McMurdo Water Plant
Standard Operating Procedure

OP-M-901

Revision 1

Approved by [redacted]

Posting Date 2/21/07

Active Divisions/Departments:
McMurdo Area Directorate

Raytheon Polar Services Company
McMurdo Area Directorate
Contract No. OPP 0000373

Table of Contents

This document is maintained by the RPSC Area Directorate.

Send updates and requests for correction to: DEN-AAODocumentPOC@usap.gov

Purpose

This procedure identifies responsibilities and requirements for operating and maintaining the water treatment plant at McMurdo Station. The plant has two Reverse Osmosis (RO) units for producing potable water from seawater. It produces water that meets EPA standards for safe drinking water:

pH	6.5 to 9.0
Chlorine	4.0mg/L MRDL (Maximum Residual Disinfection Level)
Total Dissolved Solids	500mg/L

Scope/Applicability

This procedure applies to all water plant operators at McMurdo Station.

Terms and Definitions

ºC
Temperature in degrees Celsius

ºF
Temperature in degrees Fahrenheit

BACtalk
Brand name for an automated, remote monitoring system for physical conditions (temperature, pressure, vacuum, electrical current flow, etc.). BACtalk is a registered trademark of Alerton Technologies.

bar
Metric unit of measure for pressure. One bar equals 14.5037738 pounds per square inch (absolute).

Cl_2

Chemical symbol for chlorine

CO_2

Chemical symbol for carbon dioxide

Coliform

Bacteria found in fecal matter

CSEC or Crary Lab

The Crary Science and Engineering Center, Building #1 at McMurdo Station.

DDC

Direct digital control. A remote monitoring and operation system for building utilities such as heating, ventilation and air conditioning systems. The brand name of the software used in the water plant is BACtalk. This document refers to the BACtalk computer when discussing the software display and input screen. The computer is dedicated to BACtalk and is located in the control office.

DI Water

Deionized water

FEMC

Facilities, Engineering, Maintenance and Construction. A division of Raytheon Polar Services Company.

Fire-Eye

Brand name for the boiler in the supplemental glycol heating system.

FW

Fresh water

GPM

Gallons per minute

He

Chemical symbol for Helium

HOA Switch

Hand/Off/Automatic switch. A three-position switch providing manual or automatic control of a device.

HP
High pressure

HTH
Registered trademark of Arch Chemicals, Inc. Sometimes used as shorthand for "High Test Hypochlorite." It is calcium hypochlorite in dry powdered form with usually 65% available chlorine.

Hz

Hertz. A measurement of frequency in cycles per second. For example: U. S. residential electric power is maintained at 60 Hertz (60 cycles per second.)

JSOC
The Joint Spacecraft Operations Center, Building #189 at McMurdo Station. JSOC houses the Network Operations Center (NOC), Nasa's McMurdo Ground Station (MGS), help desk personnel, network administrators, and other computer and communications staff and equipment.

Langelier Index
A formula that is useful in useful in determining the balance (corrosive or scale-forming tendencies) of water. The formula is: Langelier Index = pH + TF + CF + AF - 12.1*

Where:

- pH equals relative alkalinity/acidity of the water,
- TF equals the Temperature Factor of the water (determined from a chart)
- CF equals the Calcium Hardness Factor of the water
- AF equals the Alkalinity Factor of the water

* -12.1 is a constant used in the calculation of the Langelier/Saturation Index. AF, CF and TF are established values predetermined in the Langelier reference tables.

LN_2
Chemical symbol for liquid nitrogen. A liquid nitrogen generation plant is housed in the water plant building. Technicians and lab supervisors in the CSEC (Science Support Division) are primarily responsible for the plant and provide liquid Nitrogen to science parties as needed. When operational, water plant operators monitor the plant as part of their regular duties.

MCC

Motor Control Center. It is the large electrical equipment panel on the outside wall nearest the power plant. It houses the main breaker and breakers for all the major systems in the water plant. It is also referred to here as the main breaker panel.

mg/L

Milligrams per liter

ml

Milliliter (1,000 milliliters = 1 liter)

MOV

Motor Operated Valve

MRDL

Maximum Residual Disinfection Level

MSDS

Material Safety Data Sheet. Information sheets produced by manufacturers indicating potential hazards of, and protective actions required with a specific product.

MTFI

Main Trial for Ignition. An operating stage for the glycol boiler.

pH

Symbol (used with a number from 0 to 14) used to identify the relative acidity or alkalinity of a substance. A pH of 7 (water) is neutral. Relatively higher numbers indicate more alkaline solutions while relatively lower numbers indicate more acidic solutions.

PLC

Programmable Logic Controller. A control device incorporating a microcomputer that allows storing predetermined responses to a variety of input conditions.

PM

Preventive maintenance. Routine maintenance performed on specific equipment according to manufacturer's specifications after a set number of operational hours or other time period, i.e. annual and 6-month PMs.

PPE

Personal protective equipment. PPE includes face mask, gloves, safety glasses, and other items as needed to protect against injury or long-term exposure to chemicals used in the water plant.

ppt
Parts per thousand

Product water

Potable water produced by the system after the addition of chemicals and adjustment of its pH. It is representative of the water as soon as it has passed through all processes. Compare to station water which has been in a tank since processing and is being distributed to town. The sampling line in the lab can be set to product water or station water as needed.

PSA bed
Pressure Swing Absorption bed. A system that produces nitrogen by absorbing other gases out of ordinary air.

psi

Pounds per square inch. psi is a standard measure of pressure.

PTFI
Pilot Trial for Ignition. An operating stage for the glycol boiler

RO
Reverse osmosis

RO skid

All the components of each RO system are mounted in a rectangular floor area referred to as a "skid."

SDI
Silt Density Index. A measurement of the undissolved solids in a water sample.

Set Point
A predetermined temperature, pressure or other physical condition that triggers the action of a mechanical device. For example: the temperature at which a thermostat activates a heating or cooling system is the thermostat's set point.

Sitrep

Abbreviation for "situation report." All departments and stations submit weekly sitreps to Denver headquarters.

SSC
The Science Support Center, Building 4 at McMurdo Station. The SSC houses the

Mechanical Equipment Center (MEC), Field Safety Training Program (FSTP), and field support management offices.

Station Water

Potable water that is being distributed to town. This water has been stored in a tank since it was produced. Compare to product water which can be collected at the end of the processing cycle. The sampling line in the lab can be set to product water or station water as needed.

TDS
Total Dissolved Solids

Throttle
Decrease flow through a valve.

uS
Microsiemens. A measure of electrical conductivity (1,000,000 ohms = 1 microsiemen).

VFD
Variable frequency drive. A device which controls the speed of an alternating current motor by varying the cyclic frequency of electrical energy supplied.

Wind box
A chamber in a boiler or furnace, below the grate or surrounding a burner, through which air under pressure is supplied for combustion of the fuel.

WHS

Waste Heat System, also shown as W/H Loop (Waste Heat Loop). The system shunts waste heat from the power plant into a network of glycol-filled piping through town. The system provides the primary heat for several buildings including the water plant, several dormitories, SSC, JSOC, CSEC, and others. The main pumps and control equipment are housed in the water plant and operators monitor its operation as part of their regular duties. FEMC is primarily responsible for operations and maintenance of the waste heat system.

Responsibilities

Operations Manager

The operations manager receives information from the power/water/wastewater supervisor about the status of water production and makes recommendations to station management regarding water conservation.

Power/water/wastewater supervisor

The power/water/wastewater supervisor is responsible for ensuring that procedures in this SOP are followed.

Water plant operator

The first responsibility of a water treatment plant operator is to provide clean and safe drinking water to the community. Operators are required to follow the procedures established in this SOP and industry best practices. Operators are required to take all necessary safety precautions and operate equipment and instruments in a safe and reasonable manner.

FEMC

FEMC is responsible for construction operation and maintenance of the water plant infrastructure. FEMC is responsible for operation and maintenance of the waste heat system.

Crary Lab

Science Support Division's Crary Lab supervisor and staff are responsible for the liquid nitrogen plant and for coordinating de-icing procedures with aquarium water temperature requirements.

Discussion

Description of the system

The McMurdo water plant is an integrated set of systems that takes in seawater, filters it at several stages in the process, removes the salt by reverse osmosis (RO) and adds chemicals back in to adjust for hardness and pH. Chlorine is also added to ensure that there are no harmful organics in the drinking water. The primary systems comprising the McMurdo water plant are

- Seawater intake system: Intake, pumps, glycol heating loop and storage tank
- Desalination: Two reverse osmosis systems
- Polishing: Lime beds and chemical injection systems for treating the desalinated water to make it safe for people and pipes
- Storage and distribution: Four potable water tanks with a combined capacity of 205,000 gallons
- Basic lab with monitoring instrumentation
- BACtalk automation and control software and hardware.

This section provides a simplified overview of the water system. The Procedures section describes management of the system and operator tasking in greater detail.

Seawater intake

Seawater is pumped into the water plant at about 270 gallons per minute. The salty water is 28 ºF and is heated to about 37 ºF using waste heat from the power plant. The warmed seawater is stored in an 18,000 gallon capacity tank from which it is pumped to the reverse osmosis (RO) processing system.

Desalination

Reverse osmosis is a process that removes enough salt from seawater to make it drinkable. As seawater under high pressure moves through the RO units, pure water molecules penetrate a membrane leaving highly concentrated saltwater behind. Reverse osmosis has been used for desalination since the early 1970s. The desalination process takes place in two

interconnected RO systems called "skids." Each skid has four RO vessels and other component parts such as pumps, flush tanks, filters, valves, etc., required for processing.

Before entering the RO units, the seawater is routed through two multimedia filtration tanks containing anthracite coal, sand, garnet, and gravel to remove particles larger than 25 microns and then through a 5-micron filter. Next, a high pressure pump raises the water pressure to 700 psi and an energy recovery turbine boosts the pressure to 850 psi so that the reverse osmosis process can take place at the molecular level. The water travels through the RO tubes at 80 gallons per minute for a total processing capacity of 40,000 gallons per day. As the high pressure water moves through the tubes and across the 24 membrane layers, 28 gallons per minute of fresh water is sent to the next stage in the process and 52 gallons per minute of concentrated brine is sent back into the bay. During summer operations, an automatic self-cleaning 25-micron filter in the old aquarium building is in operation. The product stream has little salt compared to seawater, but more salt than naturally occurring fresh water. The RO process also removes other minerals commonly found in water including calcium, iron, copper, and other ions, as well as any organic compounds. In this pure form, water is an aggressive solvent, leaching minerals out of pipes that carry it, and out of the body of anyone who drinks it. Thus the RO water must be further processed (known in the industry as "polishing") to adjust the mineral content (hardness), pH and chlorine levels.

Polishing

Carbon dioxide (CO_2) is injected into the water as soon as it emerges from the RO units. CO_2 enables the pure RO water to take up calcium carbonate from the lime beds. Thus hardness is controlled by the CO_2 injection rate which is the next step in the process. Two tanks hold calcium-carbonate charged sand where the water spends ten to fifteen minutes contact time. The calcium-hardened water is then sent through overhead pipes towards the next step in the process, injection of soda ash and chlorine.

Soda ash (sodium carbonate) is added to raise the pH of the processed water, thus the pH level is controlled by the soda ash injection rate. Water with a low pH can be acidic, soft and corrosive, leaching metals from pipes and fixtures as well as minerals from the human body. It can also cause aesthetic problems, such as a metallic or sour taste and laundry staining. Water with a high pH is hard and although it causes no health concerns, it can result in a bitter taste and build-up of scale on pipes and fixtures. The recommended pH range for potable water is 6.5 to 8.5. The pH of product water entering the fresh water storage tanks is maintained at 9.0 to achieve a goal of 8.8 pH being sent to town.

Because the RO process purifies the water while removing salt, disinfection is not needed as it is in municipal water systems elsewhere. However a small amount of chlorine is added at the end of the treatment process to reduce the risk of contamination in the distribution system. The McMurdo water plant uses calcium hypochlorite (HTH), a granular form of chlorine for easier handling than the toxic gas form. The free-chlorine residual level in the storage tanks should be maintained to approximately 0.40 milligrams per liter. A detectable residual should be present throughout the distribution system to ensure that the water remains free of harmful contaminants.

Storage and distribution

After the polishing agents are added, the water must be allowed to "age" for a short time before distribution. Product water is sent into one of four holding tanks through a motor operated valve (MOV) at the top of each tank. The sampling line in the lab is usually set to product water so that wall-mounted chlorine and pH monitoring instruments in the lab constantly sample the product water. Product water will have a higher pH than stored water after it has matured in the tank.

Storage tanks are numbered one through four. Tanks one through three are inside the water plant building and hold 50,000 gallons at water levels of 14 feet 6 inches inside each tank. Tank four is outside the building and holds 55,000 gallons at a water level of 10 feet 6 inches inside the tank. Tank four is heated by the waste heat system from the power plant. The total storage capacity of all four tanks is about 205,000 gallons. At least 100,000 gallons should be in storage at all times to accommodate firefighting requirements and provide a one to two day water supply for the station in case of an emergency shutdown for critical repairs. Of the approximately 205,000 gallon capacity, 29,000 gallons are not useable because of the quantity of water in the distribution pipes throughout town.

With a few exceptions, one tank is always being filled while one tank is always distributing water to town. When switching from one tank to another for filling or for distribution, the operator always opens the second tank before closing the current tank. If no tank's valve is open for filling, the pressure in the piping system becomes too great and will burst a pressure plate and spill water. The occasions when no tank is being filled is when the RO units are off or sent to drain.

All tanks have spigots at the bottom for testing the water that is accumulating in the tank. The pH level is checked from the tank while filling because the processing parameters can always be adjusted to change the incoming water, thus adjusting the overall quality of the water in the

tank as it matures. Once a tank is filled, there is no mechanism for further adjustments. If the quality is not within specifications, the operator can drain several feet from the tank, re-fill it and adjust the chemical inputs to eventually adjust the quality as the tank's content matures.

Lab

Two sampling instruments are installed in the lab and connected to the water sampling line, a pH meter and a chlorine analyzer. The line can be set to product water or station water. Product water is the water produced by the system after the addition of chemicals and adjustment of its pH. It is representative of the water as soon as it has passed through all processes. Station water is water that is being distributed to town. This water has been stored in a tank since it was produced. Samples from these two sources will have slightly different readings. Also in the lab are equipment and supplies for manually testing water samples.

