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Original Language

OPERATION & MAINTENANCE MANUAL

SYSTEM: ZeeWeed* 500D Ultrafiltration System

CLIENT: Government of Nunavut

LOCATION: Pangnirtung, Nunavut, CAN

PROJECT: U-500615

REVISION: 1

DATE: October, 2014

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PREFACE

The Operation & Maintenance (O&M) Manual provides installation, operation, maintenance, and ownership information for this system. It must be read and internalized in its entirety by all operators.

Failure to adhere to the instructions provided in this manual may result in severe injury or damage to property, and may render the warranty null and void.

USING THIS MANUAL

This manual provides a description of the system's overall design and functionality as a single unit, including installation, operation, maintenance, and troubleshooting procedures. Information specific to individual components, such as pumps, valves, and instrumentation, is provided in the accompanying *Volume I - Vendor Data Manual*.

In cases where a procedure requires the operator to perform a function that involves a specific component, such as a valve or meter, a reference to any necessary component-specific information will be provided.

Control documentation and technical drawings have also been provided separately, and can be found in *Volume III - Controls & Drawings Binder*.

TYPOGRAPHICAL CONVENTIONS

Typographical conventions used within this manual are defined as follows:

Bold - indicates a control with which the operator is required to interact.

Bold italicized - indicates important information.

UPPERCASE - indicates the name of a mode or state of operation.

> ***For more information on the topics discussed above . . .***
>
> - "More Information" boxes provide cross-references to topics related to those discussed in a particular section.

NOTICE

Warns against an unsafe situation or practice that, if not avoided, could result in property damage.

⚠ CAUTION

Warns against an unsafe situation or practice that, if not avoided, could result in minor or moderate injury.

⚠ WARNING

Warns against an unsafe situation or practice that, if not avoided, *could* result in severe injury or death.

⚠ DANGER

Warns against an unsafe situation or practice that, if not avoided, *will* result in severe injury or death.

Tagged Components Within This Manual

TIP: *Tag numbers for components not specifically mentioned within this manual can be found in Volume III - Controls & Drawings Binder.*

The following table lists the tag numbers associated with various system components mentioned within this manual.

Table i.i - Tagged Components

Component	Qty.	Tag Number
Pretreatment		
Equalization tank	1	N/A (by others)
Anoxic chamber	1	(16-TK-201)
Aerobic chamber	1	(16-TK-401)
Process blower	2 (1 duty/1 standby)	(16-B-401-1/2)
Level transmitter	1	(16-LIT-403)
Ultrafiltration		
System inlet valve	2	(20-FV-203-1/2)
Membrane tank	2	(20-TK-201-1/2)
Membrane blower	2 (1 duty/1 standby)	(20-B-209-1/2)
Process pump	2	(20-P-301-1/2)
Backpulse tank	1	(20-TK-601)
RAS pump	2	(20-P-501-1/2)
Vacuum ejector	2	(20-E-802-1/2)
Miscellaneous		
Air compressor	1	N/A (by others)
Antifoam tank	1	(15-TK-201)
Antifoam pump	1	(15-P-201)
Sodium hypochlorite tank	1	(23-TK-101)
Sodium hypochlorite pump	2	(23-P-110/120)
Citric acid tank	1	(23-TK-301)
Citric acid mixer	1	(23-MX-301)
Citric acid pump	1	(23-P-310)
Sodium hydroxide tank	1	(15-TK-301)
Sodium hydroxide pump	1	(15-P-301)

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SECTION 1

GENERAL SAFETY

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1.1 INTRODUCTION

This section provides general personal and environmental safety information that applies to all personnel required to work with or around the system.

Material Safety Data Sheets (MSDSs) for chemicals provided by GE W&PT can be found within this manual (MSDSs for chemicals provided by other manufacturers may be inserted here as well). Safety information for specific components can be found in *Volume I - Vendor Data Manual*.

CAUTION

Failure to observe the following precautions may result in injury or damage to the system.

For more information on the topics discussed above . . .

- Refer to *Section 15 - Material Safety Data Sheets* for more information on MSDSs.

1.2 PERSONAL SAFETY

The following sections provide general guidelines regarding personal safety and cleanliness. Refer to local codes and regulations for more detailed information.

1.2.1 PERSONAL PROTECTIVE EQUIPMENT

The equipment listed here constitutes the minimum scope of protective gear that should be available to all operators. Local codes and regulations may require the use of additional equipment beyond what is mentioned below.

1.2.1.1 Head & Facial Protection

- At all times while in the plant operating area, wear a hard hat and safety glasses with side shields.
- When handling chemicals or working near pressurized lines, (air and liquid), wear a full face shield.
- When exposed to noise levels that exceed 85 dB, wear adequate hearing protection.

1.2.1.2 Limb Protection

- When working near pinch or thermal hazards, wear protective gloves. When handling chemicals, wear chemical-resistant gloves.
- At all times while in the plant operating area, wear safety boots with crush-resistant toe caps and shank inserts.

1.2.1.3 Fall Protection

- When working in a position where the possibility of falling a significant distance (approximately 3 m (10 ft)) is present, wear an approved safety harness in accordance with local safety requirements. The harness safety line should not allow the person to fall more than 1.5 m (5 ft) before arresting the fall.

1.2.2 Cleanliness

Working with or around this system poses a number of potential health hazards that make consistent personal and site cleanliness practices essential. Immunization protects against infection, but common sense and care are required at all times when in the system operating area.

Ensure that cuts and open sores are protected from exposure at all times, and ensure that hands are washed with an antibacterial soap on a regular basis, especially prior to eating, drinking, or smoking.

1.3 SAFETY ON SITE

The following sections provide information regarding general site safety and proper conduct during various procedures that may be performed onsite. This information is not intended to replace or override local codes and regulations.

1.3.1 GENERAL PRECAUTIONS

The following list provides general recommendations intended to ensure the safety of personnel working in and around the system operating area:

- Ensure that all personnel have been made familiar with the proper operating procedures described in this manual and the accompanying *Volume I - Vendor Data Manual*. In particular, procedures related to the handling of acidic or caustic chemicals and the maintenance of pressurized lines or components with rotating parts should be emphasized.
- Ensure that safety shower and eye wash stations are operational and in close proximity to areas where chemicals will be used. Consider installing an alarm (visible and audible throughout the plant operating area) that will activate if an emergency shower or eye wash station is used.
- Install flange guards on all chemical lines.
- Ensure that all guards and other coverings are securely installed before activating either a specific component or the system as a whole.
- Keep up with all preventive maintenance schedules provided in both this manual and in *Volume I - Vendor Data Manual*.
- Install spray curtains or Plexiglass shields around all chemical skids and ensure that dilution stations are available nearby in case of a chemical spray or leak.

- Ensure that chemical-resistant protective clothing is worn by all personnel working near acidic or caustic substances, or components that may contain such substances.
- When preparing to perform maintenance on pipes or tubing, ensure that all connected lines are either isolated or emptied.
- Ensure that all personnel working with hazardous chemicals are properly trained and familiar with both government and plant-specific safety requirements.
- Ensure that areas where chemicals will be handled are well lit and that access is not restricted.
- Personnel engaged in a procedure that involves obvious risk of injury (example: entering a confined space) should work under the supervision of a colleague prepared to provide assistance if required.
- Personnel engaged in a procedure they do not feel properly trained for must cease action immediately and seek advice from a supervisor.

1.3.2 Safety Checklist

It is recommended that operators complete the following checks and inspections before starting up the system for the first time:

- Test all safety showers and eye wash stations.
- Ensure that all chemical flange guards are fitted properly.
- Post contact information for emergency services in a highly visible location.
- Ensure that all operators are familiar with applicable safe workplace practices and regulations.
- Confirm all pump shutoff and emergency kill-switch locations.
- Ensure that all couplings and connectors have been tightened according to the required torque values.

- Confirm that all components are properly tagged.
- Ensure that there is adequate space and lighting around all components.
- Store all required chemical protective gear near the chemical skids. This includes, but is not limited to, full-face shields, rubber suits, and gloves.
- Ensure all components are clean and undamaged.
- Provide adequate ventilation to all plant locations.
- Ensure that a system for maintaining up-to-date operating records is in place.
- Ensure that guidelines are in place to prevent operating temperatures from exceeding maximum limits.

1.3.3 Electrical & Thermal Hazards

⚠ WARNING

Only qualified personnel should perform installation and maintenance procedures for electrical components.

Servicing energized components: Even with the power switch in the OFF position, certain components inside a control panel or other electrical device may remain energized. No service work can be performed until the power supply to the device is first disconnected.

Heated surfaces: Areas on certain components, such as pumps, can become heated to the point where contact with skin will inflict severe burns. Ensure that all safety guards and other protective measures are in place and familiarize personnel working with or around such components with the relevant documentation in *Volume I - Vendor Data Manual*.

1.3.4 MECHANICAL & CHEMICAL HAZARDS

MSDSs: For ease of reference, add MSDSs for chemicals purchased from suppliers other than GE W&PT to the related section within this manual.

PUMPS: When working with or around pumps, take the following precautions:

- Before performing maintenance, isolate and drain all piping connected to a pump.
- Before performing maintenance, turn off power to a pump and complete all lockout procedures required by government and plant-specific regulations, as well as any included in *Volume I - Vendor Data Manual*.
- After completing maintenance, replace any guards or other safety components removed during the procedure.
- Personnel working on pumps used to transfer chemicals must be familiar with the safe-handling procedures associated with the chemicals involved.
- When working with diaphragm pumps used to transfer chemicals, be aware that some media may remain within the pump's diaphragm chamber even after the pump has been drained.

WARNING

Failure to tighten a coupling according to the manufacturer's required torque values may result in an explosive rupture or violent release. Following installation, all couplings must be inspected for tightness as part of the regular preventive maintenance process.

TIP: *For systems equipped with Straub couplings, torque values for each coupling are provided on a decal applied to the coupling itself.*

COUPLINGS: During installation, ensure that all couplings have been tightened according to the required torque values. Also, inspect the tightness of all couplings on a regular basis. For more information regarding torque values for a specific coupling, refer to the manufacturer's instructions provided in *Volume I - Vendor Data Manual*.

For more information on the topics discussed above . . .

- Refer to *Section 15 - Material Safety Data Sheets* for more on MSDSs.
- Refer to *1.4.1 Locking Out Components* for more on lock-out/tag-out procedures.

1.3.5 PINCH & FALL HAZARDS

⚠DANGER

Exposed rotating parts can catch clothing, fingers, or tools and cause severe personal injury or death.

ROTATING COMPONENTS: Before operating components with rotating parts or other possible pinch hazards, ensure that all shields, guards, and emergency kill-switches are in place.

FALL HAZARDS: Fall hazards include any situation where the possibility of either personnel or equipment falling from a significant height (approximately 3 m (10 ft)) is present. Ensure that personnel exposed to this risk are secured using a harness and that all equipment involved is stored and handled in a way that prevents it from falling.

For more information on the topics discussed above . . .

- Refer to *1.2.1 Personal Protective Equipment* for more on harness requirements.

1.3.6 NOISE HAZARDS

HEARING PROTECTION: Extended exposure to excessive noise levels can be harmful to human hearing. When the possibility of exposure to such noise levels is present, use adequate hearing protection at all times. Generally, levels above 75 dB are considered harmful, however, regulations regarding acceptable levels and required protection will vary between regions. Adhere to all local regulations while working with or around the system.

1.3.7 Pressure & Rupture Hazards

Some pumps and compressors are capable of pressurizing lines to as much as 1,000 psi, and the danger of an explosion due to overpressurization may arise if proper operating procedures are not observed. In particular, pressure relief valves should be checked regularly, and tubing used to convey pressurized air, such as actuated valve air lines (typically operated at 80 psi), should be regularly inspected for cracks.

1.3.8 Infection & Exposure Hazards

The degree of risk associated with exposure to wastewater will vary greatly between systems. In general, personnel should take every measure to avoid contact with or ingestion of wastewater.

If exposed to wastewater which poses the risk of bacterial infection or chemical contamination, eyes should be immediately rinsed at an eye wash station and exposed skin should be cleaned thoroughly with soap and warm water, particularly before eating, drinking, or smoking. If wastewater is ingested, notify a supervisor immediately.

GE W&PT recommends that all employees working in a water treatment plant should be vaccinated for tetanus and hepatitis A and B.

Any concerns about possible bacterial infection or chemical exposure should be brought to the attention of a medical physician immediately.

1.4 High-Risk Procedures

⚠ DANGER

The procedures described in this section pose a significant risk to personnel involved. The possibility of severe injury or death will be significant if the instructions provided below, as well as all relevant plant and local regulatory practices, are not followed.

1.4.1 Locking Out Components

When preparing to lock out a device for service, replacement, or repair, ensure the following:

- All relevant local guidelines and procedures must be observed.
- Only operators qualified to work with the device should perform a lockout procedure.
- Lockout tags should be applied before performing the lockout procedure and should be removed only after work has been completed and by the person who applied them.

1.4.2 Entering Confined Spaces

Any area characterized by one or more of the following features should be considered a confined space:

- The accumulation of hazardous gases, vapors, dust, fumes, biological contaminants, or the creation of an oxygen-deficient atmosphere may occur.
- A space not intended for frequent or extended human occupancy.
- Access is gained through a restricted entry as a result of design, orientation, or location.

GE W&PT strongly recommends that any personnel required to enter a confined space first complete an official confined space entry training program.

Prior to entering a confined space, ensure that the following equipment is available and functional:

- Gas detector.
- Tripod.
- Body harness and safety line.

- Charged cellular phone and list of emergency numbers.
- Portable ventilator and generator.
- Suitable breathing apparatus.
- Protective clothing (if exposure to harmful substances is possible).
- Ladder (where required).
- Flashlight and alarm horn (where required).
- Manhole opener (where required).
- Traffic control equipment (where required).

The above list of required equipment may vary according to local regulations. Any item that does not pass inspection or which cannot be calibrated properly must be replaced or repaired before work may begin.

Section 2

Cautions Specific to This System

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2.1 INTRODUCTION

All operators must read and understand the following information in its entirety before working with or around the system:

NOTICE

Failure to adhere to the following information may result in damage to the system.

- Membranes placed in storage must be kept in the following conditions:
  - Moist at all times.
  - Ambient temperature of between 5 - 35°C (41- 95°F).
  - Protected from freezing temperatures.
- The use of unapproved chemicals on ZeeWeed membranes will render the warranty null and void and will leave the customer solely responsible for any damage incurred as a result. Contact GE W&PT before using any chemicals not outlined in this manual.
- To avoid damaging the membranes, all prescreening measures must be in operation at all times. ***Do not bypass prescreening processes under any circumstances***.
- Compressed air used to test membrane integrity must be clean, dry, and free of oil. ***Do not exceed the maximum recommended pressure.***
- Do not allow membrane fibers to come in contact with sharp objects, become entangled with equipment or tools, or be pulled tightly.
- Do not clean the membranes with a high-pressure water stream (example: pressure washer, firehose).

- If the system has been preserved (example: for shipment or shutdown), any shipping preservatives must be flushed from the system prior to startup.
- Membranes must be immersed in a biocidal solution prior to storage, shipping, or system shutdowns longer than 72 hours.
- Membranes that are to be returned to GE W&PT must be cleaned, sanitized, and preserved before shipment. Contact GE W&PT for instructions before returning membranes.
- At all times, ensure that debris is prevented from entering the membrane tanks. If work that may produce debris (example: grinding) must be performed near a tank, ensure that the tank is sealed, covered, or otherwise protected before starting work.

Section 3

System Overview

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3.1 INTRODUCTION

TIP: Technical illustrations are provided in Volume III - Controls & Drawings Binder.

This section provides a high-level description of the system, including information about its performance specifications, structure, and production process.

Detailed information about the theory of operation and about specific procedures, modes, and settings is provided later in this manual.

3.2 SYSTEM DESIGN PARAMETERS

The following tables outline the design and performance parameters for this system.

Table 3.1 - MBR Biological System Design Summary

System Feature	Value
Flow basis of biological design, m^3/day	290
Minimum design temperature Note 1, °C	15
Total anoxic volume, m^3	150
Total aerobic volume (excluding membranes) Note 2 and 3, m^3	250
Total reactor volume (excluding membranes) Note 2 and 3, m^3	400
Design HRT, hrs	37.41
Design SRT, days	15.57
Bioreactor MLSS, mg/L	8000
Minimum side water depth, m	4.0

NOTES:

- **Note 1:** A minimum temperature of 5 °C is used for membrane system design. A minimum temperature of 15 °C coupled with average daily flow and loading are used for biological volume calculation given that 5 °C conditions are infrequent and are not necessarily tied to the peak flow events.
- **Note 2:** Tank dimensions are preliminary only and may change once final detail design commences.
- **Note 3:** The biological system is designed for installation within bolted steel tank(s) supplied by GE.

Table 3.2 - Ultrafiltration System Design Summary

System Feature	Value
Type of membrane	ZeeWeed 500D
Number of train	2
Number of ZMOD L process pump skid	2
Type of cassette	16 module (short version) cassette
Number of cassette installed per train	2
Number of module installed per cassette	16
Total number of cassette	4
Total number of module	64

Table 3.3 - Influent Quality

Parameter	Influent Concentration	Loading (kg/day) Note 1 (Daily Average)
Minimum influent temperature for membrane system design Note 1, °C	5	N/A
Minimum influent temperature for biological system design Note 1, °C	15	N/A
BOD_5, mg/L	1000	290
TSS, mg/L	1070	310
TKN, mg/L	250	73
NH_3-N Note 2, mg/L	188	54.4
TP, mg/L	40	12
Alkalinity, mg/L	500	N/A

NOTES:

- **Note 1:** A minimum temperature of 5 °C is used for membrane system design. A minimum temperature of 15 °C coupled with average daily flow and loading are used for biological volume calculation given that 5 °C conditions are infrequent and are not necessarily tied to the peak flow events. MDF-specific organic loading was used for sizing process aeration system (diffusers and blowers).
- **Note 2:** Assumed values, to be confirmed.

Table 3.4 - Influent Flow Data

Parameter	Value
Average day flow, m^3/day	290
Maximum day flow, m^3/day	360
Peak hour flow, m^3/hr	28.125
Maximum flow with one train offline for maintenance or cleaning (less than 24 hrs), m^3/day	290

NOTES:

- Any flow conditions that exceed the above-noted flow limits must be equalized prior to treatment in the membrane bioreactor unit.
- Average day flow (ADF) - The average flow rate occurring over a 24 hrs period based on annual flow rate data.
- Maximum day flow (MDF) - The maximum flow rate averaged over a 24 hrs period occurring within annual flow rate data.
- Peak Hour Flow (PHF) - Nominally, the maximum flow rate sustained over a 1 hr period based on annual flow rate data. For this project, this condition can potentially last for as long as 8 hrs maximum.

Table 3.5 - Effluent Quality

Parameter	Value
BOD_5, mg/L	≤ 20
TSS, mg/L	≤ 5
NH_3-N, mg/L	≤ 1.25 @ 15 °C
pH	6.5 - 9.0

3.3 PRIMARY SUBSYSTEMS

The following sections provide a brief description of the primary subsystems and assemblies that compose this system, and describe the order of subsystems that wastewater moves through as it is processed.

Information regarding specific components used in the subsystems described below has been created and supplied by the third-party vendors who manufactured the component, and is provided in *Volume I - Vendor Data Manual*.

GE W&PT has not independently verified information provided by vendors and offers no representations or warranties of any kind, expressed or implied, as to its quality, suitability, accuracy, timeliness, or completeness. GE W&PT does not accept liability for the consequences of any action or inaction taken on the basis of information provided by third-party vendors.

3.3.1 PRETREATMENT

All other pretreatment processes and components included upstream of the system inlet valve (20-FV-203-1/2) have been provided by others and cannot be accurately documented within this manual.

