GE Water & Process Technologies

Tri-City WPCP Phase 1
CONTROL NARRATIVE

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1 Plant Overview

This document covers a general description of the controls by MBR master PLC for the following unit processes:

- ZeeWeed® Trains,
- Backpulse Equipment,
- Aeration Equipment,
- Clean-In-Place (CIP) Equipment,
- Utilities Equipment.

2 General Information

The reader should refer to the Piping and Instrumentation Diagrams (P&ID's), Operations Sequence Chart (OSC) and the Control Logic Summary Chart (CLSC) for a complete understanding of the plant control scheme as described below.

The MBR master PLC follows specific steps to automatically control valves, pumps, etc. during the operating states for the treatment plant. These steps are listed and described in the OSC.

Details of the control logic, setpoints, etc. that are required to operate the plant are given in the CLSC.

In the documentation the Programmable Logic Controller is referred to as the MBR MASTER PLC. The MBR MASTER PLC provides automated control of the ZeeWeed® equipment. All the programming for the control of the ZeeWeed® plant is stored in the MBR MASTER PLC.

Setpoints, alarms, and calculated parameters, etc., are assigned tags in the MBR MASTER PLC code. When tags are used in the Control Narrative, they are identified by an alpha-numeric label, for example, 110-39-021, for the first train's Filtrate pump. In the OSC and CLSC alpha-numeric labels are used for alarms, setpoints, button, etc.

Modes are a series of steps the train follows to perform various operations, such as a cleaning. A specific mode discussed in this document is shown in capital letters, such as MAINTENANCE CLEAN. Buttons displayed on the HMI screen that the operator can press to initiate a mode or other operation are shown with the first letter capitalized. For example, one button that is used to put a train to OFF mode is the Off button.

3 ZeeWeed® Permeate Equipment Operation & Control

A ZeeWeed® train is functionally described as a group of ZeeWeed® modules and cassettes connected by a common permeate collection header. The filtrate pump draws the clean water through the membranes and delivers it through the common header.

Train 1 refers to the equipment associated with membrane tank 1A; train 2 refers to the equipment associated with membrane tank 1B; train 3 refers to the equipment associated with membrane tank 2A; and train 4 refers to the equipment associated with membrane tank 2B.

The production cycle for a train is PRODUCTION mode followed by either BACKPULSE mode or RELAX mode. This cycle repeats until a stop trigger switches the train to STANDBY or a scheduled MAINTENANCE CLEAN is triggered. The operator can interrupt the production cycle by selecting one of the following buttons: Maintenance Clean, Relax, Backpulse..

3.1 Membrane Tank Isolation Gate

Membrane tank isolation gate is used to isolate the membrane tank from the influent flow during MAINTENANCE CLEAN, RECOVERY CLEANS. During PRODUCTION, BACKPULSE, RELAX, and intermittently in STANDBY this gate is open. Consult the OSC for further details on the gate's position.

3.1.1 Influent Flow, Mixed Liquor Transfer Return Channel Level & Permeate Flow Control

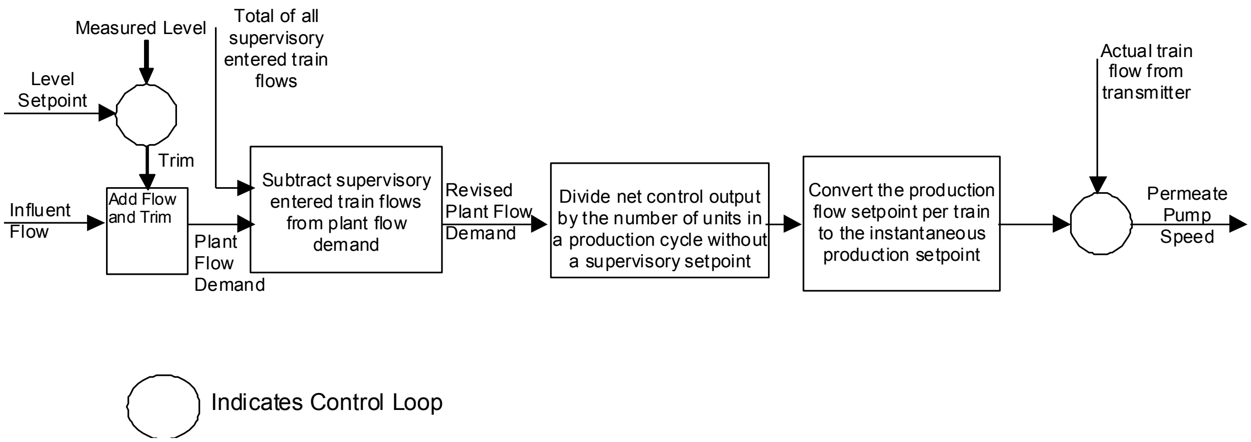
The influent flow signal is used for the plant flow demand. As the influent flow increases the plant flow demand increases, causing the filtrate pump(s) to speed up. To prevent standby and overflow conditions, the level in the mixed liquor transfer return channel is used to trim the plant flow demand. Level control is accomplished with Proportional control. The MBR MASTER PLC performs these calculations. The plant flow demand is the net permeate flowrate required from the GE W&PT system and does not include additional permeate the system produces for non-production operations, such as BACKPULSE.