BACtalk automation control software and hardware

BACtalk is a software and hardware computer system that provides remote monitoring and control for physical conditions such as temperature, pressure, pump status, tank levels. It is primarily used to monitor the waste heat collection and distribution system throughout town, but it also contains limited information about water tanks. The BACtalk computer uses a graphical interface to display the following information:

- Water levels in all four freshwater tanks and in the seawater tank. Sonar water level monitors in each tank send a signal to the computer.
- Status of pumps and temperatures in the seawater tank and heating system
- Status and temperatures of the waste heat system pumps housed in the water plant.
- Setpoints for alarms and the ability to activate and deactivate alarms.

Other screens in the in the BACtalk system display information about the waste heat system in other buildings.

Other systems housed in the water plant building

The power plant depends on a waste heat system comprising a number of glycol loops to heat station buildings. Some of the pumps for the waste heat collection and distribution system are

housed in the water plant and water plant operators monitor their status. Operation and maintenance of the system is the responsibility of FEMC. This SOP contains only monitoring duties performed by the water plant operators. The appendix includes more information on the system to enable water plant operators to assist FEMC personnel as needed.

A liquid nitrogen (LN_2) plant is housed within the water plant and operators are responsible for monitoring the plant while in operation. They are also capable of starting and stopping the plant. Maintenance and operation of the plant including collecting and distributing the liquid nitrogen, is the responsibility of the Science Support Division. This SOP contains only startup, shutdown, and monitoring duties performed by the water plant operators. The appendix contains more information on the system to enable water plant operators to assist Crary Lab staff as needed.

Water plant records

Log book

The operating log constitutes an official record and legal document of water plant operations. Confine remarks to plant operations; no personal comments. Make all entries in ink. Make no erasures. When a correction is necessary, draw a single line through the original entry so it remains legible. All entries except dates should be preceded by the current time using the 24-hour clock.

Operators are required to log all events relating to the operation of the water plant. Details of a routine procedure are not necessary, only unusual situations should be noted. A sample log entry is shown in Appendix C. Below is a list of events that must be logged. Operators can use their discretion as to whether to log additional events or make other notes in the log.

- At 2400, record
    - Current FW tank levels,
    - Quantities produced, consumed, and in storage
    - Fuel usage
    - The new day and date
- At 0001 under the new day and date, list what equipment is online
- RO start-up and shutdown.
- Waste heat system startup or shut-down.
- The results of all potable water tests.

- Coliform bacteria.
- Starting or stopping of any chemical pump.
- Refilling any chemical tank. Enter amounts added to tanks and highlight in yellow.
- Operational changes to the RO units, i.e. when RO output is sent to drain and returned to production.
- Alarm conditions.
- Remarks concerning plant operations to be passed on to the other operators.
- Changes to equipment and chemical systems, i.e. change CO_2 bottles, equipment that goes out of service
- Injury to plant personnel.
- Activities elsewhere in town (firehouse, water truck), which could affect water plant.

Work orders

Work orders are generated and submitted by the power/water/wastewater supervisor and operators perform the tasking. An operator may identify tasking that requires a work order and advise the power/water/wastewater supervisor. Work orders are required for work that is not covered during routine rounds and waterplant daily operations. Examples of work order tasking are

- Change 5-micron filters
- Recharge the lime (calcium carbonate) tanks
- Replace and repair pumps
- Preventive maintenance (PM) on waterplant equipment
- Annual cleaning operations
- Inspections and maintenance of the seawater intake tube

Weekly maintenance report

As tasks are performed, operators log their activities on the weekly maintenance report. The power/water/wastewater supervisor uses the report to generate the department's weekly Sitrep and re-order parts and supplies as needed. The report calls for equipment hour meter readings, and water meter readings. In the "work performed" section, operators indicate Mapcon numbers of parts and supplies put into service. If the tasking is covered in a work order, note the work order number. Examples of the work noted in the report are:

- Change 5 micron filter on RO #1
- Produced ultra pure water for glycol flush

- Set up equipment to fill and disinfect lime tanks
- Cleaned sodium metabisulfate on RO #1
- Rebuilt backup RO feed pump,. WO # 8484658

Other paperwork

- Hand-write readings taken during the two- and four-hour rounds.
- Maintain a supply of blank daily logsheets in the desks' file drawer in the control room.
- Place completed handwritten daily logsheets in the file cabinet in the storage area in the mezzanine.
- Using the main computer in the control room, enter handwritten readings taken during rounds into the appropriate spreadsheet in the water plant folder on the network drive.
- Using the main computer in the control room, record operator time on a weekly timecard in the water plant folder on the network drive.
- The power water plant supervisor has access to the files on the water plant network folder, so operators need not submit the daily logsheets and timecards.

Operator Duties and Responsibilities

Operator shifts and duty cycles will be determined by the power/water/wastewater supervisor. All tasking discussed below applies to both shifts unless otherwise noted. If duties or assignments require the use of a truck, the operator may get the key from the power plant operator. The truck is to be used for official business only.

IMPORTANT	AT ALL TIMES, THE WATER PLANT OPERATOR KEEPS THE POWER/WATER/WASTEWATER SUPERVISOR APPRISED OF ABNORMAL CONDITIONS IN THE WATER PLANT INCLUDING LOW STORAGE LEVELS, INTERRUPTIONS IN PRODUCTION, SITUATIONS IN WHICH USAGE EXCEEDS PRODUCTION, ETC. THE POWER/WATER/WASTEWATER SUPERVISOR IN TURN, KEEPS THE OPERATIONS MANAGER APPRISED OF THOSE CONDITIONS. THE OPERATIONS MANAGER WILL IMPLEMENT WATER CONSERVATION MEASURES AS NEEDED.

Safety

Depending on conditions and station staffing, the power/water/wastewater supervisor and/or power/water/wastewater operators may elect to establish a contact schedule between the plant

operators. For example, during winter and/or significant storms on-site personnel may feel that periodic contact between operators in separate buildings is necessary to ensure the safety of the individuals.

- Perform all duties and tasking in a safe manner.
- Wear appropriate personal protection equipment (PPE) including earplugs, safety glasses and air filter face masks. All are available in the water plant.
- When laying hoses on the floor for temporary use, place orange cones to alert people working in the area.
- Be familiar with material safety data sheets (MSDS) and their locations in the water plant.
- Know where the eyewash station is and how to use it.
- Immediately notify the power/water/wastewater supervisor of any serious injuries.
- Under no circumstance, allow any intoxicated persons on the premises. If problems arise, immediately notify the firehouse and/or the power/water/wastewater supervisor.
- Attend weekly safety meetings. Power/water/wastewater employees attend the same meeting at a convenient time for all set by the power/water/wastewater supervisor

General duties

- Perform all duties and tasking in a manner consistent with best practices for the industry.
- At all times, be aware of plant operating status, chemical levels, tank levels, etc
- Immediately notify the power/water/wastewater supervisor of any serious equipment failures that affect water production or plant safety.
- Prepare chemical indicators and reagents as needed.
- Keep water plant clean (see Appendix B).
- Assist in water distribution for fire emergencies (see" Firefighting Emergencies" on page 44).
- Notify the mechanic and the power/water/wastewater supervisor of any equipment problems.
- Turn outside lights on and off when necessary.
- Initiate and complete work orders as required.

Shift Change

- Outgoing operator briefs the incoming operator of current plant operations and equipment status.

- Incoming operator signs the logbook and assumes responsibility for plant.
- Incoming operator conducts walk-through inspection.
- Incoming operator reviews the logbook and log sheets.
- Check the status of the BACTalk alarms and correct or log any discrepancies

Daily tasking

- Log all information relating to plant operations.
- Perform frequent plant inspections, including before leaving and after returning to the water plant
- Perform 2-hour and 4-hour rounds and record in logs
- Transcribe handwritten logs to spreadsheet files on the network server
- Test pH and chlorine content of processed water.
- Fill chemical injection tanks as necessary.
- Night shift only
    - Perform 2400 Readings and Report.
    - Perform conductivity test of online RO and product header. Record readings on RO data log sheet.

Weekly Reading and testing schedule

Day Shift

- *WEDNESDAY or THURSDAY:* Test and record pH and Chlorine levels from these sources:
    - All storage tanks, one through four
    - Buildings 143, 209. (These buildings are representative of the end and the beginning of the distribution system)
    - Product water
    - Station water
- *WEDNESDAY or THURSDAY:* Using the water samples from buildings 143, 209, and station water, perform testing to obtain Langelier index. Record readings in Langelier index logbook and in the Langelier spreadsheet.
- *FRIDAY*: Take FW meter readings from representative buildings between 0900 and 1000. Enter all readings into the daily spreadsheet:
    - Bldg 155 Laundry
    - Bldg 202 - 1st floor closet

- Bldg 206 - Lounge, 1st floor.
- Bldg 207 - Lounge, 1st floor.
- Bldg 208 - Lounge, 1st floor.
- Bldg 209 - Lounge, 1st floor.

- *FRIDAY*: Take equipment hour meter readings in the water plant unless otherwise noted:
  - RO units.
  - LN_2 plant.
  - Distribution pumps.
  - Seawater intake pumps.
  - Seawater bypass valve
- *FRIDAY*: Submit to the power/water/wastewater supervisor, the mechanic's weekly report with meter readings.

Night Shift

- *MONDAY:* Perform silt density index (SDI) test on one of the running RO units. Enter readings into RO data log sheet.
- *TUESDAY:* Take the following readings and record on RO data log sheets.
  - Conductivity test of online RO vessels.
  - pH and conductivity of seawater surge tank,
  - Header pH of online RO vessels.

Monthly Tasks (first day of the month)

Day shift:

- Perform coliform test on all storage tanks and seawater surge tank. Record readings in coliform log sheet.
- Check oil levels in chlorine and soda ash injection pumps. (Use food grade oil only.)
- Rotate seawater intake pumps.
- Rotate glycol pumps for waste heat recovery system.
- Rotate chlorine pumps.
- Rotate distribution pumps.

Night shift:

- Gather all reports from previous month pertaining to water plant and file in cabinet, upstairs Building 198.

- Clean and inspect strainer on chlorine injection station.

During Bad Weather

- In high winds, CLOSE the roof hatch above tank #1.
- Closely monitor the seawater intake flow meter because the intake pipe can freeze. The water flow will decrease due to ice or other problems. Alert the mechanic of any problem especially if the flow falls below 210.
- Keep all doors closed and keep floor mopped of melted snow at entranceways.
- Keep all stairs into building shoveled and clear of snowdrifts and ice.

Starting the BACtallk computer

1. Log into Windows[tm] as woperator, password water (lowercase letters).
2. Be patient for the boot-up sequence
3. Double-click the BACtalk icon on the desktop
4. Be patient for the BACtalk startup. A town map will be displayed when the system has launched successfully
5. Click BACtalk then LOGIN LOGOUT in the top menu bar.
6. Login using the same name and password as above
7. The same town map appears but this time with the buttons for each building page displayed on the left.
8. Click WATER PLANT to go to the water plant monitoring page.

Plant inspection and rounds

At all times, operators must be aware of conditions in the water plant. That includes paying constant attention to all of the items noted during walk-through inspections and rounds, being aware of the operating parameters when in any area of the plant for any reason, and paying attention to sounds, water or oil on the floor, and anything unusual or out of place. These activities serve to heighten awareness and help ensure that if something is amiss, the operator will spot it quickly.

Walk-through Inspection

Whenever operators prepare to go on or off duty and leave or return to the plant, they conduct informal walk-through inspections. Throughout the day, as they perform tasks in any part of the plant, operators constantly observe the operating parameters wherever they are.

Throughout the plant

- Listen for abnormal noises.
- Look for leaks of water, oil, or fuel.
- Pay attention to unusual smells and investigate.
- Look for burned out light bulbs including overhead lights and equipment indicator lights. Replace if able, otherwise notify the supervisor.
- Observe the operation (temperatures, pressures, levels, valves) of plant equipment for appropriate operating ranges and positions.

Fire Alarm Panel

- Check that power light is ON.
- If the alarm or trouble light is on, call the Firehouse at 2555. They will notify the fire alarm technician.

Seawater Intake System

- Observe the water level on the BACtalk computer.
- Observe the seawater tank temperature on the BACtalk computer.
- On the breaker wall, observe that both RO breakers are on and the lights are green
- On the breaker wall, observe that one seawater intake pump is running (green light) and the other is not (red light)
- **At the breaker wall during the two-hour rounds, record the values shown on the log sheet.**
- At the pump control panel, observe the seawater intake flow meter. If it drops below 210 and remains at or below that level, the intake pumps may require de-icing. **During the two-hour rounds, watch for a few minutes and record the maximum and minimum flow rates.**
- At the pump control panel, observe that the seawater intake pump is operating within an acceptable range. During normal operations, it should be in the 72 to 74 psi range. The pressure can be adjusted at the pump using the black knob on top. In the event of a firefighting emergency, both pumps should be on and the pressure will be correspondingly higher.

- **During two-hour rounds record the pump minimum and maximum psi.**

Chlorine Residual Analyzer

- Check the chlorine reading. During normal operations it should be between 0.35 and 0.45. Change the injection rate by rotating the control knob at the pump. A small change can have the desired effect.
- Verify that the water source is on product water while in production. If water is not being produced, ensure that the water source is on station water. Water must be running through the instrument at all times.
- **During the two-hour rounds, record the chlorine reading.**

pH Monitor

- Check pH reading. During normal operations a reading of about 9.9 on this instrument usually results in station water of acceptable levels. It is important to verify pH levels in the filling tank rather than relying solely on this instrument.
- Verify that the water source is on product water while in production. If water is not being produced, ensure that the water source is on station water. Water must be running through the instrument at all times.
- **During the two-hour rounds, record the pH level on the monitor.**

Chemical Tanks

- Be aware of the levels in chlorine and soda ash tanks.
- Verify that the pumps are pumping by observing and feeling the tubes. If not, clean strainer and prime the pump. If it still doesn't pump, notify mechanic.
- **During two-hour rounds, record the levels.**

Freshwater Tanks

- Be aware of which tank is filling.
- Be aware of which tank is to distribution.
- Be aware of water levels in all tanks.
- Check to see that the water level indicator valve at the bottom of each tank at the indicator tube is open. If the valve is closed, the tube will give a false indication of the water level in the tank.
- **During two hour rounds, record all tank levels by reading the water level indicator at the tanks.**

Distribution Pumps

- Check distribution system pressure. It should be about 75 psi. **During two-hour rounds, record the system pressure.**
- Check oil level in Hydroconstant drive. (Sight glass). If it is less then half full, notify the mechanic and/or the power/water/wastewater supervisor. Do not add the oil. Only food grade turbine 68 oil will be used in the pumps.