3.3.2 BIOREACTOR

The wastewater from the equalization tank (by others) is passed through the bioreactor. The bioreactor contains micro-organisms that convert colloidal and dissolved carbonaceous organic matter into byproducts, such as cell tissue, that can then be removed from the mixed liquor when it is passed through a subsequent solids separation process.

The bioreactor for this system consists of the following zones:

ANOXIC TANK (16-TK-201)**:** The oxygen-deficient environment within the anoxic tank supports the micro-organisms required for the denitrification process.

AEROBIC TANK (16-TK-401)**:** The aerobic (oxygen-rich) tank provides an environment that facilitates the BOD_5 removal and nitrification processes.

After passing through these zones, the mixed liquor exits the bioreactor and flows into the subsequent ZeeWeed membrane tanks (20-TK-201-1/2) through system inlet valves (20-FV-203-1/2). For more information about the overall structure and flow path of the bioreactor, refer to *Volume III - Controls & Drawings Binder*.

Due to the delicate nature of the microbial population housed within the bioreactor, the following operational features must be carefully monitored at all times:

AERATION: Air required by the micro-organisms is provided by the process blowers (16-B-401-1/2) and is introduced into the bioreactor through an air diffuser array. The amount of aeration required depends on the current temperature and dissolved oxygen (DO) concentration within the bioreactor. These levels should be monitored regularly and adjusted as needed.

VOLUME CONTROL: The liquid level in the bioreactor is monitored by a level transmitter (16-LIT-403) which will relay a signal to the onscreen interface if a predetermined level setpoint is triggered.

pH CONTROL: One byproduct of the organic process is the accumulation of acids that will gradually alter the pH level within the bioreactor. To counteract this effect, the sodium hydroxide pump (15-P-301) periodically introduces a sodium hydroxide solution intended to maintain a pH level of 6.5 - 8 within the bioreactor.

ANTIFOAM (15-P-201): It is added in the wastewater flow for the purpose of antifoaming in the bioreactor tank.

For information about a specific component associated with the bioreactor, such as a pump or sensor, refer to *Volume I - Vendor Data Manual*.

3.3.3 ZEEWEED ULTRAFILTRATION MEMBRANES

The following sections provide an outline of the ZeeWeed Ultrafiltration (UF) subsystem.

3.3.3.1 ZEEWEED TRAINS & MEMBRANES

ZeeWeed membranes, which consist of bundles of hollow fibers, are suspended in the mixed liquor and operate under a negative pressure created within the hollow membrane fibers by the process pumps (20-P-301-1/2). This negative pressure draws permeate through the membranes, leaving contaminants behind in the membrane tanks (20-TK-201-1/2). The RAS pumps (20-P-501-1/2) pump back these contaminants to the bioreactor.

The process pumps move UF permeate to a common header where it is dosed with sodium hypochlorite by sodium hypochlorite pumps (23-P- 110/120) for bio-growth prevention. This dosed UF permeate then flows to the backpulse tank (20-TK-601) (if the tank requires filling) or to the disinfection system (by others).

For information regarding ZeeWeed train layout, including the number of membrane modules in this system, refer to *Volume III - Controls & Drawings Binder*. Additional information about membrane specifications and performance parameters is provided within this manual.

3.3.3.2 AERATION SYSTEM

The membrane blowers (20-B-209-1/2) create turbulence within the mixed liquor by introducing air into the membrane tank near the bottom of the membranes. This aeration scours the outside of the membrane fibers, which dislodges accumulated solids and extends the amount of operation time between chemical cleans.

This system incorporates GE W&PT's LEAPmbr aeration process, which consists of a multi-stage course bubble diffuser system designed to produce large, "mushroom cap" bubbles. Compared to traditional aeration methods, LEAPmbr systems provide a more effective means of foulant removal while requiring less air and ensuring lower overall operating costs.

Aeration enhances the functionality of the membrane system and must be performed whenever the system is operating. If the system is shut down, the blowers must be manually activated for a minimum of one 30-minute span every 24 hours.

3.3.3.3 AIR EXTRACTION

The vacuum ejectors (20-E-802-1/2) are used to intermittently remove air from the permeate header. This process, known as "priming," prevents large pockets of air from being drawn into the process pump.

The ejectors use compressed air (by others) flowing through an orifice to create a vacuum (the Venturi effect). Permeate (liquid) entering the ejectors is discharged to drain along with the ejected air.

It is not usually necessary to reprime the system if air accumulates in the permeate header during production. However, if the amount of accumulated air becomes significant and begins to affect pump performance, an additional priming sequence can be initiated manually.

3.3.4 CLEAN-IN-PLACE ASSEMBLY

In addition to the various subsystems and components involved in treating raw water, a Clean-In-Place (CIP) assembly has also been provided. This subsystem is used to prepare and circulate chemical solutions used to remove accumulated fouling from the membranes during regular cleaning sessions.

For more information on the topics discussed above . . .

- Refer to *Volume I - Vendor Data Manual* for more on individual components in this assembly, including all associated instrumentation and valves.
- Refer to *Section 8 - Cleaning* for more on cleaning chemicals and procedures.
- Refer to *Section 15 - Material Safety Data Sheets* for MSDSs related to chemicals provided by GE W&PT.

3.3.5 CONTROL INTERFACE

Most processes involved in operating the system can be overseen by the operator at the onscreen interface, which consists of a panel-mounted control display located at the system control panel.

For information about the electrical connections within the control panel, or about the specific components it contains, refer to *Volume III - Controls & Drawings Binder* or to *Volume I - Vendor Data Manual*, respectively.

For more information on the topics discussed above . . .

- Refer to *Section 6 - Operating the System* for more on using the onscreen interface.

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SECTION 4

DESIGN & THEORY OF OPERATION

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4.1 INTRODUCTION

This section provides a general description of the ZeeWeed membrane system, including its primary components, design, and theory of operation.

4.2 PRIMARY COMPONENTS

The main elements of the ZeeWeed system are the membrane fiber, the membrane module, and the cassette.

4.2.1 MEMBRANE FIBERS

The core of the ZeeWeed UF product line is the membrane fiber, an outside-in supported polyvinylidene fluoride (PVDF) hollow tube. The UF membrane fiber is capable of producing high-quality permeate by allowing the passage of water while physically blocking the passage of suspended solids, protozoa, bacteria, and most viruses.

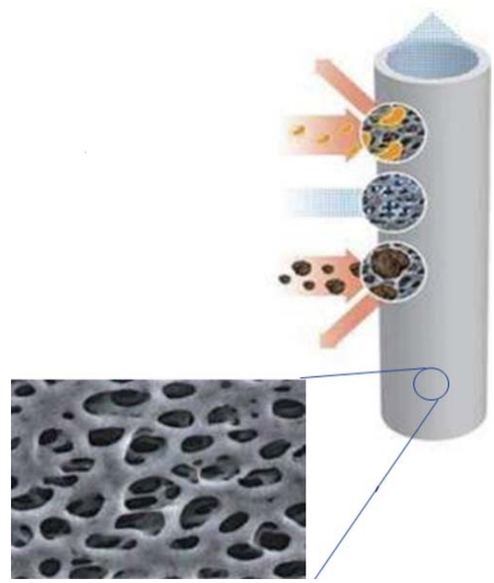


Figure 4.1 - ZeeWeed Membrane Pores

Two distinct membrane chemistries exist. The first, with a nominal pore size of 0.04 µ, is intended for use in tough-to-treat, higher-turbidity applications, such as surface water treatment and membrane bioreactors (MBRs). The second has a nominal pore size of 0.02 µ, and is used for lower-turbidity applications, such as drinking water or tertiary treatment.

4.2.2 MEMBRANE MODULES

Membrane fibers are arranged vertically between the membrane module's two headers.

Water is drawn through the fibers and into the permeate header. From here, it then exits the module via the permeate spigot or saddle.

The following table outlines the general specifications of the ZeeWeed module.

Figure 4.2 - ZeeWeed 500D Module

Table 4.1 - Module & Membrane Specifications

Module Dimensions	Value
Height	183.5 cm (72.25 in.)
Width	49 mm (1.9 in.)
Depth	84.4 cm (33.2 in.)
Module Weight	**Value**
Maximum shipping weight (crated)	24 kg (53 lbs)
Lifting weight (varies with solids accumulation)	24-58 kg (53-128)
Membrane Properties	**Value**
Nominal surface area	27.9 m^2 (300 ft^2)
Material	PVDF
Nominal pore size	0.04 μ
Surface properties	Non-ionic, hydrophilic
Fiber diameter (outside/inside)	1.9 mm/0.8 mm
Flow path	Outside-in
Operating Specifications	**Value**
TMP range	-55 - 55 kPa (-8 - 8 psi)
Maximum operating temperature	40°C (104°F)
Operating pH range	5.0 - 9.5
Cleaning Specifications	**Value**
Maximum cleaning temperature	40°C (104°F)
Cleaning pH range	2.0 - 10.5
Maximum chlorine concentration	1,000 ppm

4.2.3 CASSETTES

Cassettes provide support to modules, and consist primarily of a reinforced frame, permeate collection piping, and an integral aeration assembly. When installed, modules are connected in parallel into the top and bottom saddles, which are linked by a 5.08 cm (2 in.) PVC permeate downcomer pipe. The top saddle connects into the 20.32 cm (8 in.) permeate manifold. The cassette is then linked to an external permeate header on the train using a hard pipe connection.

Figure 4.3 - ZeeWeed 500D 16M Cassette

Each cassette comes equipped with a single 7.6 cm (3 in.) air connection. Air from this line enters a central pipe, and is then directed to the aerator assembly located at the base of the cassette.

The following table outlines the general specifications of the ZeeWeed cassette.

Table 4.2 - Cassette Specifications

Parameter	Value
Height	250.4 cm (98.6 in.)
Width	73.8 cm (29.1 in.)
Depth	174.4 (68.7 in.)
Number of Modules	8 - 16
Permeate connection	1 x 4 in. FNPT half-coupling
Air connection	2 x 3 in. pipe FNPT half-coupling
Maximum shipping weight (crated, fully populated)	714 kg (1,574 lbs)
Lifting weight (varies with solids accumulation, number of modules, and module surface area)	756 – 1,464 kg (1,667 – 3,254 lbs)

4.3 THEORY OF OPERATION

The following sections provide information regarding the theory and processes of UF in general and of the ZeeWeed system in particular.

4.3.1 FILTRATION

Filtration is defined as the separation of one or more components from a fluid stream. In conventional usage, it usually refers to the separation of solid or insoluble particles from liquid or gaseous streams.

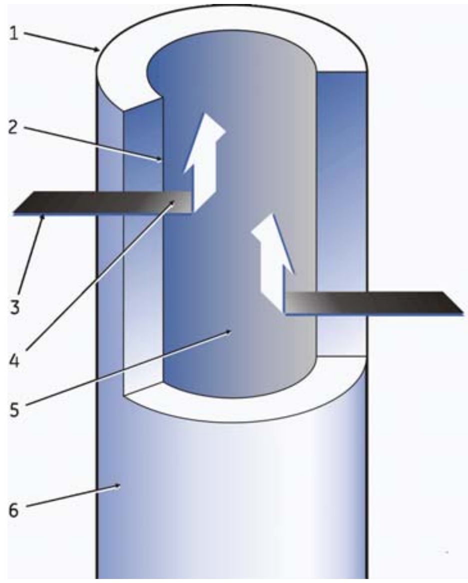
Membrane separation processes can be categorized in various ways, three of which are pore size, molecular weight cut-off (MWCO), and operation pressure.

As the pore size gets smaller (and the molecular weight cut-off decreases), the pressure applied to the membrane for separation generally increases. The water treatment objectives of each system decide the basis on which a process is selected and operated.

4.3.2 ZEEWEED ULTRAFILTRATION

Ultrafiltration (UF) is a process that filters particles on the basis of size. In membrane separations, UF is typically used to separate or remove relatively large particles, such as microbes, bacteria, and macromolecules with molecular weights greater than approximately 300,000 Daltons. UF uses "loose" membranes, meaning those that have relatively large pores.

The ZeeWeed membrane filtration surface is a neutral, strong polymeric membrane cast on the outside surface of a porous support fiber. Each fiber can be divided into three parts: The membrane, the support braid (or reinforced structure), and the lumen.

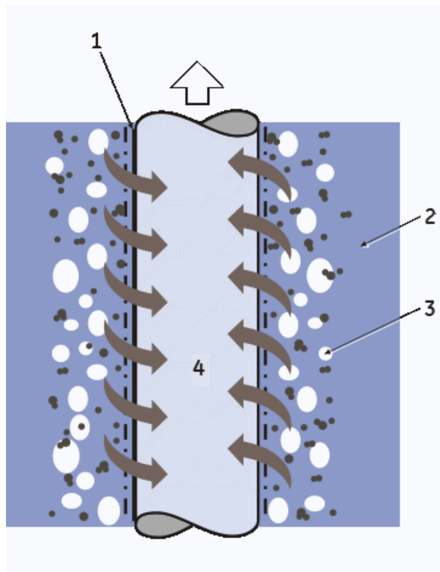


1. Membrane
2. Support braid (reinforced structure)
3. Influent
4. Permeate
5. Lumen
6. Hollow fiber

Figure 4.4 - ZeeWeed Membrane Fiber

Treated water passes through the membrane as permeate while contaminants are rejected. The subsystem maintains a turbulent flow pattern along the membrane fibers with the use of low-pressure air to keep the filtration surface clear of contaminant buildup (fouling), which causes a reduction in membrane efficiency.

The following image depicts a ZeeWeed membrane fiber in operation. Permeate is drawn through the membrane from the wastewater by a partial vacuum created within the membrane fiber. Periodic sessions of aeration without permeation (RELAX mode) help to dislodge accumulated foulants from the membrane surface. When regular Relax sequences prove insufficient to remove fouling, the membrane is backpulsed by pumping permeate back into the membrane fiber, forcing flow back out through the membrane to scour foulants from the surface.



1. Membrane
2. Wastewater (containing solids)
3. Aeration bubbles (for fluid agitation)
4. Permeate

Figure 4.5 - ZeeWeed Membrane Schematic

SECTION 5

INSTALLATION & TESTING

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5.1 INTRODUCTION

This section explains how to handle the ZeeWeed membranes when they arrive on site, how to install them in the system, and how to test them after installation is complete.

This information must be read and understood in its entirety by all operators prior to attempting to handle, install, or test the ZeeWeed membranes.

5.2 INITIAL REQUIREMENTS

The following must be available before installation may begin:

APPLICABLE DRAWINGS: The Process and Instrumentation Diagram (P&ID), General Arrangement (GA), and Electrical drawings for the system are provided in *Volume III - Controls & Drawings Binder*. These drawings will be needed during installation.

WATER: Water introduced into the system during installation must be free of particulates. Any debris allowed to enter tanks or piping must be removed immediately.

ELECTRICITY: GE W&PT is not responsible for supplying power to the system. During installation, a qualified electrician must verify the following:

- All electrical connections meet local government and industry standards.
- All electrical cables have been properly fitted.
- All motors have been wired for proper rotation.

QUALIFIED PERSONNEL: A qualified electrician, pipefitter, and millwright are required on site when commissioning the system.

5.3 Personal Safety

It is crucial that fall arrest equipment be worn when working overtop the membrane tank. A fall arrest harness must be worn and appropriate tie-off lanyards must be used while installing and/or working on a cassette.

In addition to the information provided in this manual, operators must also be familiar with all local government, industry, and facility guidelines regarding personal protective equipment.

Figure 5.1 - Harness & Lanyard

For more information on the topics discussed above . . .

- Refer to *Section 1 - General Safety* for more on personal protective equipment.

5.4 Receiving the Lifting Module

TIP: *The only exception to this rule is the cassette uprighting procedure, during which lifting straps may be used as outlined in this manual.*

Cassettes cannot be lifted by connecting chains, hooks or lifting straps directly to the cassette framework. Instead, the ZeeWeed lifting module must be used at all times. This includes when the cassette is first uncrated and installed within the membrane tank, as well as when it must be removed from the tank for routine maintenance or repair.

In order to prepare for the cassette installation process, the lifting module must be unpackaged, inspected, and readied for use. To do so, perform the following steps:

⚠ WARNING

Only qualified personnel should operate a forklift.

1. Using a forklift, move the packaged lifting module to its designated set-down area. The lifting module must be stored indoors on a flat, dry surface.

2. Remove all packaging, including any plastic wrap, crating and shipping straps.

⚠ WARNING

The hook used to connect the lifting module to the hoist (or crane) must meet the minimum width and bearing requirements for the type of lifting module supplied with this system. The hook's specifications must be verified by GE W&PT before the lifting module may be used.

NOTICE

Do not allow any part of the lifting module to come into contact with carbon steel. Doing so will contaminate the lifting module, which may in turn contaminate the cassette.

3. Lower the hook of a properly rated hoist (or crane) and connect it to the lift-point located at the center of the lifting module.

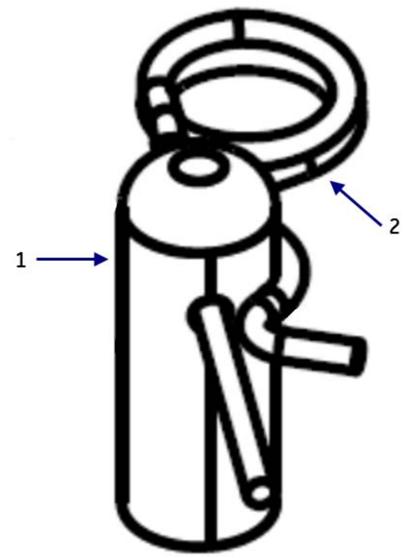
4. Raise the lifting module to a height at which it is comfortable and safe to work with.

TIP: *The diagram shown here is a general example. Refer to the GA drawings for specific illustrations of the lifting module provided with this system.*

5. Ensure that all four support pins are fitted with locking pins. The support pins are located at each corner of the module.

6. Inspect the lifting module for any damage which may have occurred during shipping, such as dents, bent or broken parts, or chipped paint.

7. Slowly lower the lifting module until it sits level on the ground.



1. Support pin 2. Locking pin

Figure 5.2 - Lifting Module Pin Diagram

For more information on the topics discussed above . . .

- Refer to *Volume III - Controls & Drawings Binder* for details regarding the lifting module's weight and for illustrations showing the location of the lift-point.
- Refer to *5.8.16.1 Connecting the Lifting Module to the Cassette* for more information on adjusting the lifting module hooks.

5.5 RECEIVING CASSETTES

The following sections provide information regarding the steps involved in receiving, inspecting, and uncrating new cassettes.

ZeeWeed cassettes are shipped with the modules already installed. Cassettes are sealed in a plastic bag filled with a preservative solution that prevents the membranes from drying out. Ensure that this bag is not damaged while the plywood shipping crate is being removed.

5.5.1 UNLOADING CASSETTES

The Installer is responsible for unloading the cassettes when they arrive on site. During the unloading process, ensure that the following precautions are observed:

- The cassettes must be unloaded onto a stable, level surface.

WARNING

Only qualified personnel should operate a forklift.

NOTICE

Do not stack shipping crates.

- When moving shipping crates, lift from the bottom using a forklift.
- Any damage observed or caused while unloading the membranes must be reported immediately to GE W&PT.

5.5.2 CONFIRMING MEMBRANE CONDITION

After the membranes have arrived on site, confirm the following:

- All items listed on the shipping manifest have been accounted for.

NOTICE

Do not open the shipping crates when confirming the condition of the membranes. Verification is limited to external examination only.

- The membranes have arrived undamaged and with their packaging unopened. Any signs of damage or non-conformance must be reported immediately to GE W&PT, and should be documented by digital photograph.
- None of the handling indicators attached to the shipping crates containing the membranes have triggered.

For more information on the topics discussed above . . .

- Refer to *5.5.3 Confirming Handling Indicators* for more on locating and reading shipping indicators.