The trim flowrate, which is a calculated flow, is added to or subtracted from the influent flowrate according to the level in the mixed liquor transfer return channel and the difference from the level setpoint. As the level increases above the setpoint in the mixed liquor transfer return channel, the trim increases causing the overall plant flow demand to increase. When the plant flow demand increases, the filtrate pumps for the trains in operation are ramped up to increase the plant permeate production which brings the level down in the mixed liquor transfer return channel. Conversely, if the mixed liquor transfer return channel is below the setpoint, the calculated trim flowrate is a negative flow and the overall plant flow demand decreases. The filtrate pumps are ramped down, decreasing permeate production, and the mixed liquor transfer return channel level increases as a result of the decreased permeate production.

The flow setpoints for trains with a manual flow setpoint are added together and subtracted from the plant flow demand which includes the level trim. This revised plant flow demand is then divided equally to the trains in operation without a manually entered flow setpoint. This becomes the net production flow setpoint for a train. A correction factor is calculated to account for the time when the train is not producing water (i.e. Relax or Backpulse) and to produce additional water required for backpulsing the train, when trains are being backpulsed. The net production flow setpoint multiplied by the correction factor is then used to calculate the instantaneous flow setpoint for the train. This value controls the filtrate pump speed through the flow PID loop.

A flow setpoint may also be entered for each train manually. The supervisor can do this by setting the production flowrate for some or all of the trains on the HMI. The system will maintain the operator entered production flowrate or MBR MASTER PLC calculated production flowrate up to a maximum TransMembrane Pressure (TMP) or a minimum tank level.

Figure 1: Influent Flow, Level Control & Permeate Flow Control Chart



3.1.2 Production TransMembrane Pressure (TMP)

The MBR MASTER PLC continuously calculates the TMP value while in PRODUCTION. If the TMP is too low, (i.e., too negative) the TMP low trigger is active and the flow control PID loop output is captured. This value becomes the maximum value for the flow control PID loop output.

When the TMP low trigger becomes active, the MBR MASTER PLC gradually reduces the maximum for the flow PID loop output until the TMP low trigger is not active, (i.e., TMP is less negative). At the moment when the TMP low trigger becomes inactive, the maximum value is then gradually increased until the TMP low trigger is active again, or continues to increase until the maximum value for the flow control PID loop output equals 100%. This control strategy allows the MBR MASTER PLC to vary the pump speed to maximize flow while avoiding excessive TMP across the membranes.

3.1.2.1 TransMembrane Pressure (TMP) Calculation

TMP is calculated by using the equation below. During PRODUCTION the value is negative, for backpulses and CIP, it is positive.

TMP = Header Pressure + C x (A + B - Membrane Tank Level)

Where:

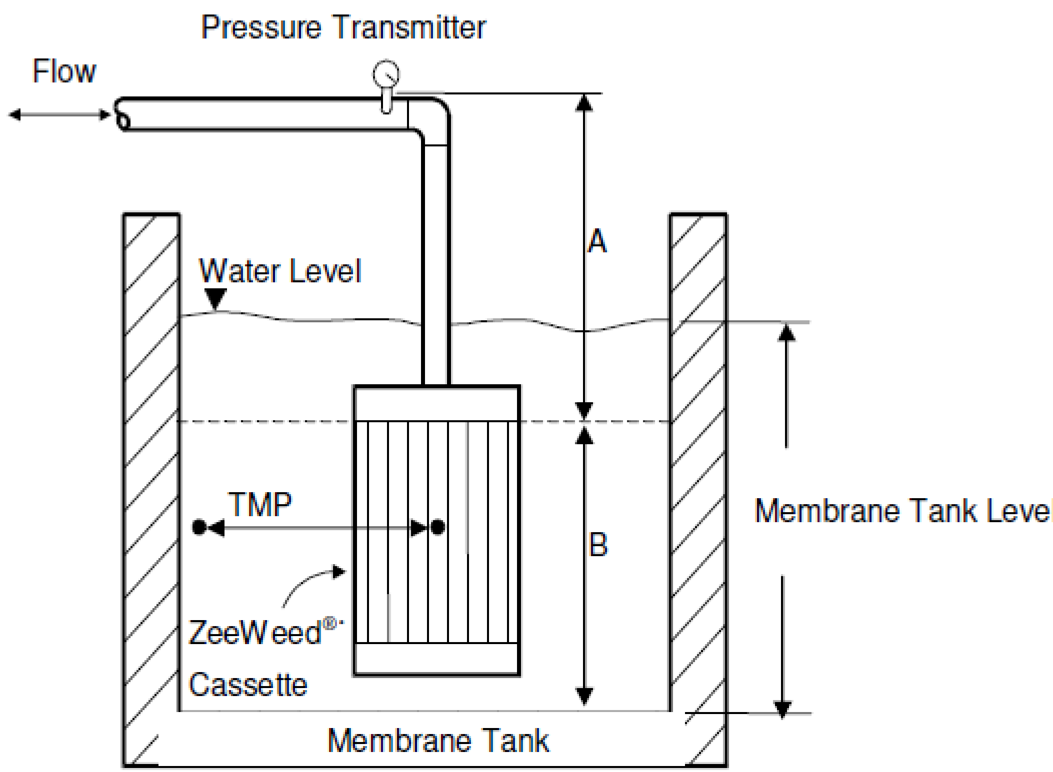
A is the height of the pressure transmitter above the top of the membranes.

B is the height to the top of membranes in the membrane tank.

C is a conversion factor (water depth to pressure), consult the CLSC for the value.

In PRODUCTION, an increased TMP value means a larger pressure differential because the pressure inside the membranes is lower than outside the membranes. This corresponds to a lower number as expressed in engineering units. Therefore a high production TMP is actually expressed as a Pressure Differential Alarm Low.

Figure 2 TMP Chart



3.1.3 Start & Stop Train Triggers

The number of trains in operation at any given time will vary depending on the plant flow demand. As this demand increases the number of trains in PRODUCTION will increase as start triggers become active. The start and stop train triggers are used to determine when another train is to start or when a train is to be placed to STANDBY. These triggers are defined in the CLSC.

3.1.4 Putting a ZeeWeed® Train to STANDBY

Several triggers may cause a train to go to STANDBY rather than shutting it down. These triggers include a low membrane tank level, low plant flow demand, or a loss of compressed air. If a low membrane tank level occurs, the train will immediately proceed to STANDBY. If the STANDBY triggers no longer exist and a start trigger is active, the train will proceed into PRODUCTION.

3.1.5 Train Rotation

Trains are automatically rotated from PRODUCTION to STANDBY when another train is in STANDBY based on an adjustable cycle timer, which is typically set to 4 hours. As long as there is at least one train in the Production cycle, the cycle timer operates and when the timer times out, a Standby request is initiated to stop one train, the train that has operated the longest compared to the other operating trains. This lead train is put to STANDBY at the end of its next Backpulse/Relax, and a train that is in STANDBY starts in PRODUCTION. Train rotation allows each available train to operate as the lead train for no more than the duration of the cycle timer, such as 4 hours, plus the time remaining in the train's Production cycle when the train is triggered to proceed to STANDBY.

When the cycle timer times out, if there is no train available in STANDBY to start in PRODUCTION, the lead train continues in the Production cycle and the request to put a train to STANDBY is maintained, waiting for a train to become available.

If plant flow demand decreases and triggers a train to stop, the cycle timer resets and resumes timing.

4 Backpulse Equipment Control

At this facility, the membranes are backpulsed using Backpulse Pumps (110-63-011 and 110-63-021). Water from the non-potable water wet well tank is periodically reversed back through the membranes to maintain stable transmembrane pressures.

The backpulse pumps provide the water for the pulsing steps of the MAINTENANCE CLEAN and the RECOVERY CLEAN.

4.1 Backpulse Pumps

The backpulse pumps will alternate their duty based on the run time of the individual pump. This run time is entered at the HMI by the operator. After the pump has run for the set amount of time the lead will switch to the other pump when the current pump is no longer operating.