Reverse Osmosis Skids

- Observe the operation (conductivity, temperatures, pressures, flush tank levels, valves, etc.) for appropriate operating ranges and positions.
- Observe the levels in anti-scalant tanks.
- Check the pressure in CO_2 tanks and Rotameter for proper flow rate. If necessary, adjust the flow rate. The typical rate when both ROs are operational is 2.5.
- Verify chemical injection pumps are on and pumping.
- Check high-pressure booster pump drip buckets and empty if necessary.
- Observe the oil level in the high-pressure booster pump sight glass. When it gets below the halfway mark, add REGAL OIL R & O 150.
- If an RO is offline, check the pressure in the associated media filters. If there is pressure in the tank, open RO-6 to bleed it off.
- If an RO is offline, check the pressure in the vessels. If it is over 20 psi, open RO-14 or RO-28 to bleed it off
- **During four hour rounds, record all values required in the log sheet.**

Waste Heat Recovery System

Operation and maintenance of the waste heat recovery system is the responsibility of FEMC. The water plant operator is responsible only for recording readings during the 4-hour rounds. If readings are out of compliance, contact the power plant operator at 2362, the firehouse at 2555, or the FEMC work order planner at 2696.

- Look for glycol leaks and report them to the power/water/wastewater supervisor.
- Check glycol make-up tank level. The typical range for normal operation is 54 or 55 gallons.
- Check the status of alarms on the BACtalk computer
- **During four hour rounds, record the pump pressures and speeds.**
- The waste heat recovery boiler is used only if the temperature of the glycol supply from the power plant drops below the set point. Perform these checks when it is running:

- Check flame (if on-line, orange or blue, notify mechanic).
- Check front of boiler for fuel leaks.
- Check the relief valves for any leaks.

Liquid Nitrogen (LN2) Plant

Operation and maintenance of the LN2 plant is the responsibility of Science Support/Crary Lab. The water plant operator is responsible only for recording readings during the 2-hour rounds when the plant is operational. If readings are out of compliance, or anything is amiss, contact Crary Lab main office at 4168.

- Visually check the operation (temperatures, pressures, levels, valves) for proper operating ranges and positions.
- Check the helium pressure and ensure it is between 23 and 25 bar.

CAUTION	*DO NOT EXCEED 25 BAR HELIUM PRESSURE.*

- Adjust the flow of nitrogen gas from the PSA bed to about 30%. Increase or decrease the gas flow to maintain 2 bars on the pressure gauge below the Rotameter.
- Check cooling system for leaks.
- **During 2-hour rounds when the plant is operating, record values on the logsheet.**

Operator Rounds

In addition to constant awareness of plant operating conditions and informal walk-through inspections, operators make rounds at two- and four-hour intervals. During these rounds, operators fill out log sheets with the current operating parameters of the water plant. The log sheets provide cumulative information that can reveal trends that may indicate upcoming events. For example, falling pump suction readings on the RO units may mean that the 5-micron filter will need to be changed soon.

Throughout the day as time is available, operators transcribe data from the hand-written log sheets to daily spreadsheets on the network server.

Hourly Rounds

- Check CO_2 tank pressures.
- Check chlorine residual analyzer.
- Check pH monitor.
- Monitor flow meter gauge for seawater intake pumps.
- Check seawater surge tank level.

- Check temperature of seawater surge tank on the BAKtalk computer.

Two Hour Readings

- Walk through the plant, noting everything listed under "Walk-through Inspection". Log all information onto water plant data log sheet
- Compare current reading to previous two hour reading for any significant changes that may indicate a problem.
- Monitor FW Distribution flow meter. If an unusually high reading is noticed, inspect water plant for obvious leakage and then call the firehouse to alert the plumbers of possible leakage, or high water usage not reported to water plant personnel.
- Ensure that chemical levels are dropping from tanks in use.
- If the liquid nitrogen plant is running, log readings onto LN_2 log sheet.

Four Hour Readings

- Conduct two-hour readings and record in the log sheet.
- Log all information onto RO data log sheet.
- Compare current readings to previous readings for any significant changes that may indicate a problem.
- Check RO for leaks.
- Listen for any abnormal noises.
- Take readings from the waste heat recovery pumps and record into the log sheet.

2400 Readings and Report

- Enter midnight readings for that day into "Water Plant Weekly Summary Sheet".
    - Boiler fuel meter, gallons IN.
    - Boiler fuel meter, gallons OUT.
    - FW storage tank levels in FEET and INCHES.
    - RO #1, 2 & 3 product flow meters.
- Record midnight readings from "Water Plant Weekly Summary Sheet" on the daily spreadsheet on the waterplant network folder, J:\PowerWater\Power & Water\Water Plant\H20-2007 (or current year).
- Once the "Daily Spreadsheet" has calculated the resulting numbers, transfer these numbers (Fuel used, FW storage tank gallons, total FW storage, gain or loss, each RO

production, total RO production, consumption) onto the "Water Plant Weekly Summary Sheet" for that day.

- Record the calculated results from "Daily Spreadsheet" (total FW storage, total RO production, consumption, fuel used) into the water plant log book.
- On Thursdays, transfer end-of-week numbers to new water plant weekly summary sheet. The spreadsheet will automatically transfer these numbers to next week's spreadsheet.

Procedures

This section discusses procedures that must be performed during routine operation of the water plant, presented in the order of the process flow. They are performed as needed, some occasionally (i.e. diversion to drain) and others several times a day (i.e. recharging the soda ash tank). Plant inspections, rounds, and general awareness of plant operating conditions will determine when to perform these procedures. Non-routine procedures requiring technical skills and expert knowledge of the equipment and process flow (i.e. cleaning or replacing an RO membrane) are not described here. Experienced operators will refer to manufacturer's documentation as needed for non-routine procedures.

Seawater Intake System

The seawater intake system comprises two submersible pumps and intake pipes at the old aquarium, a glycol loop and heat exchanger to heat the water, a surge tank for flow control, and two centrifugal pumps that send the seawater to the ROs. Two intake pumps are submersed about 35 feet in the intake casing. A Hotfinger heating element prevents freezing of pipe and pumps. Maintenance and replacement of the Hotfinger is an FEMC responsibility.

Pump Shutdown/Startup

WARNING: NEVER RUN BOTH PUMPS SIMULTANEOUSLY. ALWAYS SHUT DOWN ONE PUMP BEFORE STARTING THE OTHER.

Follow these steps in this order to SHUT DOWN the pump

1. In the water plant, turn the pump selector switch to the OFF position.
2. If switching pumps, check the seawater flow meter to ensure there is no flow before starting the other pump.

Follow these steps to START the pump:

1. At the intake, ensure that pump switches are in the AUTO position
2. In the waterplant, turn the pump selector switch to HAND. The switch is on the wall at the side of the surge tank which faces the power plant building.
3. Check the seawater flow meter to ensure the flow is at least 210 gallons per minute. The flow meter is next to the distribution pump control panel.

De-Icing the Intake

The intake pipe and pumps require de-icing when ice forms in the casing or in the pumps and restricts seawater flow into the water plant. This procedure warms the water in the surge tank to between 50 and 60 degrees F and then back flushes it through the intake casing and pumps. If that doesn't clear the ice, a longer procedure that warms the water in the surge tank to 70 degrees can be used.

The water supply for the aquarium in Crary Lab comes from the same intake pipe. Experiments may be underway that would be ruined by even a slight warming of the aquarium water. It is imperative, therefore, that water plant operators coordinate de-icing procedures with the operations manager and with the Crary supervisor before beginning the procedure.

IMPORTANT	*NOTIFY THE OPERATIONS MANAGER AND CRARY LAB SUPERVISOR BEFORE BEGINNING. COORDINATE TIMING OF THE PROCEDURE WITH CRARY STAFF.*

1. On the BACtalk computer WP ALARMS page, place these alarms in ACTIVE (disarmed) status:
   - HX-8 Discharge Temp Alarm
   - HX-9 Discharge Temp Alarm
   - Seawater Tank Temp
   - Seawater Tank Level

2. Drain the seawater surge tank to about the two-foot level.

3. On the BACtalk computer WATER PLANT page, under “Seawater Heating System,” change the BYPASS TANK/FILL TANK control to FILL TANK. Set HX-8 and HX-9 valve positions to 100% OPEN.

4. Put the seawater bypass valve into MANUAL mode. The labeled switch is mounted on the wall behind the surge tank.

5. Decrease the flow by turning the hand crank until the temperature on the discharge side of the heat exchangers is 50 to 60 degrees F (maximum is 70 degrees F). The hand crank is marked with an arrow indicating which way to turn it to increase the temperature.

6. Sometime during the fill, drain some of the colder water from the tank.

7. Fill the seawater surge tank to 10 feet with the warmed water, then divert incoming flow to the ocean. Notify the Crary Lab Supervisor that the water plant is ready to begin the back flush and they will determine our actual start time. The reason to continue pumping to the ocean is to avoid any back-feeding, to the casing, of heated seawater before the aquarium pumps are shut down. When the aquarium shuts their pumps down, the power plant will get a seawater flow alarm for Crary Lab.

8. When Crary lab has notified the water plant that they are ready to begin the back flush, shut down the intake pump. (Water in the surge tank should be about 50 – 60 (deg F). Do not go over 70 degrees F. Return the seawater heat exchanger valves to the automatic (NULL) setting.

9. One person now goes down to the intake building #179 and installs the 2” camlock-fitted hose on the drain valve at the well in the intake building. The pump pipelines may need to be wedged apart in order to insert the end of the hose into the casing. Open the 2” drain valve.

10. Connect 1 1/2" I.D. hose from the valve at the base of the media filter 1-B to the connection in the intake priming line, in the corner near where the intake line enters the building behind FW tank #2. (The media filter camlock connection has been installed on RO 1).

11. On media filter 1-B, close RO-2, RO-4 and open RO-1, RO-3 and use a wrench to open the ball valve located at the 1 1/2" camlock hose connection.

12. Close the butterfly valve in the intake line, in the corner behind FW tank #2.

13. Behind FW Tank #2, ensure all backflow-preventor valves are closed and then open the rising-stem valve located downstream from the backflow-preventor.

14. Just before starting feedwater pump #1, make phone contact with the person in Bldg 179 (phone number 2238) to ensure hose/valve lineup. Start seawater feed pump #1 to begin pumping water from the surge tank into the intake line (use pump #1 or align valves at manifold to allow cross-feeding if needed).

15. Continue pumping until the level in surge tank reaches about 3 feet.

16. Shut off seawater feed pump #1, bleed off media filter 1-B pressure by opening RO-6, close RO-3 on media filter, open RO-2 and close the ball valve where the hose was attached to media filter 1-B and finally close the rising-stem valve behind FW tank #2.

17. Close the drain valve at the well in the intake building.

18. Open the butterfly valve in the water plant, behind FW tank #2.

19. Put the seawater bypass valve switch in AUTO and set the BACtalk seawater tank fill control to bypass the tank. Start the seawater pump to purge warm water from the system without filling the seawater tank. Watch the flow and pressure meters to confirm proper pump operation.

20. When the water temperature has returned to normal, return the bypass/fill control back to NULL on BACtalk. Notify the Crary supervisor that the back flush procedure has ended and seawater flow has been restored only when you are certain that the intake pump is on for good and will not be turned off for any reason.

21. Draining the surge tank through the drain line will not be fast enough to cool the surge tank down for plant startup, so you will need to vacate the water much quicker using the following method:

    a) On two of the RO's media tanks, open RO-1 and RO-3.

b) Close RO-2 and RO-4.

c) Open RO-5 and quickly start the feedwater pump for that RO. It is possible that the feedwater pump could have air in it. If so, bleed air out through the discharge pressure gauges. Watch the surge tank level carefully.

22. On the BACtalk computer, return HX-8 and 9 Discharge Temp alarms, Seawater Tank Temp alarm and Seawater Tank Level alarm back to NULL when temperatures and levels have returned to normal.

Past experience has shown this method to restore normal seawater flow. However, if the first attempt at de-icing is not successful, it is possible to warm the water in the surge tank to about 70 deg F, and repeat the procedure. Using this method, however, requires that the Crary Lab casing pumps be shut off for the duration of this procedure because of a possibility of warm water seepage from the water plant into the casing. In that case, use the following steps:

IMPORTANT	*NOTIFY THE OPERATIONS MANAGER AND CRARY LAB SUPERVISOR BEFORE BEGINNING. COORDINATE TIMING OF THE PROCEDURE WITH CRARY STAFF.*

1. Fill the surge tank and shut down the intake pump.

2. On the BACtalk computer, set the seawater heat exchanger valves HX-8 and HX-9 to the 100% open position.

3. Align valves to allow recirculation of water from surge tank through the heat exchanger and back into the surge tank.

   a. Line up flow to one media filter and close the valves to the R.O. and the drain, and open the valve for the connection at the base of the filter. Open any other valves in line with the intake priming line connection.

   b. Butterfly on intake line just inside where the line enters the building should be open.

   c. Place seawater intake divert valve in the FILL TANK position. (May be done on the BACtalk computer).

4. Start seawater feed pump (use pump #1 or align valves at manifold to allow cross-feeding if needed). Water will start re-circulating through the heat exchangers and back into the surge tank. The flow will be about 50 gallons per minute, but may

not show on the seawater intake flow meter, so to confirm that water is flowing, check the following:

a. Note the drop in temperature at the seawater heat exchanger outlets (temperature will rise while no water is flowing, then drop to about 70 deg (F) when the water starts re-circulating).

b. Check the discharge pressure at the seawater feed pump (should be about 55 to 60 psi).

5. Allow water to re-circulate until surge tank warms up to no more than 70 deg F. This takes about six hours.

6. Repeat the de-icing procedure as outlined above, starting with step 5.

Reverse Osmosis System

Two interconnected RO skids comprise the RO system. During normal water production both units are operational. The system operates automatically and must be monitored. Either of the RO units can be shut down as needed for maintenance. Water from one or both of the units can be diverted to the ocean drain as needed. This section describes starting and stopping the RO units and diverting their output to drain. For comprehensive information on the reverse osmosis process and chemistry, see any of several reference publications in the water plant office. For more complete information on the RO units, see the manufacturers' documentation. Record all startup, shutdown, and divert to drain operations in the water plant log book.