5.5.3 CONFIRMING HANDLING INDICATORS

At all times during shipment, the membranes must be stored at a temperature of 2 - 35°C (35 - 95°F), with an ideal temperature of 20°C (68°F).

All shipping crates containing membranes are equipped with handling indicators which monitor the integrity of the membranes during shipment. These indicators should be checked immediately after the membranes have been unloaded.

A handling indicator will trigger if ideal conditions were not maintained during shipment. If a handling indicator has triggered, inform GE W&PT immediately.

Figure 5.3 - Shipping Indicators

5.6 STORING MEMBRANES

The customer or the customer's contractor must provide all facilities and services required for the storage, maintenance, and protection of the membranes and any other materials provided by GE W&PT.

NOTICE

Membranes must remain in their original packaging until the installer is ready to place them in the membrane tank.

When storing membranes, ensure that the following conditions are met:

- Store the membranes in assigned lay-down areas, indoors (or within a secure shelter), and atop wooden pallets or a similar form of raised platform. Do not store the membranes in locations where they may be contaminated by dirt or water.
- If the membranes must be stored outdoors, the shelter used to house them must be weatherproof, well ventilated, and secure against theft and vandalism (example: construction trailer).
- Protect the membranes from exposure to excessive vibration or jostling.

In addition to these general precautions, ensure that the guidelines provided in the sections below are observed, depending upon the current state of the membranes and their packaging material.

5.6.1 Storing Packaged Membranes

When storing membranes that are still in their original packaging, ensure that the following conditions are met:

- Membranes must be placed in a sheltered area protected from direct sunlight, temperatures below the freezing mark, extreme heat, and winds that may accelerate the drying process.

CAUTION

The glycerin solution used to preserve the membranes can create a severe slip hazard if spilled. Clean any spilled solution immediately.

- Membranes are delivered in a vacuum-sealed bag which must remain sealed until the installer is ready to place them in the membrane tank.

The membranes have been manufactured and preserved to comply with the contractually specified delivery and installation schedule. Should installation be delayed longer than one month, contact GE W&PT for additional instructions.

New modules that are preserved with glycerin solution, bagged, and factory-sealed may be stored for up to 12 months from the date they were manufactured. For the exact expiry date of a particular module, contact GE W&PT.

5.6.2 STORING WETTED MEMBRANES

Allowing membranes to come into contact with water (wetting) will compromise the preservative solution that protected them during shipment. After this has occurred, membranes must not be allowed to dry out under any circumstances.

NOTICE

Membranes will be damaged irreversibly if they are allowed to dry out.

Wetted membranes may be exposed to the air for a maximum of 45 minutes, so long as they are out of direct sunlight and wind. If the membranes are ***frequently, lightly misted*** (not sprayed with fire hoses or pressure washers) from the time they have been taken out of the water, they may be left exposed to the air for a maximum of 6 hours at a temperature between 5 - 35°C (41 - 95°F).

If required by compliance regulations, the standard procedures for rinsing and disinfection may be used before membranes are put into operation. If the membranes have been wetted and it becomes impractical to immerse or repeatedly spray them during the time before they can be placed in the membrane tank, the membranes should be cleaned, preserved in glycerin solution, and rebagged.

For more information on the topics discussed above . . .

- Refer to *5.11 System Shutdown & Membrane Preservation* for more on bagging membranes.

5.7 PREVENTING DEBRIS CONTAMINATION

It is critical that debris capable of damaging the membranes (example: anything over 2 mm (1/16 in.) in size) be prevented from entering a membrane tank. Damage caused by debris may not be covered by the membrane warranty. Possible contamination pathways include:

- Wastewater laden with debris.
- Debris allowed to enter the tank during work performed nearby.
- Debris left within piping connected to the membrane tank.
- Residue from piping or process equipment.

Examples of common materials that can cause damage include, but are not limited to, the following:

- Cable ties.
- Plastic turnings from drilling.
- Pieces of wire.
- Broken measuring tapes.
- Weld slag and metal debris from grinding.
- Twigs and leaves.
- Shells, sand, and fish.

As a general rule, seal, cover, or otherwise protect the interior of the membrane tank whenever work that may generate debris is being performed nearby.

5.8 UNCRATING & INSTALLING CASSETTES

A GE W&PT FSR should be present to assess the site before installation, and provide supervision while the installation process is being performed.

Two operators (at minimum) must be present to perform the procedures described below.

5.8.1 GENERAL PRECAUTIONS

NOTICE

All piping and tanks must be installed, cleaned, and subjected to a wet test before membranes may be installed.

CAUTION

Failure to observe the following precautions may result in injury or damage to the system.

While performing the installation procedure, ensure that the following precautions are taken:

- The membranes must not be allowed to dry out.
- Avoid moving or working beneath a cassette while it is being lifted.
- Do not allow permeate connections to fill with water while the cassette is being lowered into the membrane tank.
- Do not touch, pull, or otherwise handle membrane fibers during installation.

5.8.2 PREPARING THE SITE

The Membrane Pre-Installation Checklist (provided separately) must be completed and signed before cassettes can be uncrated and installed.

The membrane tank must be cleaned thoroughly.

All loose-shipped parts required for the cassette installation must be located and all guide brackets, permeate piping and air piping installed before the membranes can be installed.

The area where cassettes will be uncrated must be clearly designated and closed-off to all personnel who will not be taking part in the procedures outlined below.

5.8.3 PARTS & EQUIPMENT

TIP: *Refer to Volume I - Vendor Data Manual for more information regarding material specifications.*

Verify the type and quality of materials available for installation, including the following points:

- Hose length and material.
- Lifting bracket and sling condition.
- Leveling pin quality (for cassettes which are leveled using pins instead of adjustable support beams).

The following tools should be available:

- Two sheets of 90 x 90 x 1 in. foam padding.
- Four hoist-ring assemblies. A single assembly includes the following components:
  - One 3/4 in. 316 carbon-steel hoist-ring.
  - Two 3/4 in. 316 stainless-steel flat washers.
  - One 3/4 in. 316 stainless-steel hex nut.
- Four lifting slings.

- One four-point spreader bar.
- One two-point spreader bar.
- One 1 1/8 in. socket-wrench.

NOTICE

Do not use silicone-based lubricants. For systems intended to produce drinking water or water in any other way intended for human consumption, a food-grade lubricant must be used.

- Water-based lubricant.
- PVC glue and primer.
- One NEFAB tool or flat-head screwdriver.
- Applicable safety equipment (example: gloves, safety harness).
- One Module-removal tool.

The following materials are required to install a single cassette:

- Four 3 1/4 x 3/4 in. 316 stainless-steel bolts.
- Eight 3/4 in. 316 stainless-steel nuts.
- Four 3/4 in. 316 stainless-steel flat washers.
- Four 3/4 in. 316 stainless-steel Nord-lock washers.

NOTICE

Ensure that all lifting equipment is capable of supporting the weight of a single cassette.

A forklift will be required to move the crated cassettes to the work area. After the shipping materials have been removed, an overhead chain hoist or equivalent lifting device will be required in order to install the cassette in the membrane tank.

For more information on the topics discussed above . . .

- Refer to *Section 4 - Design & Theory of Operation* for more on cassette specifications.

5.8.4 SAFETY DURING INSTALLATION

The uncrating and installation procedures should only be performed under the supervision of a GE W&PT FSR.

When uncrating and installing a cassette, always ensure the following:

WARNING

Failure to adhere to the following safety requirements may result in serious injury or death.

- A minimum of two operators must be present to perform the installation.
- Confirm that all lifting equipment is in proper working order and rated to carry the required weight.
- Operators must wear an appropriate safety harness or similar fall-arrest equipment when working overtop of the membrane tank or in any other position were a fall from a significant height is possible.
- Ensure that all personnel stand clear and remain within sight of the forklift operator while a cassette is being moved.
- Cassettes must not be lifted overtop areas where personnel are standing or may enter into.

5.8.5 UNCRATING CASSETTES

The uncrating procedure must be performed with an FSR present to monitor the process. Failure to do so may affect the membrane warranty.

Cassettes must be uncrated on a dry, level surface that is not exposed to direct sunlight.

NOTICE

Cassettes are fragile and must not be tilted, jostled, or exposed to excessive heat or cold.

Cassettes are not to be uncrated if any of the following activities are taking place in the immediate vicinity:

- Painting or wiring.
- Roofing or carpentry.
- Grinding, welding, or other metalwork.
- Pipe-flushing.
- Sandblasting or drilling.
- Use of power tools that discharge debris (example: circular saw).
- Any other activity judged reasonably likely to cause damage to the membranes.

To uncrate a cassette, perform the following steps:

WARNING

Only qualified personnel should operate a forklift.

1. Using a forklift, move a single crated cassette to the work area. ***All local regulations concerning the operation of a forklift must be followed***.

NOTICE

If a crane is being used in place of a hoist, it must be located at an appropriate distance to prevent collision with the cassette during lifting.

2. Place the crated cassette on level ground directly underneath the hoist.

3. Using a NEFAB tool, bend out the interlocking tabs as straight as possible. A flat-head screwdriver may be used if a NEFAB tool has not been provided.

4. Carefully remove the top panel of the crate.

5. Remove one long side panel. The end panels remain supported by the other long side panel.

6. While another operator supports the long side panel, remove one of the end panels.

7. While the other operator continues to support the long side panel, remove the remaining end panel, and then remove the long side panel.

5.8.6 Removing the Cassette Bag

NOTICE

Ensure that cassette and membrane fibers are not damaged while removing the membrane bag.

The cassette is packaged in a vacuum-sealed bag ***which must remain in place until the installer is ready to place the cassette in the membrane tank***.

To remove this bag without damaging the fibers, select an area well above the membrane fibers, and then make a shallow cut along the bag and roll it down to the crate bottom. The bag can then be cut at the base and discarded.

Figure 5.4 - Shipping Braces

After the bag has been removed, record the serial numbers for each module and for the cassette itself.

Depending upon certain shipping requirements, the cassette may have been fitted with a set of yellow shipping braces. If these braces have been included, remove them prior to uprighting the cassette.

5.8.7 Inspecting Cassettes Prior to Uprighting

After the cassette has been uncrated and while it is still on its side, confirm the following:

- Ensure that aeration assembly is secure and has not shifted or come loose during shipment.
- Ensure that all saddles are securely clipped to the cassette frame.
- If the cassette is not fully populated with modules, ensure that the non-permeating "blank" headers are installed and in the correct location (that is, wherever there is no module installed).
- If the cassette is not fully populated with modules, ensure that the aeration channels for all unpopulated module positions have been blocked with aeration plugs.
- Ensure that the main aeration pipe is installed and secure.

5.8.8 INSTALLING UNIONS ON CASSETTE AERATION PIPES

Before the cassette can be uprighted, either a PVC union or a hose-barb fitting must be glued to the cassette's PVC aeration pipe.

5.8.9 UPRIGHTING CASSETTES

After the cassette has been inspected and the aeration assembly has been prepared, the cassette is ready to be uprighted.

Before beginning the uprighting procedure, remove all crating material from the staging area and ensure that there is a clean, flat surface for the uprighted cassette to be set down upon.

It is recommended that an overhead hoist be used for this procedure. However, if a hoist is not available, a mobile crane or similar device may also be used, so long as it is fully rated to support the cassette's weight.

NOTICE

If a crane is being used in place of a hoist, it must be located at an appropriate distance to prevent collision with the cassette during lifting.

5.8.9.1 ATTACHING HOIST RINGS

The image on the right shows the connection points for the hoist ring assemblies.

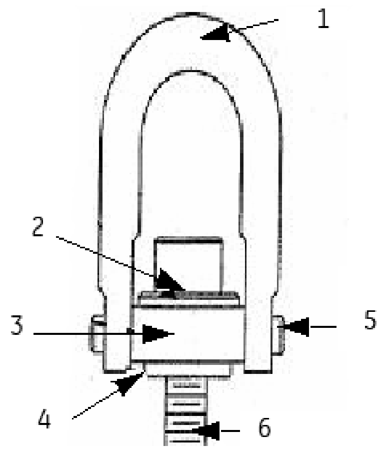
NOTICE

Hoist rings are made of carbon steel. To avoid contaminating the stainless-steel cassette frame, ensure that the stainless-steel flat washers and hex nut are used.

Figure 5.5 - Hoist Ring Locations

While installing the hoist rings, ensure the following:

- Confirm that the hoist ring bolt, shoulder pins, and bail are free of cracks or signs of wear.
- The hoist ring bolts must be tightened to 100 ft/lbs.
- Ensure that the bushing of the hoist ring is sitting flush against the frame.
- Verify that the hoist is free to swivel and pivot in every direction.
- Ensure that the shoulder pins are secure.



1. Bail
2. Washer
3. Body
4. Bushing
5. Shoulder pin
6. Bolt thread

Figure 5.6 - Hoist Ring Assembly

5.8.9.2 REMOVING THE SKID

After the hoist rings have been attached, the skid must be removed in preparation for uprighting the cassette.

To remove the skid, perform the following steps:

1. Place one of the foam sheets on the ground in the area where the cassette will be uprighted. Ideally, this will be directly next to where the cassette currently sits upon the skid.

NOTICE

Ensure that the hoist rings do not touch or press against the cassette frame.

NOTICE

Use slings made of a fabric capable of supporting the cassette's full weight. Using chains may cause damage to the cassette.

2. Attach the lifting assembly to the hoist rings. If possible, a four-point lift frame and spreader bar should be used. If this is not possible, use slings that have been arranged according to the following requirements:

    - Connect a fabric sling (1.2 m (4 ft) long) to each hoist ring, and a properly rated cable (6 m (20 ft) long) to each sling.

    - When taut, the slings should be at a minimum 60° angle to the cassette if a spreader bar is used, or at 75° for a single-point lift.

Figure 5.7 - Lifting a Cassette Without a Four-Point Lift Frame and Spreader Bar

WARNING

Ensure that all personnel have been cleared from the immediate area before beginning the lift.

NOTICE

If a crane is being used in place of a hoist, it must be located at an appropriate distance to prevent collision with the cassette during lifting.

3. After attaching the lifting assembly, slowly lift the cassette until it is high enough that it can be moved without touching the skid underneath (not more than 5 cm (2 in.) above the skid).

4. Carefully move the cassette over to the foam sheet, and then gently lower it onto the sheet.

5. Remove the skid and the remains of the vacuum-sealed bag.

6. Ensure that any spills or debris have been thoroughly cleaned.

7. Disconnect the lifting assembly, and then remove the two hoist rings attached to the bottom side of the cassette (that is, the side that will be placed on the ground when the cassette is uprighted).

5.8.9.3 LIFTING CASSETTES DURING UPRIGHTING

After the skid has been removed and the work area cleared of spills and debris, upright the cassette by performing the following steps:

1. Place the second foam sheet on the ground next to the cassette.

NOTICE

The lifting assembly must be equipped with a two-point spreader bar.

2. Attach the lifting assembly to the two hoist rings.

WARNING

Ensure that all personnel have been cleared from the immediate area before beginning the lift.

NOTICE

If a crane is being used in place of a hoist, it must be located at an appropriate distance to prevent collision with the cassette during lifting.

NOTICE

At all times during the lift, keep the hoist (or crane) aligned directly overtop the hoist rings. Failure to do so could result in the cassette swinging violently when it leaves the ground. Do not attempt to stop the cassette if it begins to swing.

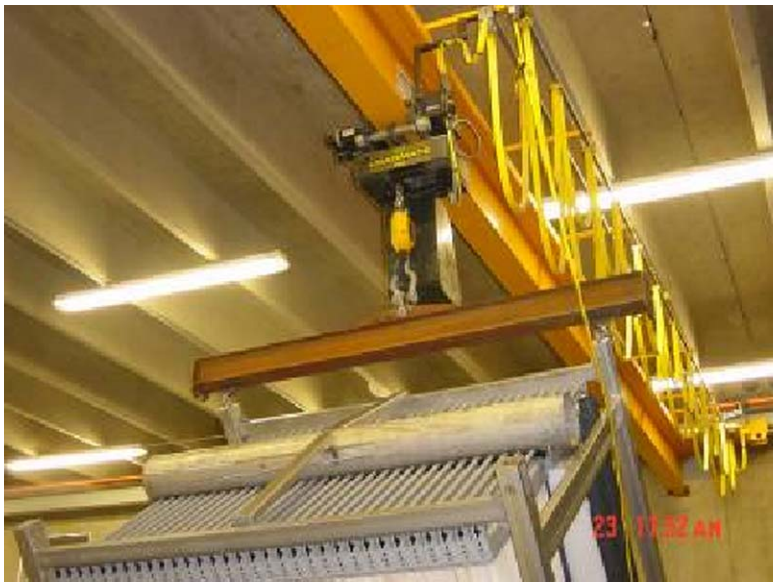


Figure 5.8 - Hoist With Spreader Bar

3. Carefully begin lifting the cassette. As it is raised, the cassette will begin to tilt. As the cassette tilts, move the hoist (or crane) horizontally in order to keep it above the hoist rings.

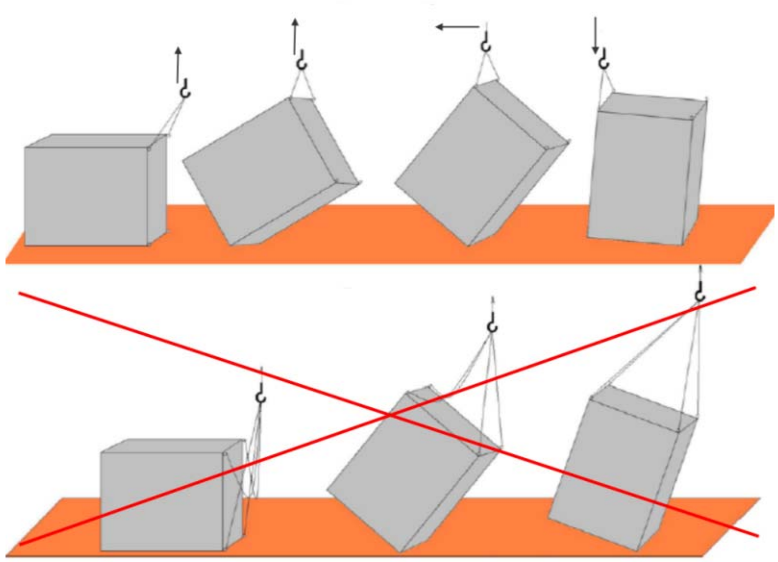


Figure 5.9 - Proper Uprighting Procedure

4. Lift the cassette until it pivots onto its side, then lower it until it rests in the upright position and fully atop the second foam sheet.

5. After the cassette sits firmly upon the ground, disconnect the lifting assembly, and then remove the hoist rings.

5.8.10 Installing Cassette Hanger Arms

The cassette hanger arms allow the cassette to be moved using the lifting bracket, and support the cassette after it is installed in the tank. These arms can be installed only after the cassette has been uprighted.

NOTICE

A torque of 104 ft-lbs must be applied to all 3/4 in. Nord-lock nuts used to fasten the cassette arms in place.

Figure 5.10 - Cassette Hanger Arms

There are two left-side arms and two right-side arms. When installing them, ensure that the correct arm is attached to the correct side of the cassette.

Hanger arms are installed on the four corners of the cassette. When installed correctly, each arm should be identical to the one installed on the opposite (diagonal) corner, and should be the opposite type compared to those installed on the two adjacent corners.

Figure 5.11 - Hanger Arms Attached

When identifying the two types of arms, note the position of the open end of the arm and the position of the small tab at the bottom of the arm.

There are two different types of slots found on the top of each hanger arm. The slot that is nearest the center of the cassette when the arm is installed is for connecting the cassette lifting bracket. This slot is circled at the top of the image to the right.