The MBR MASTER PLC controls the pump speed to backpulse the trains at a set flow rate per train up to a maximum TMP. A transmitter on the membrane header is used to calculate the BACKPULSE TMP. This provides membrane protection against over-pressurization. If the TMP is too high, the TMP high trigger is active and the flow control PID loop output is captured. This value becomes the maximum value for the output of the flow control PID loop.

When the TMP high trigger becomes active, the MBR MASTER PLC gradually reduces the maximum for the flow PID loop output until the TMP high trigger is not active, (i.e., TMP is less positive). At the moment when the TMP high trigger becomes inactive, the maximum value is then gradually increased until the TMP high trigger is active again, or continues to increase until the maximum value for the flow control PID loop output equals 100%. This control strategy allows the MBR MASTER PLC to vary the pump speed to maximize flow while avoiding excessive TMP across the membranes.

The backpulse duration, production cycle duration, TMP setpoint and flow setpoint for all ZeeWeed® trains can be set through the HMI. All ZeeWeed® trains in the plant share the same backpulse duration and production cycle duration.

4.2 Backpulse Sequencing

The MBR MASTER PLC backpulses trains sequentially to limit the number of starts and stops on the backpulse pump. The ZeeWeed® trains in PRODUCTION are backpulsed starting with the first train followed by the second train, then the third train, and so on, without stopping the backpulsing pump.

Trains are backpulsed in the order of their train number. If, for example, train 2, 4, are in PRODUCTION, then train 2 is backpulsed first, and then train 4. Near the end of backpulsing one train, the speed of the backpulse pump is reduced to the minimum speed and valves are aligned to backpulse a second train. The second train begins backpulsing and the first train completes BACKPULSE and returns to PRODUCTION. Sequential backpulsing involves an overlap of backpulsing steps to allow the backpulse pump to continue to operate as one train completes its backpulse and another train begins its backpulse. For the trains with RELAX selected, these train will be sequentially relaxed when the trains requiring backpulsing are finished.

The operator can initiate a BACKPULSE from the HMI for any ZeeWeed® train by pressing the Backpulse button. This button is disabled if any other train is in BACKPULSE, MAINTENANCE CLEAN, RECOVERY CLEAN, and NEUTRALIZATION. The train will immediately begin a BACKPULSE if the resources are available.

4.3 Relax

RELAX control is an alternative to backpulsing. If a backpulse failure occurs and no pump is available, the MBR MASTER PLC will place the trains into RELAX mode.

In RELAX mode, the MBR MASTER PLC will stop permeating and the membranes will sit for an operator entered duration before continuing production. During this time solids that have concentrated around the membrane will be distributed away from the membrane surface by the aeration.

5 Recirculation Flow Control

The mixed liquor transfer return pumps (110-39-502 and 110-39-512) operate as one duty pump and one standby pump. The mixed liquor transfer return pumps will alternate their duty based on the run time of the individual pump. The operator enters the run time at the HMI. After the pump has run for the set amount of time the lead will switch to the other pump when the current pump is no longer operating.

The wastewater treatment plant circulates water at an operator adjustable ratio based on the required plant flow demand. As the plant flow demand increases the recirculation flow demand increases, causing the recirculation pump to speed up. The MBR MASTER PLC performs these calculations.

6 Membrane Aeration Control

There are three blowers (210-37-012, 210-37-022, 210-37-032) designated as two duty blowers and one standby blower. Blower duty is alternated according to an operator entered run time. The blowers supply low pressure air into a common air header for all of the trains. This common air header then divides into multiple air headers to the membrane tanks. For further details on blower operation, refer to the OSC and CLSC for the occurrence and number of blowers to be running at any given time.

6.1 Sequential Aeration

There are three types of aeration: constant aeration, 10/10 aeration, and 10/30 aeration. The MBR MASTER PLC automatically determines the type of aeration for the trains based on the number of aeration valves open, the membrane performance, and the plant flow demand.

For 10/10 sequential aeration, valves cycle air within a train, reducing both the air required and the operating costs. In 10/10 aeration, the aeration valves for a train alternate open and closed every 10 seconds. Sequential aeration may be deactivated for a train by the MBR MASTER PLC due to a cyclic valve failure.

In constant aeration, both aeration valves for a train are open.

6.1.1 10/30 Cyclic Aeration

The alternative aeration strategy is referred to as 10/30 Cyclic Aeration. 10/30 Cyclic Aeration is accomplished by aerating a given membrane module for 10 seconds, then not aerating for 30 seconds. The only change with respect to the standard 10/10 aeration is the time between aeration events increases from 10 to 30 seconds. The extension from 10 to 30 seconds of no aeration significantly reduces the aeration requirement for the entire plant.