During walk-through inspections and rounds, the water plant operator monitors normal operations of the RO system. One skid at a time may shutdown as needed for maintenance, repairs, and cleaning. When only one skid is operating, the water plant operator must adjust the chemical feeds and monitor chlorine and pH levels to maintain the product water of acceptable quality.

IMPORTANT: ADVISE THE POWER/WATER/WASTEWATER SUPERVISOR WHEN ONE OR BOTH ROS ARE SHUT DOWN.

Pre-Start

Before startup, record in the RO log sheet the date, RO number, and product meter reading. After startup, divert all product water to floor drains until the conductivity reading is below 700 (typically 10 to 15 minutes). When putting the ROs back online, ensure that the Tech-Taylor valve (RO-13) is at zero. Then increase the pressure slowly and incrementally over about 5 minutes to 18 gpm. Before starting the RO units, the operator must ensure that the plant components integral to the RO process are ready for startup.

Surge Tank

During normal operations, the surge tank is always operational with the following conditions already set. If starting from a complete shut-down, the operator must first ensure that the surge tank is ready to go:

- One intake pump is in the HAND position.
- The surge tank level is at least six feet.
- Seawater flow rate is adequate, typically 215 to 270 gallons per minute.
- Water temperature is between about 35° F and 37° F. If it is above 40° F, open surge tank drain valve to allow level in tank to drop to five feet. The bypass valve should automatically open and fill tank with +35° F water. Close tank drain.

Feed Pump

There is one feed pump for each RO unit at surge tank outlet pipe. They are labeled “Sea water pump RO-1” and “Sea water pump RO-2.” During normal operations, both feed pumps are operational with the following conditions already set. If starting from a complete shut-down of one or both pumps, the operator must first ensure that the feed pump is ready to go:

- At the pumps, the suction and discharge valves are open.
- At the RO control panel, the feed pump control switch is in the RO AUTO position.

Product Line to Fresh Water Tanks

During normal operations, one RO unit will be on at all times and it will not be necessary to divert startup water to drain. If starting from a complete shut-down of both ROs, make sure the product divert valve above FW tank # 1 is open to the drain in lab and all tank fill valves

are closed. This prevents the water from going into storage until the ROs are fully operational and the water meets quality standards.

Multimedia Filters

Media filters should be purged of warm water prior to start up. If purging air or fast-rinsing following a backwash, do one filter at a time. If a substantial amount of air has been allowed to enter the filters, the fastest way to eliminate the air is to perform a short backwash. If rinsing to eliminate warm water prior to RO startup, it is permissible to do two filters at a time.

To transition from backwash to fast rinse without shutting down the feed pump, throttle RO-6 on the second filter backwashed (water is still flowing in reverse through this filter), open RO-2 on first filter (already backwashed), then open RO-5 on the first filter and finish closing RO-6 on the second filter. If rinsing both filters together, open RO-5 on the second filter at this time.

For details on multimedia filter backwash and fast purge/rinse, see “RO Multimedia Filters” on page 38.

Chemicals, gauges, and settings

- Ensure that the anti-scalant pre-treatment tank (MF-600) has an adequate level, 10 to 35 gallons.
- Ensure that the CO_2 tank has adequate pressure. Leave tank valve closed until needed.
- At the RO control panel
    - Ensure that the main breaker lever is in the ON position.
    - Ensure that the CONTROL POWER SWITCH is ON and the indicator light is illuminated.
- Depending on whether transitioning from the fast rinse or backwash, the feed pump may be on or off. Use the appropriate set of three steps:

If the feed pump is ON	**If the feed pump is OFF**
1. Close RO-5 on either media filter	1. Open valves RO-1, 2, and 4
2. Open RO-4 on both media filters	2. Close valves RO-3, 5, and 6
3. Close RO-5 on the second filter	3. Turn feed pump switch to ON

4. Continue to run the feed pump until the temperature drops below 40° F on the RO.

5. Turn the feed pump OFF.

6. On the control panel, set the switches to the following positions:

RO Process	AUTO
Feed pump	AUTO
HP pump	AUTO
Flush pump	OFF
Alarm	OFF

Valve Positions

Open Valves RO-14 (concentrate) and RO-28 (product). Ensure the valves flow are in the following positions for process flow:

- OPEN: RO-9-11-15-16-22-27-28.
- CLOSED: RO-7-8-10-10A-12-17-18-19-19A-20-20A-21-24-25-26-29-30

Startup

1. Turn the control power ON and supply pump switch to AUTO.

2. Momentarily turn the RO PROCESS switch to START then release. If the pump suction is below 20 psi, the process will halt, the alarm will sound and the feed low-pressure light will illuminate. Should this happen, turn the CONTROL POWER SWITCH OFF and then back ON to reset the timers. Then try the start button again. Observe the following actions taking place automatically:
   - MOV-1 (behind the control panel) will open.
   - Feed pump green light will illuminate.
   - Cartridge inlet and pump suction pressures will increase to more than 30 psi.

3. Slightly open RO-12 to vent the five-micron filter. Observe the following actions taking place automatically:
   - After one or two minutes the high pressure pump will start.
   - The high pressure pump (green) light will illuminate at the control panel.
   - MOV-2 will automatically close over a five-second period.
   - Membrane feed and concentrate pressures will increase.
   - The turbine whine will increase in pitch.

- The product flow meter will indicate flow rate.

4. Monitor the pressure gauges for feed, concentrate and product.

IMPORTANT: AFTER START-UP, DIVERT PRODUCT WATER TO THE FLOOR DRAINS UNTIL THE CONDUCTIVITY READING ON THE CONTROL PANEL IS BELOW 700. DURING THIS TIME, ADJUST RO-13 (Tech-Taylor™ Valve) TO ABOUT 18 GPM. THE FLOOR DRAIN CAPACITY IS ABOUT 20 GPM.

5. When quality specifications are met, adjust RO-13 to 28 gallons per minute. If this product flow cannot be achieved with RO-13 fully closed, throttle RO-23 in the closed direction **SLOWLY**, until production increases.
   - The red (product quality and product divert) lights will illuminate due to normal high startup conductivity.
   - MOV-3 and MOV-4 will reposition to divert to waste.

CAUTION! EXCESSIVELY HIGH PRODUCT PRESSURE INDICATES THAT MOV 3 AND 4 ARE CLOSED. USE STEPS A-C BELOW.

   A. Push RELAY 1 on the Pulsatrol conductivity meter to cycle MOV #3 and #4 (yellow light). Wait 30 seconds.

   B. Push RELAY 1 again (red light). Wait 30 seconds.

   C. Push RELAY 1 a third time (no light). The product pressure should return to normal.

6. Wait for the product divert light to clear, indicating that conductivity is below the alarm set-point.
   - MOV 3 and MOV 4 will open to product. Continue running to drain for at least 15 minutes or longer until conductivity stabilizes.

7. Open RO 25 and close RO 28 to send water to product line; open RO 20A to fill flush tank. If one unit is already on line, open RO 20A and allow flush tanks to fill before sending water to product line (throttle RO 28 as needed), then open RO26.
   - Product water will first fill the two 140 gallon flush tanks until the high level float valve shuts the flow off. The product pressure will increase, and the total volume of product water will flow to the product line.

8. Place the flush pump switch to FLUSH/AUTO position.

9. Turn the alarm switch ON.

10. Open RO-30.

11. Open the CO_2 tank valve and adjust Rotameter to proper flow rate. (0.5 liters/hr per RO, or as required to achieve desired hardness. An increase in the amount of CO_2 required to achieve a specific target is an indication that the calcium beds are partially depleted). If one RO is already on line, adjust the CO_2 injection rate on the flow meter already in use and adjust soda ash and chlorine injection to compensate for the increased flow rate.

12. If necessary, change the sample line to the chlorine and pH monitors to product water. If another RO is online, the sample line will already be on product water.

13. Monitor pH meter to determine when water treated with CO_2 has worked its way through the calcium carbonate beds, then start or adjust soda ash and chlorine injection of product water.

14. If necessary, open the fill valve on one of the freshwater storage tanks. If another RO is online, a tank will already be filling and this step is not necessary.

15. Close the product divert valve on top of tank 1, open RO 26 and close RO 25 to send product water through meters.

16. Record the start time in the water plant log book.

Diversion to Drain

The RO startup process includes diverting water to drain until the conductivity returns to processing standards. Another occasion that calls for diversion to drain during normal operation is when three of the four freshwater tanks are full the operator may decide to send the RO output to drain. Doing so will reduce the total quantity in storage so that tanks do not require frequent rotation of the filling and distributing tanks. The ideal situation is for tank levels to be managed so that it takes at least five hours to fill at the typical rate of about one foot per hour. The steps below must be followed in order. Performing these actions on both RO skids will result in all the RO water going to drain rather than filling any tank.

1. In the lab, change the sample line from product water to station water following the instructions at the valves on the lab wall. To protect the instruments, water must constantly flow through the Chlorine and pH monitors.

2. At each RO, reduce the product flow to about 18 gpm. The capacity of the floor drains is about 20 gpm and the typical operating flow of 28 gpm will flood the equipment room.

3. On each RO, OPEN RO-28 and CLOSE RO-26. Try to do this simultaneously to prevent being splashed by the overflow valve.

4. CLOSE the CO2 tank valve and CLOSE RO-30.

5. If shutting down just one skid, ensure that the CO2 associated with the operational unit is on and reduce its injection rate by about half.

6. Secure or adjust the Chlorine and soda ash injection pumps. Make a note of the levels before reducing or securing to return to them afterwards

To return the flow to the storage tanks, follow the same basic steps with slight differences:

1. At each RO, CLOSE RO-28 and OPEN RO-26 simultaneously.

2. OPEN one CO2 tank valve and OPEN the corresponding RO-30.

3. At each RO, Increase the product flow to about 28 gpm. Take care not to increase it over 28 gpm.

4. Reset the Chlorine and soda ash injection pumps to previous levels.

5. In the lab, change the sample line from station water to product water following the instructions at the valves on the lab wall.

Normal RO Shutdown

1. Add fresh sodium metabisulfite to the flush tanks. The amount will depend on the length of time that the unit will be out of operation. Consult the manufacturer's documentation for details.

2. If shutting down both RO's, open the product divert valve on top of tank 1 and close the valve to the tank that was last being filled. If shutting down just one, continue filling an available tank with its output.

3. Divert RO output to drain (see "Diversion to Drain" on page 34).

4. If shutting down both ROs, allow them to run long enough to flush the CO_2-charged from calcium carbonate beds. It takes about 30 minutes and can be confirmed by watching the pH monitor in the lab.

5. Close RO-19 and 20A.

6. Turn OFF the alarm so that it does not sound during the operation.

7. At the control panel, push red SEQUENCE STOP button to initiate the automated shutdown sequence:
   - MOV-2 opens.
   - Membrane feed and concentrate pressures decrease.
   - After 1-2 minutes, the high pressure pump stops.
   - The green lights go out.
   - When the feed pump stops, MOV-1 closes. If MOV-1 does not close, isolate media filters from RO by closing RO-4 A and B.
   - The flush pump will start and the amber flush pump light will illuminate. This flushes the RO vessels with fresh, non-chlorinated water.
   - After four minutes the flush pump will stop and the associated light will go out.

8. Close RO-14. Monitor product pressure and relieve if it exceeds 10psi.
   - In the event of an incomplete flush cycle or no flush cycle, osmotic pressure will cause excessive pressure to build up on the feedwater side of the membranes. Do not close RO-14 in event of a power failure.
   - If during a normal shutdown, most of the water in the flush tanks is not pumped out by the flush pump, continue the flush manually until most of the water has been used.

9. If shutting down both ROs, close RO-26 on both skids. If shutting down one RO, close RO-28 (RO-26 will have been closed previously).

10. Set pump switches to the OFF position.

11. Turn the control power switch to the OFF position.

12. Turn the breaker OFF at main breaker panel on the wall nearest the power plant.

13. Record the time of shutdown in the log book.

14. Monitor pressures in media filters as temperatures increase to room temp. Bleed off as needed, using RO-6 to relieve pressure, then close again.

Emergency RO Shutdown

CAUTION	USE THIS EMERGENCY SHUTDOWN PROCEDURE ONLY WHEN THERE IS IMMEDIATE DANGER OF PERSONNEL INJURY OR EQUIPMENT DESTRUCTION

1. At the RO control panel, turn off the CONTROL POWER switch. If it is not safe to approach the panel, de-energize the circuit breaker at the main breaker panel on the wall facing the power plant.
2. No control or flush sequences are operable, so they must be performed manually:
    i. Open MOV-2 using the yellow handle or wait until the next startup sequence when the valve will automatically return to the open position.
3. If CO_2 was being injected on the stopped RO, close the CO_2 tank valve then close RO-30. If required, adjust or start CO_2 injection on the other RO.
4. Adjust or secure chlorine and soda ash injection.
5. Set the alarm switch to the OFF position.
6. Set the switches on the RO control panel to their OFF positions.
7. Turn off the control power switch.
8. Close RO-26 (or other product valve(s) depending on mode of operation when the emergency occurred).
9. If no other RO is on-line, change the sample line in the lab to station water.
10. Log the time of shutdown and type of emergency.
11. Notify the mechanic.
12. Perform fresh water flush as soon as possible.
13. Close RO-14. Monitor product pressure and relieve as needed.

14. Monitor pressures in media filters as temperatures increase to room temp. Bleed off as needed, using RO-6 to relieve pressure, then close again.

RO Multimedia Filters

Backwash

Backwashing means routing water backwards through a filter to flush out the collected particles. In the McMurdo water plant, the multimedia filters must be backwashed when the difference between the two pressure gauges equals or exceeds 5 psi. They are backwashed one at a time at 40-50 PSI feed pressure. Use the following steps to perform the operation:

1. Shut down RO associated with the multimedia filters to be backwashed.
2. Open RO-1 and 6.
3. Close RO-2-3-4 and 5.
4. Re-energize the control panel breaker and turn the CONTROL POWER switch ON.
5. Open RO-2 on the first filter to be backwashed, then place FEED PUMP switch to the MANUAL position.
6. Throttle RO-2 then slowly open RO-3 on the first filter to be backwashed. Next, finish closing RO-2.
7. Backwash for thirty minutes or longer until water in the observation tube is clear.
8. To backwash the second filter, slowly open RO-3 on the second filter, then slowly close RO-6 on the first filter. Close RO-3 on the first filter. Backwash for 30 minutes until water in the observation tube is clear.
9. If re-starting the RO after backwashing, continue with “Media Filters Fast-Rinse/Purge” procedure. Otherwise, shut off feed pump and close RO-6.