Figure 5.12 - Hanger Arm Slots (Top View)

If the hanger arm has been installed correctly, the other slot will sit on top of the support beam when the cassette is installed in the tank. This slot is elongated parallel to the beam, and is circled at the bottom of the image to the right.

For more information on the topics discussed above . . .

- Refer to *Volume III - Controls & Drawings Binder* for illustrations showing cassette arms and how they are connected to the cassette.

5.8.11 REMOVING THE PLASTIC WRAP

Figure 5.13 - Cutting the Plastic Wrap

Cassettes are shipped with a plastic wrap beneath the sealed cassette bag. This wrap must be removed carefully so that the membrane fibers are not damaged.

To remove the wrap, make a cut close to the corner of the cassette frame, away from the membranes.

To avoid contaminating the stainless-steel frame, do not allow the blade to touch the cassette frame while the cut is being made. Discard the wrap after it has been removed.

5.8.12 REMOVING THE PROTECTIVE FOAM

Cassettes are shipped with protective foam placed against the vertical permeate piping. Before removing the foam, ensure that any fibers which may have become stuck to it are carefully separated. After doing so, slowly pull the foam out of the cassette.

NOTICE

To avoid damaging the membranes, use extreme caution when removing the foam.

Figure 5.14 - Removing the Protective Foam

5.8.13 INSPECTING CASSETTES AFTER UPRIGHTING

After the cassette has been uprighted, confirm the following:

- Check the entire cassette for loose or missing nuts and bolts. Torque specifications are noted in the GA drawings.
- Inspect all welded joints for rust spots.
- Verify that the module keys are in the locked (vertical) position.
- Record the serial numbers of each membrane module on the membrane map (provided separately). Also, if multiple cassettes will be installed within the same membrane tank, record the position within the tank where each cassette will be installed.
- Ensure that the top and bottom expander blocks are tight, fully engaged, and flush with the bottom surface of the key side outer assembly.

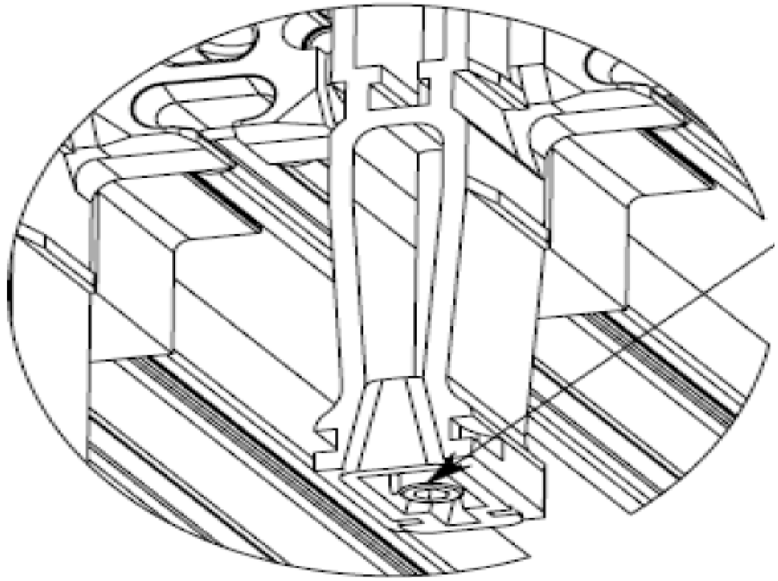


Figure 5.15 - Tighten Expander Blocks

> ***For more information on the topics discussed above . . .***
> - GA drawings have been provided in *Volume III - Controls & Drawings Binder.*

5.8.14 Assembling Aeration Piping

Some parts of the cassette aeration spool may be assembled before the cassette is installed within the membrane tank. After the cassette is in place, the pre-assembled piping can then be connected.

The technical drawings provide a detailed illustration of the piping assembly. After the piping as been assembled, set it aside in a safe area where it will be protected from damage or contamination until it can be installed.

> ***For more information on the topics discussed above . . .***
> - Refer to *Volume III - Controls & Drawings Binder* for technical drawings.

5.8.15 Leveling Cassettes

The cassettes must be individually leveled to a tolerance of ± 1/8 in. per cassette within a train. All cassettes across adjoining trains must be within ± 1/4 in. level tolerance of one another.

Prior to installing the cassettes, it is recommended that a laser level be used to ensure that the required tolerances are achieved. Cassettes that are not properly levelled may exhibit more rapid fouling as a result of improper air distribution.

Cassettes are leveled by setting the angle of the cassette support beam. If necessary, shims may be used to adjust the level of the support beam.

Refer to the technical drawings for detailed illustrations which show how support beams should be positioned.

For more information on the topics discussed above . . .

- Refer to *Volume III - Controls & Drawings Binder* for technical drawings.

5.8.16 Installing Cassettes in the Membrane Tank

When ready to install a cassette within the membrane tank, do so by performing the procedures outlined in the following sections.

These procedures apply to both the initial installation process as well as whenever a cassette is being returned to the membrane tank following routine inspection or repair.

5.8.16.1 Connecting the Lifting Module to the Cassette

Before using the lifting module, inspect it for any obvious signs of wear or damage, including the following:

- Worn or deformed parts.
- Cracked welds.

- Extensive rusting or other corrosion which appears significant enough to possibly compromise the structural integrity of the lifting module.

When using a lifting module, ensure that the following dangerous activities are avoided:

- Do not exceed the rated load capacity of the lifting module, or use it to lift anything other than the cassettes it was designed for.
- Do not lift cassettes higher than necessary, and do not leave suspended cassettes unattended.
- Do not remove the warning or identification labels from the lifting module.
- Do not attempt to operate a damaged or malfunctioning lifting module.

⚠ WARNING

The lifting module supplied by GE W&PT must be used at all times when lifting cassettes. *Do not use chains or fabric straps to lift cassettes unless specifically instructed otherwise by GE W&PT.*

NOTICE

Ensure that all local government and facility regulations regarding fall-arrest precautions and tie-off points are observed during this procedure.

After ensuring that the precautions outlined above have been observed, connect the lifting module to the cassette by performing the following steps:

1. Lower the hook of the hoist (or crane) and connect it to the lift-point located at the center of the lifting module.
2. Raise the lifting module to a height at which it is comfortable and safe to work with.

3. If the cassette is already installed within the membrane tank, lower the water level within the membrane tank so that the permeate header is above the water.

4. Remove the locking pin from the support pin located at each corner of the lifting module.

5. Position the lifting module above the cassette, and then carefully lower it until it nears the cassette hanger arms. At this point, an operator will need to tilt the lifting module so that it can be lowered to just beneath the connection-points on the hanger arms.

6. Carefully raise one corner of the lifting module and guide the module's support pin up through the hole in the cassette's hanger arm, and then secure the support pin with the locking pin.

7. Slowly raise the lifting module while guiding each support pin into the corresponding hole. Secure each pin with a locking pin after it has been positioned correctly.

After all four support pins have been secured, the cassette is ready to be lifted.

5.8.16.2 Lowering Cassettes into the Membrane Tank

After connecting the lifting module to the cassette, install it within the membrane tank by performing the following steps:

⚠ WARNING

The hoist (or crane) must be load-tested, inspected, and properly rated for the full weight being lifted. All hoist (or crane) operators must be fully certified.

⚠ WARNING

Ensure that all personnel have been cleared from the immediate area before beginning the lift.

1. Lift the cassette a short distance off the ground, and then confirm that the load is secure before continuing.

NOTICE

If using poles or lines to guide the cassette, touch only the cassette frame. Do not push or pull on the membrane fibers.

2. Carefully maneuver the cassette until it is above the membrane tank.

3. Slowly lower the cassette down into the tank. Another operator should stand facing the far side of the cassette in order to assist with placement.

4. After the cassette is low enough that the cassette's permeate header can be reached comfortably, mount the permeate coupling onto the cassette header.

5. Connect the first section of the permeate pipe spool to the coupling on the cassette header, and then tighten the coupling so that it supports the full weight of the pipe spool section. Do not install the entire pipe spool at this time.

6. Tighten the coupling so that it can support the full weight of the spool.

7. Continue to lower the cassette until it rests firmly on the leveling pins.

8. After the cassette is sitting level within the membrane tank, install the rest of the piping spool. If necessary, remove the lifting module in order to continue installing the rest of the spool.

5.8.17 Installing Permeate & Air Connections

After the cassette has been installed in the membrane tank, the final piping and hose connections must be installed as shown in the technical drawings and as described in the procedures outlined below.

WARNING

Failure to tighten a coupling according to the manufacturer's required torque values may result in an explosive rupture or violent release. Following installation, all couplings must be inspected for tightness as part of the regular preventive maintenance process.

For more information on the topics discussed above . . .

- Refer to *Volume III - Controls & Drawings Binder* for illustrations showing piping and hose installations.

5.8.17.1 CONNECTING PERMEATE PIPING

The permeate header will be located above the cassette and will have to be connected to piping that runs down to the cassette header.

NOTICE

The cassette is not designed to support significant weight. Do not walk, lean, or climb on the cassette while installing connections.

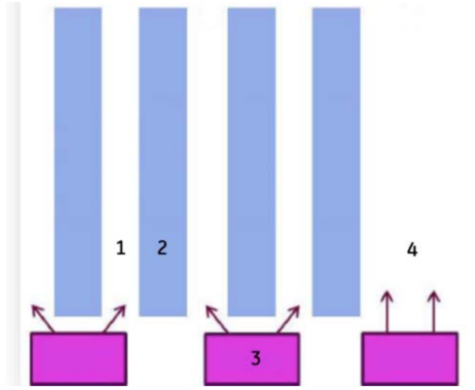
Regardless of the connection type, after the hoist and lifting assembly have been removed, complete the permeate connection by installing the remaining permeate spool pieces onto the partially assembled spool that has already been mounted on the cassette's permeate header.

5.8.17.2 CONNECTING AERATION PIPING

TIP: *If a cassette is not fully populated with modules, aeration plugs are used to block the aerators connected to empty module spaces.*

Each cassette comes equipped with a single 7.6 cm (3 in.) air connection. Air from this line enters a central pipe, and is then directed to the individual aerators.

Each aerator has two channels. For most aerators in the cassette, these channels direct air into two of the gaps which separate the modules. The only exception is the aerator at the end of the cassette, which has both channels directed to the open space next to the last module.



1. Gap
2. Module
3. Aerator
4. End space

Figure 5.16 - LEAPmbr Aeration Pattern

After the permeate connection has been installed, complete the aeration connection by performing the following steps:

NOTICE

To avoid damaging the cassette aeration assembly, connect the line to the train's aeration header first and then to the cassette aeration connection.

1. Connect the aeration line to the train's aeration header.
2. Connect the other end of the line to the union on the cassette.

For more information on the topics discussed above . . .

- Refer to *5.8.17.1 Connecting Permeate Piping* for more on installing permeate connections.
- Refer to *5.8.8 Installing Unions on Cassette Aeration Pipes* for more on connecting aeration hoses to cassettes.

5.8.18 Documenting Installation

Using the Membrane Map, record the serial number and location of each cassette and membrane module as it is installed. This form should be retained and updated whenever cassettes or modules are moved or replaced.

5.9 Testing Integrity During Commissioning

With the cassette(s) installed, the following tests must be conducted in order to confirm the integrity of the membranes:

- Bubble Test.
- Aeration check.

5.9.1 Bubble Test

A Bubble Test is used to locate leaks in the membranes. This procedure is to be performed on all new cassettes following installation, as well as whenever turbidity rises above acceptable levels.

To ensure that bubbles from broken fibers can be easily seen, the Bubble Test should be performed with the cassette submerged in relatively clean, clear water, such as UF permeate. This requires that the cassette first be removed from the membrane tank, desludged, and placed in a separate dip tank where the Bubble Test can be performed.

To complete a Bubble Test, perform the following steps:

1. Reduce the water level in the membrane tank to a point below the permeate connection, so that no water can get into the cassette after the connection is removed. ***The membranes must remain completely submerged.***

NOTICE

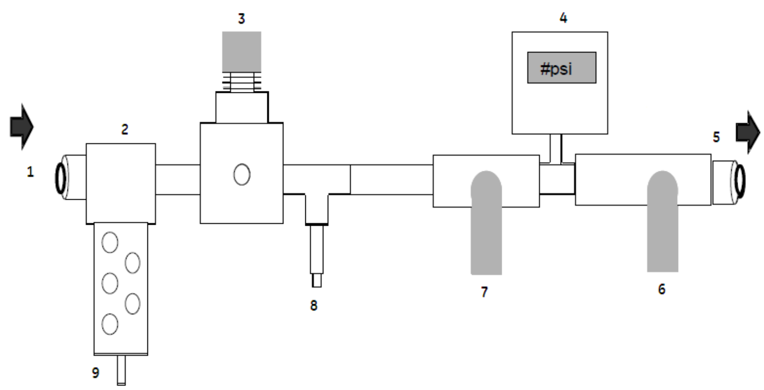
Before making any connections, ensure that the membrane safety isolation hand valve (HV-9581B) and the pressure relief valve (PSV-9564) are closed.

2. Isolate the cassette by closing the permeate and air isolation hand valves.

NOTICE

When installing adapters, prevent water or materials from entering the open permeate line.

3. Disconnect the permeate connection and attach the adapter supplied with the Portable Pressure Test Device (PPTD) to the permeate connection on the cassette.



1. High-pressure air connection from compressed air line (TP-01)
2. Air filter (F-95)
3. Pressure regulating valve (fine adjustment) (PRV-9583A)
4. Pressure gauge (PI-9541)
5. Low pressure air connection to membranes (TP-02)
6. Membrane safety isolation hand valve (HV-9581B)
7. Supply isolation hand valve (HV-9581A)
8. Pressure relief valve (PSV-9564)
9. Drain

Figure 5.17 - PPTD Parts Diagram

4. Connect the PPTD to the cassette by performing the following steps:

a. Ensure that the membrane safety isolation hand valve (HV-9581B) is closed.

TIP: *If the test pressure value has not already been provided by GE W&PT, contact GE W&PT now and request it before proceeding.*

b. Ensure that the setting for the pressure relief valve (PSV-9564) is set sufficiently low enough to prevent damage to the membranes. This setting will be slightly above the test pressure specified in step 5 below.

c. Open the supply isolation hand valve (HV-9581A).

d. Attach the high-pressure air connection (TP-01) to the compressed air supply. The connection is found on the side of the PPTD and is labelled "IN."

e. Attach the low-pressure air connection (TP-02) to the tube fitting on the membrane hose adapter, which is on the supplied camlock fitting. The connection is found on the side of the PPTD and is labelled "OUT."

TIP: *The button used to turn the gauge ON and OFF is located just above the screen.*

f. Ensure that the pressure gauge (PI-9541) has been turned ON. If the display fails to activate when the button is pressed, check the battery. If the value displayed does not appear accurate, disconnect the air supply. If the value does not revert to "0.00," contact GE W&PT, as the gauge may need to be recalibrated.

NOTICE

Ensure that pressure does not exceed the required test level.

5. Slowly adjust the pressure regulating valve (fine adjustment) (PRV-9583A) until the pressure reading shown on the gauge reaches the required test pressure of 207 mbar (3 psig).

6. After the pressure reading has reached the required level, slowly open the membrane safety isolation hand valve (HV-9581B), and then wait a minimum of 30 seconds in order to allow the pressure to stabilize.

7. After the pressure has stabilized, adjust the water level to 5 cm (2 in.) above the bottom of the cassette's permeate header (the membranes will remain fully submerged), and then wait 15 minutes to ensure the water has been purged from within the membranes.

8. Examine the membranes for escaping bubbles (indicating a leak).

9. If a leak is found, analyze it and determine what type of bubble stream is being produced. The repair procedure will vary depending on the type of bubble stream.

10. Repair any leaks found during the first examination, and then reduce the water level until it is level with the bottom of the cassette permeate header. Continue to examine the membranes and repair as needed.

If a module requires difficult or numerous repairs, contact GE W&PT for further information.

For more information on the topics discussed above . . .

- Refer to *5.9.2 Bubble Types* for more on analyzing bubble streams.
- Refer to *7.6 Repairing Fibers* for more on performing fiber repairs.

5.9.2 Bubble Types

The size and type of bubbles released by a leak during a Bubble Test indicate the type of leak that has occurred. Bubbles are classified according to four types, as outlined below.

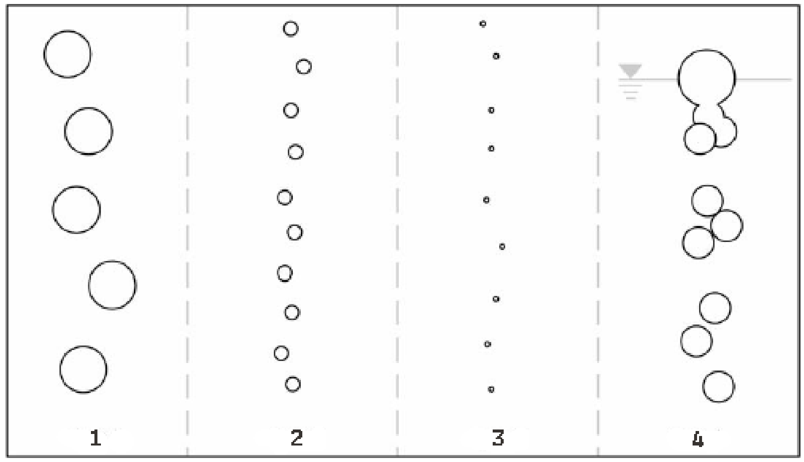


Figure 5.18 - Bubble Types

TYPE 1: A Type 1 bubble stream appears as a steady flow of large bubbles, typically 10 mm (0.4 in.) in diameter or greater. Type 1 streams are usually released by a severed membrane fiber. However, if the stream appears to come from one of the permeate headers, it may also be caused by an improperly installed O-ring.

TYPE 2: A Type 2 bubble stream is characterized by a steady flow of moderate-sized bubbles between 1 - 10 mm (0.04 - 0.4 in.). This form of leak is typically minor and often caused by punctured fibers or "pin holes" in the membrane. Type 2 leaks may not always require repair. Any larger leaks found during the Bubble Test should be repaired first, after which a second test will determine whether additional repairs for Type 2 leaks are necessary to bring performance up to specified levels.

TYPE 3: A Type 3 bubble stream appears as an intermittent stream of small bubbles (less than 1 mm (0.04 in.)). This type of stream is typically due to air passing through unwetted pores. Unwetted pores allow passage of air but not water, and do not need to be repaired.

TYPE 4: Type 4 bubbles gather at the top of the cassette and release when the bubble is sufficiently large. This type of bubble is usually formed by accumulated Type 2 or Type 3 bubbles.

5.9.3 CHECKING AERATION

If the installation procedure has been carried out correctly, the aeration assembly should be perfectly horizontal, providing an even distribution of air over the membranes.

Before installing hatches or other coverings over the cassettes, perform an aeration check by completing the following steps:

NOTICE

Install all cassettes before performing an aeration check.

1. Start the blower and ensure that air is being supplied to the membrane cassettes.

NOTICE

Air distribution must be as even as possible. If aeration is too high, it may cause excess vibration that will damage the membrane modules. If aeration is too low, it may not dislodge accumulated solids as intended.

2. Observe the bubble pattern on the surface of the tank. The surface should bubble evenly above the cassettes. If any uneven aeration is observed, the system must be stopped and the cause isolated. If the airflow is uneven, check the cassette's alignment and ensure that it rests level in the tank.

3. Check the air pipe connections for leakage and repair as necessary.

4. If multiple membrane tanks are used, turn aeration on in one membrane tank and off in another tank. Ensure there is no aeration in the membrane tank that is off.

After the system is fully installed and put into production, observe the aeration pattern within the individual cassettes to determine whether all of the modules are receiving equal airflow.

5.10 Returning Damaged Membranes

Contact GE W&PT by phone before returning goods for repair, warranty evaluation, or credit. When calling, have the original sales order or invoice ready.

