Saltworks

Saltworks Technologies Inc.

SaltMaker Operating Manual

Revision A

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DOCUMENT FOR INFORMATION

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1 Safety

This section highlights the safety considerations during installation, operation, and maintenance of a SaltMaker plant. Operating ranges and constraints are given and must be followed for reliable and safe operation.

1.1 Personal Protective Equipment (PPE)

Figure 1: PPE required

The following PPEs are required for operation of the SaltMaker:

- CSA approved safety boots.
- Safety glasses for eye protection.
- Long sleeves and pants for skin coverage.
- Appropriate gloves for skin protection.
- Hardhat and full face shield when appropriate (e.g. chemical handling).
- Hearing protection inside balance of plant containers when appropriate (e.g. working near air compressors or tank pneumatic vibrators).
- Respirators when appropriate (e.g. chemical handling).

1.2 General Safety

- Identify hazards and take proper steps to reduce or eliminate them before commencing work.
- Know and correctly use PPE for Plant operation.
- Know evacuation routes and keep them clear of all objects.
- Know the locations of Plant Emergency Stop buttons.
- Know the locations of Plant Material Safety Data Sheets (MSDS) and ensure MSDS is up to date.
- Know how and where to isolate sources of energy, such as electrical, thermal, compressed air etc.
- Know the locations of safety equipment (fire extinguisher, eye wash station).
- Establish a list of emergency contacts that is easily accessible by operators. (e.g. plant manager, fire, police).
- Understand potential physical and chemical hazards associated with plant operation.
- Ensure tools and equipment are in good working condition before use.
- Watch for slips, trips and elevation hazards.
- Prior to getting to task, stop and think about your safety and your co-workers

1.3 Hazards and Awareness

A hazard review with qualified individual should be conducted before operations. Personnel should complete risk assessments prior to commencing operation of SaltMaker. Operators should pay particular attention to

the water source and hazards it may pose when water is concentrated or stored in open-top tanks. If a new water source is being operated, a qualified chemist or engineer should be consulted. Lock-out procedures shall be followed. SaltMaker specific hazards and precautions are summarized below.

- Tripping hazards (structure/piping across floor). Uneven floors.
- Slippery surfaces – clean spills and keep floor dry.
- Splashing (skin/eye protection) – exercise care when filling tanks.
- Low ceiling/pipe height – take care when moving in passageways and moving around equipment.
- Voltage/current (disconnect & lockout before servicing) – ask a qualified electrician to perform work on electrical systems.
- High temperature water and steam: take extra precaution when in the vicinity of heat sources and hot water.
- Pressurized piping: confirm isolation and bleed down system prior to work on any pressure system. Only qualified personnel are to open, and work on pressure systems.
- Process Chemicals - check site MSDS for before use; process fluid in the SaltMaker is being concentrated and hazards may be amplified.
- Compressed air & high pressure liquids – take caution when connecting, purging, and disconnecting lines, regularly inspect hoses and fittings for leaks or wear.
- Noise - hearing protection is required near air compressor or other noisy equipment
- Ergonomics - provide adequate task lighting, kneeling pads as necessary.

1.4 Emergency Stop

Multiple emergency stops (E-stops) are located around the plant for an immediate shut-down if operators notice conditions that place operators and other personnel in danger (ex. smoke, burst pipes etc). Pressing the E-stop will initiate a stop to all motors and processes. Once stopped, the SaltMaker will cool down and process fluid will likely crystallize inside the plant. If the hazard is removed, release the E-stop and initiate a normal shutdown flush. The normal shutdown sequence flushes the plant of process fluid and ensures that internal crystallization does not occur.

If an E-stop is pressed and the plant cools for greater than 20 minutes, there is a very high likelihood that after an emergency stop, operators will face:

- Damaged pump seals
- Salt crust formation and clogged pipework

These risks can be mitigated by completing a “pre-startup flush” prior to starting up. This can be activated in the “100 Overview” selection tab under “Auto Settings”. Refer to *Appendix K: Salt Crust Prevention and Instructions* for more details.

1.5 Operating Ranges and Constraints

For the safety of the operator and protection of equipment, all inlet water must be within operating range of the SaltMaker.

- Operating pressure 100-150 kPa / [15psi]
- Max operating pressure 700 kPa / [100psi]
- Max operating temperature 90 °C / [194 °F]
- Max/min heat source temperature 120 °C/60 °C [248 °F/140 °F]
- Air loop pressure < 15 kPa
- Compressed air system built in, 150 psi
- Outside temperatures -40 °C to +40 °C / [-40 °F to 104 °F]

Inlet Specifications

- Inlet suspended solids < 1 mm (basket strainer)
- Inlet total dissolved solids (TDS) *No limit
- pH: 2 < pH < 11
- Organics *No limit
- Hydrocarbons *No limit
- Chlorides *No limit

Feed water must be chemically compatible with wetted parts: PVC, PVC solvent glue joints, polypropylene (PP), polyethylene (PE), fiber reinforced plastic (FRP), noryl, and titanium.

The equipment within the SaltMaker is not explosion proof rated, therefore flammable fluids and vapors should not be treated in this system.

The SaltMaker heat recovery module uses titanium heat exchangers to transfer heat between air and brine. Titanium heat exchangers have excellent corrosion resistance to concentrated brine. However titanium is not immune to all types of corrosion. Ensure compatibility of the process brine and titanium before operating the SaltMaker. Contact Saltworks if unsure.

All personnel must be familiar with this manual and the Manufacturers Data Registry (MDR) before operating or maintaining the SaltMaker. The MDR contains piping and instrumentation diagrams (P&ID), electrical schematics, operating and maintenance manuals, datasheets and other useful documentation. Original manufacturer's documentation is included in the MDR. Operators must be familiar and skilled with water pumps and piping systems.

Inappropriate SaltMaker operation or maintenance will void Saltworks' warranty.

2 Process Understanding

This section outlines a high level process overview of the SaltMaker, followed by operating procedures. General maintenance and troubleshooting procedures are located in the appendices.

2.1 SaltMaker Process Overview

The SaltMaker plant is based on a humidification-dehumidification (HDH) cycle to produce condensate (freshwater) and concentrated brine/solid salt. To increase energy efficiency and production, the SaltMaker uses a multiple effect humidification concept. Moderate grade heat (80° to 100ºC) is used to evaporate and condense water in an air stream in successive effects. The latent heat of condensation is recycled as it is downgraded, with each effect operating at 10-15°C lower than the previous effect. Each effect is operated in series. Within these effects there are multiple sets, which operate in parallel. See illustration below:

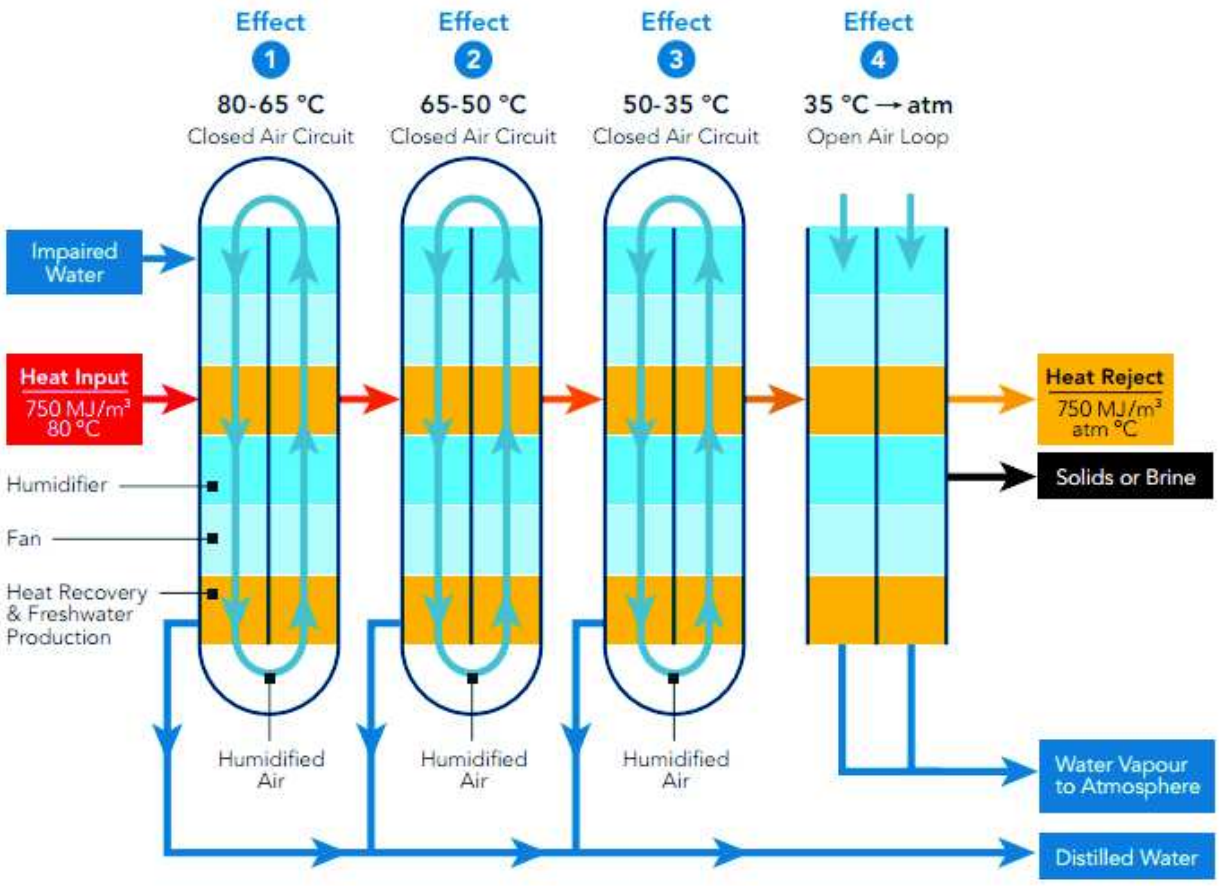

Figure 2: Simplified SaltMaker Process

A simplified process diagram shows how saltwater feed is transferred from effect 1 to subsequent effects. Note that the diagram describes a four effect SaltMaker with the first three effects being closed air loop and the fourth effect open to atmosphere. Depending on the configuration, the fourth effect may be a closed air loop system for zero air emissions. Further note that the plant is normally configured such that effect 1 and 4 concentrate the saltwater, and then blow down process fluid to effects 2 and 3 for crystallization. Please refer to your plants' specific design PFD for details.

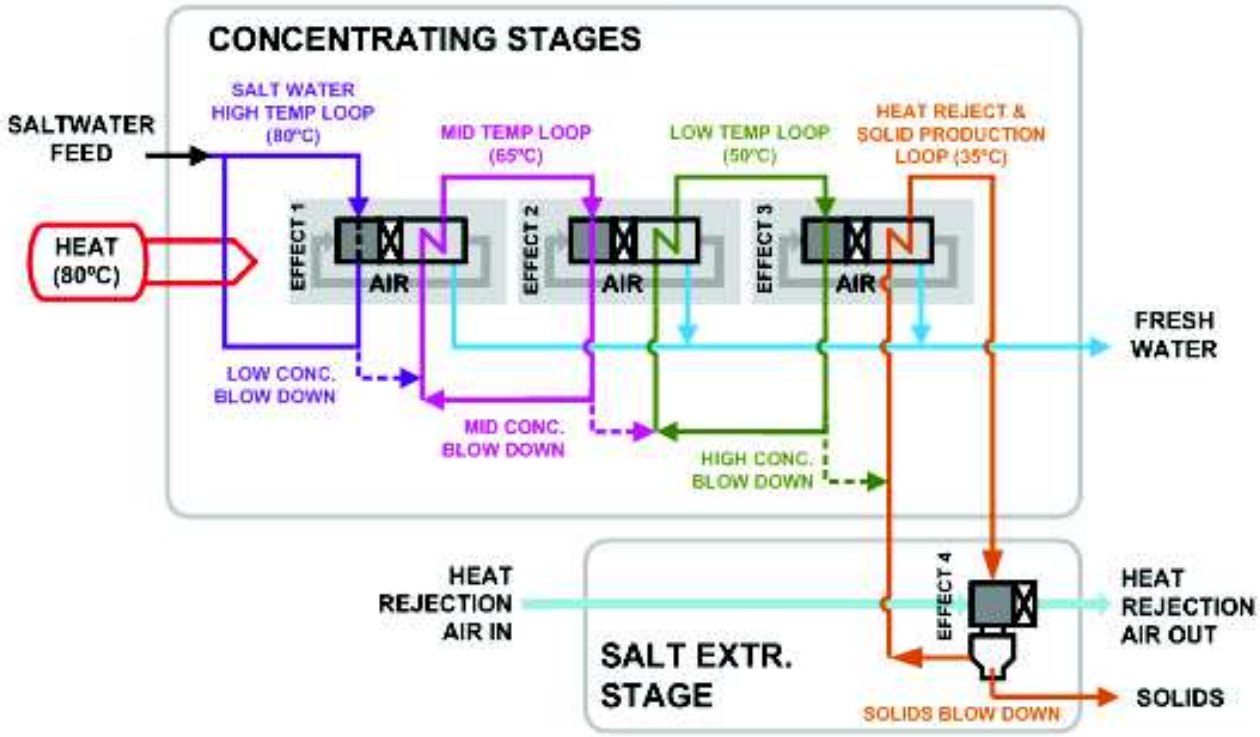

Figure 3: Multi Effect - SaltMaker Elementary Process Diagram

2.2 Humidification – Dehumidification Cycle

The SaltMaker concentration process involves concentrating feed water through a humidification – dehumidification (HDH) process. This is a low temperature process, which enables use of fiberglass reinforced plastic (FRP) for plant module construction, and cPVC and PVC for the pipe work system.

Each effect operates at a lower temperature than the previous effect. Effects 1, 2, and 3 operate in closed loop configuration at higher temperatures to increase plant capacity while effect 4 operates in open loop. Air can hold more moisture per unit volume at higher temperatures. This means that the capacity of the SaltMaker will increase when effect 1 is ran at a higher temperature. Ideally the plant will operate at its maximum E1 temperature of 90ºC to maximize capacity.

Effect 4 operates at near wet bulb temperature (lowest temperature of all effects) in an open loop configuration. For emission concerns, there is an option to run effect 4 in closed loop.

2.3 SaltMaker Effects

The SaltMaker can be composed of four effects or five effects. In the first effect of both a four and five Effect SaltMaker, the process water is heated by an external thermal source. Process water in successive effects is heated by latent heat of condensation in the heat recovery module of the previous effect. This process allows the SaltMaker to use the recycle heat four times to drive evaporation. The fourth effect operates at the lowest temperature. In a five effect SaltMaker, Effect 5 functions as the SaltMaker feed tank and effect four cooling. Addition of the fifth effect increases capacity by additional cooling of the fourth effect brine.

2.4 Freshwater System

The freshwater system collects SaltMaker condensed water and delivers it to either the hot wash system or discharges it from the SaltMaker plant for re-use, further treatment of volatiles such as ammonia, or disposal. Hot wash cycles are described below. Optional systems for further treatment of SaltMaker condensed water is described in section 3.2.

2.5 Hot Wash System

The hot wash system is critical for SaltMaker maintenance and operation. It aids in salt crust removal on equipment and ensures longevity of the plant. Hot wash cycles consist of periodically flushing each effect with hot water to remove salt crust build up, reducing maintenance and keeping wetted parts of equipment operating smoothly. Described below are the different types of SaltMaker hot washes, which include: evaporator basin wash, pipe work wash, evaporator packing spray wash, level sensor wash and pump seal flush. All wash cycles, except for manual cone tank wash, can be initiated by a set timer or manually by the operator. Hot wash frequency varies with water chemistry, but should be kept to a minimum to prevent brine dilution and to limit effect downtime.

2.5.1 Evaporator Basin Wash

The evaporator basin wash is a short hot wash used to clean the saltwater pump, piping, the heat recovery radiator, and the evaporator. Once the evaporator wash is initiated (automatically or manually), hot water is sent through the pump and into piping. This water then flows through the heat exchanger and into the evaporation module. This wash reduces salt build up with minimal downtime and brine dilution. Normal operation of the SaltMaker resumes immediately after this burst of hot water is sent through the system.

When operator suspects a salt build-up problem (e.g. pump loads increase), it is recommended that the operator try this wash first. This wash will be enough to help clean pumps and dislodge salt buildup in many cases.

2.5.2 Pipe work Wash

The pipework hot wash is a thorough wash to clean the saltwater pump, piping, and the heat exchanger in the heat recovery module. Once the pipework wash is initiated (either manually or automatically), compressed air

will enter the piping and push the saltwater back into its respective main tank for a user defined duration. Hot water flows closed loop through the piping, pump, heat exchanger, and back to the satellite hot wash tank. The duration of this cycle will be set by the operator. Once the hot wash is finished with the first set, it will then clean the remaining sets in the effect using the same order of operations described above. For the final set, instead of returning hot wash water back to the satellite tank, the hot wash water will be cycled back into the main tank.

2.5.3 Evaporator Spray Wash

The evaporator spray hot wash cleans the evaporator fill. Nozzles are mounted inside the evaporator to increase the effectiveness of the spray. Once the evaporator spray wash is initiated, the pump will stop, and the valve for the evaporator spray wash will open. The hot water from the evaporator spray wash will come from the main hot wash system. Duration of the evaporator spray wash can be set by the operator.

2.5.4 Pump Seal Flush & Pump Shaft Wash

The pump shaft wash is a short hot wash that sprays water directly onto the pump shaft to prevent salt buildup. Once the pump shaft hot wash is initiated hot water from the main hot wash system is sprayed onto the pump shaft. Duration is set by the operator. Use this wash when there is visible salt build up around the shaft between the pump and the motor.

2.5.5 Shutdown and Start-up Wash

Shutdown washes should be performed before plant shut down to remove concentrated brine from the SaltMaker pipe work system to prevent potential salt crystallization and clogging in valves, pumps, or pipe work. The shutdown wash sequence is automated. Before shutting down the SaltMaker, confirm the "Shutdown Wash" control is enabled for each effect, and the system will perform the proper washes before shutting down.

Before commencing SaltMaker operation after an emergency stop or alarm trip with no shutdown wash, the operator should perform a start-up flush. This wash cycle will aid in removing any crystallized salts resulting from concentrated brine remaining in the system. It is important to remove any crystallized salts from the system to protect equipment (e.g. pumps, valves, pipe work) and ensure SaltMaker reliability, The start-up wash is manually initiated by selecting "FLUSH NOW" under the "Overview" auto settings 1 tab on the HMI.

2.5.6 Chemically Enhanced Hot Wash

A chemically enhanced hot wash is used in the event that the SaltMaker heat exchanger surface or pipe work system becomes crusted with salts. This hot wash involves cycling a chemical solution through the pipe work system where the crust has formed; the type of chemical solution used in the hot wash cycle is dependent on the type of crust formation. Manual inspections of heat exchanger surface and evaporator will inform the operator the need of a chemically enhanced hot wash. Procedures on chemically enhanced hot washes and chemical solution preparation can be found in *Appendix K: Salt Crust Prevention and Instructions*.

2.6 P&ID and Tagging System

Saltworks' standardized tagging system is listed below:

- SaltMaker tanks (TK)
- Pumps (P)
- Valves (ABV/MBV)
- Solenoid valves (SV)
- Air lines (CA)
- Fluid lines (SW)

Tags include the component name, component size, drawing number, SaltMaker effect number, and a sequential number. Table 1 provides some exemplary SaltMaker tag descriptions.

Table 1: SaltMaker Tagging System

SaltMaker Component	Label Example	Label Description
Valve	ABV4-214-1 or MBV4-214-1	• "ABV" is an automatic ball valve • "MBV" is a manual ball valve • "4" is the valve component size, in inches • "214" is the drawing number, where 1 is the effect number • "1" is the sequential number
Fluid Lines	SWA4-001-P80	• "SWA" is the fluid type • "4" is the pipeline size, in inches • "001" is the sequential number • "P" is the material type • "80" is the schedule
Air Lines	CA25-001-CP210-3	• "CA" is the SaltMaker air line • "25" is the air-line size • "001" is the sequential number • "CP210-3" is the panel that the line originates from
Fluid type	---	• SW: Saltwater • CON: Condensate • HW: hot wash • TS: Thermal Source • ACD: Acid

		• ATF: AntiFoam • BIO: Biofilm
Air Line Size	---	• 75: 0.75” • 50: 0.50” • 25: 0.25”

3 SaltMaker Construction

This section describes the major physical components of the SaltMaker system.

3.1 SaltMaker System

The SaltMaker is designed for full modularity; everything from individual subsystems to plant packaging is modular. Modularity offers the following benefits:

- Rapid site dispatch, simple site installation, and flexibility for future plant capacity expansion by adding additional “blocks”.
- Transport and installation using readily available trailers and cranes.
- Each module is mass produced and quality assured for repeatable production.
- Modules slide in and out for easy installation, cleaning, and replacement. (see Figure 8)
- Modules can be easily cleaned by “power washing” and then reinstalled.

Figure 4: Repeatable Mass Produced Evaporation Modules

Figure 5: Fan Modules

Figure 6: heat recovery modules

Figure 7: Assembled Modules

Figure 8: Module Removal by Forklift

Future expansion can be achieved with the addition of side-by-side SaltMaker sub-systems. A SaltMaker consists of the following core elements:

A. Two lower level 40' Balance of Plant (BOP) containers
B. Four upper level 20' effects, with two said effects placed on one lower BOP Container
C. Four piping cages, one on top of each upper level 20' effect
D. Work platforms between and beside each BOP container, allowing for maintenance access to effects.

The above core elements are shown in the figure below. Developing larger plants or expanding an existing plant requires additional elements, modules, and containers. For larger plants, some ancillary services may be shared. For example, larger air compressors and hot water heaters may be installed in place of multiple smaller units.

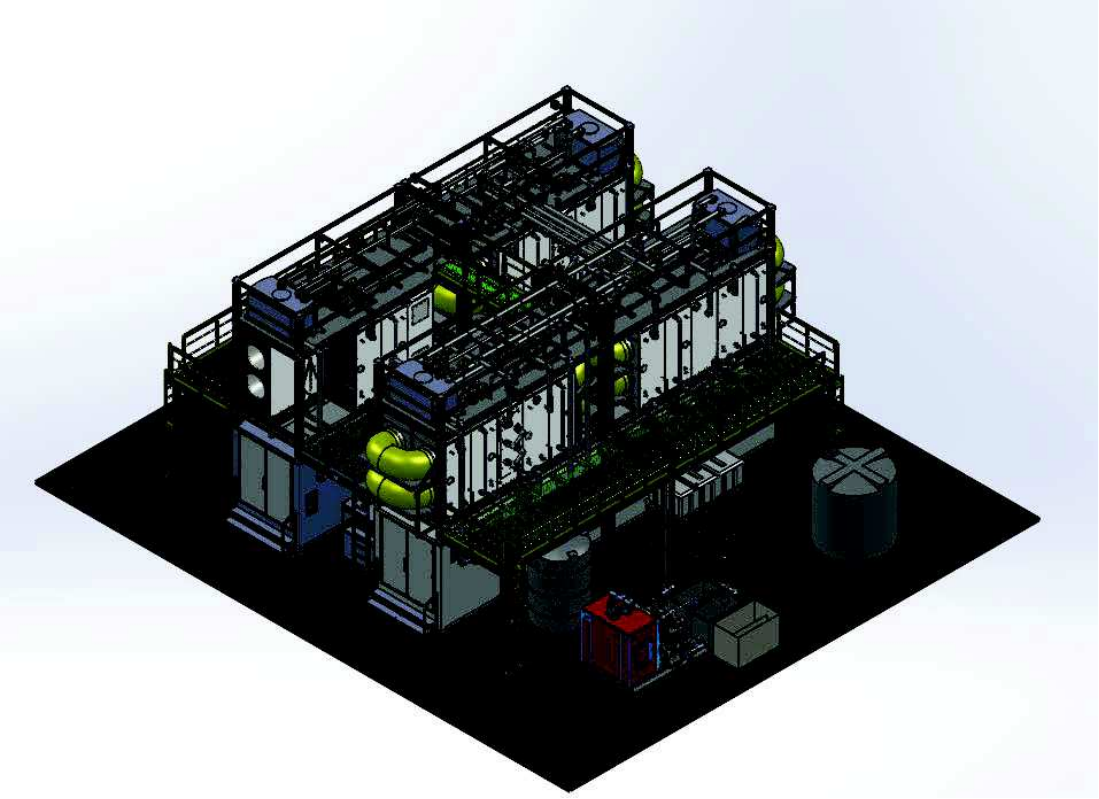

Figure 9: SaltMaker Isometric View: 2 x 40’ BOP & 4 x 20’ Effects + Work Platforms

3.1.1 Containers

Each main floor container houses Balance of Plant (BOP) systems. These systems include saltwater inlet, heat recovery, freshwater, hot wash, electrical, controls, and air distribution.