Fast-Rinse/Purge

If purging air or fast-rinsing following a backwash, do one filter at a time. If a substantial amount of air has been allowed to enter the filters, the fastest way to eliminate the air is to

perform a short backwash. If rinsing to eliminate warm water prior to RO startup, it is permissible to do two filters at a time.

1. To transition from backwash to fast rinse without shutting down the feed pump, throttle RO-6 on the second filter backwashed (water is still flowing in reverse through this filter), open RO-2 on first filter (already backwashed), then open RO-5 on the first filter and finish closing RO-6 on the second filter. If rinsing both filters together, open RO-5 on the second filter at this time.

2. If starting from scratch (i.e. in preparation for RO startup), line up both filters as follows.

3. Open RO-1 and 2.

4. Close RO- 3, 4, 5 and 6.

5. Energize control panel and turn CONTROL POWER switch ON.

6. Open RO-6 on either filter and place the feed pump switch on the control panel in MANUAL.

7. Throttle RO-6, open RO-5, then, finish closing RO-6 on first filter. If rinsing both filters together, open RO-5 on second filter at this time.

    - The fast rinse/purge time should be 15 min. or until the water stream is clear and free of air, whichever is longer.

8. To rinse second filter (if rinsing separately), throttle RO-5 on first filter, open RO-5 on second filter, then finish closing RO-5 on first filter.

Proceed to the RO startup procedure or stop feed pump and immediately secure RO-5 on both filters. Leaving RO-5 open with feed pump off will allow the water to drain from the filter and necessitate repeating the procedure for purging air from the filter(s).

Extended Shutdown (more than one week)

The interior of a spiral membrane element, being dark and moist, is an excellent breeding ground for microorganisms. When the RO unit is intermittently used, tested, or operated, the elements will be exposed to bacteria. The biocidal lay-up procedure sterilizes the system. If any valves are opened within the system after the treatment has been completed, it will be necessary to re-sterilize the system again.

1. After a normal shutdown, refill both flush tanks using RO product water from an on-line unit (no chlorination or other post treatment).

2. Add 12.5 pounds of Sodium Metabisulfate to each flush tank (150 gallons of water). Therefore, a total of 25 pounds will be used per unit. If shutdown will exceed one month, also add 30 gallons of glycerine to each flush tank – 60 gallons total).

3. Energize control panel and place flush pump switch to "**CLEAN**" position. (All other switches to the "**OFF"** position.) Open RO-14. (Check valves 20A, 25, 26, 28. These should already be closed following a normal shutdown).

4. Turn "RO PROCESS" switch to "START" momentarily and release.

5. Pump solution into membranes and stop pump when level in tanks is just above the suction inlet. Close RO-14, tag main breaker with caution tag stating "**Unit in biocidal lay-up**" and log in Maintenance History Book and Water Plant logs.

6. Periodically check the pH of the solution. When it reaches 3.0 or below, mix up a new solution (per Filmtec).

7. Re-establish sterilization lay-up after one month! (per Filmtec)

Return To Service

1. Energize control panel. Open RO-14.

2. Using supply pump only, flush unit with seawater for 30 minutes.

3. Proceed to start procedures. Divert product water to waste for one hour before sending to storage.

Chemical Tank Levels and Refill

IMPORTANT	THE WEIGHING SCALE, FILL LEVELS AND INJECTION RATES ARE NOT CALIBRATED AND NEED NOT ADHERE TO HIGHLY PRECISE MEASUREMENTS. QUALITY CONTROL IS MONITORED USING CALIBRATED LAB INSTRUMENTS. CHEMICAL LEVELS ARE MANAGED AND ADJUSTED ACCORDING TO LAB MONITORING.

CAUTION	WEAR ALL PROTECTIVE EQUIPMENT WHEN HANDLING CHEMICALS. MATERIAL SAFETY DATA SHEETS (MSDS) ARE IN A BINDER IN THE CONTROL ROOM. ALL OPERATORS MUST BE FAMILIAR WITH SAFE HANDLING PROCEDURES.

Pretreatment

To prevent scale buildup in the RO membranes, the raw water is pretreated with a polyacrylic sequestrant (Formula MF600 or equivalent such as Flocon 100) diluted with RO water: The dilution ratio is 0.5 gallon MF 600 per 4.5 gallons of non-chlorinated product water. The injection rate is about 5 gallons every 24 hours of operation. When the pretreatment tank on each RO skid reaches a level of 10 gallons, recharge the solution as shown below:

1. Wear protective gloves, mask, and safety glasses.
2. Using the bucket provided fill to the 2-gallon mark.
3. Use the service hose from the operating RO to add 18 gallons of product water.

Soda Ash Post Treatment

When the tank level reaches the 20-gallon mark, it can be recharged with 9 pounds (3 scoops to the fill line) of soda ash and 30 gallons of water. Alternatively, when the tank reaches the 10-gallon mark, it can be recharged with 12 pounds (4 scoops to the fill line) of soda ash and 40 gallons of water. The dosage of soda ash may be varied according to operating conditions.

Periodically inspect inside of tank for buildup If buildup occurs, use all personal protective equipment (PPE) and long-handle brush to remove it.

1. Wear protective gloves, mask, and safety glasses.
2. Turn the post-treatment pump OFF.
3. Turn the post-treatment mixer ON.
4. Start adding water to the tank.
5. Add the soda ash and continue filling the tank. The best practice is to stand at the tank while filling to ensure it does not overflow.

6. Turn the pump ON.
7. Turn the post-treatment mixer OFF after about 30 minutes.
8. Record in the log book, the time, the amount of soda ash, quantity of water, and highlight the line in yellow.

Chlorine

The main tank can be recharged when the level reaches 15 gallons or less. The tank is recharged from pre-mixed chlorine solution in a smaller tank on top of the main tank. After recharging the main tank, pre-mix the solution for the next recharge. Pre-mixing the chlorine well in advance of recharging the main tank gives the mixture time to settle after being mixed.

FIRST recharge the main tank:

1. Wear protective gloves, mask, and safety glasses.
2. Note the current quantity in the tank and add 40. That is the number you will fill the tank to.
3. Turn the Chlorine injection pump OFF.
4. Open the top of the small tank just enough to make the contents visible.
5. Remove the strainer and momentarily drain the tube from the upper tank to eliminate the milky liquid that has collected in the tube. Do not drain the tube into the main tank but use the receptacle provided.
6. Replace the filter on the tube and start adding water to the main tank, although not at full flow. Full flow will fill the main tank sooner than the small tank drains.
7. Open the valve on the small tank and drain the contents, until just before the surface layer is drained. This prevents the residue on the surface from entering the main tank.
8. Finish filling the main tank so that 40 gallons are added to the previous level.
9. Turn the Chlorine injection pump ON.

SECOND, pre-mix dry chlorine for the next recharge:

1. Measure the chlorine and pour it into the small tank. For 40 gallons of water, use about 4 ounces in summer and 3 ounces in winter, or as needed per operating conditions. Adjust the dilution ratio so that a pump stroke of at least 30% is required to achieve the desired dosage. At 30% and above, further pump stroke adjustments will be more precise.

2. Refill the small tank to the fill line. Be ready to close the valve because it fills quickly.

3. Turn the chlorine mixer ON for about 30 minutes.

4. Remember to turn it off because it needs to settle before the next main tank recharge.

5. Record in the log book, the time, the amount of chlorine, quantity of water, and highlight the line in yellow.

Fresh Water Storage

A minimum level of fresh water must be maintained in storage for two reasons: First, a cushion over and above expected usage must be maintained in the event of an emergency shutdown for critical repairs. During the summer months, the cushion will supply the town for 1-2 days depending upon usage. Second, a sufficient quantity of water must be available for firefighting. The storage capacity of all four tanks is 207,000 gallons. Only about 176,000 gallons are useable because of the size of the distribution network. In other words, about 31,000 gallons remain in the tanks, distribution pipes and pumps at all times. The storage quantity is 100,000 gallons. Below that, there are serious implications for possible firefighting requirements.

> CAUTION! DO NOT LET THE FRESHWATER TANKS DRAIN BELOW THE 2-FOOT MARK.

FW Tank to Distribution

Always open the new tank for distribution before closing the current tank. If the current tank is closed before opening the next tank, the pressure in the will exceed what the pipes can

handle and a pressure place will blow out. Always record changes in the water plant log book. Use the following steps to change distribution from one tank to another:

6. Open distribution valve on tank to be used.
7. Close valve on tank coming off-line.

Filling FW Tanks

Use switches located on wall in lab area.

1. Open tank to be filled. (Do not fill tank currently in use.)
2. Close tank that is full.

CAUTION	NEVER ALLOW ALL FOUR VALVES TO BE CLOSED AT THE SAME TIME WHEN AN RO IS ONLINE UNLESS PRODUCTION WATER IS DIVERTED TO DRAIN.

3. Record in the water plant logbook.

Distribution Pumps

Firefighting Emergencies

1. Place both HOA switches to “HAND” and open all isolation valves on FW tanks.
2. Monitor tank levels until emergency is over.

Normal Operation

One HOA service switches should be in AUTO and the other in MANUAL positions. Rotate the pumps once a month. If the pressure drops below 59 psi for 15 seconds, the second “Lag” pump will start up until pressure stays above 69 psi for 15 minutes.

CAUTION	DO NOT START BOTH PUMPS AT SAME TIME; ALLOW PUMP TO STABILIZE BEFORE ENERGIZING THE SECOND PUMP.

Startup

1. Ensure one FW tank is on-line.
2. Ensure heat exchanger cooling water valves are open to Hydroconstant drive.
3. Check oil level in Hydroconstant drive.
4. Open suction and discharge valves on pump.
5. Set HOA service switch to "HAND" when one pump is on-line. If two pumps are on-line, set both HOA service switches to "AUTO".
6. Note in logbook.

> CAUTION: IF THE OIL LEVEL IS LOW, DO NOT ADD OIL, BUT NOTIFY THE MECHANIC. ONLY FOOD GRADE TURBINE 68 OIL IS TO BE USED IN THE DISTRIBUTION PUMPS.

Shutdown

7. If one pump will stay on-line, set its HOA service switch to "HAND".
8. Set HOA service switch to "OFF" on pump being taken off-line.
9. Close suction and discharge valves on pump being taken off-line.
10. Apply Lockout/Tagout procedures to the pump being taken out of service at the MCC disconnect.
11. Note in the water plant log book.

Portable Reverse Osmosis Unit

Some station maintenance operations require ultra-pure RO water. Water plant operators are responsible for making this water as requested. To make ultra-pure water, use the Matrix portable reverse osmosis unit. It is 110V AC and is capable of making 500 Gallons/Day (0.35 GPM) from a pressurized seawater source that is approximately 25 degrees Celsius. The unit loses 1.9% production capability for every 1 degree Celsius cooler the source water supply is! This unit can make up to one thousand gallons per day (0.69 GPM) from a pressurized freshwater system.

> CAUTION USE ONLY NON-CHLORINATED WATER IN THE PORTABLE RO UNIT. CHLORINATED WATER WILL RUIN THE MEMBRANE.

The unit has a high-pressure switch which will shut it down at about 850 PSI. It is not recommended to be adjusted higher than 1,000 PSI. There is also a low-pressure switch which will shut down the unit if the feedwater supply pressure to the high-pressure pump suction is less than 15 PSI.

The unit has a conductivity monitor, which will divert the product water to the waste line via a solenoid divert-valve if the conductivity exceeds 1000 micromhos of conductivity. This meter is adjustable up to 2000 micromhos, which is the maximum allowed by the World Health Organization for human consumption.

The pre-filtration consists of two blue filter housings that can be installed with a combination of filters for the kind of source water used. For seawater, the upstream filter housing contains a 30 micron (blue) pleated filter cartridge and the downstream filter housing contains a 5 micron (white) pleated filter cartridge. For potable water, the upstream filter housing contains an Activated Charcoal (blue wrapped) solid housing filter cartridge for de-chlorinating the supply water and the downstream filter housing contains a 5 micron (white) pleated filter cartridge.

The high-pressure reciprocating plunger pump requires a minimum of 15 psi at its suction to operate correctly. It is capable of 2.3 gallons per minute when the pressure control valve (black knob) is fully opened. By closing the pressure control valve, the pressure increases between the discharge of the high pressure pump and the valve. This increases the pressure on the membranes, thereby forcing the freshwater through the membrane. The incoming seawater stream is split into a concentrated flow stream and the product stream, both of which pass through the flow indicators. The concentrate stream is sent to waste and the product water stream passes a conductivity cell which determines if the quality is above, or below the established set-point for conductivity.

If the quality is above the set-point, the product stream is diverted through a solenoid divert valve and joins the concentrate stream to waste. The quality of the water is measured on the analog meter.

The unit should not be run in excess of 30% recovery with a potable water supply source, or 16% using seawater as its supply. Any production past these recovery limits will shorten the life of the membranes, thereby reducing the water quality and requiring more frequent membrane cleaning/replacement.

Startup

1. Put a utility pump (Wayne) between the larger RO and the small RO in order to boost pressure.
2. On the large RO, open the valve that will feed the small RO.
3. Ensure that the concentrate discharge and the inlet valves are open on the small RO.
4. Ensure that the 30 and 5 micron filters are in filter housings. Ensure that the proper filters are in place for the water supply (potable or seawater).
5. Connect electrical power cord to outlet and turn breaker to ON position.
6. Ensure the pressure control valve is in the OPEN position (totally counterclockwise).
7. Turn on the pump (plug it in) and ensure there is flow to the drain.
8. Vent the filter housings of air after water flows through the unit for several minutes, at greater than 15 psi, and observe that no air bubbles remain in the concentrate flow-meter.
9. Turn the OFF / RUN / START switch to START and release. The switch will spring-return to the RUN position. The two green lights will illuminate.
10. Start the unit with approximately 40 psi at the suction gauge. If supply pressure is inadequate, the starting of the unit will pull down the supply pressure and the low pressure switch will shut down the unit.
11. Turn the pressure control valve clockwise to increase pressure until the product flow-meter reads 0.35 GPM for seawater or 0.69 GPM for fresh water feed.
12. The conductivity meter should indicate a salinity reading and if it is too high, will divert product water to waste. When conductivity is below set-point, the OFF/RUN/START switch will illuminate and product will divert to the discharge hose.

SHUTDOWN

1. Turn the pressure control valve counterclockwise until fully open.
2. Turn the OFF/RUN/START switch to OFF.
3. Unplug the utility pump to stop flow.
4. Secure the outlet valve on the large RO.
5. On the small RO, turn the concentrate discharge and the inlet valves to the closed position.