The reduction in aeration is made possible by monitoring the condition of the membranes and determining the level of fouling on the membranes. When membranes are in a clean condition the trains will operate in the 10/30 aeration. If the membranes become fouled, the aeration is returned to 10/10 aeration in order to increase the shear on the membranes and remove any solids accumulation. Experience has shown that it is possible to operate in 10/30 aeration for periods where the wastewater flow is at or below the average day design value. During peak flow conditions the MBR MASTER PLC switches to 10/10 aeration automatically.

Table 1: Membrane Aeration Chart

Number of trains requiring aeration (SB, P, BP, R, MC, RC)	Number of Trains in an Aeration Mode			Number of open valves	Number of blowers operating
	Constant	10/10	10/30		
1	1	0	0	2	1
2		2		2	1
3	1	2		4	2
3		1	2	2	1
4		4		4	2
4			4	2	1

6.1.2 Standby Aeration

The method of standby aeration is varied according to the number of aeration demand to optimize membrane aeration and the number of operating blowers

When an even number of trains are in the production cycle or only Standby trains require aeration, the Standby trains are aerated intermittently based on frequency and duration timers. The MBR MASTER PLC aerates trains in Standby sequentially to limit the number of starts and stops on the membrane aeration blowers. The trains in Standby are aerated starting with the first train followed by the second train, then the third train, without stopping the blower. Trains are aerated in the order of their train number. If, for example, train 2, and 3 are in Standby, train 2 is aerated first, and then train 3. Sequential aeration involves an overlap of aeration to allow the membrane aeration blower to continue to operate as one train completes its aeration and another train begins its aeration.

When an odd number of trains are in the production cycle in 10/10 aeration and trains are in STANDBY, then the STANDBY trains are aerated for the duration timer one after another without stopping aeration. The frequency timer is ignored.

When three trains in the Production Cycle are enabled for 10/30 then the standby train is paired with a train in the Production Cycle and operates in 10/30. The frequency and duration timers are ignored.

When two trains are aerating in 10/10 but are enabled for 10/30 aeration and train(s) are in STANDBY then the production cycle trains switch to 10/30 and the standby train is in 10/10. The standby trains are aerated for the duration timer one after another without stopping aeration. The frequency timer is ignored.

6.2 Blower Low Airflow

A low air flow switch is located on the discharge of each blower, for blower protection. If the switch is active, an alarm occurs and the MBR MASTER PLC changes the lead to the next available blower. If there is no other blower available, a different alarm occurs and the MBR MASTER PLC shuts down all trains.

7 Integrity Monitoring & Control

Integrity of each train is monitored with on-line turbidimeters. Turbidity is displayed and monitored for alarms when trains are in PRODUCTION.

There are three turbidity alarms used to assist the operator in running the system. One alarm is used to detect a problem that is not a spike and will immediately shutdown the train in PRODUCTION. For example, a train will be shutdown when the turbidity is above the setpoint, 0.5 NTU, for 2 minutes.

A second alarm is used to detect a spike in turbidity and will set all trains that are in BACKPULSE mode to RELAX mode. For example, the alarm is active when the turbidity is above the setpoint, 5 NTU, for 10 seconds. The alarm will also skip all scheduled MAINTENANCE CLEANS until the turbidity alarm condition no longer exists. From this time on, MAINTENANCE CLEANS will again be completed as scheduled.

The third alarm also detects turbidity spikes but at a lower setpoint and is used to notify the operator of a potential problem which needs to be addressed. For example, the alarm is active when the turbidity is above the setpoint, 0.2 NTU for 60 seconds.

The turbidity alarm setpoints and the time delays, before the alarms become active, are adjustable at the HMI. For further details consult the CLSC.

8 Clean In Place (CIP) Controls

The membranes require cleaning to maintain peak performance. There are two types of cleaning methods; MAINTENANCE CLEANS and RECOVERY CLEANS. Maintenance Cleans are scheduled through the HMI and are automatically initiated by the MBR MASTER PLC based on a 24 hour clock. Recovery Cleans are operator initiated and should have the operator present during the majority of the clean.