3.1.2 Frames

Four 20’ frames are placed on top of each container. Their purpose is to provide structure and support for standard evaporation, heat recovery, and fan modules.

3.1.3 Effects

Each SaltMaker effect is made up of repeated units which slide in and out of the ISO container structure for ease of site construction and service.

3.1.3.1 Evaporation Module

Heated water enters the top of the module and moves through the fill. Some of the water evaporates as air passes through the fill, concentrating the brine solution.

3.1.3.2 Heat Recovery Module

Water vapor condenses on the heat recovery heat exchanger, producing freshwater. The condensing water vapor transfers latent heat of condensation to the heat exchanger surface, which warms the brine solution of the subsequent effect.

3.1.3.3 Fan Module

The fans move air around the humidified air loop. There is one fan module per closed air loop effect. There are two fan modules per open air loop effect.

3.1.3.4 Fan Duct

The fan duct connects end modules together for humidified air to flow through. The fourth effect is normally open to atmosphere and does not include an air duct. Instead, air is driven in parallel by two fan modules and flows through two ducts.

Figure 10: SaltMaker Effect

Figure 11: Site Installation

Figure 12: Evaporation Module

Figure 13: Heat Recovery Module

Figure 14: Fan Module

3.1.4 SaltMaker Tanks

The SaltMaker tanks are designed to hold brine or wastewater. Tanks are made with fiber-reinforced plastic (FRP), polyethylene or polypropylene. Tanks holding process waters are insulated to retain heat and increase process efficiency. Each tank has a level indicator attached for easy level identification. The tanks include a variety of drains and process instrument attachments per your P&ID.

3.1.4.1 Tank Pneumatic Vibrators

Tank pneumatic vibrators are used to agitate and keep saturated fluids from coagulating in the brine tank to prevent clogging of pumps, pipes and valves. Tank pneumatic vibrators are triggered by operator-set timers. Pneumatic vibrator function is readily confirmed by noise. If vibrator failure is suspected, the vibrators should be removed and replaced. The problematic units can be sent to Saltworks for rebuild.

3.1.4.2 Auger / Hose Pump

The solids extraction auger or hose pump is designed to remove slurry that settles at the bottom of the brine cone tank. Depending on brine chemistry, solids or slurry will be extracted from the brine tank into a collection bin. In the case of slurry extraction, solids are extracted out and the supernatant liquid is pumped back to the brine tank. Refer to your P&ID for your solids extraction system.

3.1.5 Pump Skids & Pipework

The SaltMaker uses variable speed pumps to circulate saltwater around effects. The pumps are driven by variable speed drives that provide a controlled start-up and shut-down of the plant. The pipes are mounted on a pump skid that includes the pipework and instrumentation necessary to connect to the effect modules and

the hot wash system. The drives also vary speed of the pumps to induce turbulent flows to reduce scaling and fouling. The electrical draw of the VFD pump is monitored for indication of system fouling.

The SaltMaker effect pipework treating high temperature brine including effects 1, 2 and 3, and hot washes are constructed from schedule 80 cPVC. cPVC can operate reliably at up to 90ºC at low pressures. The pipework on the effect running at the lowest temperature, effect 4, is constructed from PVC, schedule 80, and can operate reliably at up to 60ºC.

3.1.5.1 Pump Seal Flush & Pump Shaft Wash Systems

The pipework on the pump skids include pump seal flush & pump shaft wash systems. These systems keep salt crystals from accumulating near the pump seals and the pump shaft and are crucial for long term reliability of the SaltMaker. If the salt crystals accumulate, they would wear out the pump seals and cause premature failure of the pump.

3.1.6 Thermal Source

The thermal source system provides the heat energy the SaltMaker requires for treatment of brine solutions. The main components of this system are titanium heat exchangers used to transfer heat from the hot waste source (90ºC to 120ºC) to the 1st effect brine. The 1st effect heat exchangers are supplied with a hot fluid provided by external means. The hot fluid provides the energy required for evaporation of brine in the 1st effect. The maximum temperature of 1st effect treated water is 90 ºC. This heat is recycled to the 2nd, 3rd, and 4th effects through the heat recovery modules.

3.1.7 Electrical and Control System

The electrical system provides the electrical power needed for pumps, fans, and controls. The control system consists of an industrial Programmable Logic Controller (PLC), Input and Output (I/O) modules and networking hardware, and the human machine interface (HMI). See figure below for an overview of the electrical and control system.

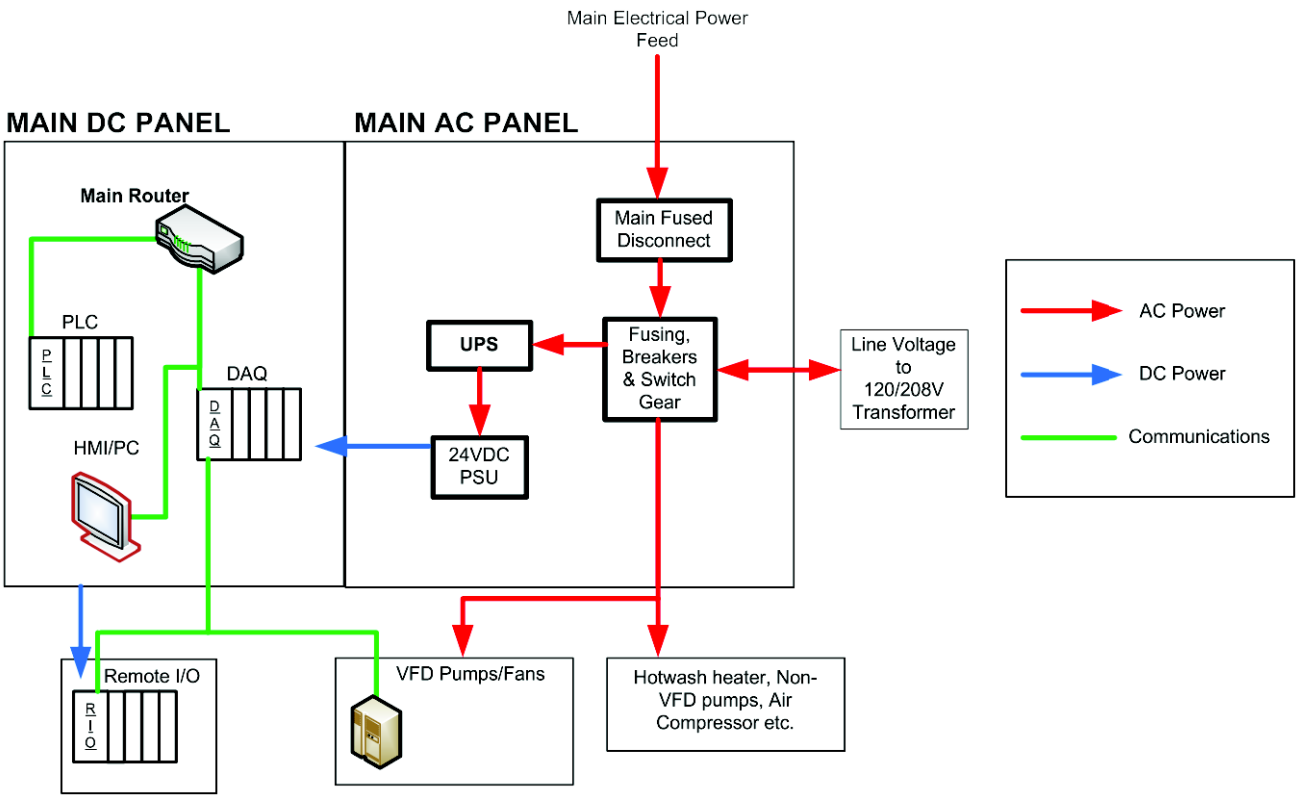

Figure 15: Simplified Electrical & Control System Architecture

3.1.7.1 Main AC Panel

The Main AC Control Panel is located in the electrical section in one of the BOP containers, and supplies AC three-phase power to Satellite AC Effect panels as well as BOP level equipment. This panel houses power distribution hardware and circuit protection devices for the freshwater system pumps, air compressor and other equipment. The main AC control panel also houses redundant low voltage DC power supplies for instrumentation and control, as well as an uninterruptable power supply to protect sensitive equipment. The uninterruptable power supply has approximately 45 minutes of backup power. When backup power runs low, the unit will initiate a proper shutdown on the HMI PC. The figure below shows the AC panel and the main disconnect for the SaltMaker plant.

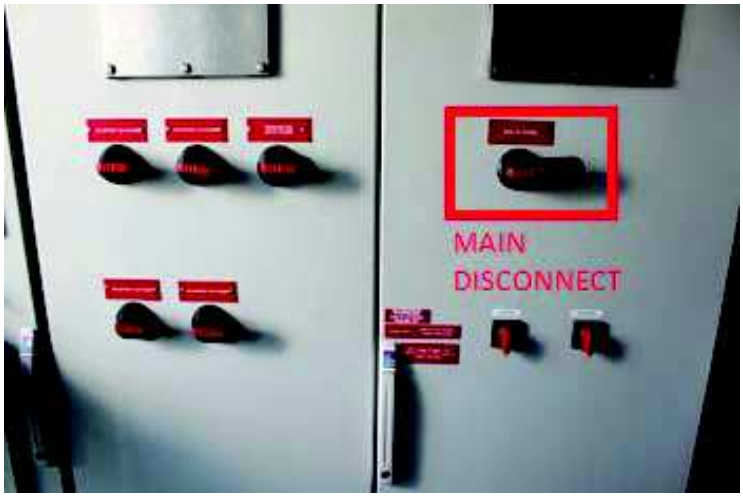

Figure 16: Main AC Panel

3.1.7.2 AC Step down Transformer

The transformer on the other side of the AC panel converts high voltage (480V or higher) VAC into 120V/240V for controls, instrumentation and container infrastructure power. This includes lights, ventilation fans, and receptacle power. Do not place any objects on the transformer – it will get hot and could cause serious damage.

3.1.7.3 Satellite AC Effect Panels

The Satellite AC effect Panels house variable frequency drives that control motors for the process pumps and fans. The panels obtain power from the Main AC Panel. Variable frequency drives allow the control system to adjust the speed of AC motors that drive pumps. The drives can also monitor torque, current, and pump load. This data gives operators information about process conditions such as the degree of scaling or fouling inside pumps and pipes.

Figure 17: AC VFD Pump Panel

3.1.7.4 DC Control Panel and Satellites

The Main DC panel and satellite DC panels house the instrumentation and control gear. The main DC panel (located beside the main AC Panel) houses the main PLC that controls all plant functions.

The PLC handles logic and controls the plant operation based on user inputs from the HMI and sensor feedback from the process. I/O modules on the PLC are connected to sensor signals. Remote I/O units are installed inside Satellite DC Control Panels to gather all instrument data and convert the data to an ethernet signal to send to the main PLC. This enables modular expansion while minimizing cable runs and risk of cable damage.

3.1.7.5 Compressed Air & Air Satellite Panels

The compressed air system is an important component of the SaltMaker. The system provides air to

- Control actuated ball valves (ABVs) to direct fluid flow, which is critical for start-up, shut down, and cleaning cycles.
- Energize pneumatic vibrators to prevent coagulation in brine tanks.
- Energize diaphragm pumps for fluid transfer and solid extraction (refer to P&ID for specific SaltMaker systems).
- Purge residual fluid to respective tanks during hot washes.

The compressed air system includes the air compressor, particle and coalescent filters, air dryer and pneumatic lines to valves and valve banks. Filtered air is provided to air satellite panels that house solenoid valve banks. When initiated, these solenoid valve banks provide air to the solenoid valves that power the pneumatic equipment, turning them on or off.

3.1.7.6 Instrumentation and Automation

The SaltMaker system uses a variety of sensors and automation hardware to achieve reliable plant operation. Sensors include temperature, pressure, flow, level, conductivity, and pH. Saltworks standardized on 4-20 mA

analogue sensor outputs to minimize signal loss issues. 4-20mA signals are read by input/output (I/O) modules on the PLC or Remote I/O units.

The SaltMaker uses the following types of instruments:

Pressure:

These sensors are used to measure pump discharge pressure on main water lines on each effect. Trends in pressure readings can help the operator identify pipe scaling issues. It can also be used to identify pump problems.

These pressure sensors use piezoresistive measuring cells (similar to a strain gauge) to measure pressure being applied on the sensor connector. A built in transmitter amplifies this signal and converts it into 4-20mA to communicate with PLC modules.

Level:

These sensors are used to measure the level on SaltMaker tanks. Different types of sensors are used depending on the fluid and process conditions.

> ***Pressure:*** these sensors use piezoresistive measure cells that are calibrated at high resolution to measure level changes in tanks. They are mounted near the bottom of the tank. Because they measure hydrostatic pressure, they are affected by density changes of the fluid.
>
> ***Ultrasonic:*** these sensors send ultrasonic sound pulses and measure the time it takes for the pulses to reflect and bounce back from the process medium below and return to the sensor. This is translated into a level measurement. These sensors are mounted on top of the tank and do not come into direct contact with process fluids.
>
> ***Radar:*** these sensors send radar pulses and measure the time it takes for the pulses to reflect and bounce back from the process medium below and return to the sensor. This is translated into a level measurement. These sensors are mounted on top of the tank and do not come into direct contact with process fluids. In general, radar has performance and reliability advantages over ultrasonic. Suitability of radar vs. ultrasonic sensors depend on actual tank conditions and is outside the scope of this manual.

Level sensor feedback allows for automated level control by filling and transfer of water in process tanks. The system is vital to continuous operations of the SaltMaker. Proper SaltMaker operations produce an unique saw-tooth pattern on main effect tanks, with a slow decrease in tank level due to evaporation and a fast increase in levels due to transfer of process fluids into the tank. Automated level warnings help operators locate issues before they become serious enough to interrupt operations.

Conductivity:

These sensors are used to measure conductivity of water, which is proportional to the ionic or salt concentration of the water. The SaltMaker deploys two different types of conductivity sensors:

> ***Contacting conductivity sensors:*** These sensors employ a potentiometric method. Two or four electrodes are submersed in the sample fluid. The sample fluid completes the electrical circuit. An

alternating current is applied on the electrodes and the voltage potential is measured. This voltage potential is proportional to the conductivity of the fluid. Saltworks uses this type of sensor to measure conductivity range from 0-5mS.

Inductive conductivity sensors: Two coils are wounded inside the ring shaped sensor. One coil drives a magnetic field with a known voltage and induces a current on the second coil. This current is proportional to the conductivity of the measured fluid. This type of sensor is suitable for measuring conductivity in the 5-1000mS range.

Conductivity sensor signals help operators monitor concentration of process water in different effects. By tracking an increase in concentration of brine over time, these sensors ensure that the SaltMaker is functioning normally.

pH:

These sensors contain a potentiometric cell made of pH-sensitive electrodes. Voltage is measured across the electrodes and the signal is amplified and processed into a 4-20mA signal. PH sensors help monitor condition of treated and untreated water. They are also used in optional acid and base dosing systems to monitor and control pH to adjust solubility of the process water to different salts.

Temperature:

These sensors measure the temperature of the process streams in the SaltMaker. The SaltMaker uses resistive RTDs (resistance temperature detectors) which are sensors that change in resistance due to a change in temperature. This signal is amplified and processed into a 4-20mA signal with a transmitter.

Temperature differences between the effects provide the main driving force for the humidification-dehumidification (HDH) process. Abnormal temperature differences would indicate problems with heat transfer between one effect and the other. These sensors help operators track temperature across all the effects to confirm normal operation.

3.2 System Options (refer to Appendices)

3.2.1 Gas Fired Thermal Power Package

Saltworks can provide pre-packaged gas fired water heater packages as the thermal source, while some clients elect to provide their own waste heat or low pressure steam. Please review your project Design Basis, or P&ID for details. Operation of Saltworks gas fired water heater package is outside the scope of this Operating Manual. Documentation for this Thermal Power package will be provided in the MDR if this option is employed on site.

3.2.2 Post Treatment RO

A reverse osmosis (RO) system may be incorporated downstream of the SaltMaker for further polishing of the produced SaltMaker condensed water. For example, the RO system is used in the removal of ammonia which may have “evaporated over” into the condensed water. Detailed RO operating procedures can be found in the *Post Treatment RO O&M Manual* in the MDR.

3.2.3 Acid, Base Dosing Systems

Depending on process water chemistry, an acid or base dosing system may be integrated into the SaltMaker processes. Acid dosing can be employed to reduce scale formation (e.g. carbonates) or to preferentially keep some compounds dissolved in the brine (e.g. ammonia) by adjusting the pH of the brine between pH 3 – 5. Similarly, base dosing can also be employed to keep compounds dissolved (e.g. hydrogen sulfide) by adjusting brine pH between pH 9 – 10.

The acid/base dosing system consists of dosing hardware as well as pH probes installed on the process water line and Effect 1 hot wash tank to continuously measure pH. Should the solution pH fluctuate above or below the operator set point, acid or base solution will be dispensed to the appropriate tank. Operating procedures on acid and base dosing systems can be found in *appendix I: Acid & Base Dosing System O&M Instructions*.

3.2.4 Antifoam Dosing System

Depending on process water chemistry, brine foaming may occur as the process water is concentrated. Foam may overflow from the tank, leading to a containment breach. To keep foaming under control, an anti-foam chemical can be added to the brine tanks. The Antifoam system consists of foam detection sensors, dosing hardware, and timer based or foam detection dosing controls. When antifoam dosing is initiated, compressed air is used to open valves and to power the dosing pump for chemical dispensing into the specific tank. Procedure on how to configure the antifoam dosing system can be found in *Appendix J: Antifoam Dosing system O&M Manual.*

3.2.5 Antiscalant Dosing Method

Antiscalants are added to the concentrated brine to inhibit formation of calcium scaling on SaltMaker wetted parts. Contact Saltworks for recommended antiscalant dosing frequency and quantity. Typically, the operator would add antiscalants once every 48 hours. Detailed antiscalant dosing procedures can be found in *Appendix K: Salt Crust Prevention and Instructions*.

3.2.6 Salt Extraction System

The SaltMaker salt extraction system is designed to include either screw augers or brine extraction pumps. Please confirm your SaltMaker design with P&ID.

3.2.6.1 Salt Extraction System: Screw Augers

The salt extraction system screw augers are designed to extract suspended or settled solids. The screw augers are located in the brine tanks of the effect 2 and 3; the highest concentration effects. These augers are controlled by a VFD and therefore speed is adjustable by the operator. Auger controls is timer-based with a high speed and low speed setting, and has forward and reverse rotation configuration. When saturation limits are exceeded, salt precipitation occurs. The screw augers extract the solids into a mesh bag inside the collection bin. The mesh bag filters the solids from any brine that may be extracted along with the solids. The brine is recycled back to the brine tank for further concentration. The solids captured by mesh bag filters can be disposed of as solid waste.

3.2.6.2 Salt Extraction System: Brine Extraction Pumps

The salt extraction system brine extraction pumps are designed to discharge concentrated brine from the base of the effect 2 and 3 brine tanks. These pumps are designed for pumping fluids near saturation. The pumps serve 2 purposes:

1) Concentration control: once effect 2 and 3 tanks reach a certain concentration, these pumps discharge some of the brine to maintain steady concentration of E2 and E3 brine.
2) Recirculation and agitation: when the salt extraction system is not discharging, the pumps run in recirculation mode to concentrate the tank to the appropriate concentration to discharge or to prevent salt crust formation when the process fluid is near saturation. Additionally there are vibrators inside effect 2 and 3 cone tanks that turn on and off based on a timer to agitate and break up solids forming in the tank.

3.2.7 Biofilm Treatment System

The biofilm treatment system is used to keep biological growth in the heat recovery modules and basins under control. The system includes a treatment solution holding tank, an air-powered pump, air-actuated valves, and a set of nozzles to spray heat recovery modules on all sets in all four effects. This treatment system distributes a disinfectant mixture to kill micro-organisms and keep slime from forming on heat exchanger surfaces and in collection basins. Details on Biofilm Treatment System can be found in *appendix L: Biofilm O&M Instructions.*

4 Operating the HMI

The SaltMaker is controlled by a programmable logic controller (PLC). This PLC communicates to an industrial PC through the plant's network. The industrial PC acts as the human-machine interface (HMI), and allows operators to monitor operating conditions in real time, adjust set-points, and investigate alarms.

All operators should first familiarize themselves with the HMI for their plant and the associate process and instrumentation diagrams (P&ID). Without controlling the plant, navigate the control screens and locate all key process devices such as pumps, fans, and actuated ball valves both on the HMI and physically in the plant. *The operator must read and understand Appendix D SaltMaker Control Narrative before starting SaltMaker operations.*

The HMI is primarily divided into two sections: controls and indicators. The left side of the HMI houses two levels of controls: plant level ("Main Mode"; upper left) and subsystem level ("Settings"; lower left). The right side of the of the HMI houses indicators that displays the visual depiction of the subsystems and their associated valves, tanks, pumps and other relevant equipment. The emergency stop button ("E-STOP") is located above the "Main Mode" in the upper left corner of the HMI. Figure 18 below shows the HMI and the sections.

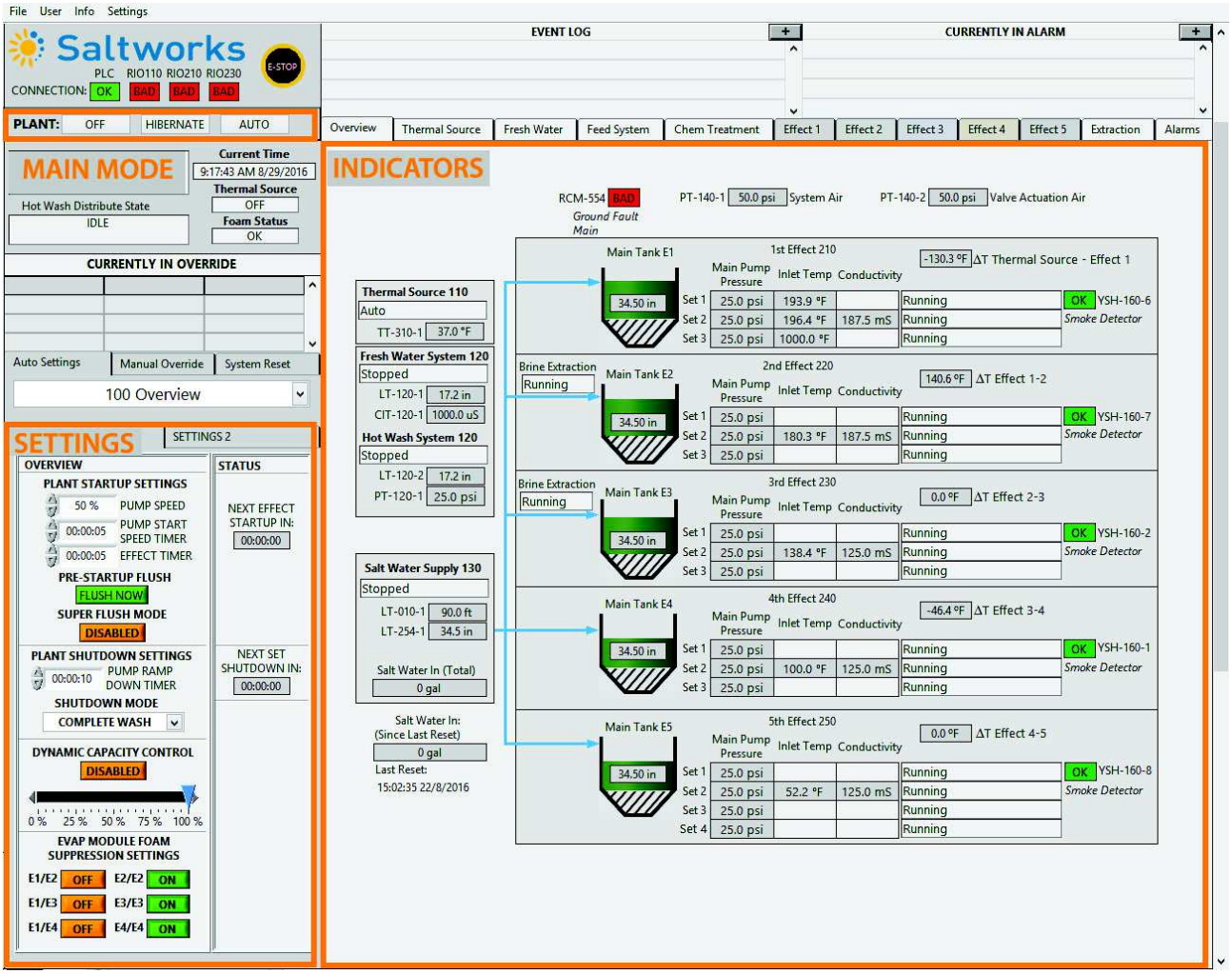

Figure 18: SaltMaker HMI[1]

The HMI has many subsystems within the plant that can be controlled independently, including:

- Overview
- Thermal Source
- Fresh Water System
- Feed System
- Chem Treatment
  - Acid Dosing System (Optional)
  - Anti-Foaming System (Optional)

[1] Numbers on this screenshot are not representative of process setpoints

    - Biofilm Treatment (Optional)
- Effect 1
- Effect 2
- Effect 3
- Effect 4
- Effect 5

4.1 HMI: Pre-Start up

4.1.1 SaltMaker Operating Parameters

SaltMaker operating settings can be loaded from and/or saved to a file with a .sil extension. To save or load the SaltMaker settings go to “File” and select “Plant settings” to bring up the Plant Settings Datafile Path dialog box (see figure below). Select the proper parameter settings file (e.g. default.sil) using the folder button on the lower left, and click “Load” to load parameters from file, or click “Save” to save the current operating settings to the selected file.