Alarms

When an alarm sounds, silence it by depressing the ACK button under the red strobe light. On the BACtalk computer a window pops up with a button to acknowledge the alarm. Pressing either button will stop the alarm. Find out what the problem is and follow the appropriate procedure to correct it. After the alarm condition has been remedied, the alarm must be reset. Do not reset the alarm until the condition has been remedied because the alarm will go off again. If the problem requires intervention by a mechanic or the supervisor, remember or write down the conditions that you observe and pass that information on to them for troubleshooting.

Reseting the alarm

On the BACtalk computer, go to the WP ALARMS page. The tripped alarm will be red instead of green.

- Click the checkbox next to the red button
- In the popup window, select ACTIVE. That means you are ACTIVATING the DISABLE ALARM function.
- Click OK and a checkmark appears in the box.

The checkmark means that the alarm is disabled and will not sound if the condition occurs again. If the condition has not yet been resolved, i.e. a storage tank level is 14 feet 7 inches, do not reset the alarm until after you use some of the water from that tank. If the condition has been resolved, reset the alarm:

- Click the checkbox or anywhere on that line

- In the popup window, select NULL.

IMPORTANT: LEAVING THE RESET BOX CHECKED WILL DISABLE ALL NEW ALARMS ON THAT DEVICE.

Alarm setpoints and status

Alarm set points can be reviewed and changed on the BACtalk computer. Click the ALARM SETPOINTS button on the WP ALARMS page. Review them on the computer for the most current information. The table below shows typical set points:

Location	**Condition**	**Set Point**
FW tanks 1 through 3	High level	14’ 6”
FW tanks 1 through 3	Low level	4’ 0”
FW tank 4 (outside)	High level	10’ 6”
FW tank 4	Low level	2’ 0”
FW tank 4	High temp	60 degrees F
FW tank 4	Low temp	38 degrees F
Surge tank	High level	10’ 5”
Surge tank	Low level	3’ 5”
Surge tank	High temp	38 degrees F
Surge tank	Low temp	33.5 degrees F

The WATER PLANT page indicates when alarms have been disabled (just above the seawater tank readings). At the beginning of your shift, review the alarm status and reset any disabled alarms that have been corrected. For example, the level alarm in a storage tank was tripped in the morning and the operator forgot to reset the alarm several hours later when that tank was put to distribution thus correcting the alarm condition.

Seawater Intake Flow Alarm

WARNING: THIS IS AN EMERGENCY SITUATION. IT MUST BE DEALT WITH QUICKLY WHEN THE WATER PLANT IS IN FULL PRODUCTION.

This alarm sounds if there is no flow within 4-8 minutes after energizing the seawater intake pump. The silence and reset controls located beneath the seawater intake pump HOA switches, next to the seawater surge tank on the wall facing the power plant. The blue pushbutton is the alarm silencer. The reset is a toggle switch. Turn it OFF, then ON. The pump will not restart until the alarm is reset. If the alarm sounds again after resetting, CALL THE MECHANIC. DO NOT RESET AGAIN. A green light indicates when the seawater intake pump is on. Monitor the flow rate on the box next to the distribution pump control panel. Also monitor the tank level. The RO's will automatically sequence shutdown when the level in the surge tank reaches two feet.

Surge Tank High Level Alarm

This alarm sounds when the water level in the surge tank is too high. During normal operations, the bypass valve will automatically divert the seawater flow to drain before the alarm sounds. Check setting of seawater tank bypass valve on the water plant page of the BACtalk computer (labeled “Seawater Heating System):

- If it was left on the “Fill Tank” setting, reset it to “Null.” This restores automatic operation.
- If the setting was already on “Null,” check the bypass valve to see if it was left in the manual fill position. Restore to automatic operation if appropriate.
- If the settings on the BACtalk computer and bypass valve are both in automatic position and the bypass valve is still not opening, it may be operated manually. Closely monitor level to avoid a low level alarm. Notify mechanic of malfunction.
- If the ROs are online, monitor surge tank level.

Surge Tank Low Level Alarm

WARNING: THIS IS AN EMERGENCY SITUATION. NOTIFY THE POWER/WATER/WASTEWATER SUPERVISOR.

This alarm sounds when the tank level falls to four feet. The ROs will automatically go into a normal sequence shutdown when the level reaches two feet.

- Check the setting of seawater tank bypass valve on the BACtalk computer. If it was left on the "Bypass Tank" setting, reset it to "Null." This restores automatic operation.
- If the setting was already on "Null," visually check bypass valve to see if it was left in the manual bypass position. Restore to automatic operation if appropriate. If valve is set for automatic operation but is not responding normally, turn the switch to the "man" position and operate the valve manually. If manual operation is required, monitor level to keep from over filling.
- Check to see that the drain valve on the surge tank has not been left open.
- Verify that the seawater intake pump is on and check the seawater flow meter next to the distribution pump control panel.
- If intake flow has stopped and cannot be restored quickly, prepare to shut down the RO's.
- If a shutdown becomes necessary and time allows, divert the product to drain at the product divert valve above FW tank 1. Secure CO_2, soda ash and chlorine injection.
- Switch pH and chlorine monitors to "Station Water."
- Press the "Sequence Stop" button on the RO's that are operating, and continue with a normal shutdown.

Waste Heat Recovery Boiler

Safety Circuit Alarms

This alarm is not on the BACtalk computer but on the boiler control panel. In an alarm condition, the boiler automatically shuts down.

1. Open blue panel on boiler.
2. Looking at the red monitor's window, note the code given. This will give vital information to the mechanic.

3. Visually inspect for fuel leaks, smoke or anything out of the ordinary.

4. If everything looks normal, press the reset button on the monitor, hold for 2 seconds, and release. This will silence the alarm and restart the boiler.

5. The boiler will go through a purge cycle and restart.

6. If the alarm sounds again, do not restart a second time. Instead make a note of the code given on the monitor. Turn the control switch OFF, reset the alarm and notify the mechanic.

Boiler Low Glycol Alarm

In the event of a major glycol line rupture:

- Glycol makeup pump/tank system will start to inject glycol.
- Waste heat recovery main circulating pumps will shutdown.
- System low-level alarm actuates at the DDC.
- If the boiler is online, the McDonnell-Miller low glycol level cutout will activate if rupture is not secured immediately, thereby shutting down the boiler.
- Upon system restart, manually reset the McDonnell-Miller cutout.

Fire Panel Alarms

Fire panel alarms are not displayed on the BACtalk computer. The fire panel is located on the outside wall nearest the firehouse, to your right when you walk in the door. Most detectors in the water plant sense heat and one detector, located in the exhaust duct of the air handler, detects smoke. When a detector goes off, an alarm sounds, the firehouse receives a transmission, and the boiler, furnace and air handler automatically shut off.

FIRE DEPARTMENT NUMBERS:	EMERGENCY	911
	GENERAL	2555

1. Determine whether it is an ALARM or TROUBLE sensor. There is a light for each that you can see without opening the panel.

2. If it is a false alarm or a TROUBLE light, IMMEDIATELY call the fire department on a non-emergency line

3. If you should have a fire that hasn't yet activated a detector, use a manual pull station, evacuate the building, and call the fire department (911).

4. If you are comfortable in doing so, you may use one of the 15-pound hand-held FE 36 or ABC Dry Chemical fire extinguishers to put out a fire. There is also a portable 100-pound (2 x 50 lb bottles) CO_2 fire extinguisher mounted on a wheeled cart.

IMPORTANT	OPERATORS MUST BECOME FAMILIAR WITH THE LOCATIONS OF THE FIRE EXTINGUISHERS AND FIRE ALARM PULL STATIONS. KNOW HOW TO USE THEM - YOUR LIFE COULD DEPEND UPON IT! ALL OPERATORS RECEIVE FIRE SAFETY TRAINING FROM THE FIREHOUSE, INCLUDING USE OF FIRE EXTINGUISHERS. BECAUSE OF THE CRITICAL IMPORTANCE OF THE WATER AND POWER PLANTS TO A FIRE EMERGENCY, AN APPENDIX TO THIS SOP INCLUDES A REVIEW OF FIRE SAFETY PRINCIPLES.

5. All fires are to be reported to the Fire Department even if they were not called out to respond.

6. As soon as possible, notify the supervisor of any equipment failures that interrupt water production, or if the Fire Department is called to put a fire out. The supervisor will notify the mechanic.

Water Testing

Sample Line

A water sample line is installed in the lab. The line can be set to product water or station water. Two sampling instruments are installed in the lab and connected to the line, a pH meter and a chlorine analyzer. Always leave the line open, usually to product water. If no water is flowing through the electrodes in the instruments, they will dry out. These instruments provide constant readings for monitoring and logging during rounds. However they are not to be used as substitutes for testing product and station water as outlined in this section

Testing schedule

The testing schedule is shown in detail under “Weekly Reading and Testing Schedule” on page 16.

Lab instruments and testing procedures

Operators must follow industry best practices and manufacturer’s instructions for testing water and using the instruments. Refer to manufacturer’s documentation and industry reference books in the water plant for details.

Calibrating Instruments

All manuals for meters, recorders and analyzers are located in upper storage file cabinet

Omega pH Monitor/Recorder

1. Turn the function switch to the pH mode.
2. Exp-norm switch, in the “NORM” (normal) mode.
3. Set the temperature compensation switch to the buffer temperature.
4. Prepare standard pH 4.00, 7.00, 10.00 buffers. Commercial liquid buffers are acceptable.
5. Place pH probe in standard pH 7.00 buffer.
6. Adjust analog meter pointer to pH 7.00 using controller set knob.
7. Adjust recorder pen to pH 7.00 using recorder zero set knob.
8. Rinse probe with de-ionized or distilled water.
9. Place probe in standard pH 10.00 buffer.
10. Adjust analog meter pointer to pH 10.00 using controller slope adjuster.
11. Adjust recorder pen to pH 10.00 using recorder slope adjust.
12. Rinse probe.

13. Check calibration and linearity of probe by using standard pH 4.00 buffer. The analog meter pointer and the recorder pen should both read pH 4.00 +/- 0.10 units. Clean probe and repeat calibration procedure using fresh buffers if pH 4.00 +/- 0.10 limit is not observed. (Checking against pH 4.00 not required on every calibration.)

Note Keep electrode immersed in a solution as much as possible while performing calibration.

Equipment care.

- The body of the pH meter is not waterproof, so care should be taken to prevent water from splashing on the face of the unit, and the unit should not be placed in standing water on the counter top.
- Once an electrode has been placed into service, it should never be allowed to dry out. If the electrode will not be used for 6 months or more, keep it immersed in 3M KCl solution, (or other storage solution as recommended by the manufacturer). For short-term storage between readings, keep the electrode immersed in 4, 7 or 10 buffer solution. Do not store electrode in de-ionized or distilled water.
- Calibration is performed using the two-point method. Use pH 7.00 buffer to set the "zero" function of the meter, and pH 10.00 buffer to set the "slope" function. (This will be satisfactory for most water plant tests).
- If testing an acidic solution, pH 7.00 and pH 4.00 buffer may be used. Use pH 7.00 to set the "zero" and pH 4.00 to set the "slope."

Capital Controls Chart Recorder

After installation, this unit does not need to be calibrated or programmed except after servicing or if the accuracy is suspect.

pH Testing

1. Rinse the electrode with D.I. water, then with a small portion of pH 7.00 buffer, then immerse in a fresh portion of pH 7.00 buffer at 25 deg C. (77 deg F - pH temperature knob should be set at 77). Allow the electrode to come to equilibrium, then press the test switch and adjust the "zero" screw to obtain a reading of 7.00. (A small magnetic stirring bar at low speed helps to bring the electrode to equilibrium more quickly and improves precision).

2. Rinse the electrode again with D.I. water, then with a small portion of pH 10.00 buffer, then immerse it in a fresh portion of pH 10.00 buffer at 25 deg C. Allow the electrode to come to equilibrium, then press the test switch and adjust the "slope" screw to obtain a reading of 10.00.
3. Replace the electrode in the 3 M HCl solution, or proceed with testing
4. Discard the old 3 M HCl solution weekly and replenish with new.
5. Determine the temperature of the sample to be tested, and adjust the temperature knob accordingly.
6. Rinse the electrode with a portion of the sample, then immerse the electrode in the sample. (Use sample bottles with pre-drilled holes to protect sample from atmosphere).
7. Allow the meter to stabilize, then press the test switch and read the pH of the sample.
8. Replace the electrode in the 3 M HCl solution.

Conductivity Test

(YSI Model 30M Salinity, Conductivity, and Temperature System)

1. Turn the meter on. The meter will perform a self-test sequence, then will display a readout of 0.0 (assuming the electrode is clean and dry) in one of three modes: conductivity, specific conductance or salinity. For conductivity and specific conductance, the units displayed will be uS (micro-siemens). If the unit is in the conductivity mode, the ^{O}C symbol will be steady; if the unit is in the specific conductance mode, the ^{O}C symbol will be flashing. For salinity, the units displayed will be ppt.
2. Select the specific conductance mode by pressing the “mode” button until the units read uS and the ^{O}C is flashing.
3. Rinse the probe with the sample to be tested, then immerse the probe in the sample. Water should come up at least to the vent hole in the probe. Try to avoid the probe contacting any solid object (such as the bottom of the container) while taking measurements, as it may have a small effect on the reading.

4. Record the reading when it is reasonably stable.

- The meter has a memory feature, which may be used to record readings if desired. For details on saving data to memory, recalling data, and erasing the memory, see the manual.

(LaMotte Multi-Range Conductivity Meter Model DA-1)

9. Switch the control knob to the "BAT.CK" position. Reading should be at least 80 micromhos/cm.

10. Set the TEMP knob at 25 deg C, the Range Selector at X100, and switch the control knob to the CAL position. Adjust the STD knob to obtain a reading of 100 micromhos/cm.

11. Measure the temperature of the sample solution, set the "TEMP" knob accordingly, and immerse the probe into at least 0.5" of solution. (Make sure there are no bubbles on the probe).

12. Select a range appropriate to the solution being tested. (i.e., X1000 for seawater, X10 for product water).

13. Switch on the control knob, read the meter, and multiply by the appropriate multiplier.

14. Switch off the control knob, rinse the probe with de-ionized water, and allow to air dry.

Accuracy of the meter may be checked periodically against conductivity standard solutions. We have 450 and 1500 micromhos/cm solutions on hand. If accuracy is suspect, based on comparison with these standards, a more detailed procedure for calibrating the meter is given in the operator's manual.