8.1 Sodium Hypochlorite Cleaning Equipment

Sodium hypochlorite is used to remove organic contaminants from the membranes. The MBR MASTER PLC requests a sodium hypochlorite pump, 64-101, for MAINTENANCE CLEANS and RECOVERY CLEANS, to run in specific steps during the cleaning procedure. Consult the OSC for these steps.

8.2 Citric Acid Cleaning Equipment

Citric acid is periodically used to remove inorganic contaminants from the membranes such as calcium carbonate, manganese and iron compounds. The MBR MASTER PLC requests a citric acid pump, 64-211 for MAINTENANCE CLEANS and RECOVERY CLEANS, to run in specific steps during the cleaning procedure. Consult the OSC for these steps.

8.3 Maintenance Clean

MAINTENANCE CLEANS are scheduled through the HMI and are automatically initiated by the MBR MASTER PLC based on a 24 hour clock. The operator may select to perform one scheduled Maintenance Clean per train per day on the MAINTENANCE CLEAN schedule screen at the HMI by selecting the Enable button and entering in the time of day when the clean is to start. He/She also selects the cleaning solution either sodium hypochlorite or with citric acid.

When it is time to carry out a MAINTENANCE CLEAN, the MBR MASTER PLC compares the current plant flow demand with the available capacity of the plant if one train is not in service. If the plant flow demand exceeds this capacity, then scheduled MAINTENANCE CLEANS are skipped but the request remains active and will be started when this demand is lower. When the MAINTENANCE CLEAN is skipped or aborted, an alarm occurs to inform the operator.

If the plant flow demand does not exceed this capacity, when it is time to carry out a MAINTENANCE CLEAN, the train will complete its current production cycle before starting the cleaning procedure. If a train is in STANDBY it will go directly to MAINTENANCE CLEAN.

The default steps for Maintenance Clean are:

1) Aerates the membrane tank;
2) Initial chemically enhanced pulse for all cassettes using the backpulse pump;
3) Relaxation period for all cassettes;
4) Chemically enhanced pulse for all cassettes using the backpulse pump;

5) Relaxation period for all cassettes;

6) Steps 4 and 5 are repeated for a number of iterations;

7) Non-chemically enhanced pulse for all cassettes using the backpulse pump;

8) Aerates the membrane tank;

9) Proceeds to STANDBY.

8.4 Recovery Clean Controls

RECOVERY CLEANS can only be carried out for a train if it is in R. CLEAN mode. The operator is required to turn the train OFF then select either R. CLEAN with hypochlorite or R. CLEAN with citric acid button for the cleaning to begin. During a Recovery Clean there are several prompts which the operator must address. Consult the OSC and CLSC for further details. As a result it is suggested to have the operator present during the Recovery Clean so that these prompts can be responded to in a timely manner.

The default steps for Recovery Clean are:

1. Aerates the membrane tank;
2. Drains the membrane tank with the drain pump;
3. Manual drain and flush step. The train will proceed to the next step after a defined duration.
4. Steps 5 to 8 are repeated for a number of iterations and then proceed to step 9.
5. Backpulses the membrane tank for a defined duration then proceeds to next step or until the tank is at a defined level then proceeds to step 7;
6. Relaxation period for all cassettes for a defined duration and then proceed to step 5.
7. Aerates the membrane tank for a defined duration;
8. Drains the membrane tank with the drain pump;
9. Chemically enhanced pulse to all the cassettes for a defined duration then proceeds to next step or until the tank is at a defined level then proceeds to step 11;
10. Relaxation period for all cassettes for a defined duration and then proceeds to step 9;
11. Final, extended relaxation period with intermittent aeration;
12. The operator selects the Neutralization button to proceed to NEUTRALIZATION mode.

The Neutralization button is available in OFF and in the last step of RECOVERY CLEAN. The default steps for Neutralization are:

1. Fills the membrane tank to defined level with feed;
2. Aerates the membrane tank;
3. Relaxation period for all cassettes for a defined duration and then either proceed to next step if the clean was with sodium hypochlorite or proceed to step 5 if the clean was with citric acid.

4. The operator manually checks the residual chlorine concentration. The operator selects the Confirm Neutralization button to proceed to next step when the chlorine residual is less than 10 ppm. The operator selects the Resume Neutralization button when the chlorine residual is greater than 10 ppm. The train will proceed to step 3.
5. Non-chemically enhanced pulse to all the cassettes;
6. Proceeds to OFF.

Consult the OSC and CLSC for specific details on the steps and setpoints used in this mode.