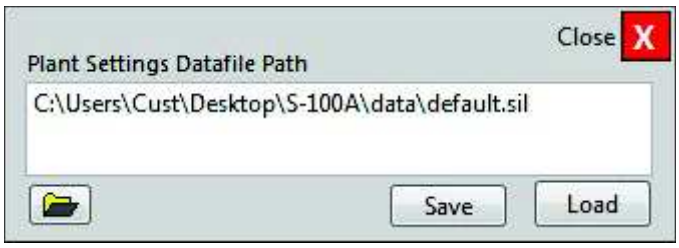

Figure 19: Save or Load Plant Settings

4.1.2 Datalogging

All data related to the SaltMaker is logged in a local file on the controls PC, and then copied to cloud storage for backup and access. Datalog settings are located under the Datalog tab, and allow the user to set the path to store the datalog files. See figure below.

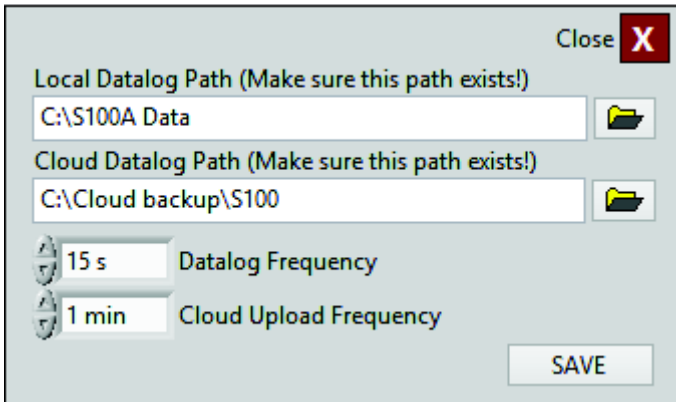

Figure 20: Data Log Settings

4.1.3 User Settings

The HMI uses accounts and user profiles to assign different access levels for different users. Three accounts and three user profiles are built into the HMI. More accounts and user profiles can be added as necessary.

The following list explains the three built-in users and their associated user profiles in the HMI:

Saltworks:

This is the account used by Saltworks engineers for taking full control of the HMI. It is assigned to the user profile “saltworks”, which grants access to all functions available in the HMI, including plant controls, alarm controls and user controls. This account should only be used by Saltworks personnel.

Admin:

This is the account assigned to administrators of the plant. This account is associated to the user profile “admin”. It also grants full access to all functions available in the HMI.

Default:

This is the account that the HMI runs on by default when launched. This account is associated to the “default” user profile, which grants access to plant settings and alarm settings, but has no access to user settings of the HMI.

Each account must be associated to an existing user profile. A new user profile can be created if a new set of access rights is required for an account.

4.2 HMI Operation

If all mechanical checks are completed and operating settings are correct, the user can change the "Main mode" (see Figure 21) from "PLANT MODE: OFF" to "PLANT MODE: AUTO". The SaltMaker system will start automatically based on operating settings.

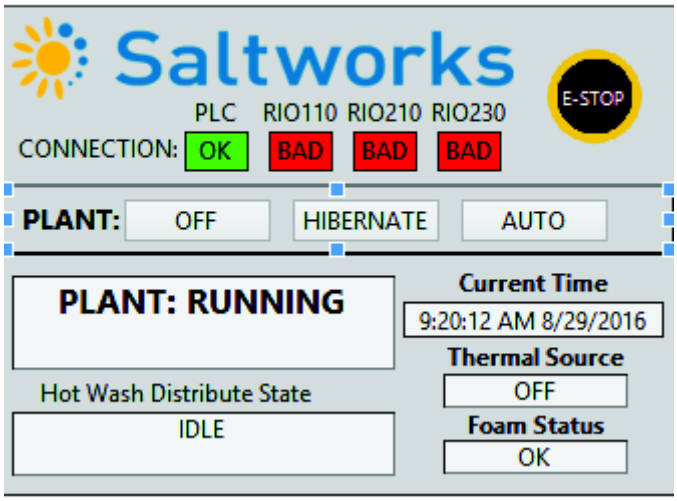

Figure 21: Selecting Plant Mode Operation

The operator can run the entire plant, as well as any sub-system, in manual or auto mode. The figure above shows the menu that lists all control modes available for Main Mode:

PLANT MODE: OFF

This mode triggers the shutdown of the plant by interrupting all ongoing processes, performing a shutdown wash and terminating all processes after the shutdown wash has been completed.

PLANT MODE: HIBERNATE

This mode runs the main pumps with valves in default positions but without the fans and thermal source. Vibrators are enabled to keep fluids in the tanks agitated. Use this mode to reduce the risk of scaling when thermal source or other plant systems have been interrupted.

PLANT MODE: AUTO

This mode runs the plant based on the set points the operator has defined. The operating set points for the plant or sub-systems should be adjusted as required by local conditions before the plant is started in automatic mode. Note that selecting "AUTO" from PLANT MODE menu will initiate all sub-systems to "AUTO" mode.

The operator has the option of manually overriding the control inputs. **EXTREME CAUTION MUST BE APPLIED AS INADVERTANT OPERATION MAY CAUSE DAMAGE**. This should only be performed with proper training and in depth understanding of the process and plant operation. To operate in override mode:

1. Navigate to the Manual Override tab of the plant controls and click OVERRIDE MODE – ENABLED. This will enable the CONTROLS buttons as shown in Figure 22.

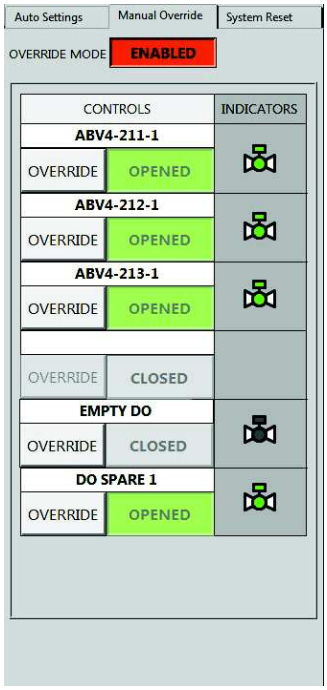

Figure 22: Enabling Manual Override

2. Enabling Override mode allows the operator to have granular control of automated valves, pumps and all other devices that are controlled by the PLC. This is useful in identifying, isolating and fixing the problem whether the plant is running or off. Refer to Appendix B: Detailed Troubleshooting and Maintenance Instructions on how to use Override Mode to help troubleshoot process and pipework problems.
3. From the display tabs, click on the device that is to be manually controlled. It will be highlighted by a red box on the display tab and on the Manual Override tab as shown in Figure 23.

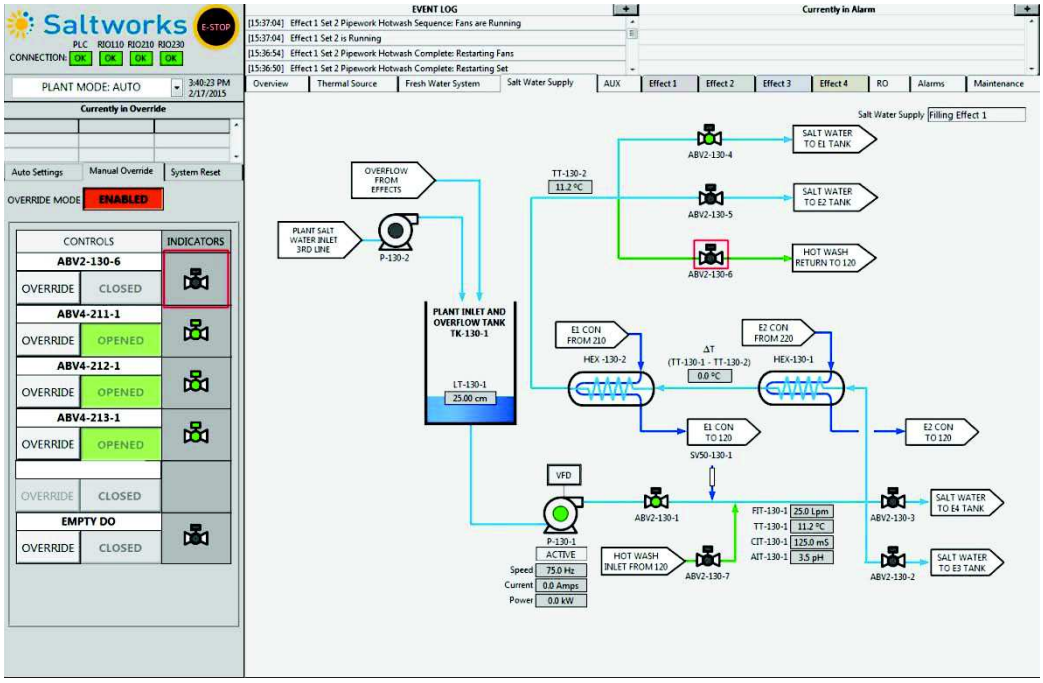

Figure 23: Selecting Instruments to Override

4. Clicking the OVERRIDE button to put the device into the override state and allow the operator to manually control the device, indicated by a blue box around the device. Above the Manual Override tab is the “Currently in Override” display that displays all devices currently in override. Figure 24 shows the “Currently in Override” display, as well as an instrument in override state.

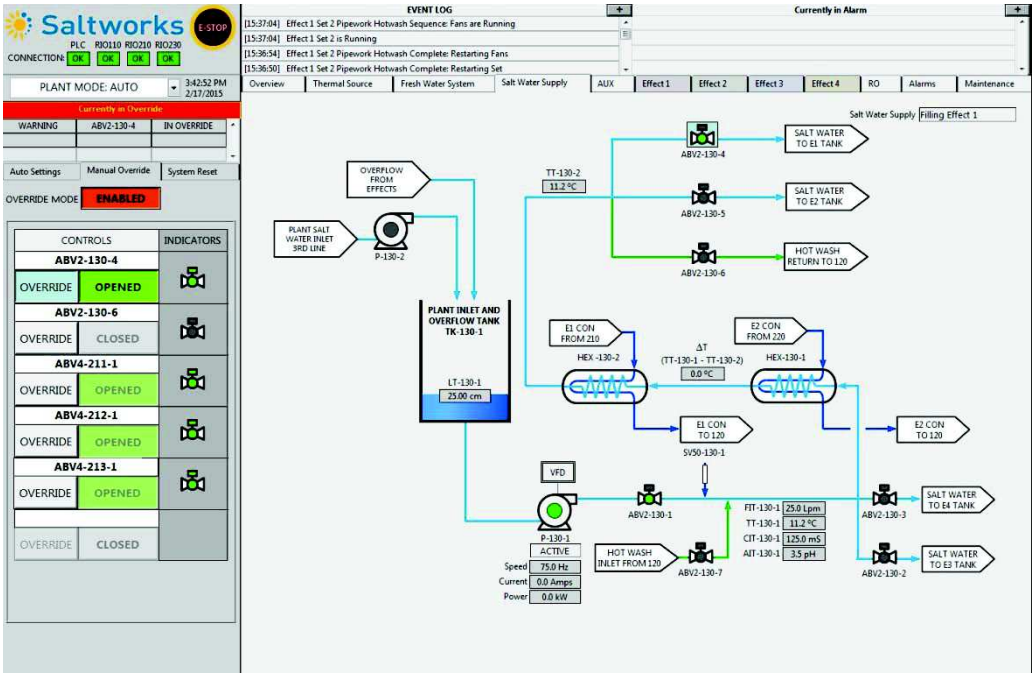

Figure 24: Overriding Selected Devices

4.3 Alarms on the HMI

The SaltMaker has alarms for each digital and analog input. A *warning* status indicates a warning that an instrument reading is outside of a predefined low (L) or high (H) threshold. This warning status does not affect the operation of the plant. An *alarm* status indicates that an instrument reading is outside a predefined alarm low (LL) or alarm high (HH).

4.3.1 Currently in Alarm Display

The "Currently in Alarm" display shows the digital and/or analog inputs that are currently in alarm. When the alarm is triggered, this display blinks in red and automatically updates tripped alarm status in real time, as shown in Figure 25.

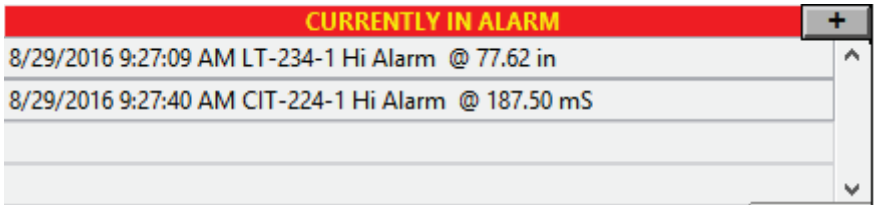

Figure 25: Currently in Alarms

4.3.2 Alarm History Display

The Alarm History display (on the main Alarms tab, Figure shows the last 500 alarms triggered. An extensive list can be found in the data logging files.

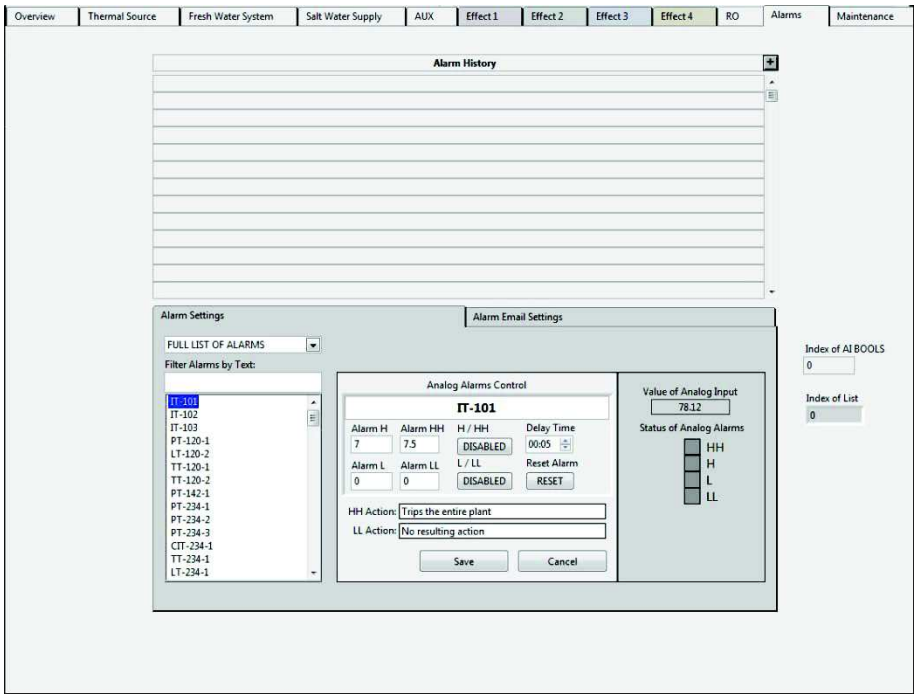

Figure 26: Main Alarms Tab[2]

4.3.3 Alarm Settings

Alarm Settings allow the user to select a specific digital or analog alarm to change its settings. Use the drop down filter to select the type of alarm to be adjusted. Select a specific alarm and change the set points in the control panel. To apply these changes, click Save. To discard changes to, click Cancel. On the far right of the Alarm Settings are the alarm indicators that display the current status of the alarm, as well as the current value of the analog input if it is an analog alarm. See Figure 27.

[2] Numbers on this screenshot are not representative of process setpoints

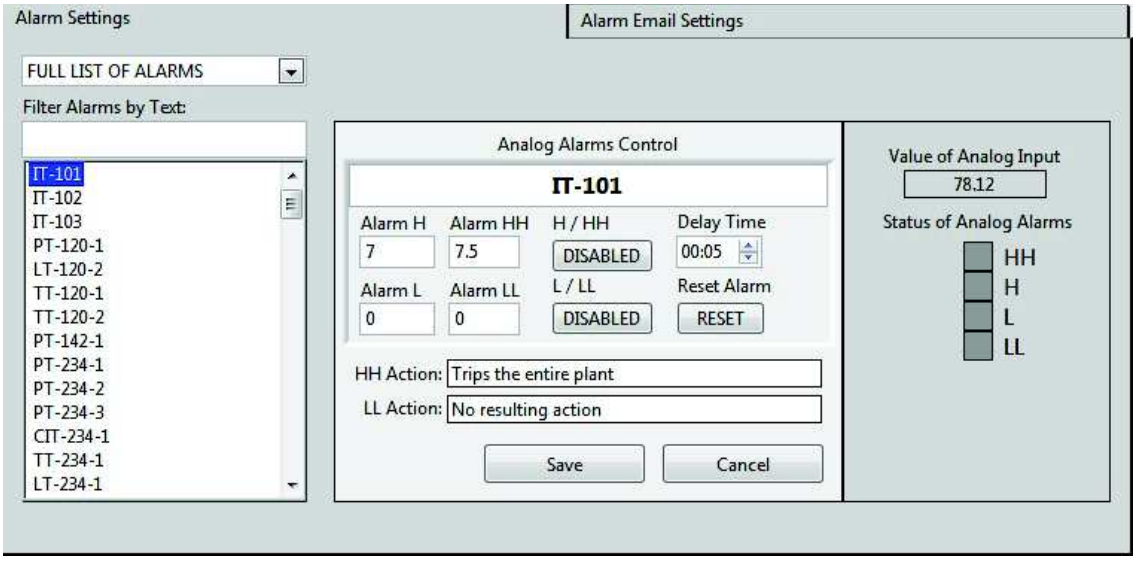

Figure 27: Alarm Settings

4.3.4 Alarm Email Forwarding

When an alarm is triggered, the HMI automatically sends an email with the alarm information to all recipients specified in the "To:" column. Make sure that you type in a valid email address without extra characters such as spaces, tabs, or the enter key. Extra spaces will not allow for alarm email forwarding. See Figure 28 below.

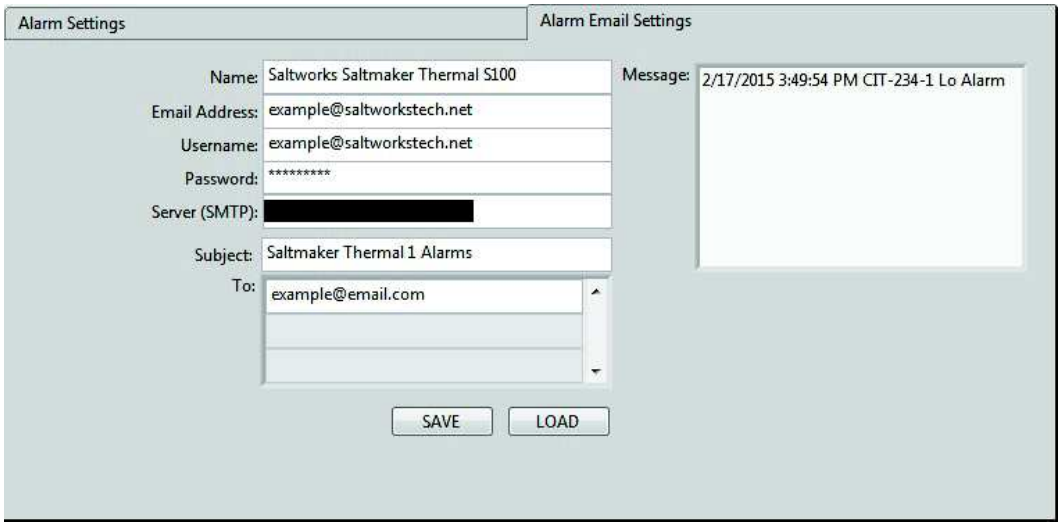

Figure 28: Alarm Email Settings[3]

[3] Numbers on this screenshot are not representative of process setpoints

4.3.5 Alarm Email Settings

The Alarm Email Settings are the email server settings that allow the program to send emails to the recipients. These settings are to be modified by authorized personnel only.

4.3.6 System Reset

The System Reset tab allows the user to reset systems or alarms. Clicking Reset All Alarms will reset all alarms that are no longer beyond alarm threshold. Select a system in the List of Tripped Sub Systems and click System Reset to reset only that subsystem from a tripped state. See Figure 29.

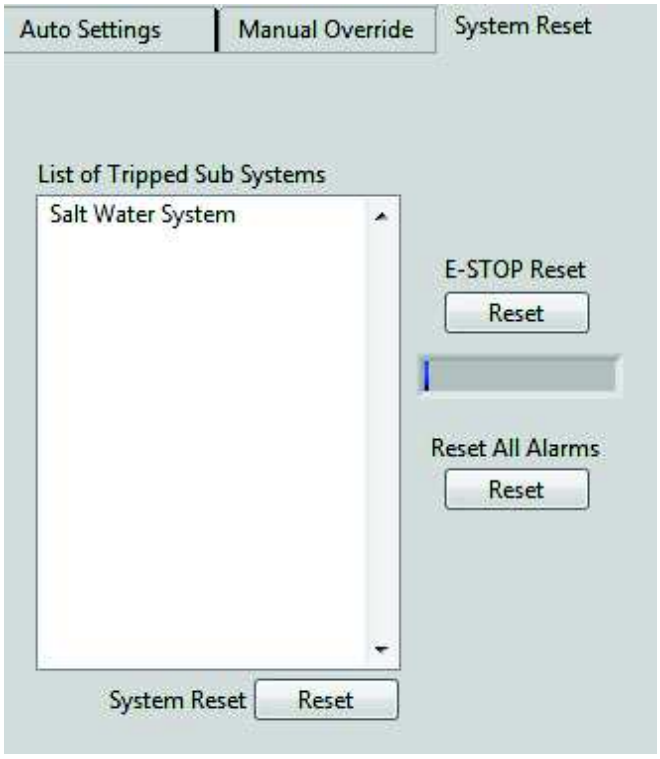

Figure 29: System Reset Tab

4.3.7 HMI Emergency Stop

When an E-STOP has been triggered, the top banner of the HMI will flash with the different possible locations where the E-STOP was triggered. After the E-STOP is physically reset, the user can reset the plant by clicking E-STOP Reset under the System Reset tab. See Figure 30.

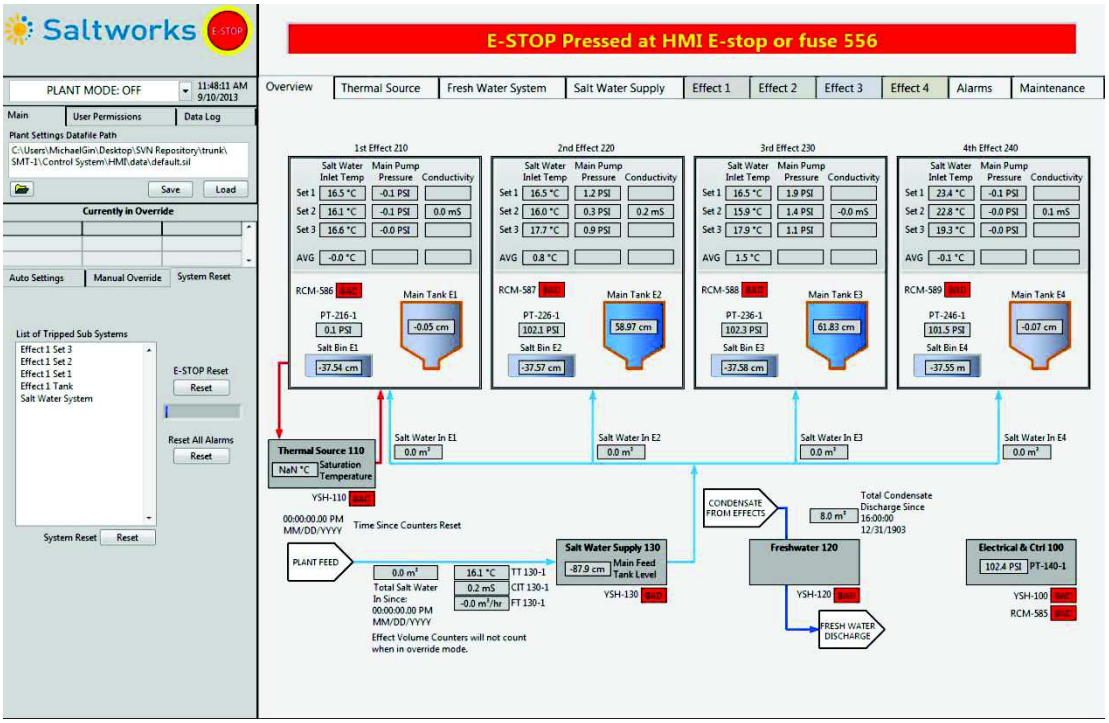

Figure 30: HMI in E-STOP

5 Operating Procedures

5.1 Start-up Procedures

Make sure you are familiar with the previous section HMI operation. For details on HMI parameters and settings, see *Appendix D: SaltMaker Controls Narrative.* Training videos are also available for viewing.