Langelier Index Determination

Determining the Langelier Index of finished product water requires testing temperature, total dissolved solids, pH, hardness, and alkalinity. Using these parameters, pH(s) (pH at the saturation point for calcium carbonate) is calculated. The Langelier index is the difference between the measured pH and the calculated pH at saturation.

1. Obtain samples. For the water plant, collect the sample from the tank which is on line. For samples from the distribution system, choose a convenient tap, flush with cold water for 1 minute, then collect the sample. Fill the sample bottle to the top, and try to eliminate all air from the sample (pH may change with absorption of CO_2 from the atmosphere). Complete testing as soon as possible after collecting samples.

2. Check the temperature of the sample, and test the pH according to the procedure above.

3. Check the TDS of the sample (total dissolved solids) using the Myron L TDS meter. Set the range selector switch to "S" and press the test button. Meter reading should correspond to the value printed on the bottom of the meter. Rinse the cup three times with sample water and then fill the cup to a level above the upper electrode. Select an appropriate range (x100 for product water testing) and press the test button. (Specific conductance of the sample times 0.56 has been shown to give a good approximation of TDS).

4. Test the sample for hardness, using the Hach corrosion management test kit.

A. Measure a 46 ml sample in a graduated cylinder, and pour into the Erlenmeyer flask provided with the test kit. Place a magnetic stirring bar in the flask and place on the magnetic stirrer at moderate speed.

B. Add 4 drops of 8 N potassium hydroxide solution to the flask.

C. Add 2 CalVer 2 calcium indicator pillows. If calcium is pink, calcium is present. If it is blue, calcium is absent.

D. If calcium is present, add 0.035 N EDTA titrant, a drop at a time, to the flask, until the sample turns from pink to blue. Note the number of drops required.

E. Calcium hardness (in mg/l as calcium carbonate) is equal to the number of drops required times 2.5.

5. Test the sample for total alkalinity, using the Hach test kit.

A. Measure a 46 ml sample, pour into the flask, add stirring bar, and place on stirrer.

B. Add the contents of 2 Bromcresol Green-Methyl Red indicator pillows to the flask. The color will change to blue-green.

C. Add 0.035 N sulfuric acid solution to the flask, a drop at a time, until the sample turns pink. Note the number of drops required.

D. The total alkalinity (in mg/l as calcium carbonate) is equal to the number of drops required times 2.5.

Note The multiplier depends on the sample size. These sample sizes were selected according to operating conditions at the time of writing. If changes in plant operations warrant it, select an appropriate sample size for changed operating conditions. See the manual in the test kit for further details.

6. Alternate alkalinity test using 0.05N nitric acid.

A. Drain most of nitric acid remaining in burette for the first test only. Zero the burette. (For subsequent tests, zero the burette or record starting point).

B. Measure a 100 ml volume of sample.

C. Add contents of two BCG-MR indicator packets.

D. Titrate with nitric acid until the color turns from blue-green to pink (or in some cases a yellow-green shade - higher chlorine concentrations tend to affect the color).

E. Multiply milliliters of nitric acid used by 25 to obtain alkalinity result in mg/l as calcium carbonate.

F. Calculate pH(s), using the formula: pH(s) = A + B - C - D, (A is based on temperature, B is based on total dissolved solids C is the log of the calcium hardness (in mg/l as calcium carbonate) and D is the Log of the alkalinity (in mg/l as calcium carbonate). Obtain values A and B from chart on cabinet in lab or from the manual. Obtain values C and D from the charts or use a scientific calculator.

G. Calculate the Langelier Saturation Index: LSI = pH (actual) - pH(s).

7. Enter the test results in the spreadsheet "Langelier.xls". The columns labeled pH(s) and LSI in the spreadsheet contain formulas that will calculate these values. Steps F and G have been left in place for reference.

Chlorine Test

Testing for Free Chlorine. 0-2mg/l.

Hach Colorimeter DR 100

1. Turn right set control fully clockwise, and insert 1 cm cell holder into the left set position of the sample well.

2. Close the light shield, hold down the "on" button, and adjust the "left set" control to align the meter needle with the arrow at the far left of the scale arc. Remove the cell holder. (After making the “left set” adjustment turn the “right set” control back to its original position).

3. Collect sample in 60 ml bottle (fill to 50 ml mark). Add 5 drops of 0.056 N sulfuric acid to adjust pH. (This should adjust the pH to between 6 and 7. Make adjustments if needed for changes in plant operation).

4. Fill both 2.5 cm sample cells to the 10 ml mark with the water to be tested.

5. Add the contents of one DPD free-chlorine powder pillow to one of the 2.5 cm sample cells. Cap and shake for 20 seconds to mix. If chlorine is present, a red color will develop. (Complete steps 7 through 10 within one minute).

6. Cap the cell containing untreated water sample and place the cell into the sample well. Close the light shield.

7. While holding the "on" button down, adjust the "right set" control for a reading of zero mg/l. Remove the blank.

8. Place the cell containing the prepared sample into the sample well, hold the "on" button down and read mg/l free-chlorine from the upper (2.5 cm) scale.

Note For additional Information, see the Hach DR 100 colorimeter manual.

Total Coliform Bacteria Test

Materials Needed

- Vacuum filtration apparatus and incubator.
- Petri dishes (1 for each sample to be taken), which include nutrient pads.
- Thio bags (1 for each drinking water sample to be taken. These are for de-chlorinating the sample).

- Nutrient broth ampoules (M-endo broth, kept in the refrigerator), 1 per sample.
- Sterile filters.

Procedure

1. Plug in incubator and adjust to 35 ^{O}C. Wipe testing table with alcohol. Wash your hands.
2. Label the petri dishes and thio sample bags for each sample to be collected.
3. Sanitize all equipment, which will contact the sample, in the U.V. sterilizer for at least two minutes or by immersion in isopropyl alcohol for at least 5 minutes, then allowing to air dry (usually takes 5 to 10 minutes). This includes the filter base and holder, the funnel attachment, and the forceps, as well as any container to be used for collecting a sample (thio bags for collecting chlorinated fresh water samples are supplied in sterilized condition as are nutrient pads and petri dishes).
4. Select sample sites and obtain samples (4 ounces each), using pre-sterilized thio bags for chlorinated samples. Samples should be processed within 1 hour of collecting. Currently we are testing all tanks on the 1st and 15th day of each month during the summer, and once a month during the winter. Additionally, a sample is drawn from the seawater surge tank as a control (it is almost always coliform-positive).

A sanitized plastic bottle of suitable size may be used for non-chlorinated samples. Allow the sample ports or taps to run at a steady rate for 3 to 5 minutes prior to collecting the sample. Be careful not to allow water from an external drip to fall into the sample container, as it could contaminate the sample. Ensure the tablet is dissolved before running the test.

Break open one of the nutrient ampoules and dispense onto the sterile nutrient pad within the petri dish and replace cover.

5. Place the filter base on top of the receiver flask, place a filter on the holder (using sterile forceps), then place the filter funnel on top of the assembly, being careful not to touch the inner surface. Secure with the spring clamp.
6. Attach the vacuum pump to the receiver flask with the flexible vacuum tubing. Pour the sample into the funnel, then start the pump to draw a vacuum on the receiver flask which will cause the sample to be drawn through the filter.

7. Remove the funnel and, using sterile forceps, transfer the filter to the petri dish. Place the filter carefully on the nutrient broth pad, using a rolling motion to obtain an intimate contact between the filter and the nutrient pad to avoid trapped air. Place the petri dish upside down in the incubator and incubate for 24 hours at 35 ^{O}C.

8. Sanitize funnels, filter holders, and forceps as described above, between samples. When done, wash the funnels, filter bases and forceps with DI water, turn off the UV sterilizer, and run the vacuum pump for a few minutes to dry it out.

9. After incubating for 24 hours, check the petri dishes for coliform colonies, using the illuminated hand magnifier. Record the results in the water plant log sheet. The Millipore Water Microbiology manual shows representative examples. The control sample from the seawater surge tank will usually contain some colonies.

Silt Density Index

The SDI is a measurement of the quantity of colloidal matter in a water supply, and an indication of a tendency for colloidal fouling to occur. Maximum recommended SDI for spiral wound membranes is 5.0 (as per Matrix).

SDI Test Procedure

The RO unit must be on-line for SDI. A minimum of 35 PSI is required. If unable to achieve this, maintain a constant pressure throughout the test and note readings in log sheet.

1. Connect the SDI test fixture to RO-10.

2. Ensuring the ball valve on the fixture is closed, open RO-10.

3. Remove top half of filter housing by loosening the three thumbscrews.

4. Crack open the fixture ball valve and purge the air out of the sample line and at the same time, wet the inside of the filter housing bottom.

5. Remove a 0.45 micron filter with the tweezers and center it on the filter housing bottom.

6. Crack open the fixture ball valve again and allow some water to completely moisten the filter.

7. Place orange o-ring on top of filter in housing and reassemble housing with thumbscrews loosely.

8. Crack open fixture ball valve and purge all the air out of the filter housing. Tighten the three thumbscrews.

9. Briefly open the fixture ball valve to purge air out of the downstream line and check that the regulator is set at 30 PSI. If not, adjust and recheck.

Note To ensure accurate results, all air must be purged from filter fixture.

10. Using a stopwatch, open fixture ball valve and measure the time it takes to fill a 500ml beaker. ***This is T1.***

11. After the beaker has been filled, divert the hose into a bucket and allow to run for 15 minutes.

12. After the 15 minutes, time another 500ml to complete the test. ***This is T2.***

13. Close fixture ball valve and RO-10. Remove filter.

14. Wash lower housing with warm water to remove saltwater from disc.

Calculate SDI

Use the following formula:

T1= initial time to fill first 500ml beaker.

T2= final time to fill second 500ml beaker.

TF= time of test (15 minutes in this case) $SDI = \frac{1 - (T1 / T2)}{TF} \times 100$

Note Currently Matrix is using the maximum SDI limit for spiral wound of 5.0 but needs to be proven by the industry. It should also be noted that SDI'S are used to determine the severity of colloidal fouling (particles with an electrical charge).

McMurdo waters experience summer algae blooms. These are considered biological foulings and have different fouling characteristics than colloidal fouling. The biological foulants are more easily removed with chemical cleaning than inert colloidal particles are.

Chloride Test

1. Rinse a casserole dish or beaker with D.I. water and a 50 ml graduated cylinder with the sample to be tested. Measure a 10 ml sample into the dish or beaker.

2. Add 2 to 3 drops of chloride indicator to the sample. Sample will turn pale blue violet or red depending on the pH.

3. Add nitric acid 0.05 N HNO3 a drop at a time until the color passes through pale blue violet and turns yellow. Then add exactly 1.0 ml more HNO3.

4. Zero the mercuric nitrate burette. Titrate with 0.01 N mercuric nitrate [Hg(NO3)2] a drop at a time while stirring until the yellow color turns to the first pale blue-violet that persists throughout the sample.

5. Record the burette reading to the nearest 0.1 ml. For a 10 ml sample, 1.0 ml of mercuric nitrate is equal to epm (equivalents per million; 1 epm = 35.5 ppm) of chloride. Record this result in the appropriate column.

6. Chloride tests may also be performed on condensate or other samples. For greater sensitivity on samples with very low levels of chloride, use a larger sample size and multiply the burette reading by an appropriate correction factor (i.e. for 100 ml sample, multiply the reading by 0.1 to obtain epm of chlorides; for 25 ml sample multiply by 0.4).

7. Mercuric nitrate is a hazardous waste, so it must be saved in the container kept for this purpose. When it is about 75 pct full, fill out a Hazardous Waste form and call the Hazmat people to make it go away and bring you a new waste container. They prefer not to have the container too full, since it will be stored outside, and might burst due to freezing if full.

Emergency Procedures

Major Fuel Oil Leak

A major leak would be fuel spraying out a pipe or fitting. Outside, a major leak is a spill over 5 gallons. For outside spills, the HazMat team will clean up and dispose of the material. They may request the assistance of water plant personnel.

1. Turn OFF the burner control switch on the boiler.
2. CLOSE both fuel supply and return valves located closest to source of the leak, or isolate the whole building using the main fuel line isolation valves outside.
3. Immediately notify supervisor who will notify fire department and mechanic.
4. Secure RO's, if waste heat recovery system will not maintain established seawater preheat temperature

Minor Fuel Oil Leak

Inside, a minor leak would be a rapid drip from a pipe or fitting. Outside, a minor leak would be up to 5 gallons, and any spillage outside requires that the HazMat team be notified.

- IMMEDIATELY notify mechanic.
- Be prepared to shut down the boiler at mechanic's request.

Electrical Loss

A loss of power can last anywhere from a few seconds to hours. Water plant operators may be asked to assist power plant operators. In that event, secure the water plant FIRST and then check with the power plant operators. To secure the water plant perform the following procedure:

1. If the boiler was running at the time of the outate, open the breaker for Boiler 2.
2. Close RO-14 on the RO's that were running.
3. Close RO-26 or RO-19 (if running to drain) on the RO's that were running.

4. Open the breakers on the running RO's.
5. Secure the CO2 injection.
6. Secure the chlorine injection and soda ash injection.
7. Switch the lab to station water.
8. On the seawater bypass valve, turn the electrical switch to manual and manually turn the valve to go to drain.

When power is restored:

1. Start a fresh water distribution pump and place the other in Auto.
2. Ensure that the waste heat glycol system is working properly. If the DDC has failed, start each pump manually.
3. Ensure that there is seawater flow from the intake pump.
4. Place the switch on the seawater bypass valve back to auto and check the computer to see that it is working properly.
5. If there are any problems, call the water plant mechanic.
6. Continue with regular plant startup.

References

None.

Records

Records are actual recorded data or information that sufficiently demonstrate and ensure that a process or activity required by the procedure has been completed effectively. Records can be maintained in any medium, i.e., hard copy, computer file on a network server, archived computer file, etc. Records management is described in PA-A-001.