9 Priming Control

Each train is provided with an ejector, 520-39-011, 520-39-031, 520-39-051, 520-39-071, which uses compressed air to operate and primes the filtrate pump during PRIME; at the beginning of BACKPULSE/RELAX; and intermittently the trains in STANDBY and PRODUCTION.

To prime the train's ejector compressed air valve opens which also opens the permeate header isolation valve. During this time, air in the permeate header is pulled up and out through the ejector, which also pulls water into the membranes and filtrate pump suction. Any water that is drawn into the ejector drains out by gravity.

The operator can manually initiate the priming sequence by pressing the Prime Train button at the HMI. The operator can manually initiate priming only when the train is in STANDBY and OFF.

10 Air Compressor Control

Local control panels, supplied by the Vendor, control the compressors. Refer to Vendor supplied information for more details.

There is one pressure switch on the common discharge piping which is used to alarm and callout and put all trains in the PRODUCTION, BACKPULSE, and RELAX mode to STANDBY.

11 ZeeWeed® Modes of Operation

Each ZeeWeed® train has separate mode buttons. There are several modes for each train, these modes are: OFF, SHUTDOWN, POWER OFF, STANDBY, PRIME, BACKPULSE, RELAX, PRODUCTION, MAINTENANCE CLEAN, RECOVERY CLEAN and NEUTRALIZATION. Using the ZeeWeed® train mode buttons on the HMI, the operator can put each ZeeWeed® train into a different mode. There are some interlocks present to prevent the user from proceeding to one mode from another. These interlocks are for membrane protection. Not all modes are selectable.

In STANDBY, the train is available for PRODUCTION when a start trigger is active. A train is in SHUTDOWN because a shut down alarm is active. A train is in POWER OFF because the loss of power alarm is active. Consult the CLSC and OSC for further details on the modes.

11.1 ZeeWeed® Train – On & Off Buttons

For the plant to operate automatically the operator needs to have all devices set to auto and select the On button for the train. The On button is only active for a train if it is in either OFF or SHUTDOWN. Pressing the On button for a train will place that train into PRIME and then STANDBY. When a start trigger is active for the train, the train proceeds to PRODUCTION and then either BACKPULSE or RELAX modes. The train continues in the production cycle, alternating between PRODUCTION and either BACKPULSE or RELAX modes, until the demand to treat wastewater decreases placing the train to STANDBY. A scheduled MAINTENANCE CLEAN will automatically interrupt the production cycle. An alarm may also place a train to STANDBY or SHUTDOWN or POWER OFF.

The operator may interrupt the production cycle by pressing one of the following buttons: Maintenance Clean, Backpulse, Relax. The train will proceed to the selected mode once the resources are available. There are interlocks preventing more than one train from entering the same mode at the same time. Consult the CLSC and the OSC for details on the interlocks.

The operator may turn a train OFF at any time. Pressing the Off button will place the train into OFF mode. It is the responsibility of the operator to ensure that if the Off button is pressed when a train is in the MAINTENANCE CLEAN or RECOVERY CLEAN modes the membrane tank's contents are suitable for a train to proceed to another mode. Neutralization may be required, or the tank may need to be drained.

12 ZEEWEED® Triggers & Alarms

12.1 Triggers

A trigger is a normal event that can clear an alarm or be one of several points in a sequence of events.

12.2 Alarms

Alarms are used to identify a problem with the plant. Depending on the nature of the problem the alarm may either shutdown the train(s), place a train to STANDBY, and initiate a callout to notify the operator that there is a problem. It is understood that the operator will acknowledge the alarm and address the situation. If the problem is not corrected, production quality and quantity will drop off quickly.

An alarm that is activated by an instrument, pressure transmitter, flow transmitters, or level instrumentation, typically requires a pump or certain device to be on to generate the required flow or pressure. Otherwise, the alarm will be ignored if the device to be protected is off.

All alarms are indicated with a message on the screen. The operator cannot reset the alarm without the correct password. All alarms and the time they occurred are recorded on the alarm history screen.

Some alarms can shutdown a ZeeWeed® train or the entire plant. These alarms close appropriate valves and stop pumps. The shutdown alarm puts the train to Shutdown mode. Restarting after a shutdown will require the alarm to be reset.

Devices which are being controlled remotely cannot have their status changed by the MBR MASTER PLC.

Consult the CLSC for details on specific alarms, the corresponding actions and reset procedures.

Typical alarms that shutdown a train and alarms that put a train to STANDBY are listed in the following tables.