Before attempting to start the SaltMaker in Full Auto mode, individual systems should be calibrated and tested in Manual Mode. For electrical and controls troubleshooting refer to Appendix C Electrical & Controls Troubleshooting and Maintenance Guide.

Checks before Start-up:

1. Ensure main power is connected and live. Confirm main disconnect is in the ON position. Confirm that subsystem disconnects are also in the ON position. The figure below shows disconnects in both ON (vertical) and OFF (horizontal) positions. If any system is in the OFF position, do a visual check to make sure the system is safe to turn ON.

Figure 31: Main disconnect in ON Position

2. Confirm that the controls, including the PLC and HMI are powered.
3. Check that air compressor is ON and there is approximately 100 psi of pressure at the compressor. Also check the pressure sensor readings on each effect air box and make sure there is at least 80 psi.
4. Trace flow paths for the saltwater circuit, freshwater circuit, and salt extraction circuit to ensure all manual valves are in the correct position. Refer to *P&ID* for normal valve positions of saltwater system, freshwater system and salt extraction system.

   NOTE: All manual valves are normally open except for drains and wash lines.

5. Check and make sure there is adequate level on the Plant Inlet Tank.
6. Check and make sure there is adequate level on all effect tanks.
7. Prime all pumps by opening the plug on pump volute, or a priming valve on the pump discharge line (shown below) until water flows out. PUMPS CANNOT BE RUN DRY.

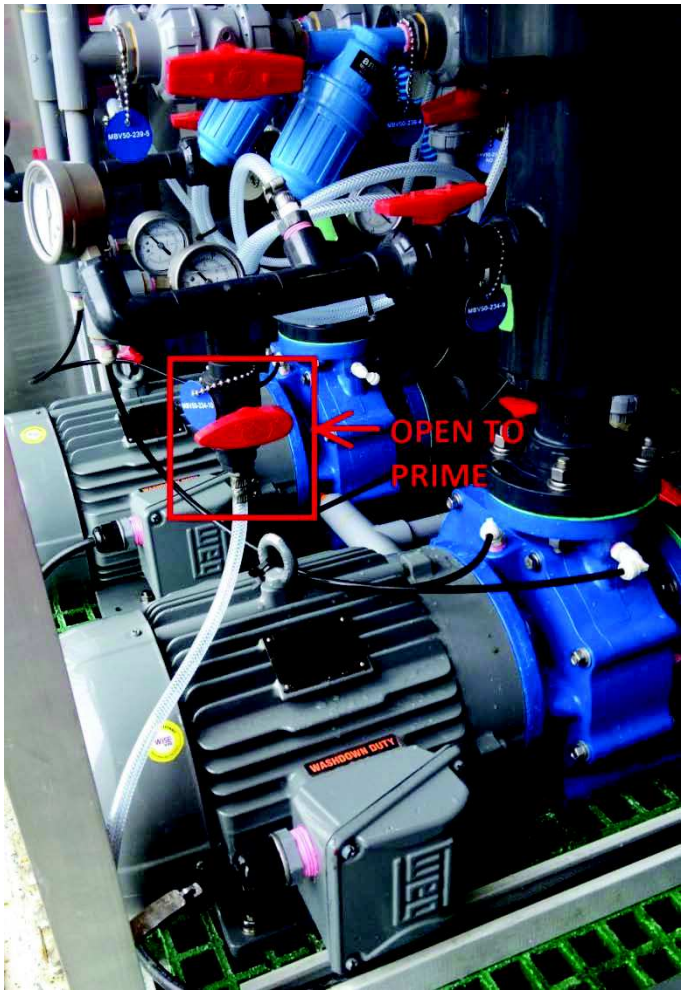

Figure 32: Open Valve to Prime Main Pumps

8. If the operator suspects that valves maybe sticky due to scaling, actuate the valves in manual override to make sure they can move freely.

9. Check alarm states and confirm all alarms are clear. If there is an alarm, identify the cause. Resolve the condition before resetting the alarm on the screen.

10. If the system is recovering from an alarm or an e-stop state that prevents a shutdown wash sequence, the user needs to perform a "Pre-Startup Flush." To perform the flush, check to make sure each Effect has "Shutdown Wash" enabled in the "Washes 1" Tab. Also make sure that the hot wash tank is near full. Fill this tank if needed. Then click on "Flush Now" button under the Pre-Startup Flush Controls in the 100 Overview Tab.

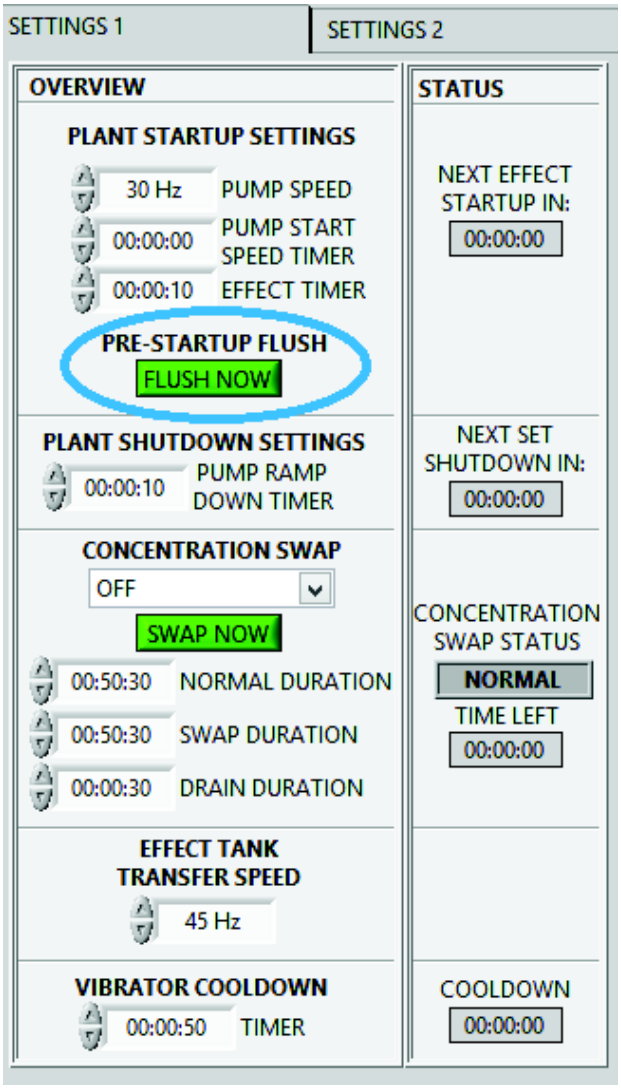

Figure 33: Activating a pre-startup flush on the SaltMaker

The plant should initiate a hot wash sequence for each set in order. Confirm there is pressure and flow through the system while each set is washing. If all sets have decent pressure and flow during the wash, the plant is ready to start once the wash is complete.

11. When ready, select "Auto" in the Main Mode Select menu. The plant will initiate the start-up sequence. Pumps will turn on sequentially.

    During startup there are two pump speeds that can be set by the operator: start up speed and running speed. Between each pump start up, there is a time delay to allow the tank levels to equalize and flow to reach steady state. The effects will start in order:

    - Effect 1, set 1
    - Effect 1 set 2
    - Effect 1 set 3
    - Effect 2 set 1
    - Effect 2 set 2 etc.

    Delays are also added between effect start-ups to make sure that levels in all tanks are at steady state before continuing to the subsequent effects. When starting each set, confirm that flow is adequate and pressure is within operating range.

    Once startup is complete, do a walk-through and inspect for leaks, abnormal vibrations and noise. Keep track of problems you identified.

5.2 Operating the SaltMaker

The SaltMaker is fully automated and can be left with minimal supervision after initial start-up. Intelligent controls will notify the user through warnings and alarms if the plant needs operator attention. The following checks should be performed before running the SaltMaker unattended for a few hours (e.g. running overnight). Daily checks are recommended to ensure increased uptime and early detection of problems. A full inspection and maintenance checklist is provided in *appendix A: Inspection and Maintenance Schedule.*

5.2.1 Confirm the Following before Running Unattended

Process and Controls:

1. Check Settings: pump speed, fan speed. Confirm that pump pressures are within normal operating range. If not, investigate for the cause.
2. Remove all over-rides, investigate and clear all alarms.

Plant Visual Inspection:

3. Do a quick check pressure gauges and on all process pumps. Listen for abnormal noises and watch for leaks and other problems.

4. Confirm that antifoam tank is full and refill as needed. **Make sure to stop the refill pump and do not leave the refill pump unattended during anti-foam refills.**
5. Visually inspect module interior by opening inspection ports. Before opening inspection ports, turn off the effect fans to reduce risk of exposure to any potentially hazardous volatile compounds.
6. Check SaltMaker post bag filters and differential pressure. Clean filters if needed
7. Leave main doors 3' open

Site Specific and Optional Systems:

8. If RO pre-conditioner is installed, confirm that RO pre-conditioner fans are ON
9. If RO treatment system installed:
   - Check RO bag filters and differential pressure. Clean filters if needed
   - Check that RO permeate flow rate is normal if it is running. Otherwise confirm flow through datalogs during the last run.
   - See *Post Treatment RO O&M Manual* in the MDR for more details.

10. Check thermal Source system:
    - Confirm thermal source water pressure > 20 psi (add water via ½" feed valve if pressure is low)
    - For gas fed thermal source make sure gas feed rate is within specs. (e.g. the CmA value is > 11)
    - See *Standard Water Heater Manual* in the MDR for more details.

5.2.2 Daily Checks

Process and Controls:

1. Check for any warnings or alarms and investigate as needed.
2. Identify and investigate if pressure, temperature, conductivity, or level readings are abnormal. A re-calibration maybe needed. (see weekly checks)
3. Confirm data logging function (DAQ / TDMS files).
4. Generate data plots and confirm saw tooth pattern on graph for:
   a. Each effect tank level vs. time
   b. Each effect brine and condensate conductivity vs. time
   c. Each effect temperature vs. time

Confirm the plant control is online (Internet connection and remote access is working).

Freshwater System:

1. Measure freshwater quality. Confirm that conductivity readings from plant sensor match handheld readings.
2. Check for biological growth. Clean or dose as needed to keep growth under control.

Pumps:

1. Confirm pump function by checking pump discharge pressure from local pressure Indicators in the system. Also check pump flow rates. Visually inspect pumps for leaks. Listen for irregular noise or vibrations from the pump. Pump shaft washes, pump seal washes, or a slug wash may help with resolving vibration or noise issues.

Saltwater System:

1. Confirm sufficient feed water level in Plant inlet/overflow tank.
2. Confirm that flow is adequate on effects and sets.
3. Visually inspect the evaporator module fill. If scaling is observed, perform an evaporator spray wash. Check hot wash, swap timer, event setting & status. NOTE: before opening inspection ports, turn off the effect fans to reduce risk of exposure to any potentially hazardous volatile compounds.
   - Confirm that hot wash & swap timer do not overlap (i.e. -03:00:00)
   - Confirm that hot wash & swap status queue is not backed up. (i.e. Cone tank swap- queued, Pipework-queued, Slug-queued & Packing spray-queued, but no action)
4. Check air velocity across drift eliminators. Air velocity should not be greater than 600 fpm (feet per min) at the drift eliminators. Air velocity sensors (units are in fps or feet per second) are installed at the duct and they can be calculated according to the following equation:

   Air speed at duct (fps) * 30.143 = air speed (fpm) at drift eliminators
   Where:
   Air speed @ duct * 60 s/min * 2 x duct area/drift eliminator area = air speed @ drift eliminators
   - Duct dimensions = 30” ID
   - Duct Area = 3.9087 ft²
   - Drift Eliminator Dimensions = 42” x 67”
   - Draft Eliminator area = 19.54 ft²

Salt Extraction System (if applicable):

1. Confirm auger functions (if applicable): speed, timer setting and salt extraction.
2. Check salt extraction bin level, bag and drain line for clogs
3. Visually inspect return pump for leaks. Listen for irregular noise and vibrations. Check hose condition.

Brine Extraction System (if applicable):

1. Visually inspect brine extraction pumps for leaks. Listen for irregular noise and vibrations. Check hose condition.

5.2.3 Weekly Checks

The weekly check should be done by the operator every week while the SaltMaker is in operation or offline.

Air System

1. Check pressure on the air compressor and make sure the reading is steady at around 100psi.
2. Check the oil gauge and add lubricating oil as needed. See MDR for oil specs.
3. Check data trend on different air pressure sensors to confirm that air supply is steady during operation.
4. Check oil lubrication level on pneumatic vibrators. Listen for irregular noise.

Sensor & Instrumentation

1. Confirm calibration of level transmitters (LT) against level indicators (LI) for tanks.
2. Confirm level transmitters and level switch probes are washed and cleaned.
3. Confirm calibration of temperature transmitters (TT) with temperature indicators (TI). Do this while the plant is operating, the pipes have sufficient flow, and perform a 1 point calibration on HMI if needed.
4. Confirm calibration of pressure transmitters (PT) against pressure indicators (PI) while the plant is in operation. Make a note on discrepancies and perform a 1 point calibration on HMI if needed.
5. Confirm calibration of conductivity meter (CIT) against handheld measurement. Make a note of discrepancies and perform 1 point calibration on HMI if needed.

Effects

1. Check and add lubrication to fan bearings as required. This can be done when the fan is off and electrically isolated.
2. Check the evaporator basin for growth. Initiate a biofilm treatment cycle as needed to keep biological growth under control.

Hot Wash

1. Check Salt water basin for salt crusts and clogged drain pipes. Confirm that level switches in the Salt water basins in the Evaporator Modules are washed and cleaned.
2. While operating, observe a full pipework wash. Check flow indicators and pressure readings to confirm that wash is effective.

5.2.4 Recommended Checks after Shutdown

1. If possible, pump out the brine from 2nd & 3rd effect cone tank to separate clean totes. Inspect salt build-up on tank bottom and clean if necessary.

2. Actuate all ABVs in manual override to prevent possible valve jamming.
3. Check physical condition of all sensors.
4. Place a bucket under the cone tank bottom drain valve and purge the bottom drain valve carefully to check for solids. If no fluid emerges, the base of the tank has salted over.
5. Record inspection results and log all available data and any abnormal conditions.

To maintain reliable operation and longevity of the plant, periodic inspection and maintenance should be carried out as per maintenance listed in appendix B.

5.3 SaltMaker Cleaning Cycles

Setting proper SaltMaker cleaning cycles is essential to continuous operation of the SaltMaker. The hot wash cycles are summarized in section 2.6. If salt crust is encountered in some of the systems and pipework, the operator can manually initiate each wash sequence. To do so, select the effect on the HMI, and choose the Washes tab. You can then choose “Wash Now” for the following:

- Pipework Wash
- Evaporator Spray
- Evaporator Basin Wash
- Pump Seal Flush

You can enable, disable and change the timer and duration of each of the washes above for each effect. The following section describes the automated control sequence for each type of wash.

5.3.1 Pipework Wash

- Turn off fans to the effect.
- Set pump shuts down.
- Open air purge valve to rumble and loosen salt collected in pipework.
- Valves open to allow process water to drain out.
- Configure valves to divert hot wash tank to set pump inlet and back to hotwash return. Isolate the process water in the effect from the pipework.
- Run set in a closed loop configuration using hot wash water for specified duration.
- When wash finishes, discharge a small quantity of wash water to the evaporator to dislodge trapped salt before stopping the pump.
- Re-configure valves to connect effect tank to set pump and evaporation module, isolate the hot wash tank to set.

5.3.2 Evaporator Spray

- Turn off fans for the effect.
- Turn off set main pump.
- Distribute hot wash water to evaporator spray for specified duration.
- When finished, restart set main pump.
- Turn on fans for the effect.

5.3.3 Evaporator Basin Wash

- While the set is running, divert a small volume of washwater through the set pipework and evaporators by opening the hot wash inlet valve for the set pump, and then closing the effect tank inlet valve for a short duration.
- Run hot wash water through the system and discharge to evaporation module through evaporator fill to evaporator basin. The low concentration hotwash water helps dislodge any salt crust that is blocking the basin.

5.3.4 Pump Seal Flush

- Keep set pump on.
- Open pump seal flush valve and run hot wash main pump to pump wash water to pump seals for set time.

5.3.5 Full Manual Washes on Specific Sections of the SaltMaker

1. Identify the section of pipe that is experiencing blockage.
2. Identify the hot wash flow path required for clearing the section of pipe containing the blockage.
3. Select and override corresponding valves to create a flow path from hot wash tank to the pipe. Identify and open/close manual valves as necessary to create flow path.
4. Double check valve positions.
5. Run hot wash main pump to divert wash water to wash the targeted section of pipe.
6. When the wash is completed, revert valves back to their normal configuration and restart the system.

For more information, refer to Appendix B: Detailed Troubleshooting and Maintenance Instructions. An example is given to illustrate how to apply these 5 steps to perform a full manual wash.

5.4 Brine Discharge (Brine Extraction Pump Option)

1. When the concentration of effects 2 and 3 go above the targeted concentration, brine extraction pumps will turn ON to discharge concentrated brine out to the concentrate discharge tank for disposal. A level switch detects when the discharge tank is full and stops the brine extraction pumps. Operator is notified when the discharge tank is full.
2. Operator will need to empty the discharge tank. Brine discharge will be enabled once the level switch is plugged in and level is back to normal.
3. Operator must confirm brine flow to the discharge tank from each of the brine extraction pumps: using the controls, turn E2 brine extraction pump into recirculation mode, while keeping E3 discharge pump ON in discharge mode, confirm brine flow to discharge tank. Confirm brine flow in second discharge pump by putting E3 into recirculation mode, while keeping E2 ON in discharge mode, confirm brine flow to discharge tank. This ensures both brine extraction pumps are discharging as they should.
4. If brine level is full or brine discharge tank is not available, the SaltMaker will keep operating until a high concentration warning level is reached. The thermosource system will turn off to prevent further concentration of process fluid, while the effects and sets keep running to prevent the formation of salt crust in effect pipework.

5.5 Shutdown

Normal Shut Down

1. In each of the effect Tabs (effect 1, 2, 3, and 4) ensure that the SHUTDOWN WASH is enabled (Figure 34).

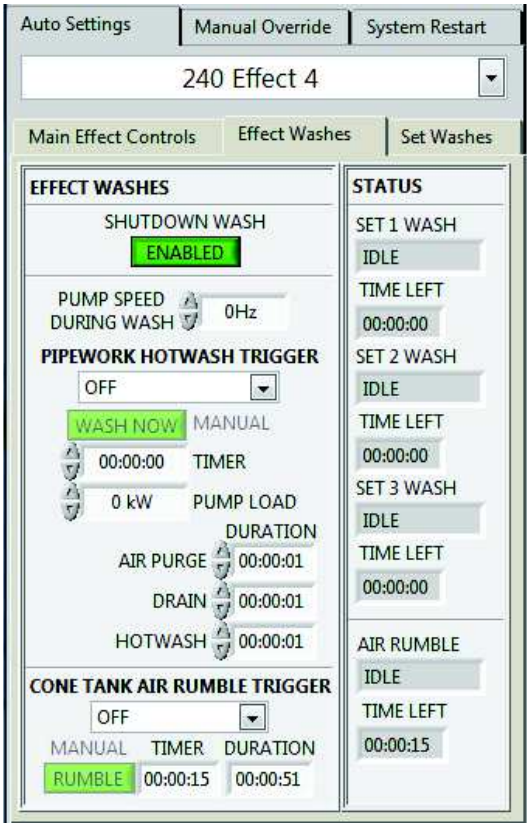

Figure 34: Enabling Shutdown Wash[4]

2. Turn Plant Mode to OFF.
   a. This will turn off the systems in correct order.
   b. A pipework wash is initiated. This will prevent salt solidification in the SaltMaker piping and pumps when the plant is down.

[4] (Note: Numbers on this screenshot not representative of process setpoints)

Emergency Shutdown or Power Lost

In the event of an emergency, the E-Stop button on the HMI or a physical E-Stop button on the control panel can be pressed.

- Once it is pressed, all systems will shut down immediately. No hot wash is initiated.
- To restart the plant, the operator needs to clear the Emergency Alarm and any other process alarms that may have been triggered during the emergency shutdown.
- After an emergency shutdown, the SaltMaker plant will require a "Pre-Startup Flush" before starting again. This can be activated in the "100 Overview" selection tab under "Auto Settings".
- An alternative would be to perform a full manual flush while power is down. See below.

5.6 Manual Flush Procedure

This flush is possible if a pressurized (30+ psi) fresh water supply is available. Before performing this wash, please ensure processed brine has drained out of the system and back to tanks. When power is lost or E-stop is engaged, air valves will go to their normal positions. This means that if an ABV in the P&ID is marked NO (normally open), it will be open. If an ABV in the P&ID is marked NC (normally closed) it will be closed.

The example below is used to illustrate a manual flush procedure. Please refer to your specific P&ID to confirm which valves to open and close. Instructions below will reference this specific P&ID.