The following information is required for all records:

Record Identification, Format, & Owner	**Active Location Storage, Protection, & Retrieval**	**Facility Storage, Protection & Retrieval**	**Retention Time (Active and/or Facilities Storage)**	**Disposition at the end of the retention time**
Water Plant Log Book, hardcopy, supervisor	Control room, available to any water plant operator	Water plant mezzanine	Active – 1 year Facilities – 5 yrs	Recycle
Handwritten long sheets, hardcopy, supervisor	Control room	Water plant mezzanine	Active – 1 year Facilities – 5 yrs	Recycle
Electronic file version of the handwritten logs, supervisor	Water plant network server	Water plant network server	Provide to next contractor	n/a
Weekly maintenance report	Control room	Water plant mezzanine	Active – 1 year Facilities – 5 yrs	Recycle
LN_2 Log Sheet, hardcopy, supervisor	At the LN2 plant	Water plant mezzanine	Active – 1 year Facilities – 5 yrs	Recycle
Water testing logs, hardcopy, supervisor	Control room	Water plant mezzanine	Active – 1 year Facilities – 5 yrs	Recycle

Record ID- Identification number or name

Owner- Person responsible for managing the record by division, department and title

Format- Hard copy or electronic. For electronic records, provide drive location or type of media and location.

Storage- Storage method and location (in file, on shelf, in drawer, location- onsite, offsite) including method of indexing

Retrieval- Who can get it, how, and when.

Retention Time- How long records are stored before disposition.

Disposition- The ultimate fate of the record, i.e. provide to next contractor, shred, recycle, demagnetize disc, etc.)

Appendix A Fire Safety Review

Fires Out Of Control

IMPORTANT	DO NOT BE A HERO! IF YOU FEEL YOU ARE IN DANGER, LEAVE THE BUILDING WITHOUT ATTEMPTING TO FIGHT THE FIRE. PULL A FIRE ALARM ON YOUR WAY OUT OF THE BUILDING AND CALL 911 FROM THE POWER PLANT.

- Turn off all fuel to the building by using the valves located outside the water plant at the corner closest to the power plant entrance.
- Remain in the vicinity outside, at a safe distance. Once the fire department arrives, the fire officer on-scene will take charge - do what he or she requests.
- Once the all-clear has been given and the mechanic has verified good mechanical condition of all equipment:
- Turn fuel to the building back ON.
- Proceed with start-up that suits current conditions.
- Closely monitor all equipment operations and watch for any malfunctions that were previously unnoticed.

Equipment Electrical Fire

IMPORTANT	DO NOT ALLOW YOURSELF TO BECOME PART OF THE CIRCUIT. NEVER POUR WATER ON AN ELECTRICAL FIRE, EVEN IF YOU HAVE SECURED THE POWER TO IT.

- Secure power to the equipment if possible.
- Once the power is off, the only thing left burning would be wire insulation.
- If the fire doesn't seem to be going out, use the FE 36 extinguisher to put it out.

CAUTION	IN THE PROCESS OF OPENING THE EQUIPMENT PANEL TO SEE WHAT WAS/IS BURNING, YOU WILL LET OXYGEN IN, WHICH WILL CAUSE A MOMENTARY FLARE-UP OF THE FIRE.

Motor Control Center (MCC) Panel Fire

The Motor Control Center is the equipment on the nearest the power plant. It is the source of all power to the water plant. The transformer is located outside by the power plant.

- Go to power plant.
- Contact LINECREW.
- Tell them it is an EMERGENCY REQUIRING IMMEDIATE RESPONSE.

IMPORTANT	ONLY LINE CREW PERSONNEL ARE AUTHORIZED TO OPEN THE TRANSFORMER TO SECURE POWER TO THE WATER PLANT.

Debris Fire

- Use the FE 36 extinguisher to put it out.

Fuel Fire

- Secure the fuel source.
- Use the FE 36 extinguisher to put it out.

Using A Fire Extinguisher

ABC Dry Chemical & FE 36

- Pull the ring pin.
- Hold upright.
- Stand 10 feet away from fire.
- Point spray nozzle at BASE of fire.
- Squeeze the handle.
- Sweep side to side.

IMPORTANT	ONCE AN EXTINGUISHER HAS BEEN USED, EVEN JUST A LITTLE, IT MUST BE RECHARGED. NOTIFY FIRE DEPARTMENT.

Carbon dioxide (CO_2) (Portable 100 lb unit).

- Unwrap hose completely before using.
- Stand unit upright.
- Pull ring from side of handle on top of one or both 50 lb bottles.
- Depress the lever on top of the bottle(s) to open the supply to the hose.
- Stand at a safe distance from the fire (about 10 ft).
- Aim the wand at the base of the fire.
- Use the lever on the wand to control the flow of CO2.

Appendix B RO valves

MOV indicates automatic valves (motor operated valve); RO indicates manually-operable valve. All valves on both skids are numbered the same. Plaques on the skid indicate the valve numbers.

MOV-1	Between multimedia filters and 5-micron filter, then on to the RO vessels
MOV-2	Between Tech-Taylor valve (RO-13) and the turbo boost pump
MOV-3	Product flow to calcium carbonate beds
MOV-4	Product flow to drain
RO-1-5	Multimedia filter system
RO-6	Backwash to waste on multimedia filter systems
RO-7	Drain line for the 5-micron filter
RO-8	Drain/cleaning connection
RO-9	Seawater to high pressure pump
RO-10a	Drain line from the 5-micron filter
RO-11	Between flush pump and 5-micron filter
RO-12	Vent at the top of the 5-micron filter
RO-13	Hand operated RO-13 “Tech-Taylor”™ valve. Adjusts the proportion of output going to product and concentrate. During normal operations, adjust for 28 gpm product output During diversion to drain, adjust for 18 gpm product output because the floor drain capacity is about 20 gpm.
RO-14	Concentrate to drain
RO-15-21	Flush tank system
RO-22	between MOV-3/4 and RO-28
RO-23	Turbo pump
RO-25	FW meter bypass
RO-26	FW meter
RO-27	Product water meter
RO-28	Product water to floor drain
RO-30	CO_2 line

Appendix C Cleaning the premises

Both Shifts

- Clean all laboratory surfaces.
- Clean chemical table at back of control room.
- Clean up any spills or leaks.
- Keep all doorways, stairs, loading docks and pathways free from snow buildup.

Night Shift – As Needed

- Sweep and mop floors.
- Clean control room windows and vacuum control room carpet.
- Clean dust/dirt from all fire extinguisher units.
- Clean dust and dirt from RO 1-2.
- Clean coffee mess area.
- Collect all burnable trash from water plant and remove to dumpster.
- Clean outside surface of all chemical storage lockers located between surge tank and #1 fresh water tank and around fresh water tank #3.
- Clean dust and dirt from around boiler and waste heat recovery equipment.
- Clean dust and dirt from LN_2 equipment.
- Remove food waste to a dumpster in front of dorms.

First of Each Month

- Clean the food refrigerator.

Appendix D Waste Heat Recovery System

Operation and maintenance of the waste heat recovery system is the responsibility of FEMC. The water plant operator is responsible only for recording readings during the 4-hour rounds. The information presented here will enable the water plant operator to assist FEMC personnel when they are working on the system. Water plant operators are not responsible for turning pumps on or off at their discretion.

The waste heat system is an essential part of the operation of the power plant in its current configuration. A primary loop removes heat from the operating generators and pumps hot glycol into the waste heat recovery system. If a pump on the primary loop is not operational, the generators can overheat. If the supply temperature from the primary loop drops below the set point, the backup boiler will be brought on-line and fired to maintain loop temperature.

Other loops connected to the primary loop by heat exchangers heat several buildings on station as well as the water plant. The water plant loop heats the building, the seawater surge tank, and the external freshwater storage tank (#4). Each loop includes two 25 hp glycol pumps. At all times, one pump in each loop is operational and the second is a backup that can be started at any time. All pumps are numbered and the two pumps for each loop are side-by-side. The BACtalk computer (also known as the DDC computer) controls the pumps in the water plant and displays information about the entire system.

P-1 and P-2	Primary loop
P-3 and P-4	Dorms 208 and 209
P-5 and P-6	Crary, JSOC, SSC, and Buildings 155 and 165
P-7 and P-8	Water plant loop

Pump start/stop

IMPORTANT	IT IS CRITICAL TO ALERT THE POWER PLANT OPERATOR BEFORE SWITCHING PUMPS ON THE PRIMARY LOOP. HE/SHE MUST START A SUPPLEMENTAL GENERATOR TO AVOID

OVERHEATING. ADVISE POWER PLANT OPERATOR WHEN THE FEMC MECHANIC HAS FINISHED.

Switching from one pump to another

- On the BACtalk computer, go to the "Pump Controls" page. Each of the two-pump sets are clearly marked with the pump numbers and name of the loop.
- Ensure that "User Controlled Speed" is selected
- Ensure that the manual speed commands show the same speed for both pumps in the set.
- On the pump to be stopped, click the button next to the yellow window; Click STOP and OK
- Quickly click the same button on the pump to be started; click RUN and OK
- At the bottom of the screen click PREVIOUS to return or click MAIN to go to the start page of the BACtalk system.

Start a pump

- Open discharge valves, turn on power to the VFD, place the HOA selector switch on the VFD enclosure in AUTO position.
- Start the pump on the BACtalk computer as described above.

Shut down a pump

- Start the pump on the BACtalk computer as described above.
- Place the HOA rocker switch on the VFD panel to OFF.
- Secure the breaker on the VFD panel.

DDC Computer

An Alerton BACtalk system is used to provide Direct Digital Control (DDC) for the waste heat collection and distribution system. This system provides integrated control of all the systems used to collect, distribute, and use waste heat from the Power Plant engines. In addition to controlling the waste heat processes, the DDC system will also provide control and monitoring functions in other station buildings. The DDC system consists of Programmable Logic Controllers (PLCs), which are located in field panels. These PLCs have the physical inputs and outputs for the system. To interface with the system, a host personal computer (PC)

is installed in both the Power and Water Plant control rooms. To start the computer, see "Starting the BACtallk computer" on page 18.

Heat Recovery Boiler

Startup

1. The 3-way diverting valve, MOV-11, (on top of the boiler) needs to be in the boiler flow position. It should send at least 20% of return flow through the boiler.
2. Open the outlet glycol gate valve the on boiler.
3. Ensure proper alignment of fuel valves.
4. On the computer, choose "Enabled or Automatic" for the boiler.
5. Place service switch in "ON" position. Located on the front of burner wind box.
6. Ensure the AUTO/MANUAL burner control switch is in the "AUTO" position and thus controlled by the DDC system.
7. Place burner control switch in "ON" position.
8. The boiler may or may not start, depending upon glycol temperature. If it starts, observe the following automatic operations:
    - Fuel oil service pump STARTS. Look for 35 psi on the pressure gauge.
    - Atomizing air compressor STARTS. Look for 8-12 psi on the pressure gauge.
    - Observe Fireye Flame Monitor sequence of operation.
    - Pre-purge is 60 seconds.
    - Pilot-trial-for-ignition (PTFI) is 10 seconds.
    - Main-trial-for-ignition (MTFI) is 10 seconds.
    - Observe condition of flame. Look for an even orange flame.
9. If it does not start, call the boiler operator or FEMC
10. Note startup in logbook.
11. Open the glycol supply butterfly valve to boiler when boiler reaches operating temperature.

Shutdown

1. Place burner switch in off position.
2. Place service switch in off position.
3. Close desired glycol flow valves.
4. Secure fuel valves.
5. On the computer, choose “Disabled”.

Appendix E Liquid Nitrogen Plant (LN_2)

Startup

Pre-start

CAUTION	IF THE PLANT HAS BEEN OFF-LINE FOR MORE THAN SIX WEEKS, THE MECHANIC MUST ADD OIL TO THE AIR END OF THE SCREW COMPRESSOR.

1. Check oil level in Cryo-generator and screw compressor.
2. Ensure that the helium pressure in cryo-generator is approximately 18 bar.

Cooling System

3. Open seawater cooling line isolation valve located on back side of seawater surge tank to pump suction.
4. Open PVC seawater return valve.
5. Ensure PVC drain valve is closed.
6. Set seawater cooling pump HOA switch to "**HAND**".
7. Check pressure gauge on circulating pump. If the pump needs priming, open the spigot on the cooling line.
8. Set the glycol circulating pump HOA switch to "**HAND**".
9. Check the glycol flow at Rotameter. It should be about 7 gpm.
10. Check the temperature of the seawater line to ensure cooling flow.
11. Check the glycol pressure at the cryo-generator cooling inlet.
12. The heat trace line will automatically de-energize.

Start

13. Open the ball valves on the PSA skid and at the screw compressor outlet.

14. Set screw compressor control switch to “START.” The compressor should not start at this point. If it does, set the mode switch in the PSA control box to "REMOTE". This slaves the air compressor to the LN_2 compressor.

15. Energize the dryer/separator at the switch located on the lower unit. The fan should start immediately.

16. If the tank has been empty, open the LN2 storage tank vent valve to purge air from the tank for 5 minutes after startup. If the pressure is above 2 bars on the tank pressure gauge, vent the tank until it is below 2 bars.

17. Set the selector on the control panel to "TEST" then to "RUN." The screw compressor should start and the indicator on the liquid nitrogen compressor will indicate a cooling water fault by displaying the number “1” in the status window. Within 90 seconds, the PSA bed should switch columns and the liquid nitrogen compressor should start.

18. Record the date and time of startup in the operator’s logbook.

19. In the equipment log found in the side compartment of the compressor, record the date and time of startup and the hour meter reading from the liquid nitrogen compressor.

20. After 15 minutes of operation:
    - Adjust the flow of nitrogen gas from the PSA bed to about 30%. Raise or lower the gas flow to maintain about 2 bar on the pressure gauge below Rotameter.
    - Set the non-condensable gas flow to 125.
    - Check glycol outlet temperature. It should not exceed 90 degrees.
    - Check the helium pressure and ensure it is between 23 and 25 bar.

CAUTION	*DO NOT EXCEED 25 BAR HELIUM PRESSURE.*

21. While the plant is on, log operating parameters into the logsheet at the same time as the 2-hour water plant rounds.

Shutdown

1. Turn the selector switch on the cryo-generator to the “OFF” position.
2. Set the screw compressor selector switch to "STOP".
3. Turn off the dryer separator.
4. Close the ball valve above the nitrogen flow Rotameter and on the screw compressor outlet.
5. Close the three valves on the liquid nitrogen receiver tank.
6. After 5 minutes, set the glycol cooling pump HOA switch to "OFF". The heat trace line will automatically energize.
7. Set the seawater cooling pump HOA switch to "OFF".
8. Close the seawater isolation valve at the surge tank and close the PVC seawater return valve.
9. Secure non-condensable gas flow.
10. Record the date and time of shutdown in the operator’s logbook. Record the date and time of shutdown along with the hour meter reading from the liquid nitrogen compressor in the equipment log located in the side compartment of the compressor.

Attachments

None