Table 1: Train Shutdown Alarms

Alarm Description	Possible Causes for Alarm
High Flow Alarm - permeate	Suction disconnecting from fittings.
Low Flow Alarm - permeate	Loss of prime of filtrate pump
Pressure High-High Alarm – permeate (measured by pressure Transmitter)	Suction hose disconnecting from fittings.
Transmembrane Pressure Low, Low	Fouled UF membranes
Filtrate pump Fault	VFD Fault
Compressed Air – Low pressure and train is in Recovery Clean	Insufficient Compressed Air Supply to operate pneumatically actuated valves

Table 2: Train Standby Alarms

Alarm Description	Possible Causes for Alarm
Low Level Alarm – membrane tank	Permeate flowrate is higher than the Feed flowrate
Power Failure	Tripped breaker inside panel
Low Flow Demand Standby Trigger	Decreased Feed – train is not required for Production
Compressed Air – Low pressure and train is in Production, Backpulse, or Relax, or Maintenance Clean.	Insufficient Compressed Air Supply to operate pneumatically actuated valves

13 ZeeWeed® PLANT OPERATING Interface

To accommodate the above operational requirements and all other control, display, and monitoring requirements, this plant employs a Human Machine Interface (HMI) for access to plant controls. The HMI communicates with the Programmable Logic Controller (PLC (referred to as "PLC" in the documentation)), which in turn controls the plant.

13.1 Password Access & Privileges

The entire plant is controlled from the MBR MASTER PLC through a HMI. The ability to silence the horn and acknowledge alarms does not require a password, but alarms can not be reset.

To gain access to make changes on the HMI, the operator is required to enter the correct password. A screensaver blanks the screen after a set amount of time of inactivity. The screen is reactivated by a single touch. Reactivation cannot select a device or operating mode.

In order to access the control screens, the individual must enter a correct password then press Enter. There are three levels of password protection; Operator, Supervisor, & GE W&PT. The operator password is factory set; consult the CLSC for the operator password. The supervisor password can be modified from the HMI. There is no limit to the number of times another password can be attempted. The password must be re-entered after a set amount of time of inactivity. For details of password privileges consult the CLSC.

13.2 Screen Color-Coding

The colors for the HMI must conform to the specification.

14 UV

The trains will operate according to the plant flow demand when the UV permissive signal is active. When the UV flow limit signal is active then the plant flow demand is limited by this signal.

15 Power Interruption / Power Up

When a loss of power occurs, the affected trains will immediately proceed to POWER OFF mode. After power returns, the plant powers up and trains will start-up automatically as described in the CLSC. The CLSC lists the order in which the common equipment and trains will power up; it also specifies the mode that a train will proceed to from POWER OFF mode.

The plant SCADA sends a start-up permissive for the membrane control system to enter its start-up sequence. The trains will operate in Relax mode when the Generator operating signal is active.

16 Loss of Communication Alarms

During operation, there are “heartbeat signals generated by each PLC. Each “heartbeat” signal is a counter that increases by one unit each second. When the communication with a PLC is lost, the PLC that is monitoring the “heartbeat” counter detects that the value of the counter has not changed for a preset time, for example after 5 seconds, and alarms. When the counter reaches 10,000 it restarts counting from zero.

Discussions of the alarms and the changes that occur to the control systems are given in the following sections.

16.1 Loss of Communication Alarm with Plant PLC

When there is a loss of communication with the plant PLC, trains continue to operate using the level in the mixed liquor transfer return channel for the plant flow demand.

Maintenance Cleans initiated by the schedule are permitted, and trains that are in a cleaning sequence continue the sequence without interruption. Recovery Cleans also continue.

16.2 Loss of Communication Alarm with Blower PLCs

When there is a loss of communication with a blower PLC, the MBR master PLC will run the available blowers. If no blower PLCs are available then the trains will shut down.

17 Signals for Communication

For the GE W&PT membrane system to maintain optimal performance, information must be communicated between the plant PLC and the MBR MASTER PLC. The signals required are both analog and digital.

If necessary, operating parameters of the GE W&PT system such as flowrates, pressures, train modes, etc. are available for communication when the plant PLC is required to only monitor these parameters. A list showing this information, however, is not provided in this document due to the large number of parameters available.

17.1 Plant PLC to the MBR MASTER PLC Signals

The list given below shows the signals that are communicated from the plant PLC over the network to the MBR MASTER PLC to operate the membrane trains.

1. Feed Flowrate
2. UV permissive signal
3. UV flow limit for the ZW trains
4. Permissive to start after a power failure
5. Generator operating signal