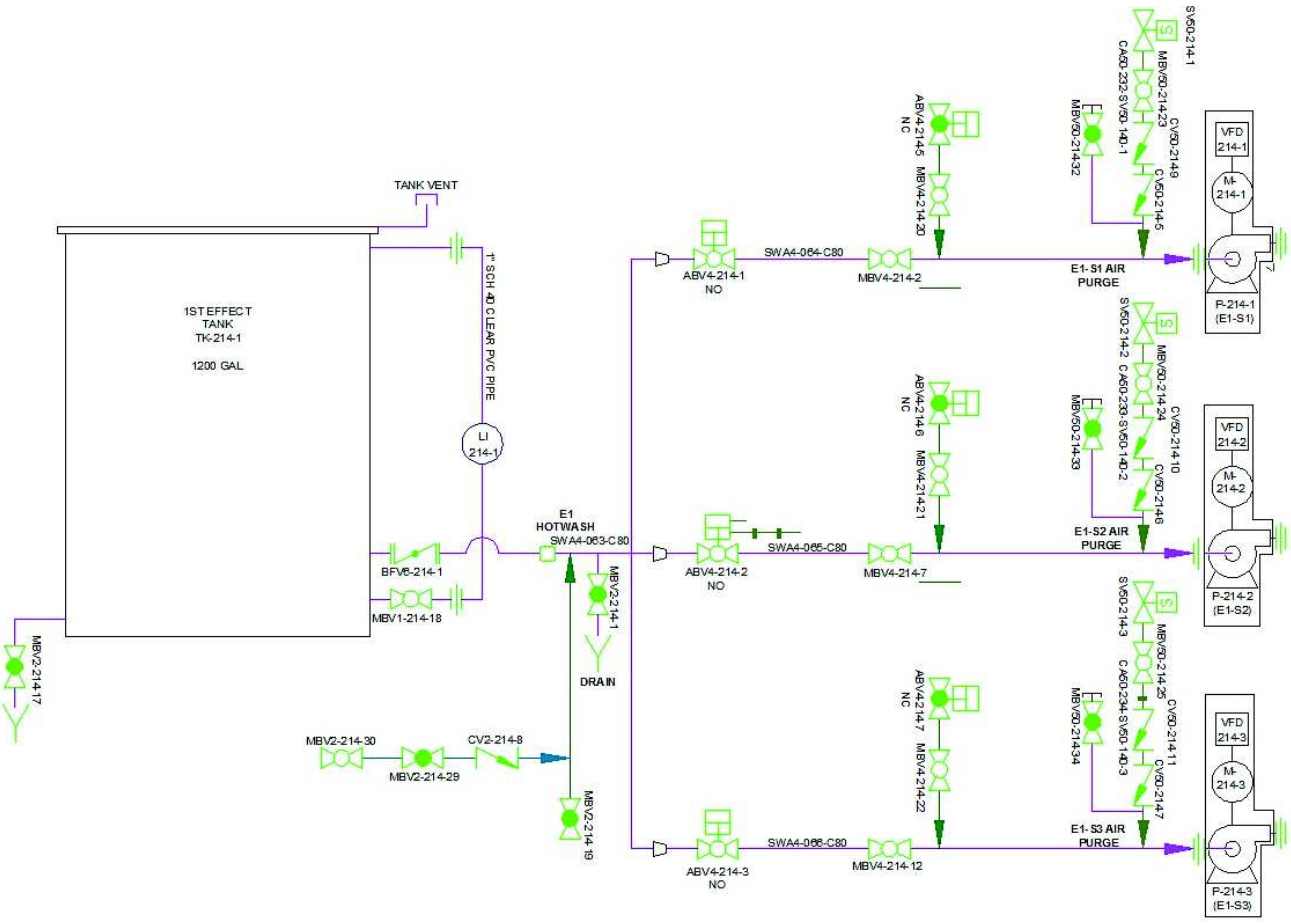

Figure 35: Manual Flush P&ID Example

1) Effect 1 Set 1 pipework flush.
   - Close BFV6-214-1 tank main shut-off valve.
   - Connect fresh water supply to MBV2-214-1.
   - Open MBV4-214-2 (valve to set 1 pump inlet)
   - Close MBV4-214-7 (valve to set 2 pump inlet), and MBV4-214-12 (valve to set 3 pump inlet)
   - Open fresh water supply and flush until fresh water returns to main tank. See figure below.
   - Close fresh water supply when flush is complete.
   - Close MBV4-214-2 (valve to set 1 pump inlet)

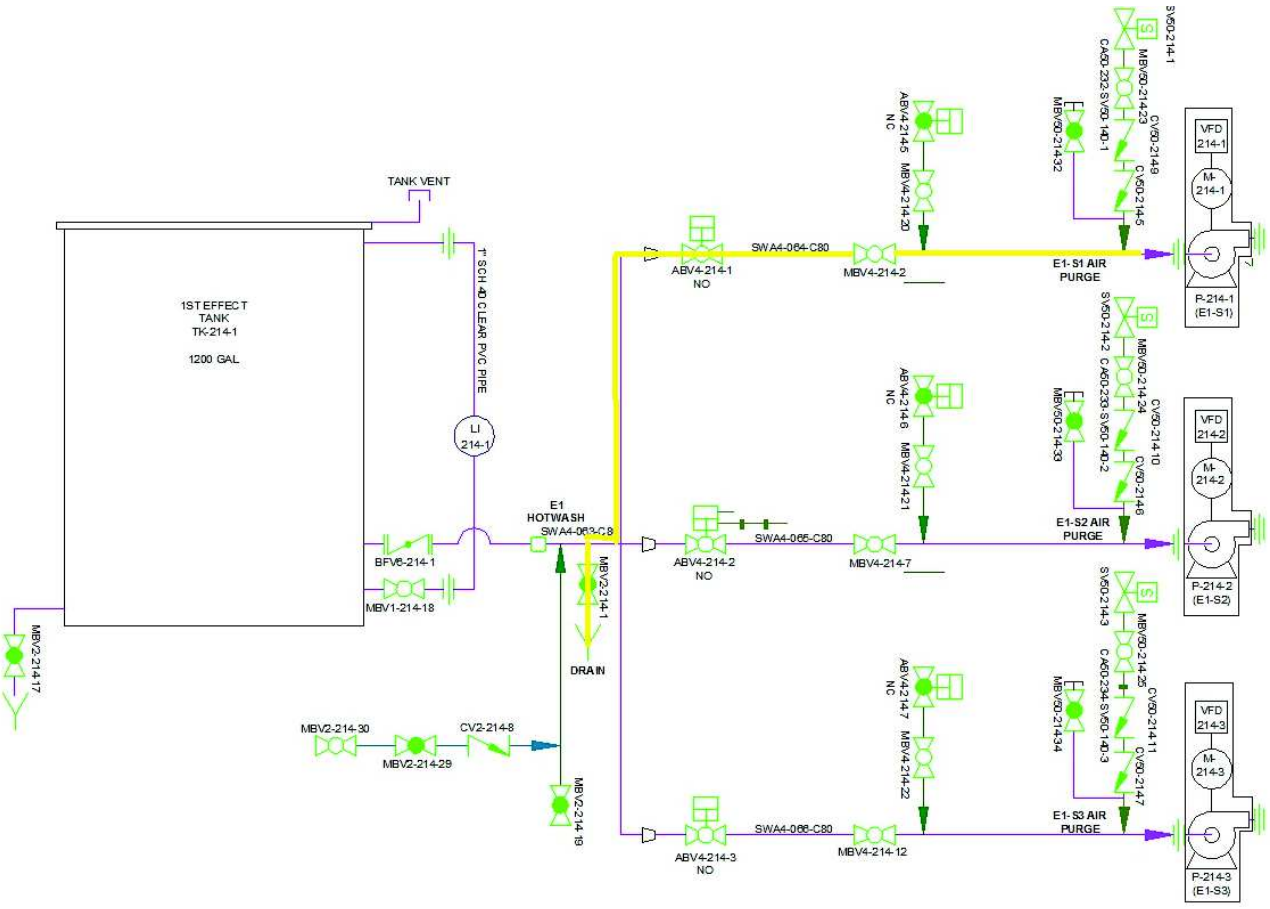

Figure 36: Flow Path for Manual Flush Effect 1 Set 1

2) Effect 1 Set 2 pipework flush.
   - Open MBV4-214-7 (valve to set 1 pump inlet)
   - Keep these valves closed: MBV4-214-2 (valve to set 1 pump inlet), and MBV4-214-12 (valve to set 3 pump inlet)
   - Open fresh water supply and flush until fresh water returns to main tank
   - Close fresh water supply
   - Close MBV4-214-7 (valve to set 1 pump inlet)

3) Effect 1 Set 3 pipework flush.
   - Open MBV4-214-12 (valve to set 1 pump inlet)
   - Keep these valves closed: MBV4-214-2 (valve to set 1 pump inlet), and MBV7-214-12 (valve to set 2 pump inlet)
   - Open fresh water supply and flush until fresh water returns to main tank
   - Close fresh water supply

Open set pump inlets for MBV4-214-2, MBV4-214-7 and MBV-214-12. Flush is now complete. **Repeat the steps above for Effects 2, 3 and 4.**

5.7 Process Disruptions and Alarm Management

The SaltMaker monitors sensor readings to make sure they are in the normal operating range. If they are outside the range, the system may notify the operator by issuing a warning. If the problem is serious enough, an alarm is issued. The system will then initiate a shut-down process to help prevent equipment damage or to avoid an unsafe condition. Both warnings and alarms can be forwarded to e-mails or phone text messages.

Notifications are separated into two categories:

- Warning Low (L) or High(H)
- Alarm condition: Alarm Low (LL), or Alarm High (HH).

A warning will be indicated on the operator's HMI with a yellow indicator, signaling that attention is needed on a specific part of the system. This allows the operator to identify and troubleshoot problems before it can trip the system.

An alarm condition will initiate a systemic shutdown of the plant similar to shutdown command. Alarms have adjustable time delays and can be enabled individually. Alarms can be configured for each sensor, including level, pressure, temperature, conductivity and pH. See section 4.3 on how to change alarm settings.

5.7.1 Air Pressure Alarms

The plant requires air to actuate valves to divert flow to different systems. When air pressure is low, the ability for valves to move fluid around is compromised.

Air Pressure Warning (L):

Shut off air vibrators and diaphragm pumps to conserve air or to protect air equipment.

Air Pressure Alarm Low (LL):

Keep recirculating Tank fluids using effect pumps. If level alarms trip while in recirculation, the system will turn off without going through the flush sequence.

Before restarting the plant, activate Start-up washes.

5.8 SaltMaker Maintenance

Please refer to the *appendix B Detailed Troubleshooting and Maintenance Instructions* for details.

6 References

Additional documents, information and tools related to the SaltMaker are listed below. Saltworks also has instructional videos available for viewing. Please refer to the MDR for access.

Appendix A: Inspection and Maintenance Schedule

Appendix B: Detailed Troubleshooting and maintenance procedures

Appendix C: Detailed Electrical and Controls Troubleshooting and maintenance procedures

Appendix D: SaltMaker Controls Narrative

Appendix E: Spare Parts List

Appendix F: Critical Tools List

Appendix G: Commissioning Manual

Appendix H: Commissioning Checklist

Appendix I: Acid and Base Dosing System O&M Instructions

Appendix J: Antifoam Dosing System O&M Instructions

Appendix K: Salt Crust Prevention Instructions

Appendix L: Biofilm O&M Instructions

Appendix M: SaltMaker Alarm List

Appendix N: Operator Handover Form

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Saltworks Technologies Inc.

SaltMaker
Operation & Maintenance Schedule and Check List

Revision B

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Table of Contents

1 Safety

1.1 Personal Protective Equipment (PPE)

- Wear proper required PPE per operation site requirement. This may include but not limited to: Steel toe boots, Safety glasses, gloves and hard hat

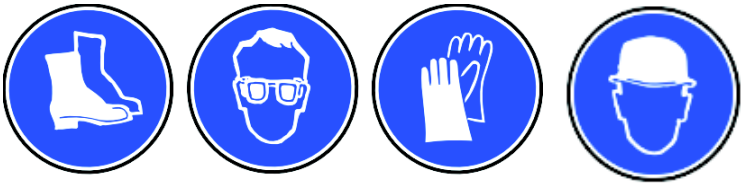

Figure 1: PPE required

1.2 General Safety

- Know and correctly use PPE for Plant operation and maintenance.
- Know how and where to isolate sources of energy, such as electrical, thermal, compressed air etc.
- Understand potential physical and chemical hazards associated with plant maintenance.

2 Maintenance Schedule

Outlined below is a maintenance schedule with estimated preventive maintenance frequency and time duration. It is noted that this schedule serves as a guide and maintenance frequency as preventive maintenance will depend on operating condition.

No.	Device	Description	*Maintenance Duration (Hour)	**Maintenance Frequency (Day)
1	Basket strainer	Cleaning	0.5	2
2	Bag filter	FW Bag filter change	0.5	2
3	Evaporator Module	Evaporator Top Basin Inspection and cleaning	0.5	2
4	Compressed Air	Desiccant filter element change	0.5	7
5	Evaporator Module	Evaporator Module Packing washing	2	14
6	Satellite HW TK	Sludge removal	2	14
7	Cone Strainer	Cone strainer cleaning	1	15
8	Radiator Module	RAD Module Radiator tube Inspection	1	15
9	Pressure Transducer	PT tubing unplugging	0.5	30
10	Brine spray manifold	Cleaning nozzles	0.5	30
11	Tank spray nozzle	Cleaning nozzles	0.5	60

No.	Device	Description	*Maintenance Duration (Hour)	**Maintenance Frequency (Day)
12	Genesys Pump	Pump Seal/Impeller Replacement	2	90
13	Fan	Fan belt replacement and motor alignment , belt tension check/Adjustment	2	90
14	Packing spray manifold	Cleaning nozzles	6	90
15	Salt extraction pump	Diaphragm replacement	2	90
16	Modules	Air seal replacement	4	120
17	MDM Advance 4000 Pump	Pump Seal replacement	2	180
18	Fan	Fan Impeller replacement	6	180
19	Fan	Fan Bearing and pulley condition check	0.5	180
20	Evaporator Module	Evaporator Module Sludge Removal (Bottom Basin)	6	180
21	Evaporator Module	Evaporator Module Sludge Removal (Top Basin)	6	180
22	Radiator Module	RAD Module Radiator fin cleaning	6	180
23	Air Solenoid	Air Solenoid valve replacement	2	180
24	4” ABV	Ball stick on the body, stem brake	1	180
25	Air compressor	Oil change	1	180
26	Bioflim spray manifold	Cleaning nozzles	6	180
27	HW Satellite tank	Sludge Removal (inside)	2	180
28	Radiator Module	RAD Module Radiator tube cleaning	8	180
29	Main HEX	HEX open up cleaning	6	365
30	Air Regulator	Air Regulator replacement	1	365
31	Burst Disc	Burst Disc replacement	1	365
32	Air Diaphragm pump	Diaphragm maintenance	1	365
33	Chemical dosing pump	Diaphragm maintenance	1	365
34	Air compressor	Belt change	2	730

* *Per device*

** *Operation dependent: Frequency will varies depending on operation conditions*

3 Check List

Please complete the following daily Plant Operation and Maintenance check list.

3.1 Daily Check List

No	System	Check Point	Yes/No	Note
1	Process/HMI	Check any alarm on HMI and investigate. If cause of alarm is relieved reset the alarm control on HMI.		
2	Process Sampling analysis	Sample required water and perform water analysis and log the results.		
3	Pump	Check for leaks at pump housing, seal and fitting.		
4	Pump	Check pump vibration and sound for any abnormal vibrations/sounds		
5	Pump	Check pump discharge pressure gauge and compare reading with pressure transmitter on HMI.		
6	Pipework	Check for leaks at joints and connections.		
7	Tank	Check for leaks at the tank fittings.		
8	Tank	Check tank level indicator and compare reading with level transmitter.		
9	Evaporator Module	Open inspection cap and check brine “raining” inside module.		
10	Evaporator Module	Open inspection cap and check air flow.		
11	Evaporator Module	Open inspection cap and check scaling and sludge accumulation on packing.		
12	Evaporator Module	Open hatch on top lid and inspect scale or sludge build up and clean as required. (Every 2 day but depending tendency of scaling/fouling)		
13	Radiator Module	Open inspection cap and check brine contamination and condensed water draining.		
14	Fan Module	Check fan vibration and sound for any abnormal vibrations/sounds		
15	Module Air Seal	Check for air seal damage or leakage, and check inflatedness.		
16	Cone Strainer	Check effect set pump discharge pressure (compare to previous day). If pressure difference > 3 psi, proceed with Hot Wash and check pressure again. If pressure difference does not reduce, inspect cone strainer and clean.		
17	Basket Strainer	Clean basket strainer if the pressure difference between Inlet and Outlet Pressure gauge is above 3 psi. (remove basket and clean)		
18	Brine Extraction system	Check brine extraction pump is ON and that there is sufficient flow during circulation and discharge. (Check sampling valve and flow sensor during discharge)		

No	System	Check Point	Yes/No	Note
19	Brine Extraction system EDP	Check brine extraction pump (Electrical diaphragm pump) oil level and color. If oil level is lower than center of sight glass, Stop the pump and top up oil. (Oil spec: Manual transmission/gear oil 80W90)		
20	Brine Extraction system EDP	Check brine extraction pump suction and discharge pulsation dampener pressure and pulsation. If pressure gauge reading is fluctuating, charge air into pulsation dampener until fluctuation of pressure gauge is less than 1 psi		
21	Freshwater System	Check bag filter pressure difference between inlet and outlet pressure gauge. If pressure difference is above 5 psi, replace bag filter. (20 micron)		
22	Air Compressor	Check oil level of compressor and engine and top up the oil if required (Refer to manufacturer's manual for procedure and oil type).		
23	Air Compressor	Drain water in the receiver tank at the end of every day.		
24	Compressed air Instrumentation	Check air pressure at local pressure gauge and compare to the reading of pressure transmitter on HMI.		
25	Compressed air Regulator	Check air regulator at main air header right after air compressor. Pressure set point should be 100 ~ 105 psi.		
26	Compressed air Air Seal	Check air pressure at air seal manifold and make sure it is at 17.5 psi.		
26	Compressed air Air Dryer	Check air dryer inlet and outlet pressure difference and check condensate drain		
27	Compressed air Pre-Desiccant Filter	Check for water accumulation in both filters. Drain if necessary		
28	All chemical dosing systems	Check all chemical feed containers and replace tote or drum or fill up the chemical if required. Proper PPE per MSDS will be required.		
29	All chemical dosing systems	Check any chemical leakage at pump suction, discharge and ABVs and feed container.		
30	Antifoam/Biocide /Base dosing system	Check air supply pressure to chemical dosing Air diaphragm pump at air pressure regulator and test pump to make sure working properly.		
31	Antifoam dosing system	Check antifoam delivery at the tank by disconnecting antifoam dosing end into bucket and manually dose antifoam		
32	Biocide dosing system	Check biocide delivery by feed container level change and pump discharge stroke frequency.		
33	Base dosing system	Check base dosing delivery at the satellite HW tank by looking into tank.		
34	Acid dosing system	Check acid valve manifold to confirm manual valve position.		

No	System	Check Point	Yes/No	Note
34	Acid dosing system	Check acid dosing line CPVC conduit drain valve with bucket ready to collect if there is any acid draining. (3 points: RO Preconditioner, SM1 and SM2 dosing line)		
35	Acid dosing system	Check acid dosing pump suction line and discharge line and pump prime.		
36	RO Preconditioning system	Check RO preconditioning cooling radiator fan operation at the outside of building.		
37	RO Preconditioning system	Check RO preconditioning cooling radiator leaking at the outside of building.		
38	RO Preconditioning system	Check RO preconditioning system pH sensor functionality by sampling RO PC Tank water and measuring pH and compare HMI AIT-321-1 reading.		
39	RO Preconditioning system	Winter time (Ambient temperature < 4 degC or 40 degF), check heat trace functionality on outside piping from RO PC tank to RO PC Radiator.		

3.2 Weekly Check List

No	System	Check Point	Yes/No	Note
1	Pump	Check pump seal wash line and port clogging. Clean if required.		
2	Instrumentation	Check Sensor reading on HMI and calibrate if required.		
3	Instrumentation	Check Pressure transmitter tube for clogging, clean if required.		
4	Instrumentation	Check flow cell of each effect pump skid and clean sludge or fouling on sensor if required.		
5	Effect Cone Tank	Drain down brine in cone tank to inspect valve fitting and solids accumulation. **Caution:** Be ready to close valve. If solid stuck inside valve it will be not easy to close valve so open again and try to close it.		
6	Evaporator Module	Check packing cleanness and wash packing with pressure washer in low pressure.		
7	Evaporator Module Packing Spray	Check packing spray plugging and plan cleaning if required		
8	Satellite HW Tank	Check sludge accumulation at the bottom of tank. Empty tank and clean sludge out with utility air diaphragm pump if required.		
9	Air compressor	Clean dust and foreign matter from cylinder head, motor, fan, air line, intercooler, and tank.		
10	Air compressor	Remove and clean air intake filters.		
11	Air compressor	Check V-belt for tightness. Refer to manufacturer's manual for procedures on how to tighten V-belt.		
12	Compressed air Desiccant Dryer	Check indicator on the head of the desiccant dryer If it is not blue, isolate the desiccant dryer, drain the air and inspect the silica gel inside the housing. If desiccant is pink, replace desiccant.		McMaster-Carr: 5163K49
13	Effect Drip Tray	Check effect drip tray draining and clean or unplug drain if required.		
14	All Air Diaphragm Pump – Air	Check air regulator for air diaphragm pump and air delivery or leakage at pump.		

3.3 Monthly/Yearly Check List

No	Period	System	Check Point	Yes/No	Note
1	Every 1 month	Radiator Module	Check radiator tube scaling by opening Radiator inlet piping		
2	Every 1 month	Evaporator Module	Check brine spray nozzle and clean/unplug if required		
3	Every 1 month	Compressed Air Pre Desiccant filter	Check Red notch indicator, if it's getting close to the top of the sightglass, order a new filter.		AMG-EL350 and AMH-EL350
4	Every 1 month	Compressed Air Post Desiccant filter	Visually inspect. If filter is becoming clogged, check flow and look to order new filter.		
5	Every 2 months	Cone Tank	Check brine tank top brine spray for plugging, clean if required		
6	Every 3 months	Evaporator Module	Check packing spray nozzle plugging, clean if required (Require module removal)		
7	Every 3 months	Actuated Ball Valve	Check all ABV actuation and position sensor function with HMI		
8	Every 3 months	Air Compressor	Check system for air leakage (around fittings, connections and gaskets).		
9			Tighten nuts and cap screws as required.		
10			Check and clean compressor valves, replace springs, discs and seats if worn or damaged.		
11			Pull ring on pressure relief valves to ensure proper operation.		
12	Every 3 months	Fan Module	Grease motor and ball bearings		
13			Visually inspect fan belt tension and tighten as required		
14			Check fan motor alignment		
15	Every 6 months	Brine Discharge pump	Inspect Electrical diaphragm pump diaphragm and replace diaphragms.		
16	Every 6 months	Fan Module	Check fan bearing and pulley condition check (Open fan module and visual and physical check)		

No	Period	System	Check Point	Yes/No	Note
17	Every 6 months	Fan Module	Visual check of fan impeller by pulling fan module out		
18	Every 6 months	Satellite HW Tank	Check Satellite HW Tank bottom for sludge accumulation and clean if required.		
19	Every 6 months	Air Compressor	Operate the safety valve		
20			Test shut-off switch		
21			Replace the air inlet filter		
22			Brush or blow off the finned surface of the condenser.		
23			Inspect and clean the electronic drain: Functioning of the drain can be checked by pushing the TEST button of the drain. Cleaning of the drain filter can be done by purging the manual drain valve for a few seconds.		
24	Every 6 months	Evaporator Module	Check sludge accumulation in top basin through inspection hole and clean if required. (To be reported)		
25			Check sludge accumulation in bottom basin through inspection hole and clean if required. (To be reported)		
26	Every 1 year	Radiator Module	Clean radiator tube by opening radiator module with special cleaning brush.		
27	Every 2 Years	Air Compressor	Replace check valve.		
28			Replace V-belt.		
29			Replace the element outlet pipe and the plastic insert.		
30			Clean fan, fan duct and element cooling fins.		

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Detailed Troubleshooting and Maintenance Instructions

Appendix B

Revision A

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Table of Contents

1 Safety Reminders

The table below outlines a list of specific hazards associated with SaltMaker troubleshooting and maintenance. The list is not exhaustive and operators are advised to review all hazards whether or not they are present in the table below.

Warning – Ensure that appropriate PPE is worn while performing any of the following mechanical maintenance and troubleshooting procedures (eye protection, appropriate gloves, long sleeves, and respiratory protection).

Table B1: List of specific Hazards

Potential Hazard	Actions to take
Moving parts (Pump impellers and Fan blades)	• Confirm fan or pump is isolated and electrically locked out
Injuries caused by forklift operations	• Ensure forklift is operated by authorized personnel. • Ensure rating of forklift is sufficient for load. • Ensure forklift is inspected and maintained before initiating work. • Ensure personnel can be seen by forklift operator when working in vicinity, viz-vest.
Heavy loads while lifting and adjusting modules	• Use proper tooling and equipment for moving modules • Get help from other personal to make adjustments
Loud Noise	• Wear appropriate hearing protection as required
Hazardous chemicals in water supply	• Confirm water chemistry and hazard risk prior to commencing work • Sample and analyze if necessary. • Follow MSDS requirements, if available. • Apply gas monitoring and additional PPE as required.
Liquid Splashes	• Eye protection, gloves, and long sleeve clothing required.
Injury due to poor ergonomics	• Ensure good task lighting. • Use kneeling pads as required, etc.
Slips due to wet surfaces	• Clean up spills and place anti slip mats as needed.

2 Troubleshooting Matrix

This section serves as a guide to solve problems that operators may face over the lifetime of the SaltMaker. See the recommended actions below.