A GE W&PT representative will provide instructions on how to obtain a Return Goods Authorization (RGA) number. This number must be acquired for all material returns and must be clearly labeled on the outside of the shipping box.

Shipping costs must be prepaid by the customer. For additional information about shipping claims, contact GE W&PT.

All materials must be rendered non-hazardous prior to shipping.

For more information on the topics discussed above . . .

- Refer to *5.11 System Shutdown & Membrane Preservation* for more on cleaning and preserving membranes.

5.11 System Shutdown & Membrane Preservation

It is strongly recommended that a chemical clean be performed before membranes are taken offline. Periodic aeration may also be necessary to prevent anoxic or anaerobic conditions from developing in the membrane tank.

NOTICE

Membranes which have been isolated must be cleaned before being returned to service. If membranes are isolated for less than a week, perform a sodium hypochlorite Maintenance Clean. If isolated for longer than a week, perform a sodium hypochlorite Recovery Clean.

The following sections provide instruction on how to preserve the membranes, depending on how long they will be taken offline.

> ***For more information on the topics discussed above . . .***
>
> - Refer to *Section 8 - Cleaning* for more information on chemical cleans.

5.11.1 SHORT-TERM SHUTDOWN

For storage periods of up to approximately 15 days, submerging membranes in water containing sodium hypochlorite at a maximum residual concentration of 3 mg/L is adequate.

To perform a short-term shutdown, complete the following steps:

1. Perform a Recovery Clean on the train containing the membranes which are being taken out of service.
2. At the main control panel, set the train(s) being taken out of service to OFF.
3. Submerge membranes taken out of service in water with a maximum residual sodium hypochlorite concentration of 3 mg/L.
4. Test water concentration weekly to ensure that sodium hypochlorite levels have not changed significantly. Adjust as needed.

TIP: *Aeration and recirculation frequencies are site-specific. Contact GE W&PT for details.*

To prevent excessive bioactivity within the membrane tank, the aeration blowers must continue to operate at a recommended frequency of 5 minutes every 30-minute period. The mixed liquor should also be circulated for 5 minutes every 1 - 4 hours.

5.11.2 LONG-TERM SHUTDOWN

NOTICE

If a long-term shutdown is being initiated so that a cassette can be reconfigured or rebuilt, a GE W&PT representative must be present in order to maintain the warranty.

To perform a long-term shutdown, complete the following steps:

1. Perform a Recovery Clean on the train containing the membranes which are being taken out of service.

2. Ensure that the membranes are free of solids.

CAUTION

The glycerin solution used to preserve the membranes can create a severe slip hazard if spilled. Clean any spilled solution immediately.

3. Prepare a solution of 50 weight percent glycerin.

4. Use one of the following procedures to impregnate the modules:

OPTION 1 - SINGLE MODULE: To impregnate a single module, soak the module in the preservative solution and apply 0.34 bar (5 psi) vacuum (0.66 bar absolute) for 30 minutes. Take the module out of the solution and place it in a container for 30 minutes to allow excess solution to drain off, then bag and seal it immediately, as described in step 5.

OPTION 2 - MULTIPLE MODULES IN A CASSETTE: To impregnate multiple modules contained within a cassette, perform the following steps:

a. With the cassette immersed in water, ensure that the membranes are full of water by operating under vacuum (permeation).

b. Close the permeate isolation valve(s).

c. Connect a reservoir (drum or small tank) with 60 L (15.8 gal) of preservative solution to a sample port or connection on the piping between the cassette and the isolation valve. Keep the reservoir level at least 91 - 183 cm (36 - 72 in.) above the top of the cassette. Do not open the glycerin supply valve yet.

d. Drain the membrane tank until the liquid level is below the bottom of the cassette.

e. Open the glycerin supply valve. The glycerin flows into the permeate side of the membrane and displaces the water in the fibers.

__TIP:__ If a module is removed from water and the permeate connection is left open, air will enter the fiber as water reverse-permeates. If the preservative is added manually while air remains in the fiber, the preservative will not enter the fibers.

f. The level in the preservative reservoir falls as the preservative replaces water within the membranes. Continue until a sufficient volume of preservative is reverse-permeated for each module in the cassette (at least 3 L (0.8 gal) per module). The volume of the hose or permeate header and subheader should be added to determine the total preservative solution needed.

5. Bag each module using a 0.15 mm (6 mil) thick plastic bag. These bags are available from GE W&PT. Seal the plastic bag using either a hand-held sealer or tape. If using tape, remove as much air as possible from the bag before taping most of the opening closed, and then remove the excess air with a shop vacuum.

__TIP:__ If possible, double-bag membranes or seal them in cardboard cartons.

6. Store the bagged membranes in a cool, dry area, out of the direct sunlight and protected from accidental contact that could damage the module or bag.

5.12 INSTALLING & UNINSTALLING NEW MODULES

New cassettes will be shipped with the modules already installed. The following sections provide information on how to install new modules that have been provided as replacements, as well as how to uninstall modules from the cassette for inspection or repair.

5.12.1 INSTALLING NEW MODULES

A minimum of two operators are required in order to install a single module.

Before removing a new module from its packaging, inspect the amount of slack within the cassette and determine whether an adjustment should be made.

The following equipment will be required during the installation procedure:

- Step ladder.
- Flashlight (optional).
- Box-cutter or similar knife.
- Water-soluble lubricant.
- 5 mm Allen key or hex wrench.

To remove the module from its packaging, perform the following steps:

1. Open the cardboard box, and then, with the assistance of another operator, lift the bagged module out of the box and transfer it to a table long enough to support the entire module when laid flat. Grasp the module by the headers at either end when lifting and carry it as shown below.

Figure 5.19 - Carrying a Module

2. Without removing the clear plastic bag, examine the module within for obvious signs of damage that may have occurred during shipping. Also, confirm that all O-rings are present. If an O-ring is missing, do not open the bag until a replacement can be found.

Figure 5.20 - O-rings on Permeate Spigot

CAUTION

The glycerin solution used to preserve the membranes can create a severe slip hazard if spilled. Clean any spilled solution immediately.

3. Carefully cut lengthwise across one end of the bag, ensuring that the knife does not touch the module header or any of the fibers. Ensure that any glycerine preservative that escapes from the bag is cleaned immediately.

4. While an assisting operator holds the module header nearest the cut end of the bag, grasp the opposite end and slowly slide the bag off the module.

After unpackaging the module, install it within the cassette by performing the following steps:

NOTICE

Modules are delicate and can be damaged extremely easily if mishandled. Never use excessive force when installing or removing modules from a cassette.

1. Apply a water-soluble lubricant to the O-rings on the module's permeate spigot.

***TIP:** When facing the front of the cassette, the aeration pipes can be seen on the left side of the cassette.*

2. Each module has one square header and one rounded header. When installed, modules will alternate, with one inserted rounded header-up while the neighboring module is inserted square header-up. Ensure that the module being installed is inserted properly by comparing it to the adjacent module(s). When populating an empty cassette, insert the first module square header-up and into the far-right position when facing the front of the cassette.

CAUTION

The glycerin solution used to preserve the membranes can create a severe slip hazard if spilled. Clean any spilled solution immediately.

3. While an assisting operator holds the opposite header, grip the module header (rounded or square) that will inserted at the top of the cassette, and then carefully lift the module off the table.

NOTICE

When moving a module, ensure that the membrane fibers are not allowed to drag along the floor or to bump against any other surface or object.

TIP: *If necessary, clean the cassette rail and apply a water-soluble lubricant to the module grooves.*

4. Using a step ladder and while the assisting operator continues to support the bottom header, raise the top header and align the grooves on the top of the header with the cassette rail. Insert the grooves into the rail, and then ***gently*** slide the module into place until approximately 25 cm (10 in.) of its length remains outside the cassette.

Figure 5.21 - Sliding Module Top Header into Cassette Rail

5. While the operator holding the partially installed top header continues to support it, align the permeate spigot on the bottom header with the permeate collector port on the cassette (a flashlight may be required when locating the port).

Figure 5.22 - Inserting the Bottom

6. Ensure that the spigot and port are properly aligned, and then, using gentle but firm pressure, carefully push the bottom header into the cassette until the O-ring seal between the spigot and the collector has been fully formed.

7. After the bottom header has been connected to the collector, gently lift the header, ***without twisting or placing excessive pressure on the collector,*** until the locating nipples on the front of the header can be slipped into the corresponding holes on the cassette frame.

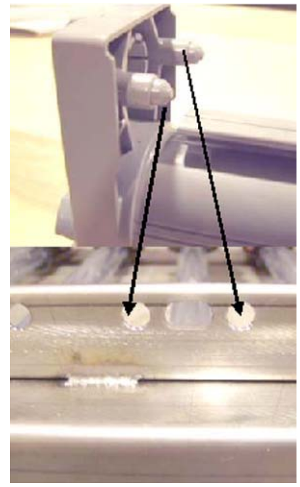


Figure 5.23 - Locating Nipples & Holes

8. After the bottom header has been installed, slide the top header into the cassette until it is fully installed as well.

9. Lock the module in place by turning the module keys on both the top and bottom headers to the locked (vertical) position. A slight "click" will be heard when the key is fully locked.

Figure 5.24 - Locked Module Key (Left)

10. Using a 5 mm Allen Key or a hex wrench, tighten the module's top and bottom key-side outer support expanders. Use care not to scrape or strip the hardware while loosening.

Figure 5.25 - Tightening Expanders

11. To ensure that the module has been installed properly, confirm the following:

    - The permeate spigot is connected securely to the permeate collector.
    - Both of the module's locking keys are in the locked (vertical) position.
    - The module's top and bottom key-side outer support

5.12.2 REMOVING MODULES FROM CASSETTES

A minimum of two operators are required in order to remove a single module from a cassette.

NOTICE

Do not use screwdrivers, pry bars or any other type of tool aside from the Module Removal Tool to remove modules from the cassette.

Typically, modules can be removed by hand without much difficulty, however, GE W&PT does provide a Module Removal Tool (MRT) which can be used to remove modules that do not slide out easily on the first attempt.

Figure 5.26 - Module Removal Tool

Figure 5.27 - Standard (Right) & Repair Adaptor (Left) MRT Faceplates

Each MRT is issued with a standard faceplate. An additional repair adaptor faceplate is also available for use with modules that have undergone repair and which have been fitted with the repair adaptor.

The MRT can be used to remove both the top and bottom header of a cassette by removing the MRT's cotter pin, sliding the faceplate to align with a new pin position, and then reinserting the pin. There are four pin locations along the main body (handle) of the MRT.

Table 5.1 - Pin Location & Function

Pin Location	Function
One	For installing and removing the top header
Two	For future use (not currently used)
Three	For future use (not currently used)
Four	For installing and removing the bottom header

Figure 5.28 - MRT Cotter Pin in First (Left) & Fourth (Right) Positions

To remove a module from a cassette, perform the following steps:

1. Using a 5 mm Allen Key or a hex wrench, loosen the module's top and bottom key-side outer support expanders. Use care not to scrape or strip the hardware while loosening.

Figure 5.29 - Tightening Expanders

2. Unlock the top and bottom module keys. A key is unlocked when turned fully horizontal. Do not apply excessive force when turning.

3. With one operator supporting the top header and another operator supporting the bottom header, attempt to slide the module out of the cassette by hand. If the module does not slide out easily, confirm that the key-side outer support expanders are loosened and that the module keys are unlocked. If the module still cannot be removed by hand, use the MRT to remove it.

Figure 5.30 - Unlocked Module Key

TIP: *To ensure a proper fit, clean any accumulated solids from grooves and cavities on the module face before the MRT faceplate is set in place.*

4. Fit the appropriate MRT faceplate (standard or repair adaptor) to the face of the module

Figure 5.31 - Fitting Faceplate to Module

NOTICE

Do not use tools or excessive force to turn the rotating ring. Doing so may damage the locking tabs. If the ring does not turn easily, apply a small amount of lubricant and continue attempting to turn it by hand until successful.

5. Ensure that the faceplate sits flush against the module, and then turn the circular rotating ring counter-clockwise until the locking tabs slide into place and the faceplate is locked onto the module.

NOTICE

Avoid pinching, catching, or stretching membrane fibers while sliding the module header out from the cassette.

6. With the faceplate locked firmly to the module, pull back on the MRT handle with a smooth, persistent force (do not wrench the handle back or jerk repeatedly) until the module comes free from the permeate saddle and begins to slide forward. Continue to slide the module outward until it protrudes approximately 25 cm (10 in.) from the cassette.

Figure 5.32 - Removing Module with MRT

7. Turn the rotating ring clockwise until the locking tabs disengage and the MRT comes free from the module.

8. Adjust the faceplate position on the MRT body, and then repeat this process for the module's other header.

9. After both headers have been partially removed from the cassette, set the MRT aside, and with one operator supporting the top header and another operator supporting the bottom, slide the module the rest of the way out by hand.

SECTION 6

OPERATING THE SYSTEM

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6.1 INTRODUCTION

This section outlines the procedures for starting up and operating the system as a whole.

For detailed information regarding a specific component, such as a pump or valve, refer to *Volume I - Vendor Data Manual*.

6.2 USING THE CONTROL PANEL

The following section describes the controls and indicators found on the system control panel, as well as how to access the onscreen interface and use it to control the system.

6.2.1 POWER CONTROL HARDWARE

The control panel disconnect switch, **system stop** button, and pilot light are located on the control panel.

6.2.1.1 CONTROL PANEL DISCONNECT SWITCH

The disconnect switch can be used to cut power to the control panel, which will in turn de-energize the PLC and any components controlled by the PLC.

6.2.1.2 SYSTEM STOP BUTTON

Pressing the **System Stop** button immediately places all PLC-controlled components into OFF mode. To resume operation, after the button has been pulled back out, the operator must follow the startup procedures outlined in the applicable sections below.

6.2.2 USING THE ONSCREEN INTERFACE

The onscreen interface is the operator's primary means of controlling the system. Using the onscreen interface, the operator can adjust the operating modes of various components, set schedules and setpoints, and monitor system status and performance levels.

6.2.2.1 ACCESSING THE ONSCREEN INTERFACE

***TIP:** Depending on the operator's security access level, some system controls may not be available.*

To access the onscreen interface controls, perform the following steps:

1. At the control panel, ensure that power is ON.
2. At the onscreen interface, ensure that the screen displays the system control graphics. If power is ON but the screen remains dark, touch the screen to activate.
3. After the onscreen interface has been activated, the Login screen appears. Enter the username and password in the appropriate fields, and then select the **Enter** button.

The first screen to appear is the Overview screen, which provides a high-level display of the system and the current status of all subsystems and major components. All other screens and menus can be accessed by selecting the buttons and symbols displayed on this screen.

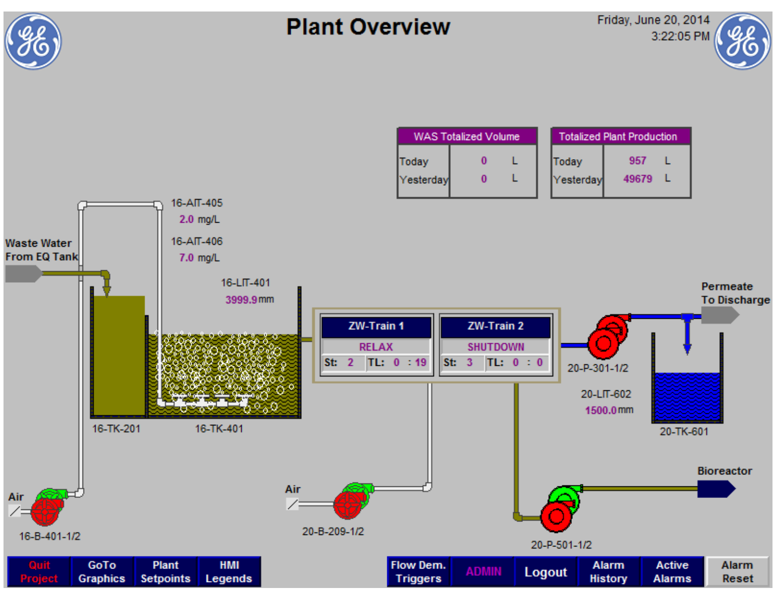

Figure 6.1 - Overview Screen

6.2.2.2 Understanding the Onscreen Interface

When using the onscreen interface, the operator navigates between screens by selecting both the labeled buttons and the images that represent various subsystems and individual components.

In the case of symbols for individual components (example: pumps, valves), the shape indicates the type of component, while the color shows its current mode (as outlined in *Volume III - Controls & Drawings Binder*).

6.3 Starting Up the System

To activate the system, perform the procedures outlined in the following sections in the order that they are provided.

The screens and menus used to control each subsystem and component involved in the procedures below can be accessed from the Overview screen.

> ***For more information on the topics discussed above . . .***
>
> - Refer to *Figure 6.1 - Overview Screen* for an image of this screen.

6.3.1 Bioreactor Subsystem

Use the following procedure to start up the various components associated with the bioreactor subsystem under normal operating conditions.

1. At the MCC, ensure that the circuit-breaker is set to ON and that the selector switches for the blowers associated with the bioreactor are set to AUTO.

2. Check the interior of the bioreactor to confirm that the following conditions are present:

- The smell within the bioreactor is musty, but not unpleasant (similar to freshly turned soil).
- The color of the mixed liquor is brown, but not too dark.
- Foam is a slightly lighter shade in color than the mixed liquor and only a few centimeters thick.

3. In the Overview screen, select the **GoTo Graphics** button. The Graphics menu appears.

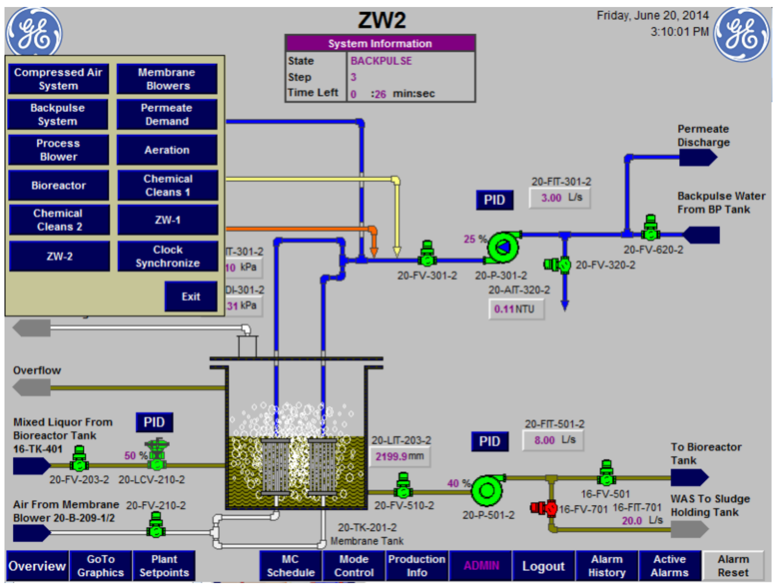

Figure 6.2 - Graphics Menu Pop-up Screen

4. In the Graphics menu, select the Bioreactor button. The bioreactor screen appears

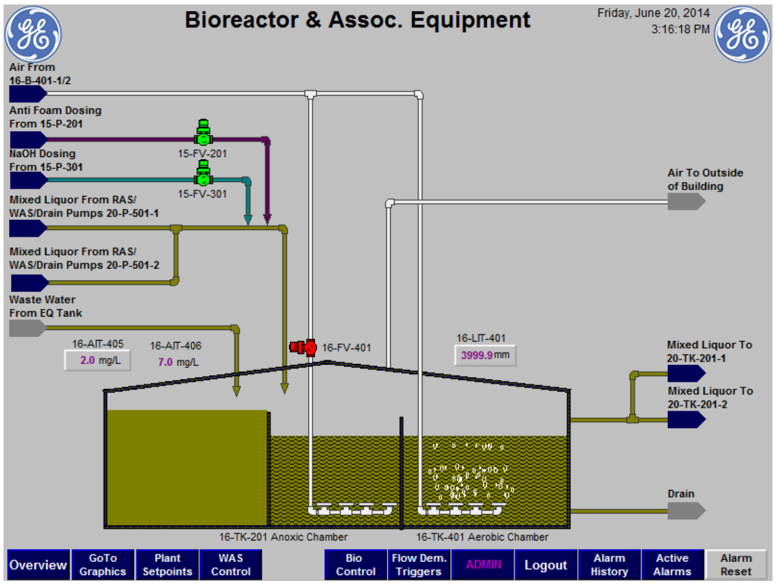

Figure 6.3 - Bioreactor Screen

5. In the bioreactor screen, set all components (example: pumps, blowers) to AUTO. If any components are not in AUTO, a warning notice will appear at the top-right corner of the screen with the message “Not All Devices in Auto” and will continue to display until all components have been set to AUTO.

