautions when working on the unit.

- It is often dangerous to work on vessels during temporary shutdown. Heat, stale air, lock of oxygen, residual corrosive liquids and toxic vapors are all potential hazards. Plant personnel are always responsible for determining when it is safe to work on the vessel for inspection or maintenance work. The plant should establish a procedure for verifying that it is safe to enter the vessel and for ensuring the safety of personnel while they are in the vessel. Confined space entry procedures are to be followed.

- Allow the unit to cool down before opening any observation doors or disconnecting any piping or components.

CAUTION

Do not excessively cold shock the unit to cool it down. Temperature differences between evaporator metal parts and cooling solution recirculated over the tube bundle should never exceed 20°F. That is, do not fill the sump with 150°F water and start recirculation over 212° tubes. Instead, blend cold water into a system that is recirculating hot water.

- Relieve all pressure before opening any part of the system.

- Disconnect electrical power and place "*DO NOT START*" signs in conspicuous places around the unit, especially on the control panel.

- Wear appropriate safety clothing and protective devices such as safety glasses, head gear, gloves and shoes. Use respirators if the evaporator contains hazardous vapors.

- Use only new gaskets when reinstalling gasketed components or piping.

- Use lifting devices of sufficient capacity when moving heavy components or subassemblies.