Table B2: Troubleshooting Matrix:

Problem	Probable Causes	Recommended Actions
No flow through evaporation module	Manual ball valve position incorrect	• Check position of manual valves and ensure flow path is open
	Air actuated ball valves not working correctly	• Check the air pressure gauge or transducer upstream of the air valve bank that feeds the actuated ball valve and confirm there is >80 psi pressure. • Check and confirm pressure at valve head • Manually actuate valve (using override on HMI) confirm valve actuates • Isolate air to the valve actuator, remove valve body, open body, clean if required
	Pumps not working correctly	• Check power to pump • Check that the pump rotates • Confirm pump direction is correct • Manually hotwash pump • Disconnect pump and check for salt build up inside head of pump
	Low water levels in Tanks	• Confirm water level in tank is above pump inlet • Manually wash cone tank outlet if a clog is suspected
Evaporation module top basin overflow	Feed nozzles plugged	• Perform slug wash • Remove module and clean manually
	Swing valves are jammed	• Check valve arrangement and ensure only one pump is feeding

		each basin • Check and confirm pressure at valve head • Manually actuate valve (using override on HMI) and confirm valve actuates correctly • Remove valve body, open body, clean if required
Low freshwater Production	No airflow through heat recovery module	• Check fans are running at the correct speed • check Evaporation module packing for crusting, and perform a wash if required
	No water flowing through the heat exchangers inside the radiator module	• Check manual valve positions and ensure flow path is open • Check ABVs and ensure proper actuation and flow path • Check pump and ensure proper operation • Perform piping wash
	Thermal source not providing heat to first effect	• Confirm thermal source supply • Confirm manual valve position in thermal source system • Confirm saltwater flow through thermal source heat exchangers
High Pump Discharge Pressure	Salt crust forming in pumps, pipework, or radiator	• Perform piping hotwash • Remove sections of piping and manually clean
	Manual valve closed	• Check position of manual valves and ensure flow path is open
	Air actuated valve not functioning properly	• Check indicator on valve head to confirm correct position • Check supply and confirm ~100psi pressure is available from the air compressor • Manually actuate valve (using

		override on HMI) confirm valve actuates • Remove valve body, open body, clean if required
No salt discharge	No salt in tank	• Confirm salt forming in tank bottom
	Auger not working	• Check auger is rotating • Confirm auger direction is correct
	Salt bridging over auger mouth	• Manually run in tank vibrators (Effect 2 and Effect 3) • Manually trigger tank air purge (Effect 1 and Effect 4) • Manually drain tank and clean
Hot wash water not heating up	Electric heater not working	• Check temperature controller settings on heater control panel • Check heater electrical wiring • Confirm adequate flow through heater • Confirm back pressure on heater by adjusting gate valve on heater discharge
Low Tank Level	Manual ball valve position incorrect	• Check position of manual valves and ensure flow path is open
	Air actuated ball valve not working correctly	• Check ABV is in the correct position and valve is not in override mode • Check pressure at valve head – confirm 100psi pressure • Manually actuate valve (using override on HMI) and confirm that valve actuates • Remove valve body, open and clean if required
	Feed pump not working	• Confirm feed tank level is above low level switch • Confirm feed pump has power • Check pump rotation

		• Inspect pump
High conductivity in condensate water	Fan speed too high	• Confirm fan speed is set correctly. • Reduce fan speed and continue to monitor condensate conductivity
	Humidifier basin plugged and overflowing	• Perform hotwash, and packing wash on humidifier • Remove humidifier module and manually clean basin
Salt Crust build up on packing	Air flow over packing during shutdown	• Confirm fans are off during wash cycles • Confirm flush cycle occurs prior to shutdown
	High concentration water operating in effect for too long	• Confirm tank swing logic is operating • Increase frequency of tank swing • Remove module and manually clean
Brine conductivity discrepancy	Problem with conductivity sensors Problem with salt crusting around conductivity sensor. Problem with calibration, or signal scaling on the HMI. Sensor malfunction.	• Confirm conductivity discrepancies with handheld meter. Recalibrate if necessary. • Confirm there is adequate flow around the sensor probe. • Confirm that sensor probe does not have heavy build up. • Check conductivity sensor wiring. Refer to manufacturer's instruction manual for more info.
	Problem with Normal or Swap Modes	• Confirm that sensor placement • Check swap mode timer
Vibrators making irregular noise/not on	Internal damage to vibrator	• Confirm vibrator logic on HMI • Disable vibrator on HMI • Remove from tank • Secure vibrator and in manual mode test the vibrator.

No air pressure	Manual air valve closed	• Check position of manual valves and ensure that flow path is open.
	Air compressor not working	• Confirm air compressor is turned on • Confirm air pressure at compressor • Confirm oil level • Confirm electrical connection • Consult air compressor manual in MDR for troubleshooting procedure
Leaking Pipes	Problem with Plumbing Fittings	• Check tightness of fittings (unions, valves or flanges) • Check gasket or O-ring on fittings, replace if required • Replace fittings and check alignment • Consult P&ID and spare parts list for exact pipe and fitting sizes.
Air actuated ball valves not actuating	No air at valve actuator	• Confirm compressor is on and there is air pressure in receiver • Check manual valves to confirm air is going to actuator
	Actuated Ball Valve not actuating	• Confirm valve actuation using manual controls • If valve is not moving, 1) check and listen for air leakage; or 2) salt build up in valve housing • If salt build up is suspected, perform hot wash to clean. • Confirm actuation using manual controls • Remove and clean valve.

3 Manual Washes

While the SaltMaker is designed to handle high concentration brines, operating interruptions may happen from time to time and prevent automated cleaning cycles from being 100% effective. Operators may see problems with clogged pipework in unexpected locations. If standard SaltMaker cleaning cycles are not adequate, operators can perform manual washes to target this specific area.

We will go through the high level steps outlined below to perform a manual wash to clear the clog outlined in *figure B1*.

- Identify the section of pipe that is experiencing blockage.
- Identify the hot wash flow path required for washing the section of pipe containing blockage. Refer to the P&ID to identify the correct valves.
- Select and override corresponding valves to create a flow path from hot wash tank to the pipe. Identify and open/close manual valves as necessary to create flow path.
- Double check valve positions.
- Run hot wash main pump to divert wash water to wash the isolated section of pipe.
- Reverse the steps above to set the valves back in normal position
- Restart the effect and set pumps.

Detailed Manual Hot Wash Procedure:

If one of the main pump pressures are reading low or the pumps are experiencing cavitation, and automatic washes are not having the desired effect, the operator can try the following:

1. Disable **pump pressure low alarms** for the effect in question. (the alarms will trip if the operator tries to do the steps below without disabling the pressure low alarms)
2. Slow down effect pumps to a low speed, and then speed up again slowly to see if the system recovers
    a. If the system recovers, lower speed set point & monitor
    b. If the system does not recover: enable OVERRIDE but leave everything else running
        - Stop pumps in the effect completely
        - Wait 2 minutes
        - Re-start pumps slowly one at a time to 40% speed, then bring all to operational speed
3. If the system does not recover, the system is likely experiencing a pump inlet blockage. (see *figure B1*).

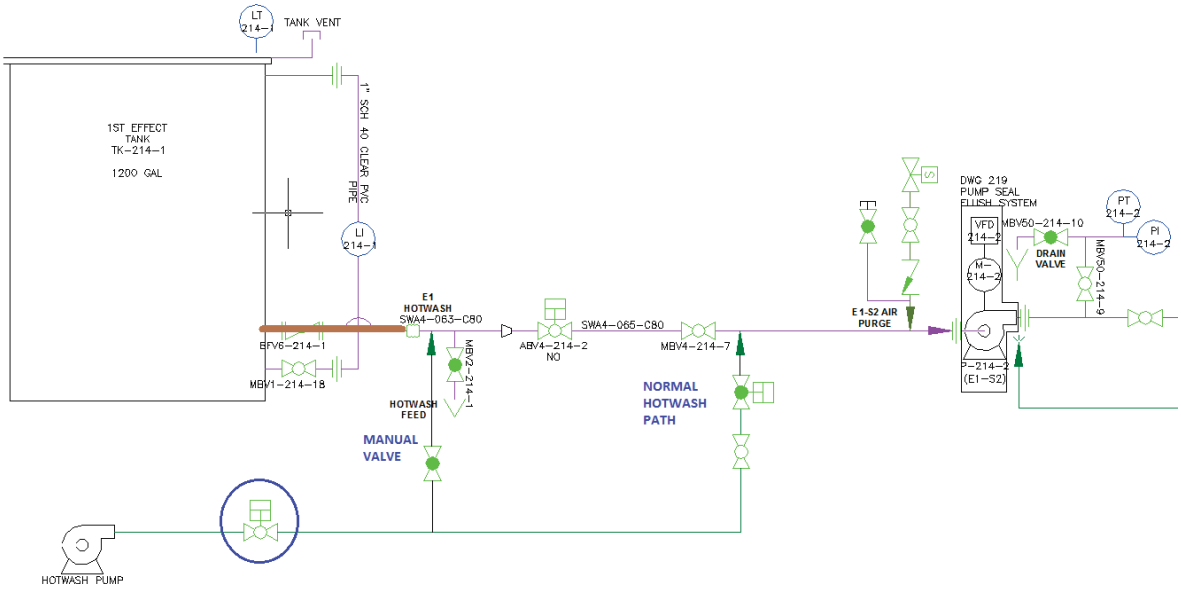

Figure B1: **Salt Crust on Pump Inlet, indicated in brown**

4. The solution is to perform a manual hotwash flush to push water back into the tank inlet:
    a. Follow above steps from 1 to 2b (to stop pumps safely without trips)
    b. Turn off fans on the effect to prevent salt crusting on packing
    c. Close pump inlet valves and close the normal hot wash valves(ABV, *location D* in figure below)
    d. Open MBV2-2X4-19 manual hotwash valve, shown as “B” in *figure B2*.
        - See *figures B3-B6* below for physical location.

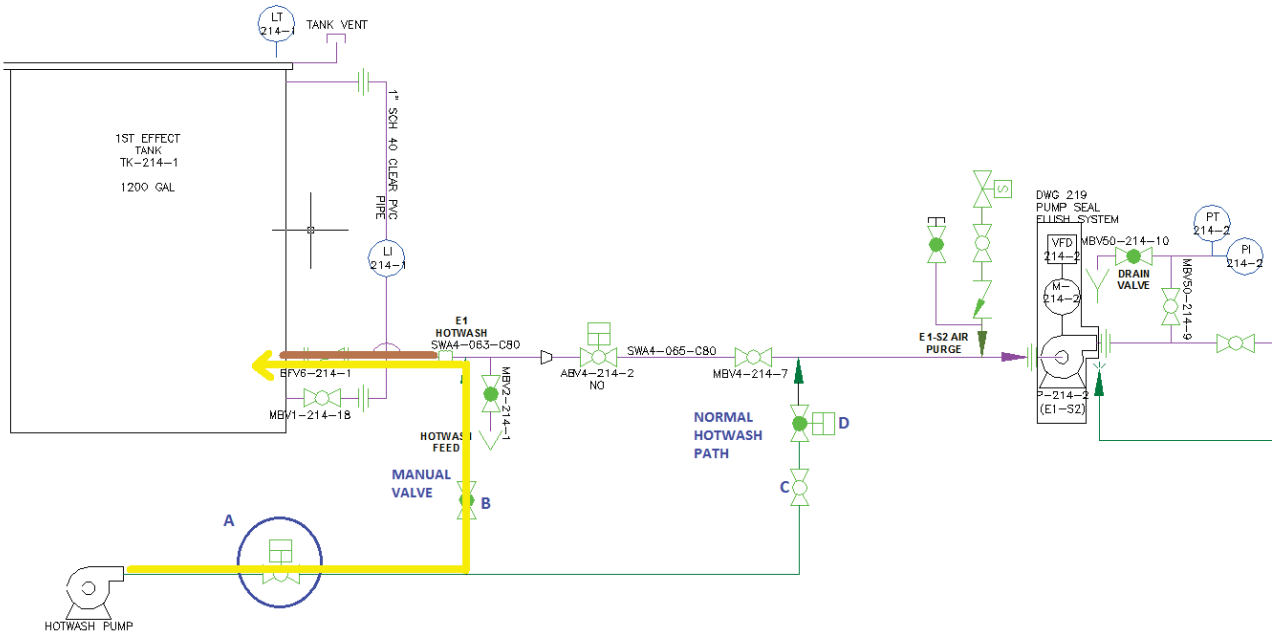

Figure B2: **Manual wash flow path**

e. Turn on Sets 1 to 3 pump seal flushes for 1 minute. This pump seal flush sequence will run the hotwash pump and flush the tank inlet.
f. Re position valves to normal
g. Re-start pumps slowly one at a time to 40% speed, confirm pressure is increasing and flow is returning to tank.
h. If pressure does not increase or there is no flow to tank, repeat steps 3a – 3g.
i. If pressure is increasing, and there is flow returning to the tank, then bring all pumps to operational speed.
j. Re-start fans

Re-enable pump **pressure low alarms!**

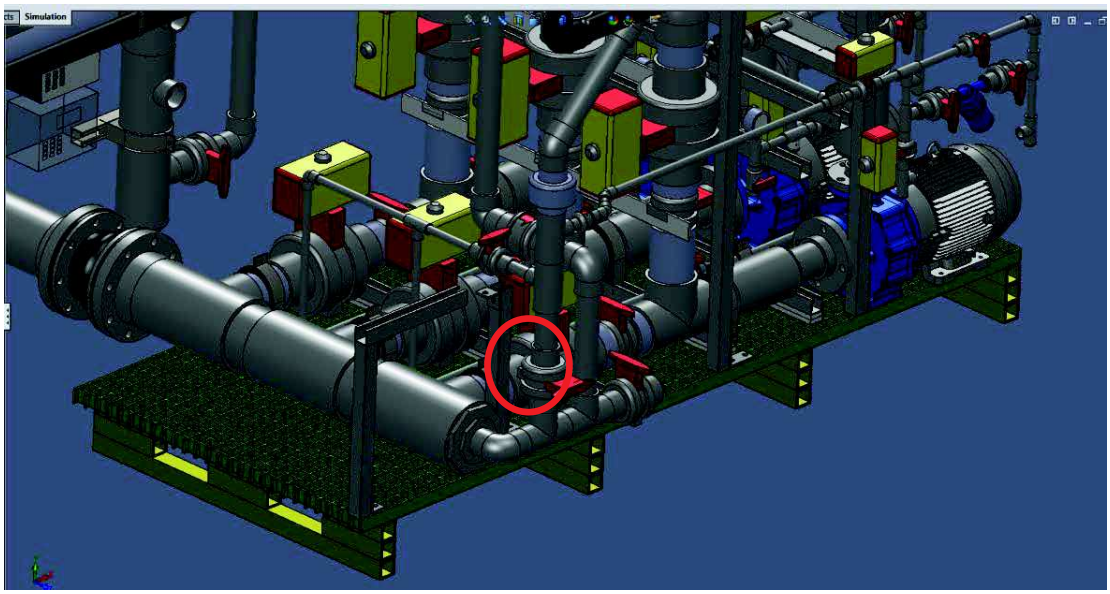

Figure B3: **MBV2-214-19 Valve Location**

Figure B4: **MBV2-224-19 Valve Location**

Figure B5: **MBV2-234-19 Valve Location**

Figure B6: **MBV2-244-19 Valve Location**

4 Pump Maintenance and Replacement

MDM Genesys Pump Maintenance

The following procedure provides a guide for safe and proper removal of the main pump system. Please see **pump seal replacement supplementary video** for reference.

1. Ensure power is turned off in the plant.
2. Close off valves to the inlet and outlet of the pump. Remove pump from piping section. The pump and motor can be removed from the system without the rest of the piping by removing the bolts connected to the volute head and pulling the pump assembly backwards out of the plant.
3. See MDR for safe work procedures for disassembling the pump.
4. Once open, operator should check for the following:
    a. Check that mounting points are secure.
    b. Check seals and bearings for wear, corrosion, scaling, damage and any other visual anomalies.
    c. Check other components of the pump (such as impeller, volute) for wear, corrosion, scaling, damage and any other visual anomalies. Replace parts as necessary.
5. Once all necessary parts are inspected and replaced as required, reassemble the pump (see MDR for instructions).
6. Reconnect to the plant piping network.
7. Run the pump and check flow.

5 Air Compressor Maintenance

Air Compressor Maintenance

Please see **air compressor inspection and maintenance video** for reference.

1. Confirm tank pressure and outlet pressures of air compressor.
2. Confirm oil level in sight glass. Refer to manufacturer's manual for instructions on refilling
3. Check tightness of V-belt. Refer to manufacture manual for tightening instructions
4. When cycle is complete confirm tank drain valve opens
5. Check water level in air compressor filter. To drain, isolate the filter by closing isolation valves. Depressurize by opening the relieve valve. Confirm using the pressure gauge if available.
6. Remove filters cups and drain water.
7. Secure filter cups and open isolation valves to pressurize system. Confirm pressure reading on pressure gauge.

6 Heat Exchanger Maintenance

In the event that the heat exchanger needs to be replaced or mechanically cleaned, the following is a procedure to safely remove the heat exchanger to perform maintenance.

1. Shut down the SaltMaker plant following the shutdown procedure in Section 5.1 of the operating manual.
2. Turn off boiler skid pump
3. Isolate the heat exchanger by closing the inlet and outlet manual ball valves.
4. Drain process fluid from the heat exchanger.

Warning: Fluid in the heat exchanger can be 90°C and can cause skin burns. Stay away from hot fluid while it is draining.

5. Undo heat exchanger inlet and outlet piping spools, and remove the heat exchanger.
6. Reconnect the inlet and outlet piping spools to new heat exchanger.
7. Open all isolation manual ball valves
8. Turn on boiler skid
9. Start-up SaltMaker plant following the start-up procedure in Section 5.1 of the operating manual.

7 Vibrator Maintenance

In the event that a vibrator needs to be replaced or maintained, the following procedure with **supplementary video** provides a safe removal and replacement of the vibrator.

1. Disable vibrator control on HMI
2. Isolate air supply at the vibrator by closing air line valve
3. To depressurize vibrator, turn on vibrator control on HMI and run until all air is consumed.
4. Disconnect and remove vibrator from tank.

Warning: surface of vibrator is hot!

5. Test vibrator outside of tank – ensure vibrator is properly secured, open air valve to pressurize, turn vibrator control on at HMI. When test is complete, isolate air and bleed as outlined in steps 2 and 3.
6. If damage is confirmed, replace vibrator.
7. Once installed, ensure air is turned on and vibrator controls are enabled on HMI

8 Fan Module Maintenance

Every 3 months or 500 operating hours the fan module needs to be serviced. Depending on the experience of the operator, this can be performed by the operator or contractor. Below is the procedure.

1. Safely shut-down the effect being serviced by following **"5.5 Shutdown"** procedures in **operating manual**.
2. **ELECTRICALLY ISOLATE THE FAN!**
3. Remove two window coverings on sight windows
4. Grease motor and ball bearings as per manufacture procedure in MDR
5. Visually inspect the fan belt tension. If tightening is required, refer to manufacturer's manual in MDR for belt tightening procedure.
6. When complete, place window coverings back on, enable electrical and start effect as per "start up procedure" in operating manual.

9 Module Removal

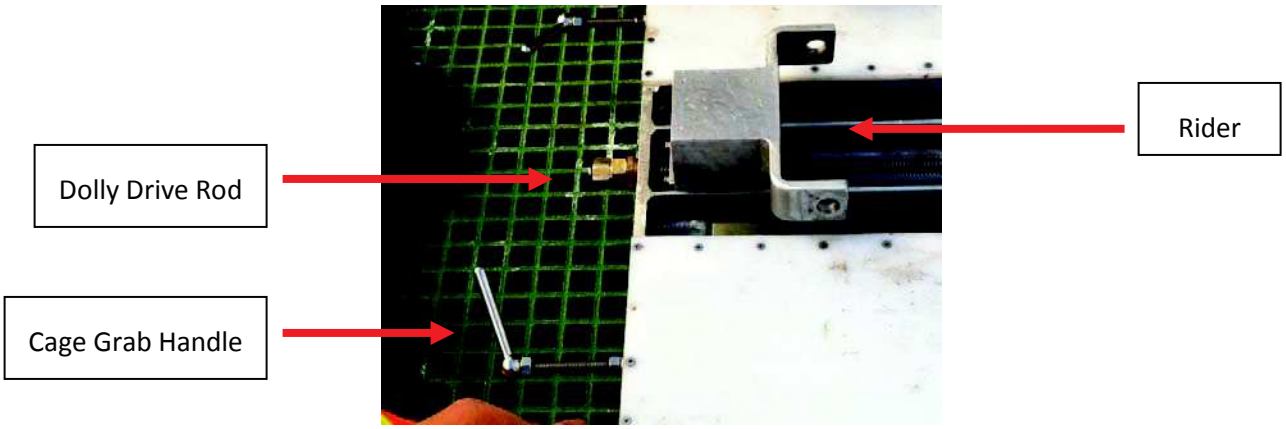

Figure B7: **Parts of a Module Dolly**

For servicing and maintenance of the modules in the SaltMaker plant, removal of sets is required.

Set Removal:

1. Ensure all pipes and air supply lines are disconnected from the module that is going to be removed.
2. Line up the module dolly with the base of the module. Hook the teeth at the end of the dolly onto the steel frame supporting the module. See Figure B4.

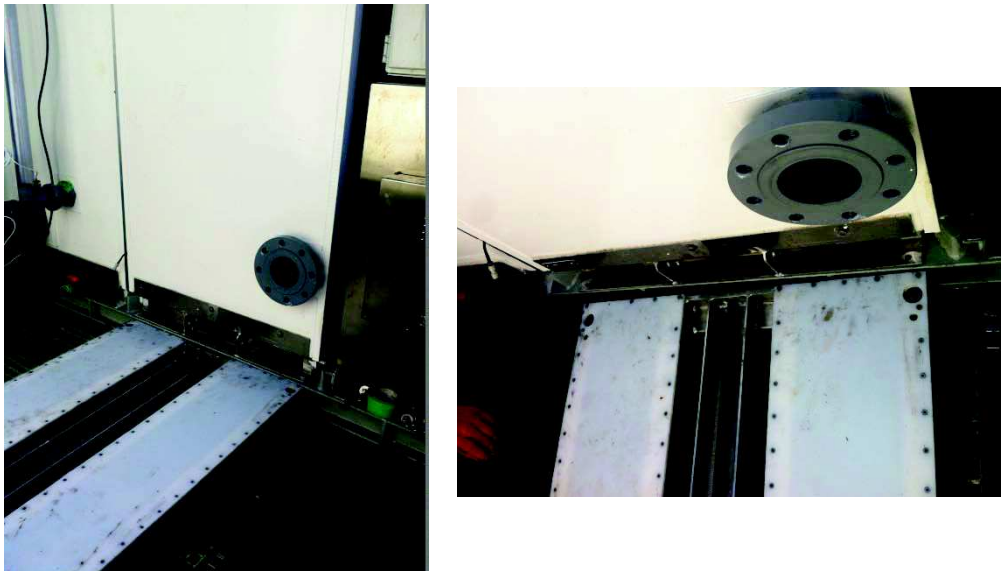

Figure B8**: Lining up Module Dolly with Base of Module**

3. Once the dolly is hooked on, turn the cage grab handles clockwise to lock onto the steel frame.
4. Lower the leg stands on the dolly wheels all the way to the ground. This ensures that the dolly will not move when the set is being removed. Using an impact gun to turn the dolly drive rod, the rider is pushed up flush against the module (Figure B5). Insert a metal rod through the holes in the rider and metal frame on the module.

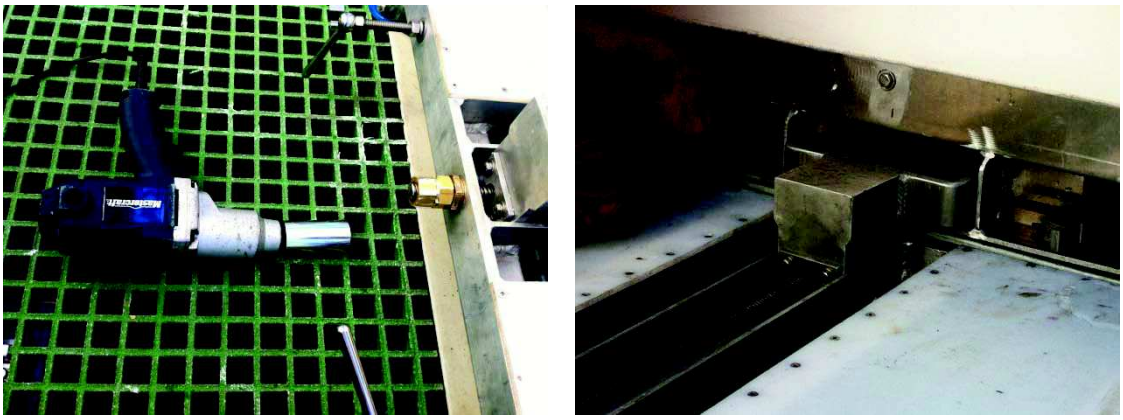

Figure B9: **Impact Gun (*left);* Rider Lined Up with Metal Frame – Metal Bar Inserted (*right)***

5. Once the module is secured to the module dolly, attach the impact gun to the dolly drive rod and turn on to pull the module out onto the dolly. Extra personnel are needed to ensure that the module is pulled out smoothly.

10 Radiator Module Heat Exchanger Cleaning

If the flow through the radiator module is significantly reduced and automated washes are not helping, it may be worthwhile to consider a full radiator module radiator wash.