For more information on the topics discussed above . . .

- Refer to *Figure 6.1 - Overview Screen* for an image of this screen.
- Refer to *Figure 6.2 - Graphics Menu Pop-up Screen* for an image of this screen.
- If restarting the system following an alarm shutdown, refer to *6.6 Resuming Operation Following an Alarm Shutdown*.
- Refer to *6.7 Controlling Specific Components Manually* for more on controlling individual components.

6.3.2 ZeeWeed UF Subsystem

Use the following procedure to start up the ZeeWeed UF subsystem under normal operating conditions:

1. Ensure that the circuit-breaker is set to ON and that the selector switches for all components related to the subsystem are set to AUTO. For information regarding startup procedures for specific components, refer to *Volume I - Vendor Data Manual*.

TIP: Automatic valves may not function properly if air pressure falls below this level.

2. Ensure that the compressed air supply is at a high enough level to satisfy the operating requirements of all pneumatically actuated valves. For more information about these requirements, refer to *Volume I - Vendor Data Manual*.

3. Set all manually operated valves in the proper position for normal operation. For information regarding valve positioning, refer to *Volume III - Controls & Drawings Binder*. For more on valve operation, refer to *Volume I - Vendor Data Manual*.

4. In the Go To Graphics screen, select the train that is to be put into production. The Train screen for that train appears.

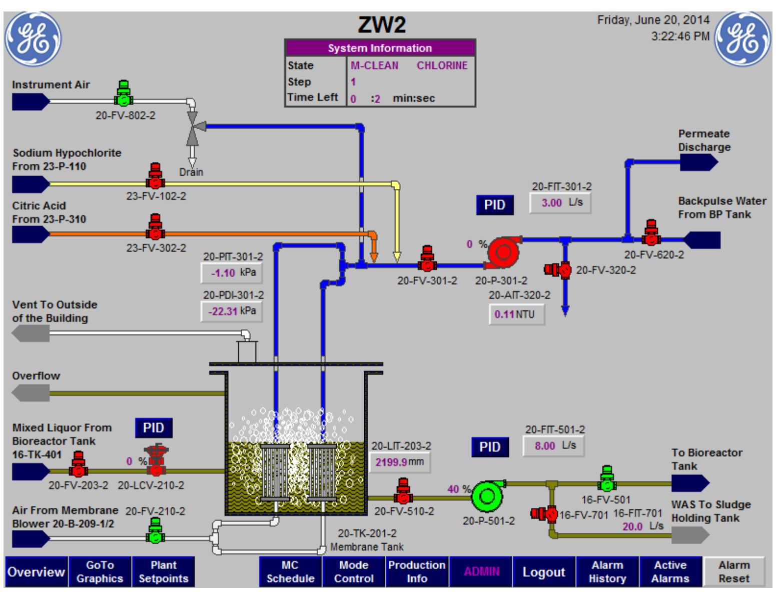

Figure 6.4 - Typical Train Screen

5. To set an operating mode for all components associated with the selected train, in the Train screen, select the **Mode Control** button. The Modes pop-up screen appears.

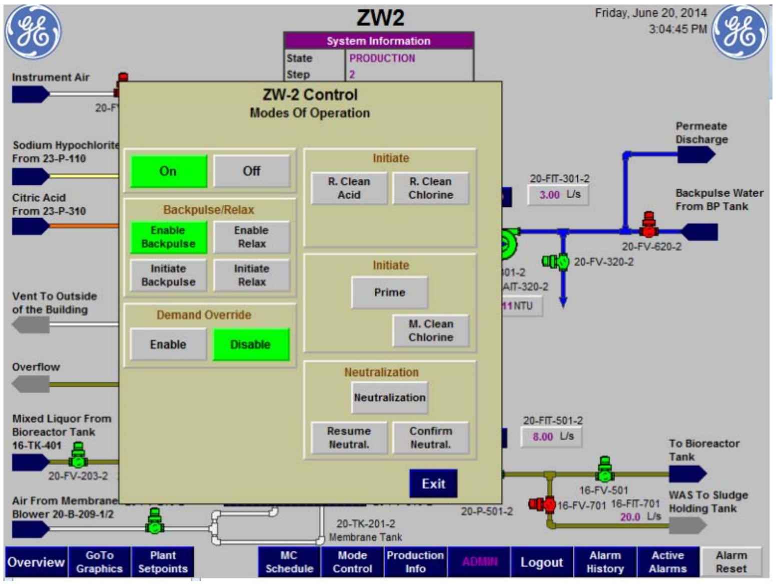

Figure 6.5 - Typical UF Modes Pop-up Screen

TIP: *The train will first enter STANDBY mode after being activated.*

6. To activate the train, in the Modes pop-up screen, select the **ON** button. The train begins operating in AUTO mode.

7. When finished, select the **Exit** button. The Modes pop-up screen closes.

The same procedure is to be followed to activate the second train.

For more information on the topics discussed above . . .

- Refer to *Figure 6.1 - Overview Screen* for an image of this screen.
- If restarting the system following an alarm shutdown, refer to *6.6 Resuming Operation Following an Alarm Shutdown*.

6.4 MONITORING THE BIOREACTOR DURING OPERATION

To maintain optimal conditions, the operator may be required to perform the following actions, depending on changes within the bioreactor:

AERATION: When aerating in DO mode, a single blower will operate at a speed that is adjusted automatically according to the oxygen demand registered by the DO probe. If aerating in Cyclic mode, the blowers operate at a fixed speed that can be adjusted by the operator. When aerating in Cyclic mode, the operator must monitor conditions within the bioreactor and adjust the variable-speed blower as needed.

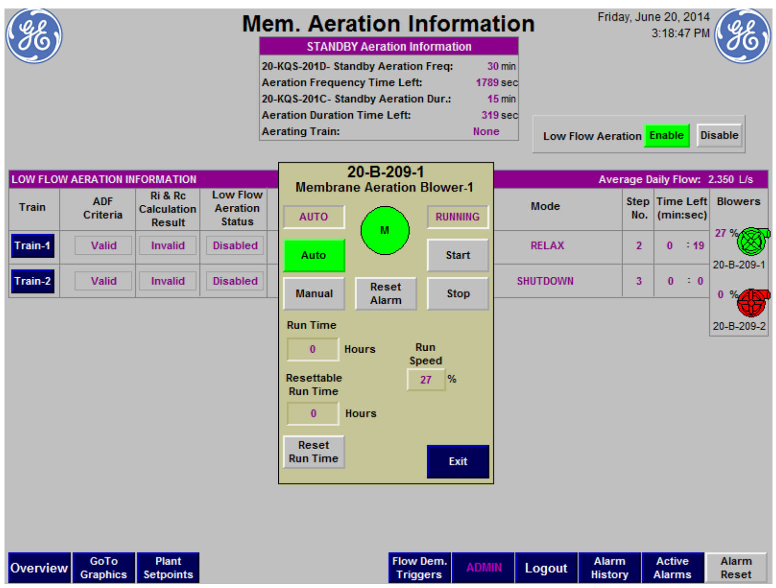

Figure 6.6 - Typical Blower Pop-up Screen

Recirculation pumps: The recirculation pumps are set in either DUTY or STANDBY mode. The mode for each pump is adjusted automatically according to the duty cycle time controlled by the operator-defined setpoint. If necessary, the operator can manually switch modes between pumps by adjusting this setpoint.

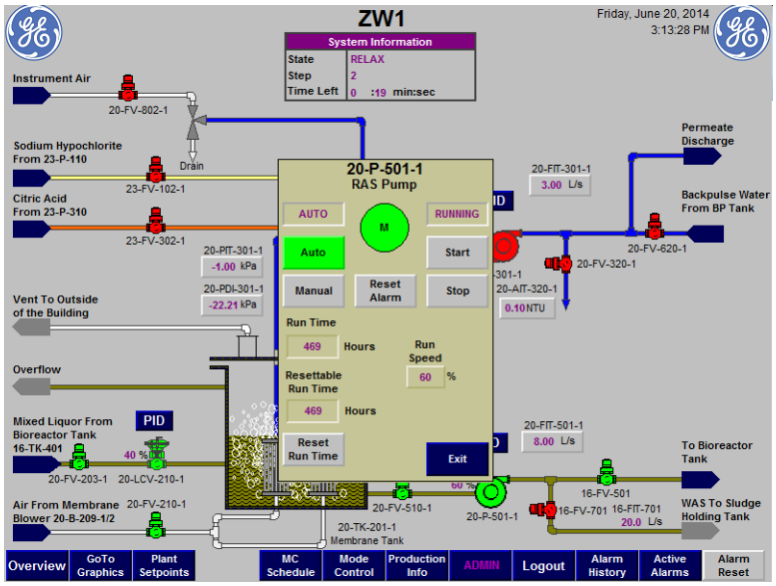

Figure 6.7 - Typical Recirculation Pump Popup Screen

NOTICE

Do not waste sludge if doing so may reduce the mixed liquor suspended solids (MLSS) count below the minimum allowable level for this system.

Tip: *The volume of sludge wasted is totalized daily.*

Wasting Sludge: In order for sludge to be wasted from the bioreactor, the operator must first define the time when the wasting will take place. The operator also defines the wasting volume and wasting frequency setpoints found in the Plant Setpoints screen. When the scheduled time is reached, the wasting process will be carried out automatically by the PLC.

To define when sludge wasting will occur:

1. In the Bioreactor overview screen, select the WAS Control button. The WAS Schedule pop-up screen appears.

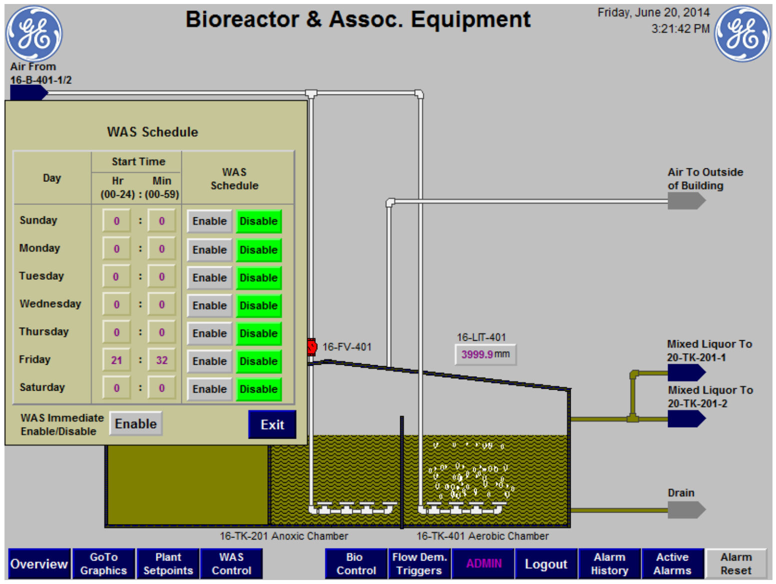

Figure 6.8 - WAS Schedule Pop-up Screen

2. In the WAS Schedule pop-up screen, select the start time for the sludge wasting. For days when sludge wasting is to occur, select the **Enable** button. For days when sludge wasting is not required, select the **Disable** button.

3. To close the pop-up screen, select the **Exit** button.

> ***For more information on the topics discussed above . . .***
>
> - Refer to *6.8 System Setpoints* for more on viewing and adjusting setpoints.

6.5 TRIGGERING AN ALARM SHUTDOWN

To trigger an alarm shutdown, press the **System Stop** button. This causes the following to occur:

- An alarm sounds.
- The onscreen interface displays an emergency shutdown notice.
- All system components immediately shut down, halting operation.

Because an emergency shutdown does not trigger the same cycles that a normal shutdown would, resuming operation immediately may damage the system. As a result, after an emergency shutdown has been triggered, all system components must be inspected and reset for startup before operation resumes.

6.6 RESUMING OPERATION FOLLOWING AN ALARM SHUTDOWN

There are numerous operating conditions that, if detected, will trigger an alarm. Examples of an alarm condition include component failure, a flow exceeding a preset safety setpoint, or an unacceptable reading from an instrument monitoring production capacity or quality.

Depending on the nature and severity of the condition, the resulting alarm may cause the system to shut down automatically in order to preserve product quality and protect the system and the operators from harm.

The Active Alarm pop-up screen lists all alarms that are currently occurring.

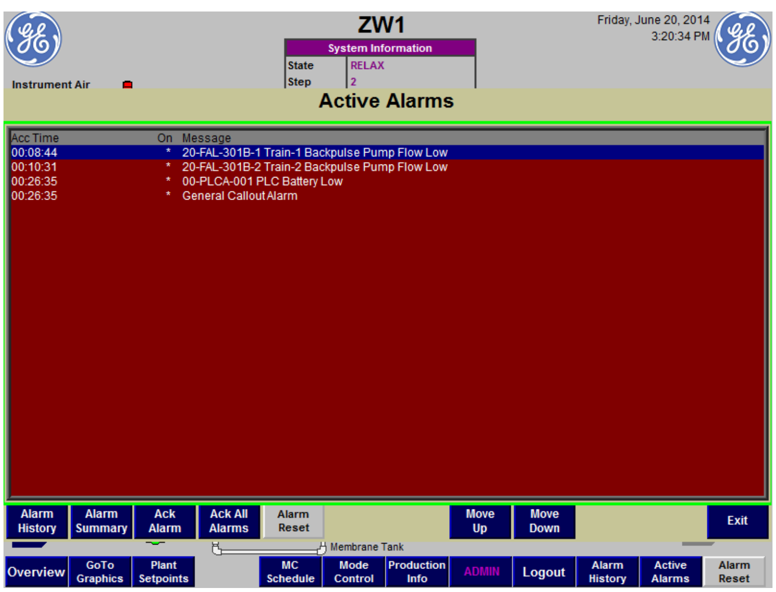

Figure 6.9 - Active Alarms Pop-up Screen

The Alarm History pop-up screen lists all alarms that have occurred.

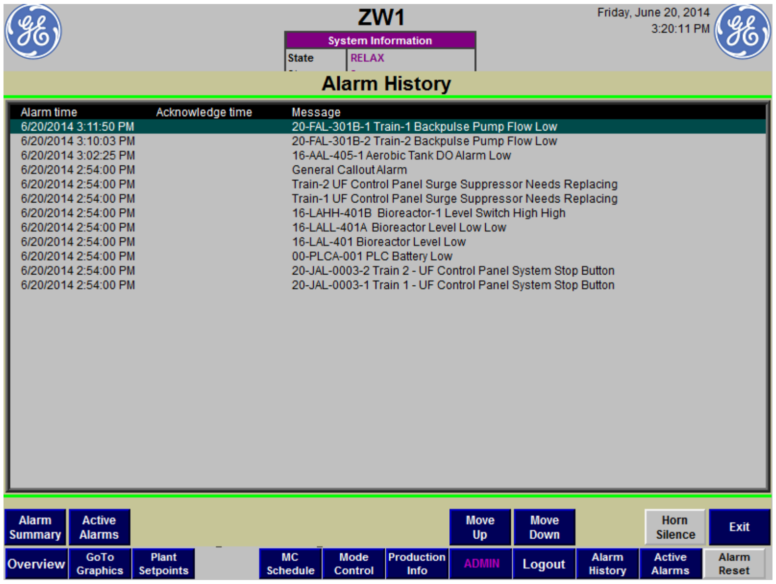

Figure 6.10 - Alarm History Pop-up Screen

If an alarm causes an emergency shutdown, use the following procedure to acknowledge the alarm, address the cause(s), and resume operation:

1. In the Overview screen, select the **Active Alarms** button. The Active Alarms screen appears.

2. Based on the information provided in the Active Alarms screen, determine what condition caused the shutdown.

3. After the alarm condition has been identified, to acknowledge the alarm, in the Active Alarms screen, select either the **Ack Alarm** or **Ack All Alarms** button.

TIP: If an alarm condition remains when the operator attempts to resume operation, the alarm will sound again and this procedure will need to be repeated.

4. Resolve the alarm condition before proceeding. For information on resolving alarms, refer to the CLC provided in *Volume III - Controls & Drawings*. Refer to *Volume I - Vendor Data Manual* for information regarding a particular component.

5. The action required to reset an alarm depends on the type of alarm that was triggered. After all alarm conditions have been resolved, to reset the alarm, complete one of the following steps:

- In the Overview screen, select the **Alarm Reset** button. The alarm resets.
- If the affected component is set in STOP mode, set it in AUTO. The alarm resets.
- In the Modes pop-up screen, select the train's **On** button. The alarm resets.

6. Reactivate the system.

If an alarm sounds but does not trigger an emergency shutdown and deactivates automatically, consult the Alarm History pop-up screen for an explanation. In most cases where this occurs, the condition that triggered the alarm was resolved automatically. However, operators should confirm this in order to rule out the possibility of a faulty alarm.

For more information on the topics discussed above . . .

- Refer to *Figure 6.1 - Overview Screen* for an image of this screen.
- Refer to *Figure 6.5 - Typical UF Modes Pop-up Screen* for an image of this screen.
- Refer to *6.3 Starting Up the System* for more on reactivating the system.

6.7 CONTROLLING SPECIFIC COMPONENTS MANUALLY

Although the PLC controls most system components during normal operation, the operator may, if necessary, manually adjust the operational setting of a specific component, such as a valve or pump.

NOTICE

Do not leave unattended any system component that has been adjusted manually (that is, one which has been taken out of AUTO mode).

The level of manual control that an operator has over the system depends on his or her security level access. Many of the controls outlined below will not be available (that is, they will not appear on the screen) if the operator who has logged in does not have authority to override the automated settings already in place.

The following sections provide general instructions for controlling specific components from the onscreen interface. For more detailed information, refer to *Volume I - Vendor Data Manual*.

6.7.1 ACCESSING COMPONENT CONTROLS

To open the pop-up screen for a specific component, at the onscreen interface, select the symbol for that component. The component's pop-up screen opens.

6.7.2 VALVES

Valves can be set in the following modes:

- AUTO - the valve is controlled by the PLC.
- MANUAL - the valve is controlled manually.
- OPEN - the valve is opened manually.
- CLOSE - the valve is closed manually.

NOTICE

Valves in MANUAL, OPEN or CLOSE mode must be monitored and controlled manually (that is, the PLC will only control valves in AUTO mode).