1. Remove external plumbing connecting the inlet and outlet of the radiator in question.
2. Remove FRP cover plate from front of radiator module by removing the bolts along the perimeter of the plate.
3. Remove Ti cover plate from front of radiator by removing the bolts around the parameter of the plate.
4. Connect the Radiator cleaning brush to a drill and clean all the tubes internal to the radiator

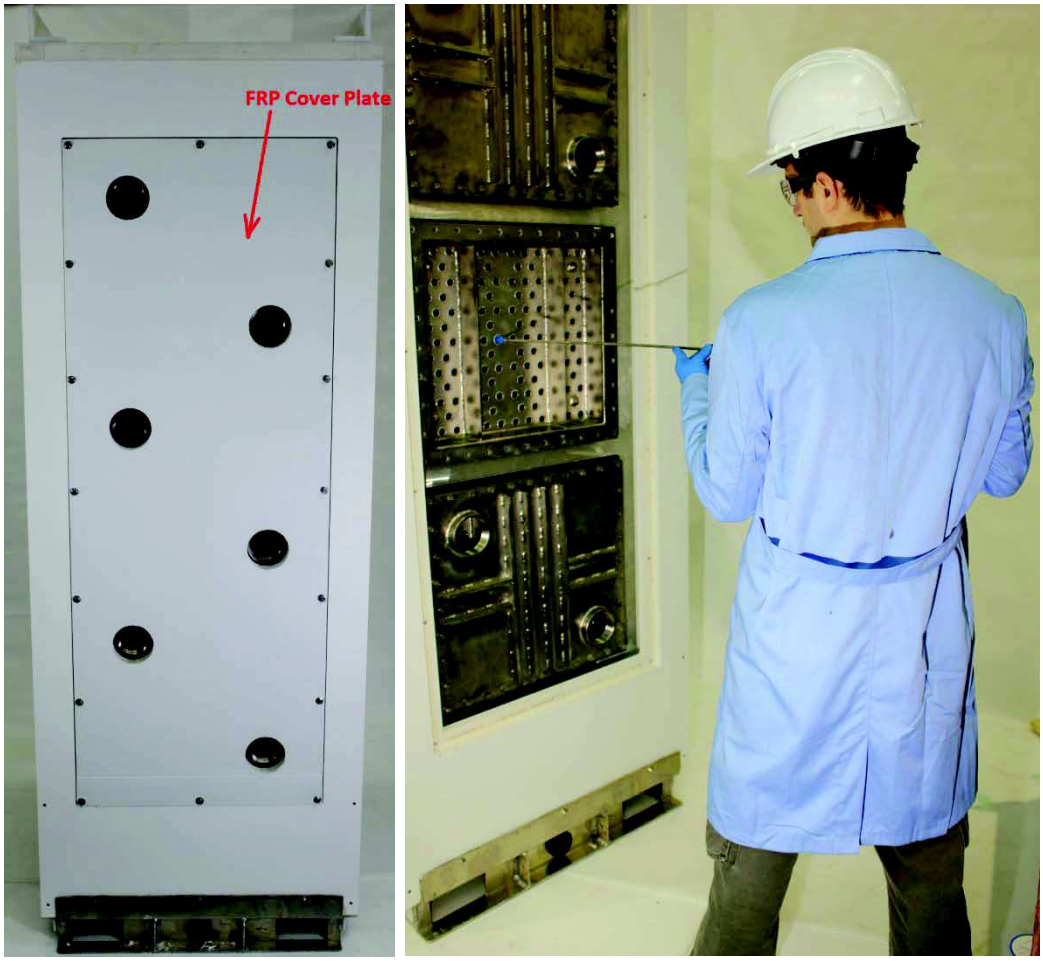

Figure 10: **(Left) Heat Recovery Module with external plumbing connections removed. (Right), Radiator module with FRP Cover plate removed and Ti cover plate removed and individual tubes exposed.**

5. Reinstall the Ti cover plate making sure to install the gasket in the proper place.
6. Repeat 3)-5) for the other 2 radiators.
7. Reinstall the FRP module cover plate over the radiators.
8. Re-connect external plumbing.
9. Open up the valves and check for leaks.
10. Restart the system and check for leaks.

Saltworks

Saltworks Technologies Inc.

Electrical & Controls Troubleshooting and Maintenance Guide

Appendix C

Revision A

CONFIDENTIAL INFORMATION

www.saltworkstech.com

Table of Contents

1 Electrical Troubleshooting

Some of the troubleshooting tasks below may require a properly trained and qualified personal such as an electrician. Do not attempt to do these steps unless you have the proper qualifications.

WARNING: Isolate power before opening and troubleshooting whenever possible to reduce the risk of shock.

Here are a list of problems an operator may encounter, their probable causes, and list of recommended actions to take to troubleshoot and resolve these issues.

Table C1: SaltMaker Electrical Troubleshooting Matrix

Electrical Problem	Probable Causes	Recommended Actions
A electrically driven motor or pump is not moving.	Fault condition causing blown fuse or tripped breaker • Overload caused by hydraulic condition (e.g. blockage in pipe increases pump load) • Overload caused by high friction (e.g. pump impeller jammed and not being able to rotate) • Electrical connection problem or winding damage Problem with the variable frequency drive VFD (if the motor is driven by a VFD). "Variable Frequency Drive Fault" for more details below.	• Identify the fault. Are the fuses blown? Has the breaker tripped? If it is driven by the VFD, does the VFD show a fault? • Lockout the motor / pump in question. • Try to rotate the motor shaft by hand. One way to do this is to access the motor fan at the back if the fan is mechanically coupled to the rotor. • If the motor cannot rotate, remove the motor load or pump head and try again. If the motor can now freely rotate, check the pump head for jams and clogs, or replace. • Check for hydraulic blockage by pumping water in with a garden hose. • Clean the motor. • Check electrical connections for burn marks or damage. Replace and test as needed. • Once the cause has been identified and fixed, then change the fuses or reset the breaker and try again.

Fan is not moving.	Fault condition causing blown fuse or tripped breaker • Overload caused by high friction (e.g. fan jammed and not being able to rotate, or alignment out of place causing excessive load) • Electrical connection problem or winding damage	• Identify the fault. Are the fuses blown? Has the breaker tripped? If it is driven by the VFD, does the VFD show a fault? • Lockout the motor / fan in question • Try to rotate the fan by hand. • If the fan cannot rotate, disconnect the fan from the motor and try to rotate the fan by hand. • If the fan can be freely rotated, check the motor if it can freely rotate. • Clean the motor. • Check electrical connections for burn marks or damage. Replace and test as needed. • Once the cause has been identified and fixed, then change the fuses or reset the breaker and try again.
Receptacles are not getting power.	Power switch or Disconnect switch is in the “OFF” position. Overload or short circuit condition resulting in a blown fuse or tripped breaker.	• Checks switch position. • Check for breaker trips. • Check for blown fuse. • Check the continuity in the wiring. • If breaker is tripped or fuse is blown, check for short circuit or overload conditions on the load side. (Devices that are plugged into the receptacle).

HMI does not turn ON.	Power switch is "OFF". Fault condition causing Blown fuse. Problem with electrical connections. Problem with HMI device.	• Check power switch position. • Check to see if there is available voltage to the HMI. • Check for blown fuse. • Check for continuity in wires connecting the HMI to the power supply. • If fuse is blown, check wiring and confirm that the positive lead (+) is not shorted to ground. • Replace HMI if wiring up to HMI is confirmed OK.
Control PC does not turn ON.	Power switch is "OFF" Fault condition causing Blown fuse. Problem with electrical connections. Problem with Control PC.	• Check power switch position. • Check to see if there is available voltage to the Control PC. • Check for blown fuse. • Check for continuity in wires connecting the control PC to the power supply. • If fuse is blown, check wiring and confirm that the positive lead (+) is not shorted to ground. • Replace control PC if wiring up to the PC is confirmed OK.
PLC does not turn ON.	Fault condition causing blown fuse. Problem with electrical connections. Problem with PLC.	• Check to see if there is available voltage to the PLC. • Check for blown fuse. • Check for continuity in wires connecting the PLC to the power supply. • If fuse is blown, check wiring and confirm that the positive lead (+) is not shorted to ground. • Notify Saltworks for PLC replacement or next steps

Variable Frequency Drive (VFD) does not turn ON or the motor doesn't move.	Fault condition causing blown fuse. The E-stop control circuit is not functioning properly. Problem with connection between the VFD and the motor. VFD drive is overheating.	• Check to see if there is available voltage to the drive. • Check for blown fuses. • See if there is a fault message on the VFD drive. • VFD error codes descriptions are available in manufacturer user manuals. Identify the fault. • If not fault is discovered, check to see if the Drive will start when an "ON" signal is given by the HMI. • If the VFD behaves normally but the motor does not move, check electrical connections (e.g. make sure connectors are making good contact and pins and sleeves are in good shape) • If overheating is suspected, confirm that the cooling devices in the panel are functioning normally. (e.g. cooling fan can be turned ON). • Check heat exchanger fin surfaces for dirt and blockage. Clean as required • Notify Saltworks if problems persist.

2 Instrumentation Troubleshooting

The sensors used in the standard SaltMaker use 4-20mA to transmit signals to the PLC. There are two types of 4-20mA sensors.

1. 2 wire Loop powered sensors connect to the power supply and transmit a 4-20mA current signal to the PLC. Power to these types of sensors is limited by the 4-20mA current loop.
2. 3 or 4 wire sensors have separate positive(+) and negative(-) leads that provide power to the sensor. The 4-20mA signal is separate from the power loop.

The output of these sensors cannot be measured using normal multimeters. Instead, a loop calibrator must be used to test these sensors. Follow the steps below to connect a sensor to a loop calibrator and measure its output.

1. Disconnect both wires of the sensor.
2. Turn on the power of the loop calibrator.
3. A loop calibrator may have multiple operation modes. Change the operation mode to "measure".
4. Connect the red terminal on the loop calibrator to the sensor's power terminal and the black terminal to the sensor's COM terminal.
5. Some sensors require some time to power up. Wait for the sensor to power up and initialize before proceeding.
6. Check the reading on the loop calibrator for the current feedback from the sensor. Normal operating range of sensors should be between 4 to 20mA.
   NOTE: Some sensors may send specific levels of current to indicate irregular operations or errors. For example 21.5mA may indicate a fault for a particular sensor. Refer to the sensor manuals for more details.
7. Calculate the measured quantity from the loop current and the sensor's set range of measurement.

Having a 4-20mA reading from the sensor will usually imply that the wiring and connections to the sensor is fine. If the cable to the sensor is disconnected or cut, 0mA would result. This will help differentiate between a wiring or connection problem vs. a sensor or process problem.

Table C2: Instrumentation Troubleshooting Matrix

Instrumentation Problem	Probable Causes	Recommended Actions
Zero value on all readings on the HMI.	Problem with PLC connection or configuration to the network. PLC and HMI PC is not connected.	• Confirm connectivity by typing in the IP address of the PLC on the web browser and see if the device webpage shows up. • Restart HMI program • Reset the PLC. If the process is running, resetting the PLC will cause the process to STOP. Please flush the system at the earliest available opportunity to avoid salt build-up.
Conductivity sensor reading discrepancy on HMI.	Problem with salt crusting around conductivity sensor. Problem with calibration, or signal scaling on the HMI. Sensor malfunction.	• Confirm conductivity discrepancies with handheld meter. Recalibrate if necessary. • Confirm there is adequate flow around the sensor probe. • Confirm that sensor probe does not have heavy build up. • Check conductivity sensor wiring. Refer to manufacturer's instruction manual for more info.
Level sensor reading discrepancy on HMI.	Problem with calibration, or signal scaling on the HMI. Problems with salt crusting and blockage if it is a pressure transducer. Problems with configuration (if it is a radar or ultrasonic non-contact level sensor) Sensor malfunction.	• Confirm HMI reading with tank level indicator. • Confirm the maximum and minimum level settings on the level sensor. • Check for line blockage (if it is a pressure sensor) • Check for obstructions and interferences. (if it is a radar or ultrasonic non-contact level sensor).

Temperature sensor reading discrepancy on HMI.	Salt scale up around the thermowell. Poor contact between thermowell and process, or between temperature probe and thermowell.	• Remove temperature probe from process connection, and insert tip of the probe in a hot and cold temperature bath. Verify temperature reading with thermometer. • If temperature probe is fine, isolate and remove thermowell from process connection. Check condition and replace as necessary. • If the temperature probe is off, perform a 2 point calibration update the result on the HMI. If problem persists, replace the temperature probe.
pH sensor reading discrepancy on HMI.	Problems with pH sensor	• Confirm pH discrepancy with handheld meter. Recalibrate if necessary. • Confirm there is adequate flow around the sensor probe. • Confirm that sensor probe does not have heavy build-up. If there is build up, wash the probe. • Check pH sensor wiring. Refer to manufacturer's instruction manual for more info.

3 IT Network Troubleshooting

The SaltMaker is controlled by multiple devices communicating over an Ethernet IP network. This network consists of a Control PC, a main programmable logic controller (PLC), remote I/O Modules, variable frequency drives, an uninterruptable power supply, and network cameras, all of which are connected through network switches to the main router. The main router and most other devices have built in web server. Information and status about a device can be accessed in an web browser simply by typing in the device's IP address. For example, if the main router has an IP address of 10.78.1.1, simply go to http://10.78.1.1 on your web browser. Refer to your specific documentation for a network map with the corresponding static IP addresses for each device. See figure C1 a sample network map.

Control PC

The standard SaltMaker uses an industrial strength Control PC that runs a full Windows operating system. (Saltworks part number: 1000755) The Control PC runs the HMI program, the interface through which the operator controls and monitors the plant performance. It is located in the main DC panel in Balance of Plant 2 container and has a static IP address listed in your **IT network diagram** in the **MDR**.

Main Programmable Logic Controller (PLC)

The main PLC controls all of the logic and processes of the plant. It is located in the main DC panel of the Balance of Plant 2 container.

Remote I/O Modules

The Remote I/O Modules communicate analog and digital inputs and outputs to and from the main PLC. There is one module located in each satellite Effect DC panel.

Variable Frequency Drive (VFD)

The standard SaltMaker uses Allen-Bradley PowerFlex series VFDs to communicate with main PLC and control the speed of pumps and motors. The

Uninterruptable Power Supply (UPS)

The standard SaltMaker uses the Eaton 5PX series UPS to communicate with and supply backup power to the Control PC when the SaltMaker loses main power. When the power remaining on the UPS is low, it sends a shutdown command signal to the control PC so that the controls PC will shut down safely before it abruptly loses power. The UPS is located in the main AC panel of the Balance of Plant 2 container.

NETWORK CAMERAS

Network cameras are installed beside each Effect Cone Tank to remotely monitor the level of salt in each salt bin. Each network camera is connected to a power over Ethernet (POE) switch (located in the main DC panel in the Balance of Plant 2 container) to receive power and network connection. The network cameras are assigned static IP addresses by the main router.

NETWORK SWITCHES

The standard SaltMaker uses industrial grade network switches to connect all the Ethernet devices together to the same network, as well as one industrial grade Antaira POE network switch to connect and supply power to the network cameras. Network switches relay network devices to the main router and do not have IP addresses.

MAIN ROUTER

The standard SaltMaker uses an Antaira 3G/4G capable router as the gateway for all network devices in the SaltMaker. Additionally, the router also issues DHCP addresses to devices without static IP addresses that are connected to the plant.

The IT Network is summarized in Figure C1 below.

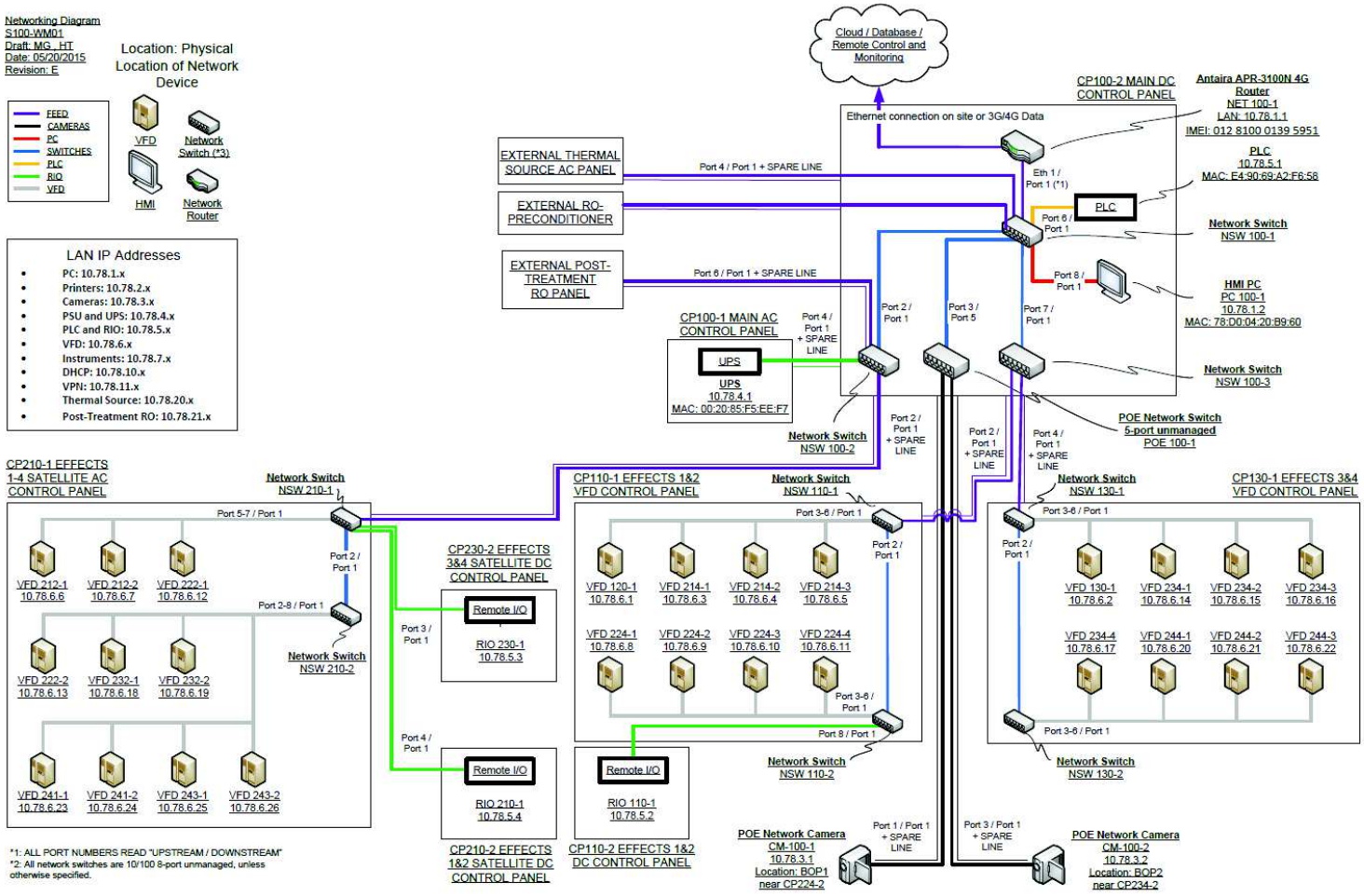

Figure C1: Sample IT Network Map (IP Addresses listed above is for demonstration purposes only, refer to the network map in your MDR for specific information)

Table C3: IT Network Troubleshooting Matrix

IT Network Problem	Probable Causes	Recommended Actions
The plant loses connection to the Internet.	Problem with Ethernet cable connection. Problem with WiFi connection. Problem with 3G/4G data connection. Problem with electrical connections. Plant router failure.	• Check that the router is powered ON. • If router is not powered ON, check for blown fuse and electrical continuity that connects the plant router to power supply. • If fuse is blown, check for short circuit or overload conditions. • If using Ethernet connection: check connectivity in the Ethernet cable connecting the source to the panel. • If using WiFi-as-WAN connection: check that the panel is receiving WiFi signal with sufficient signal strength. • If WiFi signal is weak at the panel, consider boosting the signal with an access point, removing obstructions that may block the signal, or using different connection options. • If using 3G/4G data connection: check that the router is detecting cellular signal with sufficient signal strength. • If cellular signal is weak, consider boosting the signal with an external antenna, removing obstructions that may block the signal, or using different connection options.
PLC loses connection to a panel.	Ethernet cable failure.	• Where possible, check connectivity in the Ethernet cables connecting the panel to the main DC panel.

	Network switch failure.	• If Ethernet cable has failed, replace the cable and try again. • Check that the network switches are powered ON and is routing data traffic. • If the network switch is not powered ON, check for blown fuses and continuity in the wiring that connects the switch to the power supply. • If the fuse is blown, check for short circuit or overloading conditions. • Replace the network switch if needed.
PLC loses connection to a device.	Problems with ethernet cable. Network switch port failure.	• Where possible, check connectivity in the Ethernet cables connecting the panel to the main DC panel. • If Ethernet cable has failed, switch the Ethernet connections inside the panels to the spare line. • Check that the connected port on the network switch is routing data traffic. • If the network switch is not powered ON, check for blown fuses and continuity in the wiring that connects the switch to the power supply. • If the fuse is blown, check for short circuit or overloading conditions.

HMI displays "Not connected to PLC".	Control PC lost its IP address. Ethernet cable failure. Network switch failure.	• Check Ethernet cable connection to Control PC. Replace as needed. • Reset the Ethernet adapter on the control PC.
Connection to network camera is lost.	Network camera failure Ethernet cable failure POE switch failure	• Check that the network camera is powered ON • If the network camera is not powered ON, check the connection between the network camera and the POE switch.

4 Air Control Architecture

An air compressor supplies compressed air to valves, vibrators, and air seals throughout the plant. The air compressor is located in the control room in Balance of Plant 2 container. The air then goes through filters for water, solid and oil separation.

Filtered air is supplied to the different air panels in the plant, where it is further distributed to the valves and instruments as needed. For sensitive instruments, the air goes through an air dryer for moisture reduction. Air panels are located in both BOP containers. These panels contains multiple banks of solenoid valves which provide actuate the individual air lines feeding ABVs (actuated ball valves).

Compressed air is required to actuate vibrators in the cone tanks, actuated ball valves in the pipework, as well as air seals between modules. The actuated ball valves are controlled by pneumatic signals sent by electrically-actuated solenoids, located in the control panels.

Air seals between modules are inflated with compressed air to prevent air leaking out from the closed loop of the effects.

Compressed air is regulated as following:

- 100 psi for control systems and vibrators,
- 30 psi for pipework purges, and
- 15 psi for seals between modules.

Pressure relief valves are placed after each regulator to protect the system downstream in the event of a failure. Additionally, pressure transducers are installed in each control box to measure the pressure to ensure there is enough pressure to fully actuate all valves. In the event that the air pressure drops below a specific level, the plant automatically sets an alarm and shuts down to prevent damage to the system by improperly actuated valves.

More information on the air control architecture can be found in the P&ID, Electrical & Control, and Design Basis drawings.

Table C4: Pneumatic Troubleshooting Matrix

Pneumatic Problem	Probable Causes	Recommended Actions
Pneumatic device does not actuate as expected	Air isolation valves closed or not in the correct position Problem with air solenoid not firing Air line is clogged or jammed. Incorrect air line is supplied,	• Check and confirm air pressure supply. • Confirm that air solenoid clicks when actuated. If it does not click, check electrical connection.

	or air line is reversed. Air supply pressure is low.	• Replace air solenoid if a jam is suspected. • If a blockage is suspected, identify location of air blockage.

Saltworks Technologies Inc.

SaltMaker Control Narrative Details

Appendix D

Revision 0

CONFIDENTIAL INFORMATION

www.saltworkstech.com

Table of Contents

1 Overview

This appendix describes user settings for the SaltMaker HMI. There are also reference timer settings for the plant, which provides the starting point for operators.

The Overview tab allows the operator to monitor all four effects at a glance. Figure 1 below is a screenshot of the Overview tab.