To switch modes, perform the following steps:

1. At the onscreen interface, select the symbol for the valve. The valve's pop-up screen appears.

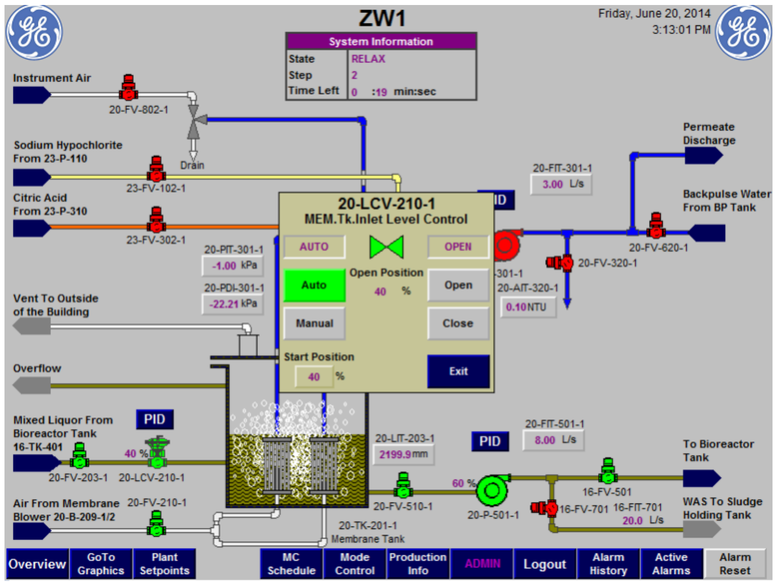

Figure 6.11 - Typical Valve Pop-up Screen

2. In the valve's pop-up screen, select the **Manual**, **Open**, **Close** or **Auto** button, as needed. The valve enters the selected mode of operation.

3. When finished, select the **Exit** button to close the screen.

6.7.3 PUMPS

The controls used to adjust a pump's settings can vary depending on the type of pump in question.

NOTICE

Do not leave unattended any system component that has been adjusted manually (that is, one which has been taken out of AUTO mode).

6.7.3.1 PROCESS PUMPS

TIP: *As membranes become fouled, the PLC will automatically adjust VFD and feed flow settings to maintain production.*

When the process pumps are set in AUTO mode, the PLC adjusts the variable frequency drive (VFD) and feed flow settings as needed in order to maintain production and reject flow setpoints (provided in *Volume III - Controls & Drawings Binder*). However, if necessary, the VFD setting can be adjusted manually in the pump's pop-up screen.

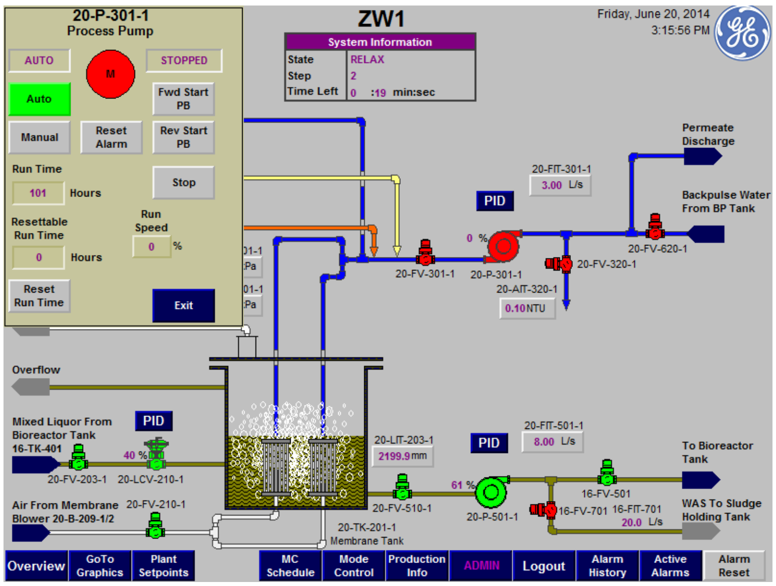

Figure 6.12 - Typical Process Pump Pop-up Screen

To adjust the start speed or runtime settings, perform the following steps:

1. At the onscreen interface, select the symbol for the pump. The pump's pop-up screen appears.
2. In the pump's pop-up screen, select either the box displaying the Start Speed value or the one displaying the Runtime value, as needed. The keypad control for the selected value appears.
3. Enter the new value, and then select the **Reset** button. The setting is updated.

The process pump can be set to operate in the following modes:

- AUTO - the pump is controlled by the PLC.
- MANUAL - the pump is controlled manually.

- STOP - the pump is stopped.
- FWD START PB - the pump transfers water from the membrane tank, producing permeate.
- REV START PB - the pump transfers water to the membrane tank, backpulsing the membranes.

NOTICE

Do not leave unattended any system component that has been adjusted manually (that is, one which has been taken out of AUTO mode).

To switch modes, perform the following steps:

1. At the onscreen interface, select the symbol for the pump. The pump's pop-up screen appears.
2. In the pump's pop-up screen, select the **Stop** button. The pump deactivates.
3. To set the process pump in FORWARD, select the **Fwd Start PB** button. To set it in REVERSE, select the **Rev Start PB** button.
4. When finished, select the **Exit** button to close the screen.

6.7.3.2 CHEMICAL PUMPS

Chemical pumps can be set in the following modes:

- AUTO - the pump is controlled by the PLC.
- START - the pump is activated manually.
- STOP - the pump is stopped.

NOTICE

Do not leave unattended any system component that has been adjusted manually (that is, one which has been taken out of AUTO mode).

To switch modes, perform the following steps:

1. At the onscreen interface, select the symbol for the pump. The pump's pop-up screen appears.
2. In the pump's pop-up screen, select the **Stop**, **Start** or **Auto** button, as needed. The pump switches to the selected mode.
3. When finished, select the **Exit** button to close the screen.

To adjust a pump's stroke speed, use the controls found on the pump itself. For more information, refer to *Volume I - Vendor Data Manual*.

6.7.4 AIR COMPRESSORS

Before activating an air compressor, set the duty cycle timer to the required setting. The factory default value is listed in the CLC provided in *Volume III - Controls & Drawings Binder*.

6.8 SYSTEM SETPOINTS

TIP: *The design values for system setpoints are listed in the CLC provided in Volume III - Controls & Drawings Binder.*

Most of the system's operating parameters, including alarm triggers, flow settings, and production schedules, are defined using setpoints. The default values for these settings are programmed during the initial commissioning process, but can be updated as necessary through the onscreen interface.

NOTICE

Record all setpoint changes. In the event of a complete loss of power, the system will restart with setpoints taken from the electronically erasable programmable read only memory (EEPROM) and any recent changes will be lost.

NOTICE

To preserve the controls design, back up the PLC processor onto the system's EEPROM memory. In addition, the PLC ladder logic and operator interface design must be copied to an external archive for future maintenance and emergency recovery.

To change a system setpoint, perform the following steps:

*TIP: The **Plant Setpoints** button is also available from most other screens.*

1. In the Overview screen, select the **Plant Setpoints** button. The Plant Setpoints pop-up screen appears.

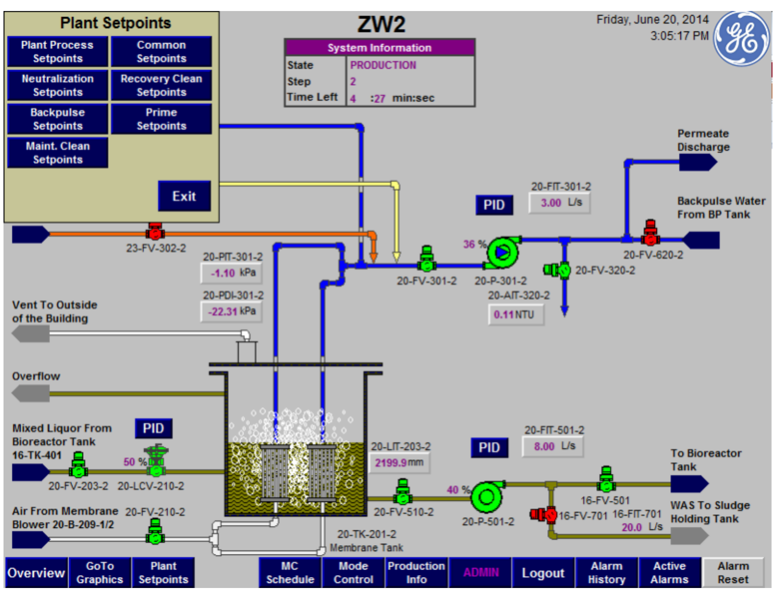

Figure 6.13 - Plant Setpoints Pop-up Screen

2. In the Plant Setpoints screen, select the button for the required setpoint subgroup. The setpoints included in that subgroup appear.

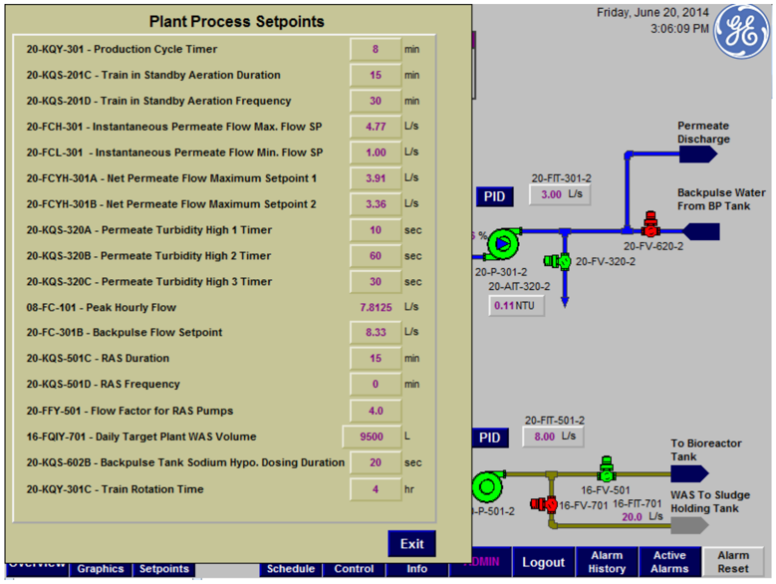

Figure 6.14 - Typical Setpoint Pop-up Screen

3. From the setpoints listed, select the box that displays the current value for the setpoint that will be updated. The keypad control for the selected value appears.

4. Enter the new value, and then select the **Reset** button. The setting is updated.

5. To close the Plant Setpoints screen, select the **Exit** button. The Plant Setpoints screen closes.

This same procedure can be used to adjust the setpoint values found on other screens as well.

For more information on the topics discussed above . . .

- Refer to *Figure 6.1 - Overview Screen* for an image of this screen.

6.9 LOGGING OUT OF THE SYSTEM

To log out of the system, perform the following steps:

1. In the Overview screen, select the **Logout** button. The Confirm Logout screen appears.

2. In the Confirm Logout screen, select the **Logout** button. The session ends and the Login screen appears.

For more information on the topics discussed above . . .

- Refer to *Figure 6.1 - Overview Screen* for an image of this screen.

6.10 SHUTTING DOWN THE SYSTEM

To shut down the system, perform the following steps:

NOTICE

Before initiating a shutdown, consult the related sections within this manual and ensure that all preservation and storage procedures are understood and adhered to.

1. In the Overview screen, select the **Quit Project** button. The Shutdown Verification pop-up screen appears.

2. In the Shutdown Verification pop-up screen, select the **Yes** button to shut down the system, or the **No** button to return to the Overview screen.

For more information on the topics discussed above . . .

- Refer to *Figure 6.1 - Overview Screen* for an image of this screen.

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SECTION 7

INSPECTION & REPAIR

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7.1 INTRODUCTION

This section outlines the various maintenance procedures required to ensure optimal membrane performance and lifespan, including information related to membrane fouling, handling, inspection, and repair.

7.2 MEMBRANE FOULING

The following section provides information on membrane fouling, types of foulants, and the processes used to remove them.

7.2.1 EFFECTS OF FOULING

The term "fouling" refers to the accumulation of unwanted deposits on a membrane surface.

Membranes form a physical barrier between water and the impurities it carries. During filtration, permeate is drawn under pressure across the membrane, leaving impurities on the outside surface. This gradual accumulation creates an increased resistance to permeation, which in turn increases the amount of transmembrane pressure (TMP) required during operation.

Membrane fouling can have the following negative effects:

- Increased TMP in order to maintain normal permeate production.
- Increased energy requirement for normal operation.
- Reduced overall membrane efficiency.
- Reduced membrane lifespan.

7.2.2 Foulant Types

Foulants include any materials that accumulate on the surface of a membrane and decrease that membrane's performance. Foulants are divided into the following four groups:

Biological: Aerobic and anaerobic living materials, such as bacteria, fungus, and algae. These organisms colonize on the surface of the membrane, blocking flow through the pores.

Precipitative: Precipitative foulants, often caused by high pH levels and extremely hard wastewater, usually appear in the form of scale. Scale develops when compounds in wastewater are concentrated beyond their solubility. Common precipitative foulants include calcium carbonate and magnesium sulfate.

Adsorptive: Adsorptive foulants include compounds that stick to the surface of the membrane, such as oil, polymers, cationic surfactants, and hydrocarbons.

Solids Accumulation: In UF systems used to treat wastewater containing a high level of solids, it is possible for solids to accumulate between the membrane fibers. At best, this type of fouling causes an increased TMP requirement. At worst, it will permanently damage membrane fibers. Adequate aeration and proper prescreening measures are the best methods for preventing this type of fouling.

Figure 7.1 - Solids Accumulation Between Fibers

7.2.3 Monitoring Fouling

Regardless of the system's application, solids accumulation must be monitored regularly. Inspections should be performed monthly at first, although this frequency may be adjusted in accordance with how often the membranes become fouled to the point where performance is affected.

Although all systems will become fouled over time, the following factors will generally result in more frequent and severe fouling:

- High TMP levels.
- Insufficient air flow during aeration.
- Non-uniform air distribution across the membranes during aeration (the cassette may not be level; the aeration assembly may be clogged or missing components).
- Operating at a high solids mass flux (either a high net flux, high MLSS, or both).
- Inadequate or malfunctioning prescreening measures.

Poor effluent turbidity or effluent nutrients are indicators of high solids accumulation, however, the most accurate way of determining the presence of solids in the membranes is through regular membrane inspections. It is important to regularly inspect the tanks and modules for accumulation. If sludging is allowed to worsen, the accumulation will quickly become more compacted and difficult to remove.

Reoccurring high solids accumulation may indicate that the system has mechanical- or process-related issues that require resolution. If frequent and/or extreme fouling becomes a problem, Contact GE W&PT for additional support.

7.2.4 PREVENTING FOULING

TIP: *The procedures and associated chemicals used may vary depending on system configuration.*

Three common methods for preventing membrane fouling are regular aeration, Backpulse, and chemically enhanced cleans. Depending on the type of fouling, a chemical cleaning sequence may be performed with ***either*** a high-pH (removes organic foulants) ***or*** a low-pH (removes precipitative foulants) chemical solution.

For more information on the topics discussed above . . .

- Refer to *Section 8 - Cleaning* for more on cleaning procedures.

7.2.5 Removing Foulants

The procedure used to remove fouling depends upon the type of foulant.

Biological: Exposure to a solution containing sodium hypochlorite will remove most biological foulants. Because it is easier to remove early biological growth, rather than established colonies, it is recommended that a schedule of frequent cleaning sessions with a low-strength sodium hypochlorite solution be established in place of infrequent cleaning sessions with a high-strength solution.

Precipitative: Membranes fouled with precipitative scale are cleaned using a citric acid solution. However, the best method of reducing precipitative fouling is to prevent it from occurring by lowering the concentration of precipitative foulants entering the system. Adding a lime water-softener and adjusting the wastewater pH level are common ways of controlling precipitative fouling.

Adsorptive: Adsorptive fouling is extremely difficult to reverse, making it critical that oils, polymers, hydrocarbons, and other foulants of this type be removed from wastewater before it encounters the membranes. For more information about preventing adsorptive fouling, or if considering the use of polymers or surfactants, contact GE W&PT.

Solids Accumulation: Because proper aeration is the most effective method of preventing solids accumulation, it is important that the aeration process be inspected on a routine basis.

7.3 Lifting & Moving Cassettes

The following section explains how to safely lift and maneuver the cassette using the lifting module.

NOTICE

Membranes will be damaged irreversibly if they are allowed to dry out.

The membranes may only be exposed to open air for a limited amount of time. To avoid unnecessary delay, ensure that this section is read in its entirety before attempting to perform any of the procedures outlined below.

7.3.1 PERSONNEL & EQUIPMENT

A minimum of two operators are required for this procedure, including at least one who is properly trained and certified to operate the crane, hoist, or other lifting apparatus which will be used.

It is also recommended that this process be completed under the supervision of a GE W&PT FSR. If an FSR cannot be present, ensure that one has been consulted regarding this procedure and any system-specific requirements before continuing.

This procedure will require approximately 2 hours to complete.

⚠ WARNING

The hoist (or crane) must be load-tested, inspected, and properly rated for the full weight being lifted. All hoist (or crane) operators must be fully certified.

The following equipment will be required:

- ZeeWeed cassette lifting module.
- Safety gloves, safety glasses, and any additional personal protective equipment as required by local government or facility regulations.
- Additional, system-specific tools or hardware (to be outlined by the FSR, if applicable).

7.3.2 Disconnecting Cassette Aeration & Permeate Piping

The following procedure must be performed when preparing to lift a cassette which is currently installed within the membrane tank.

To disconnect the cassette from the rest of the system, perform the following steps:

⚠ CAUTION

This procedure involves tasks which may result in injury due to limbs or equipment becoming caught. Use caution while working and make note of possible pinch-points.

⚠ CAUTION

This procedure involves tasks which may result in injury due to strain or overexertion if the proper care is not taken. Avoid awkward postures or repetitive movements while working and rest as needed if discomfort occurs.

1. Close and lock-out the cassette's aeration isolation valve.

⚠ CAUTION

Stand off to the side when disconnecting the aeration line from the cassette. Pressurized air may cause the coupling to release violently.

2. Partially open the aeration line's coupling and allow any pressurized air to escape slowly before continuing.

3. Disconnect the aeration line from the cassette.

4. Close and lock-out the cassette's permeate isolation valve.

5. Using potable water, thoroughly wash the permeate piping and coupling. Ensure that any accumulated sediment or debris is removed before proceeding.

NOTICE

Do not allow wastewater or debris to contaminate the coupling, or to enter the permeate piping.

6. Loosen the coupling which connects the cassette's permeate line to the permeate collection header, and then slide the coupling away from the cassette. Ensure that the cassette is completely disconnected from the permeate header.

7. Release the cassette locking pins.

8. If necessary, move or restrain disconnected lines so that they will not entangle the cassette as it is lifted.

7.3.3 PREPARING TO LIFT

WARNING

ZeeWeed cassettes may only be lifted using the lifting module supplied by GE W&PT.

When preparing to lift a cassette, connect the lifting module to it in the same manner as when the cassette was first installed.

For more information on the topics discussed above . . .

- Refer to *5.8.16.1 Connecting the Lifting Module to the Cassette* for more on this procedure.

7.3.4 WEIGHING CASSETTES PRIOR TO LIFTING

This procedure is to be performed whenever a cassette which has been in service is to be removed from the membrane tank.

⚠ WARNING

A cassette that has been in service will weigh more than it did when it was first installed. To avoid severe personal injury caused by a collapse, carefully evaluate the load limits of all lifting equipment, and of the surface that the cassette will be set upon.

A cassette that has been in operation for extended periods may have accumulated significant amounts of fouling. This will increase the cassette's overall weight. The amount of accumulated fouling will vary greatly depending on several factors, including how long the cassette has been in operation since it last underwent a cleaning sequence.

In order to ensure that a fouled cassette does not exceed the maximum capacity of the lifting apparatus, a crane scale must be used to determine the cassette's full weight before it can be removed from the membrane tank.