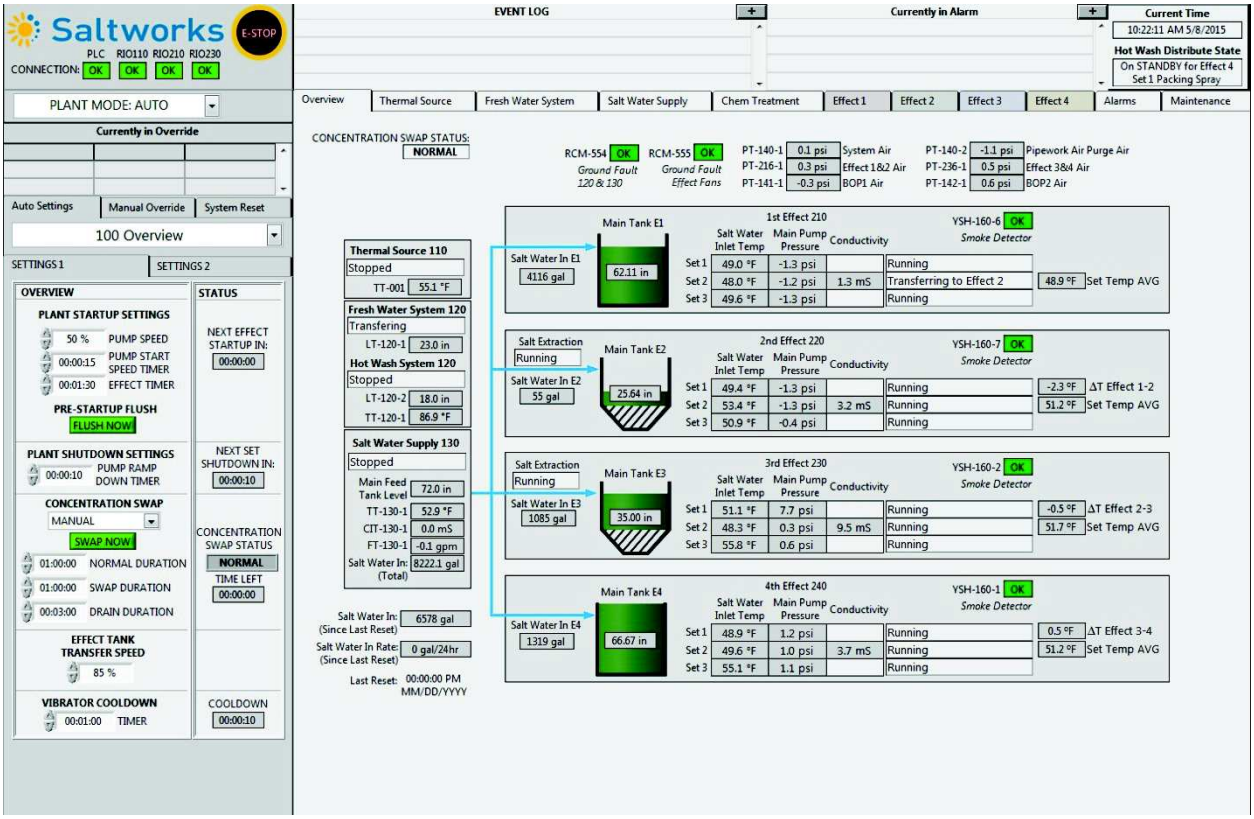

Figure 1: **PFD Overview HMI**

(Numbers on this screenshot are not representative of process setpoints)

1.1 Overview: Auto Settings

Table 1: **SaltMaker Overview Controls Settings 1**

Setting	Component	Control Function
Plant Startup Settings	Pump Speed *Reference (50%)*	Speed that the effect pumps run at during the plant start-up or shutdown.
	Pump start speed timer *Reference (15s)*	Length of time that the effect pump stays in start-up speed before ramping up to preset speed during the plant start-up.
	Effect Timer *Reference (00:01:30)*	Time delay before the next effect starts up after previous effect start-up has completed.
Pre-Startup Flush	Flush Now	Triggers a full hot wash (see section 1.3.6.2 for description) when the Plant Mode is not AUTO.
Plant Shutdown Settings	Pump Ramp Down Timer *Reference (00:00:10)*	Length of time that the effect pump stays in start-up speed before ramping down to a stop during the plant shutdown.
Concentration Swap	Off/Manual/Timer	**OFF** – Valves maintain last swap status (normal or swap mode). **MANUAL** – Change of swap status is only manually triggered by the "Swap Now" button. **TIMER** – Change of swap status is triggered by timer. Operator can also manually trigger the swap sequence with the "Swap Now" button.
	Normal Duration *Reference (01:00:00)*	Length of time for the concentration swap mode to stay in "Normal" configuration. The swap sequence is triggered to change concentration swap to "Swapped" configuration when this timer reaches zero. The timer is only active if "Concentration Swap" is in "Timer" mode.
	Swap Duration *Reference (01:00:00)*	Length of time for the concentration swap mode to stay in "Swapped" configuration. The swap sequence is triggered to change concentration swap to "Normal" configuration when this timer reaches zero. The timer is only active if "Concentration Swap" is in "Timer" mode.
	Drain Duration *Reference (00:03:00)*	Length of time for the effects 2 and 3 pipework to drain before the valves swap.
Effect Tank Transfer Speed	Pump Speed *Reference (85%)*	Controls the speed of the set pumps transferring brine to a different set.

Vibrator Cooldown	Timer *Reference (00:01:00)*	The time interval between two vibrators turning on. The cooldown time is required for the compressed air system to recover pressure.

Table 2 : **SaltMaker Overview Settings 2**

Setting	Component	Control Function
Reset Volume Counters	Reset	Resets volume counter for Salt Water In and Total Condensate Discharge to 0. The starting time and date for the "Total Condensate Discharge Since:" and "Salt Water In Since:" are also reset to the current date and time.
Pump Trip Settings	Pump Drain Duration *Reference (00:00:15)*	The length of time that the pipework drains when the plant or a sub-system is stopped due to an alarm.
	Pump Flush Duration *Reference (00:00:15)*	The length of time that the pipework flush when the plant or a sub-system is stopped due to an alarm.

2 Thermal Source

The thermal source sub-system provides the driving energy for the process. The system consists of set of heat exchangers that transfer heat from the heat source to process water.

The thermal source tab allows the operator to monitor the performance of the heat exchangers. Figure 2 below is a screenshot of the Thermal Source tab that shows the controls and displays of the thermal source sub-system.

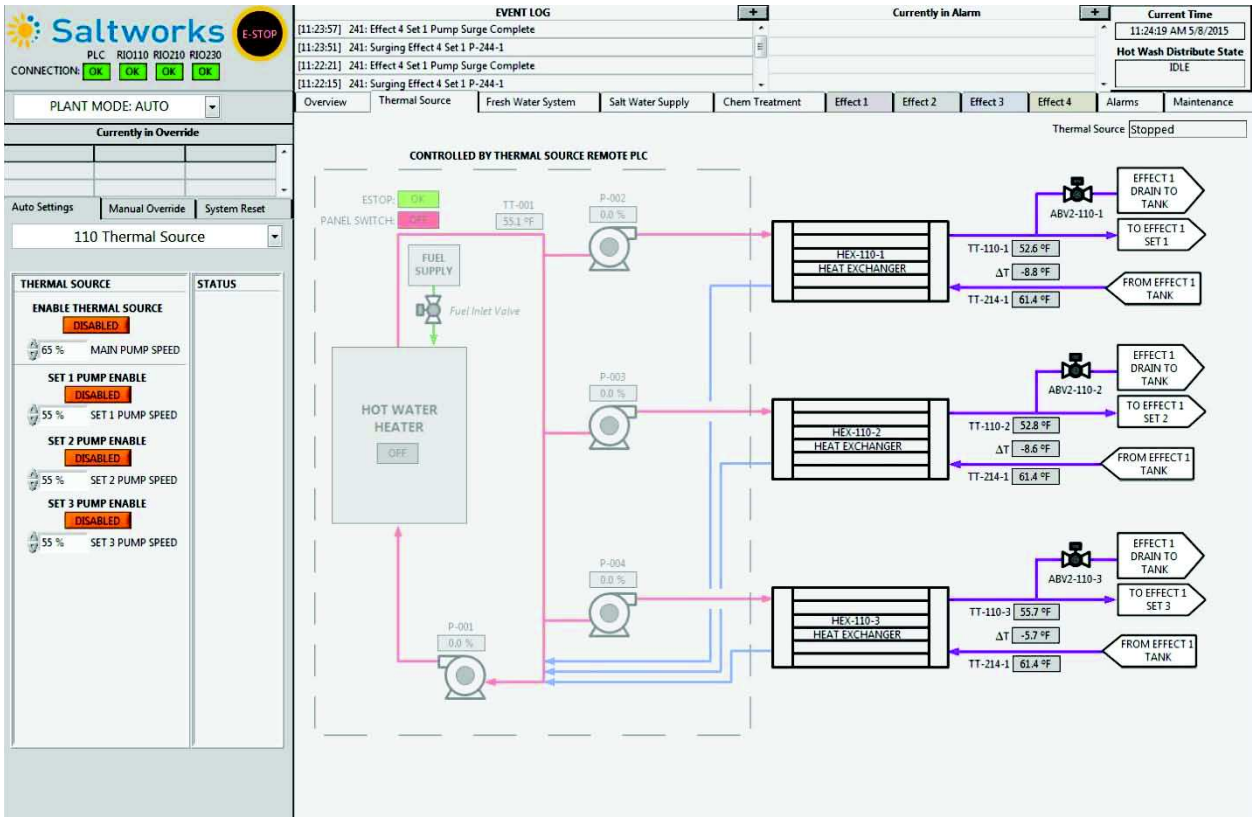

Figure 2: **Thermal Source HMI**

(Numbers on this screenshot are not representative of process set points)

Setting	Component	Control Function
MAIN PUMP SPEED	THERMAL SOURCE *Reference (65%)*	When "Enable Thermal Source" button is Enabled, The main pump will run at this set speed.
SET 1 PUMP SPEED	THERMAL SOURCE	When "Set 1 Pump Enable" button is enabled,

	Reference (60%)	the pump feeding the heat source exchanger for set 1 will run at this speed.
SET 2 PUMP SPEED	THERMAL SOURCE *Reference (60%)*	When "Set 2 Pump Enable" button is enabled, the pump feeding the heat source exchanger for set 2 will run at this speed.
SET 3 PUMP SPEED	THERMAL SOURCE *Reference (60%)*	When "Set 3 Pump Enable" button is enabled, the pump feeding the heat source exchanger for set 3 will run at this speed.

3 Fresh Water System

The fresh water system consists of two water tanks, the condensate tank and the hot water tank. The system has several primary functions, including the collection of treated water, the discharge of treated water back to site and the transfer of treated water to SaltMaker washes. The condensate tank collects the treated condensate in effects 1 through effect 3. This clean condensate water, along with optional external utility water, can be transferred to the hot water tank. The hot water tank provides the hot water required for performing the various hot washes in the plant. The condensate water from the condensate tank can also be transferred to the optional RO system if post-treatment RO is required.

The freshwater system tab allows the operator to monitor and control the main hot water Tank and Condensate Tank. Figure 3 below shows a screenshot of the Freshwater System HMI. The hot water tank controls are listed below:

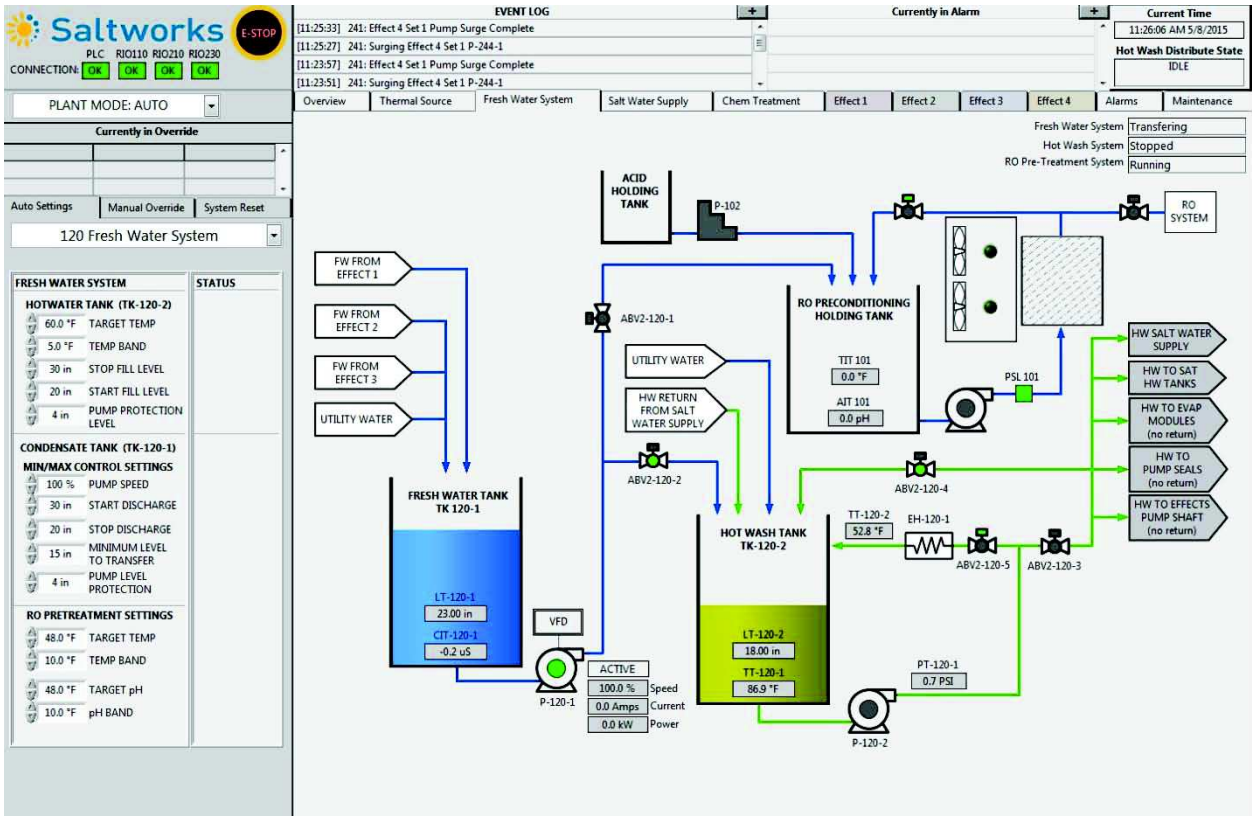

Figure 3: **Freshwater System HMI**

(Numbers on this screenshot are not representative of process setpoints)

3.1 Freshwater System: Auto Settings

Table 3 : SaltMaker Freshwater Controls

Setting	Component	Control Function
Hotwater Tank	Target Temp *Reference (60.0 °F)*	Hot water tank target temperature. If temperature is too low, the closed loop heater will turn ON to heat up the water in the tank.
	Temp Band *Reference (5.0 °F)*	Temperature drop allowance before heater cycles ON. Should be left to default setting.
	Stop Fill Level *Reference (30 in)*	The maximum level of hot water tank. The level at which the tank stops filling.
	Start Fill Level *Reference (20 in)*	The minimum level of hot water tank. The level at which the tank starts filling with freshwater.
	Pump Protection Level *Reference (4 in)*	This is level in which the transfer pump will stop running to prevent the pump from emptying the tank and running dry.
Condensate Tank	Pump Speed *Reference (100 %)*	Condensate tank transfer pump speed that flows fluid to hot wash tank or to SaltMaker discharge, or to an optional RO system depending on system configuration.
	Start Discharge *Reference (30 in)*	Maximum Condensate tank level. The level at which the condensate tank starts discharging to the hot water tank, to overflow, or to optional RO system.
	Stop Discharge *Reference (20 in)*	The level at which the condensate transfer pump turns off to stop discharging water from the condensate tank.
	Minimum Level to Transfer *Reference (15 in)*	Minimum condensate tank level when the condensate transfer pump is transferring fluid to the hot wash tank.
	Pump Level Protection *Reference (4 in)*	This is level in which the transfer pump will stop running to prevent the pump from emptying the tank and running dry.
RO Pretreatment (if applicable)	Target Temp *Reference (48.0 °F)*	This is the target temperature for the RO-pretreatment system. The system cools the freshwater before discharging to the RO system. The circulation pump and fans will turn on if the temperature gets above this setpoint plus temp band, and will stop if the

		temperature gets below this setpoint minus temp band.
	Temp Band *Reference (10.0 °F)*	This is the temperature control range for the RO Pretreatment system. Narrowing this band means more frequent cycling of the RO Pretreatment cooling system
	Target pH *Reference (pH)*	This is the target pH value for the RO pretreatment system. The system measures pH and dose the system automatically to keep the pH range in check.
	pH Band *Reference (pH)*	This is the pH control range for the RO pretreatment system. The system doses when the pH range goes outside the target pH plus pH band, and stop dosing once the target pH minus pH band is reached.

4 Salt Water Supply

The Salt Water Supply tab allows the operator to monitor and control the flow of saltwater into the plant. Salt water to be treated is held in the feed tank and transferred to the plant inlet and overflow tank, then distributed to the effects for treatment. Salt water distributed to effects 3 and 4 stay at the same temperature as distributed from the tank, while salt water distributed to effects 1 and 2 are heated in two sets of heat exchangers using the heat from hot condensate. Figure 4 below shows the screenshot of the Salt Water Supply tab.

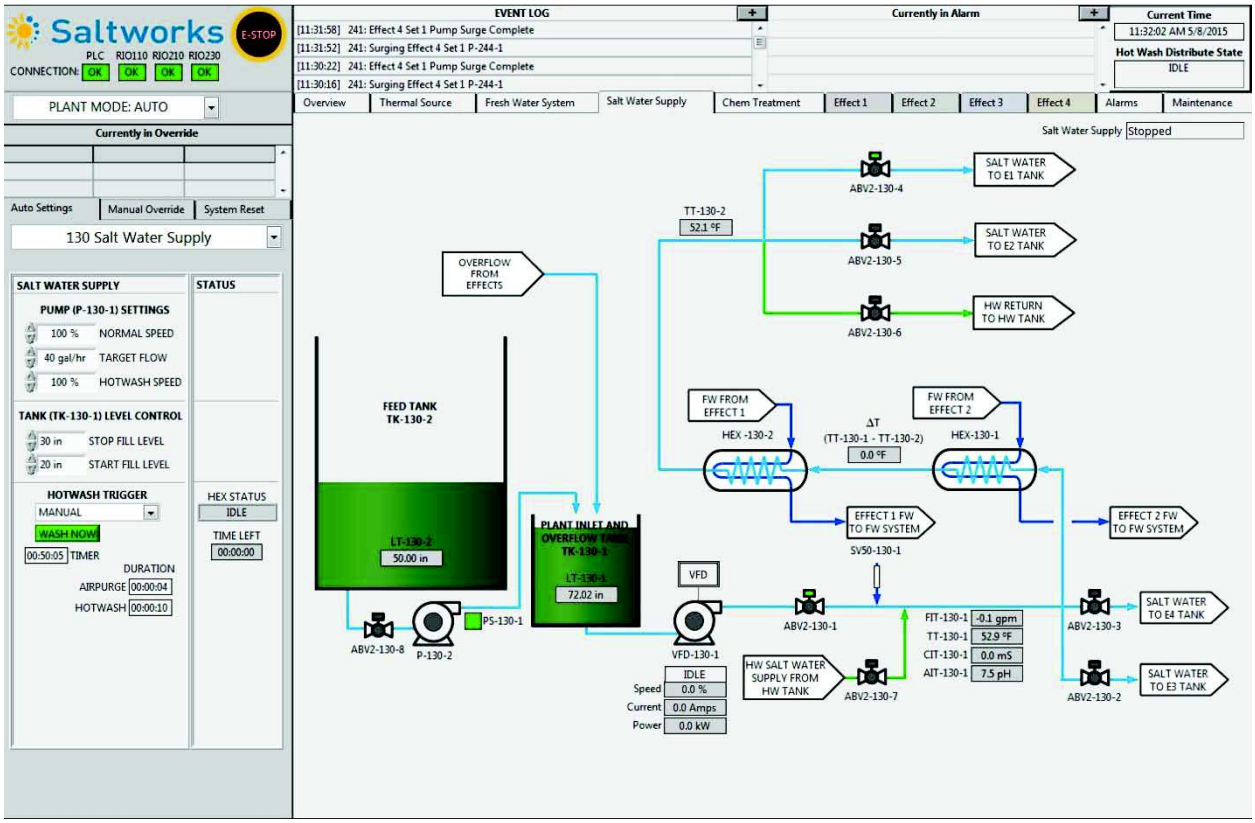

Figure 4: **Saltwater Supply HMI**

(Numbers on this screenshot are not representative of process setpoints)

4.1 Saltwater Supply: Auto Settings

Table 4 : **SaltMaker Saltwater Supply Controls**

Setting	Component	Control Function
Pump Settings	Normal Speed *Reference (100 %)*	Inlet pump speed for fluid transfer from plant inlet to SaltMaker effects
	Target Flow *Reference (40 gal/hr)*	The target flow rate for Saltwater inlet. This setting can be tuned for continuous feed of inlet water at steady state.
	Hot wash Speed *Reference (100 %)*	Pump speed during hot wash
Tank Level Control	Stop Fill Level	The maximum level of salt water tank. The level at which the tank stops filling.

	Reference (30 in)	
	Start Fill Level *Reference (20 in)*	The minimum level of salt water tank. The level at which the tank starts filling with salt water.
Hot wash Settings	Hot wash trigger (Off/Manual/Timer)	**OFF** – Salt Water System hot wash is disabled **MANUAL** – Enables the "Wash Now" button. The operator can perform hot wash by clicking "Wash Now" button. **TIMER** – The hot wash sequence is initiated when time interval expires or when operator clicks the "Wash Now" button.
	Wash Now	Operator initiated hot wash of salt water supply system when Hot wash trigger is in MANUAL or TIMER mode.
	Timer *Reference (00:50:05)*	This is the time interval between two hot wash cycles.
	Air Purge Duration *Reference (00:00:04)*	Time interval where compressed air is sent through the pipework system to push any fluid back to respective tank.
	Hot wash Duration *Reference (00:00:10)*	Duration of hot water circulation through the Salt Water Supply system.

5 Effects 1-4

The HMI for Effects 1, 2, 3 and 4 are very similar. On these tabs, the operator can monitor and control all the sets within each effect. Various aspects of the Effects can be controlled using the following four tabs found within each effect system: Controls, Washes 1, Washes 2, and Fans & Extraction. Figure 5 below shows each individual tab. The controls of each Effect are detailed in the following section.

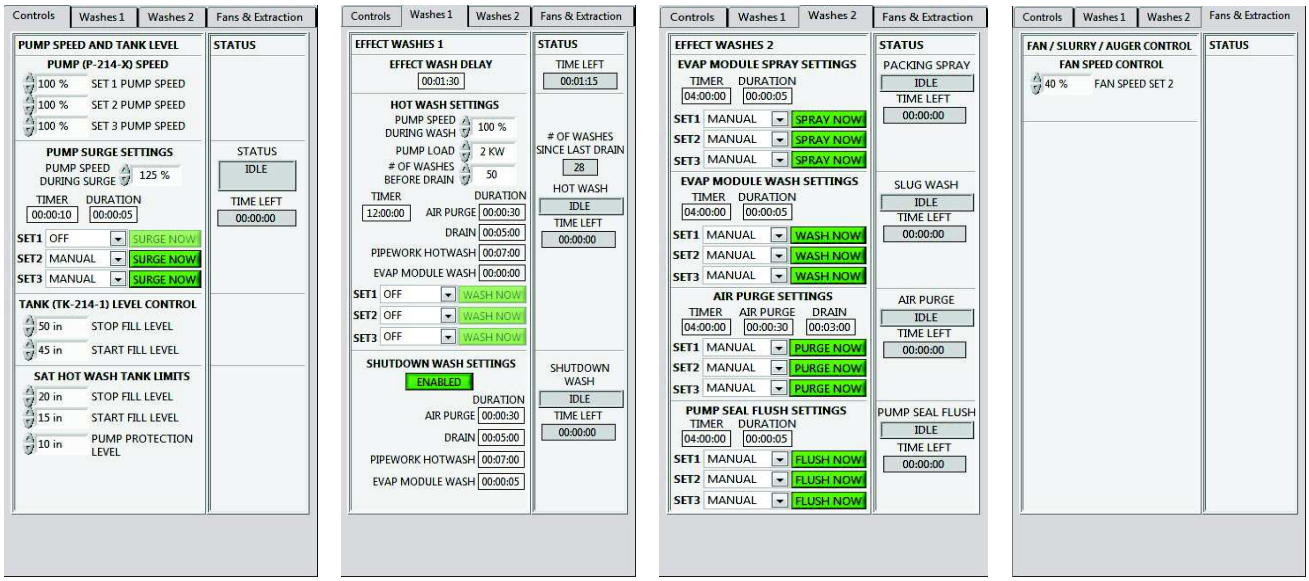

Figure 5: **Effect Control Tabs: Main Effect Controls *(left)*; Effect Washes *(middle)*; Set Washes *(right)***

(Numbers on this screenshot are not representative of process setpoints)

5.1 Effect 1-4 Operator Settings

The Effect tab allows operators to set operating parameters and monitor all components to the specific effect. The operating parameters include pump controls, tank levels, wash cycles, and extraction settings. Figure 6 below is a screenshot of Effect 1 HMI tab.