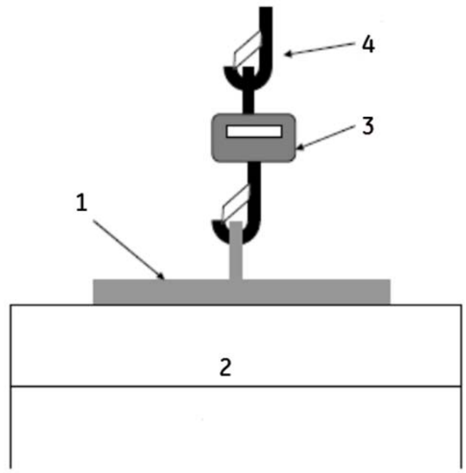
If the cassette has not yet been disconnected from the permeate and aeration lines and/or if the lifting module has not yet been connected to the cassette, perform these tasks as outlined in the sections above before continuing.

To measure a cassette's weight, perform the following steps:

⚠ WARNING

Attempting to remove a heavily fouled cassette from the membrane tank may cause excessive stress on the lifting apparatus, resulting in a collapse that could endanger nearby personnel and cause severe damage to the system.

1. Disconnect the hoist (or crane) from the cassette lifting module and install a properly rated crane scale between the crane hook and the lifting module's lift-point.



1. Lifting Module
2. Cassette
3. Crane scale
4. Crane hook

Figure 7.2 - Typical Crane Scale Assembly Diagram

2. While monitoring the reading on the crane scale, begin slowly lifting the cassette. ***If the reading begins to approach the maximum capacity of the lifting apparatus, immediately stop lifting, slowly lower the cassette back into the tank, and initiate a desludging procedure.***

3. If the reading does not approach the maximum capacity, continue lifting until the cassette has been raised 15 cm (6 in.), and then pause the lift.

4. Drain the tank until the water level has been reduced by 5 cm (2 in.), and then monitor the crane scale. After the reading has stabilized, resume the lift.

5. Repeat steps 3 - 4 until the cassette has been lifted completely out of the water. The cassette's full weight cannot be properly determined until it is fully suspended above the water level.

6. Record the cassette's final weight, and then lower it back into the tank.

7. After the cassette has settled into place, remove the crane scale, connect the crane directly to the lifting module, and then perform the cassette removal procedure. ***This procedure should not be attempted while the crane scale is still attached to the crane.***

> ***For more information on the topics discussed above . . .***
>
> - Refer to *7.3.6 Desludging Heavily Fouled Cassettes Prior to Lifting* for instructions on this procedure.
> - Refer to *7.3.7 Lifting Cassettes* for instructions on this procedure.

7.3.5 REMOVING ACCUMULATED SOLIDS DURING A LIFT

NOTICE

Never spray membranes with a high-pressure water stream.

If the cassette's weight is within the acceptable limits of the lifting apparatus, but it still contains a significant amount of accumulated solids, use a garden hose with a rounded head and a ***low-pressure stream*** to dislodge solids from the cassette as it is being lifted.

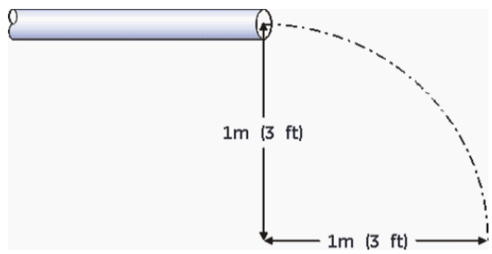


Figure 7.3 - Water Pressure Test

To ensure that the water pressure is not excessive, with the hose held horizontally and 1 m (3 ft) above the ground, confirm that the stream does not extend more than 1 m (3 ft) from the hose before reaching the ground. A stream that extends any further with the hose held at this height is too strong to be used on the membranes.

CAUTION

While performing this procedure, wear protective gloves, safety glasses, and any other protective equipment which may be required by local regulations.

***TIP:** Dense patches of sludge which have accumulated within 10 cm (4 in.) of the top or bottom headers may be left in place if they prove too difficult to remove without risking damage to the membranes.*

To remove accumulated solids during the lift, begin at the top of the cassette and work downward, spraying the cassette frame and the outermost membrane fibers. If several fibers have been bound together by dense sludge, gently remove the sludge by hand while continuing to spray the affected area.

If dense sludge is found nearer to the center of the cassette, consider partially removing the affected module(s) in order to access the buildup, rather than trying to reach through the fibers of neighboring modules.

Ensure that the base of the cassette, including the aeration assembly, is also checked for excessive buildup.

7.3.6 DESLUDGING HEAVILY FOULED CASSETTES PRIOR TO LIFTING

If, after weighing, a cassette is considered too fouled to be safely lifted, remove the accumulated fouling by allowing it to aerate without permeation for 2 - 12 hours, as deemed necessary, and then weigh it again.

If it is not possible to keep the cassette out of service for an extended aeration period, performing the following desludging procedure instead:

1. Initiate a Backpulse sequence.
2. After the Backpulse sequence has been completed, deactivate the train.
3. Drain the tank, and then fill it with permeate or potable water.

***TIP:** For best results, use water that is approximately 30 - 35°C (86 - 95°F).*

4. Manually aerate the membranes for 20 minutes at the standard aeration rate.
5. While continuing to aerate the membranes, drain the tank until the first (top) quarter of the cassette is above the waterline, and then stop draining.
6. Continue to aerate the membranes for 5 minutes.

7. While continuing to aerate the membranes, drain the tank until the first (top) half of the cassette is above the waterline, and then stop draining.

8. Continue to aerate the membranes for 5 minutes.

9. While continuing to aerate the membranes, drain the tank until the first (top) three quarters of the cassette are above the waterline, and then stop draining.

10. Continue to aerate the membranes for 5 minutes.

11. While continuing to aerate the membranes, drain the remainder of the tank.

TIP: For best results, use water that is approximately 30 - 35°C (86 - 95°F).

12. Refill the tank with permeate or potable water.

13. Repeat steps 4 - 11 while recording the turbidity value of the drained contents. Continue to repeat these steps as needed until the turbidity reading no longer shows a significant change in solids removal from one drain sequence to the next.

After completing this process, weigh the cassette again before proceeding with the cassette lifting procedure.

If the cassette is still overweight after the tank has been filled and drained several times, perform a short (2 - 3 hour) Recovery Clean using permeate or potable water that is approximately 30°C (86°F).

For more information on the topics discussed above . . .

- Refer to *Section 8 - Cleaning* for more on performing a Recovery Clean.

7.3.7 LIFTING CASSETTES

If, after weighing, a cassette is considered light enough to lift safely, remove the cassette from the membrane tank by performing the following steps:

1. Ensure that all disconnected lines have been moved so that they will not entangle the cassette as it is lifted.

2. Slowly begin lifting the cassette. Continue to lift until the bottom of the cassette is at least 15 cm (6 in.) above the top of the tank.

NOTICE

Membranes will be damaged irreversibly if they are allowed to dry out.

3. Remove the cassette to a clear, level location and inspect or replace membranes as needed ***as quickly as possible***.

7.4 INSPECTING CASSETTES

When inspecting the membranes, check for the following:

- Obvious signs of damage or wear.
- Clear differences in one module compared to others in the cassette.
- Loose or missing fasteners or other hardware.
- Broken membrane fibers.
- Cracking or breaks in piping and headers.

If any of the above signs of damage are found, contact GE W&PT for further assistance.

When replacing the membrane cassette or installing new membranes, ensure that the new membranes are flushed and sanitized before resuming production. The glycerin preservation solution and packing that the membranes are shipped in are not hazardous materials, but should be disposed of in compliance with local environmental regulations.

7.5 FIBER SLACK & SHRINKAGE

The amount of distance that separates the two headers in a membrane module can be adjusted in order to meet the specific operating requirements of each system. Although some adjustment may be required due to unique wastewater characteristics, ZeeWeed membrane modules are manufactured with an inherent amount of fiber slack (that is, the length of the membrane fibers is greater than the actual distance between the two headers).

Allowing the proper amount of fiber slack between the headers ensures that the fibers move freely during operation, which improves the effects of air scouring. Additionally, it is common for membranes to shrink slightly during operation, and permitting the proper amount of slack will accommodate this reduction in fiber length.

Figure 7.4 - Correct (Left) & Incorrect (Right) Slack for ZeeWeed 500D

7.5.1 FACTORS WHICH CAUSE FIBER SHRINKAGE

Shrinkage is a physical change that can be expected in any product composed of synthetic polymers, and is not the result of a defective or damaged product. Shrinkage can cause damage, however, if the initial amount of fiber slack is not sufficient enough to accommodate the reduction in fiber length.

The optimal amount of fiber slack is a function of operating temperature, chlorine concentration, and time, and is thus specific to each system. Significant changes in fiber slack are generally observed in systems with higher operating temperatures, or where modules are exposed to certain solvents sometimes found in certain water treatment applications.

The expected rate of fiber shrinkage is also system-specific. As a general rule, however, high wastewater temperatures will result in higher rates of fiber shrinkage.

For example, a system operating at 35°C (95°F) will typically exhibit more fiber shrinkage than a system operating at 30°C (86°F) over the same period of time. Systems operating at temperatures below 25°C (77°F) are not expected to exhibit significant fiber shrinkage, and the need for slack adjustment is unlikely.

7.5.2 Results of Fiber Shrinkage & Insufficient Slack

If the fibers shrink during operation, the predetermined slack will disappear. A module with insufficient slack ("taut fibers") may not perform at top efficiency because the random motion of the fibers during aeration is critical to efficient filtration.

It is important for operators to monitor the amount of slack in each module, even with systems operating below 25°C (77°F). Any module found to exhibit an insufficient amount of slack should be adjusted immediately.

NOTICE

Allowing modules to operate with insufficient slack for an extended period of time may cause irreversible damage to the membranes.

The following table provides a general guide as to how often fiber slack should be inspected, based upon the system's operating temperature. Photographs clearly showing the amount of slack in the module being inspected should be taken in order to track gradual changes over time.

If it appears that the slack requires adjustment, it is strongly recommended that these photographs and any other recorded observations be forwarded to GE W&PT for review and examination before the adjustment procedure is performed.

Table 7.1 - Recommended Inspection Intervals

Maximum Operating Temperature	Recommended Monitoring Inspection Frequency
0 - 24°C (32 - 76°F)	Every two years
25 - 30°C (77 - 86°F)	Once per year
Above 30°C (86°F)	Twice per year

NOTICE

Failure to identify and promptly address insufficient fiber slack may result in damage to the system. In extreme cases, failure to act may contribute to premature module failures, which may not covered under the warranty.

7.5.3 Slack Adjustment Procedure

The following section provides information regarding the procedure for loosening or tightening membrane fiber slack.

⚠ CAUTION

Do not allow bare skin to come into contact with wastewater during the following procedure.

This procedure requires the participation of two operators, both of whom should be equipped with proper safety equipment, including face mask, protective gloves, and boots at minimum.

TIP: *Depending on environmental conditions, it may be necessary to soak the membranes more frequently than described here.*

This procedure requires that the cassette be removed from the membrane tank for an extended period. Using a ***low-pressure hose***, rinse the membrane fibers after the cassette has been removed from the membrane tank to clear any solids accumulation, and then continue to gently soak the membranes every 30 minutes during the slack adjustment procedure.

The following equipment will be required during the slack adjustment procedure:

TIP: If necessary, use the mallet when inserting the pry bar under the cassette beams.

- Flat-head screwdriver (stainless-steel or plated).
- Rubber mallet.
- Pry bar (stainless-steel or plated).
- Food-grade anti-seize.
- Module removal tool.
- 3/8 in. or 1/2 in. torque wrench (25 - 250 In.-lbs or 3.6 - 29 Nm).
- 3/8 in. or 1/2 in. ratchet.
- 17 mm open wrench.
- 17 mm socket.
- Food-grade anti-seize.
- Coarse file.
- 250 mm-long M10 jack bolts (6).
- Replacement M10 Nordlocks (28).
- 5 mm Allen key socket or hex wrench.
- Drill with 13/32 bit.
- Full face-mask and protective clothing, including boots and gloves.

7.5.3.1 SLACK POSITIONS

Membrane slack can be set in one of the following four positions:

POSITION 1: Standard (as-manufactured) position.

POSITION 2: Raises the modules 8 mm (0.3 in.) up from Position 1.

POSITION 3: Raises the modules 16 mm (0.6 in.) up from Position 1.

POSITION 4: Raises the modules 24 mm (0.9 in.) up from Position 1.

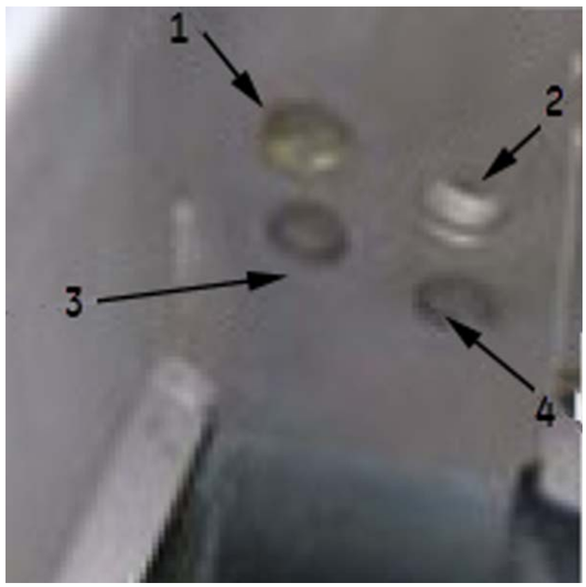


Figure 7.5 - Center Beam Position Holes

7.5.3.2 ADJUSTING SLACK

Adjusting the amount of slack within the cassette involves two separate procedures, one for repositioning the front and back bottom beams, and another for repositioning the center bottom beam.

Before the slack can be adjusted, the following steps must be performed:

1. Using a 5 mm Allen Key or a hex wrench, loosen all top and bottom key-side outer support expanders. Use care not to scrape or strip the hardware while loosening.

Figure 7.6 - Tightening Expanders

NOTICE

Avoid coming into contact with the membrane fibers while loosening the support expanders.

2. Unlock all module keys (top and bottom). A key is unlocked when turned fully horizontal. Do not apply excessive force when turning.

Figure 7.7 - Unlocked Module Key (Right)

To adjust the front and back bottom beams, perform the following steps:

TIP: *For more on which modules must be removed, refer to the GA drawings.*

1. Certain modules will need to be removed in order to provide access to the positioning bolts on each beam. Which modules must be removed will vary depending on the number of modules installed within the cassette.

TIP: *When facing the front of the cassette, the aeration pipes can be seen on the left side of the cassette.*

2. Loosen the positioning bolt found on the far left end of the front bottom beam ***without removing it completely***. Leaving this bolt in place will allow the beam to remain aligned with the adjustment holes.

3. Remove all other positioning bolts found along the front bottom beam.

Figure 7.8 - Removing the Bolts

4. On the front side of the cassette only, slide all of the modules out until they protrude approximately 5 - 8 cm (2 - 3 in.) beyond the top and bottom beams. Ensure that all modules have been completely disengaged from the permeate saddles before continuing.

Figure 7.9 - Module Slid Out of Cassette

5. Using the pry bar, lift the far-right end of the front bottom beam until the required amount of slack has been achieved.

Figure 7.10 - Adjusting the Front Bottom Beam

6. To secure the beam at the required level, apply a food-grade anti-seize to a positioning bolt, and then insert it into the adjustment hole on the far-right end of the front bottom beam. Ensure that the bolt is inserted with the threads facing outside the cassette. Do not fasten with a bolt at this time.

7. Remove the positioning bolt from the far-left end of the front bottom beam and repeat steps 5 and 6, lifting that end of the beam to the same height as the far-right end and securing it with the bolt (as with the previous bolt, apply food-grade anti-seize).

8. Apply food-grade anti-seize to the remaining positioning bolts, install them, and then tighten all bolts as described in the GA drawings. Ensure that all Nordlock nuts are discarded and replaced with new ones during reinstallation.

9. Re-install the modules that had been removed, ***but do not slide any of the modules back into the permeate saddles.***

After the front bottom beam has been secured, repeat this procedure for the back bottom beam on the opposite side of the cassette.

After both bottom beams have been adjusted, reposition the center bottom beam by performing the following steps:

1. Slide all modules on both sides of the cassette to the "stop" position on the top header.

Figure 7.11 - Slide the Modules to the Stop Position

2. Remove one of the slack adjustment clips from the bottom. Which clip must be removed depends upon the amount of slack required.

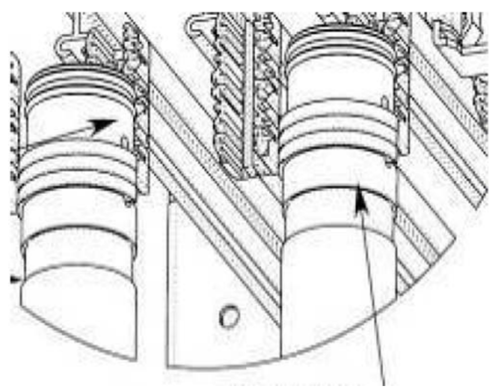


Figure 7.12 - Removing the Slack Adjustment Clip

3. Install a 250 mm M10 jack bolt into each of the threaded jack bolt holes. There is a bolt on either side of each end of the center bottom beam, as well as on either side of the middle of the beam. The following additional steps may be required, depending on the position of the hole:

    - When installing bolts into the holes at either end of the beam, it may be necessary to file the adjacent saddle in order to make room for the bolts.

- When installing bolts into the holes near the center of the beam, it may be necessary to make room for the bolt by using a drill to create an indentation in the side of the adjacent saddle.

Figure 7.13 - Jack Bolt Holes at End (Left) & Middle (Right) of Center Bottom Beam

4. If filing or drilling was required to install the jack bolts, use a ***low-pressure*** stream of water to gently wash away any filings, drill-turnings or other debris before continuing.

5. Remove the two positioning bolts found at the middle of the center bottom beam.

6. Remove the positioning bolts found at each end of the center bottom beam (four bolts in total).

7. Raise or lower the center bottom beam as needed by adjusting the six jack bolts.

8. After the center bottom beam has reached the required height, continue to adjust the jack bolts as needed until the holes at either end of the beam are aligned, and then reinstall and tighten the four adjustment bolts (two per end).

9. After the adjustment bolts have been reinstalled at the two ends of the center bottom beam, reinstall and tighten the two middle adjustment bolts.

10. Remove the jack bolts.

11. Reinstall all membranes, ensuring that the they are fully engaged with the permeate saddles and locked firmly in place.

12. Reinstall all aeration tubes in their original positions.

13. Using a 5 mm Allen Key or a hex wrench, tighten all top and bottom key-side outer support expanders. An expander is fully engaged when it is flush with the bottom surface of the key-side outer assembly. Do not exceed 5 Nm (3.6 ft-lbs) when tightening.

14. Update the Membrane Map by indicating the date of the slack adjustment, the amount of slack added or removed, and the new bolt positions used.

For more information on the topics discussed above . . .

- Refer to *7.3 Lifting & Moving Cassettes* for more on removing cassettes.
- Refer to *5.12 Installing & Uninstalling New Modules* for more on installing modules.

7.6 Repairing Fibers

TIP: *GE W&PT's optional DispensGun® silicone delivery tool can be used in place of a syringe during the following procedures.*

The procedure used to repair a damaged fiber will vary depending on the type of damage and the location along the fiber where it has occurred. The following sections outline the two primary repair techniques.

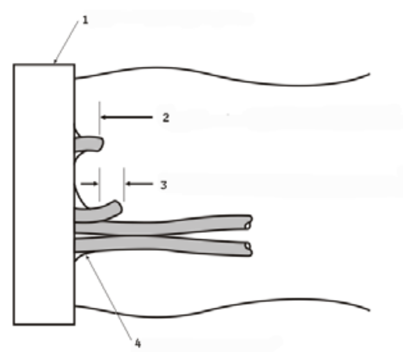
NOTICE

Do not separate strands that are glued together at the header, as this will cause damage to the membranes.

7.6.1 Axial Silicone Injection

For leaks detected at the end of the membrane fiber, or for fibers that have been cut badly or completely severed, perform an axial-injection repair by completing the following steps:

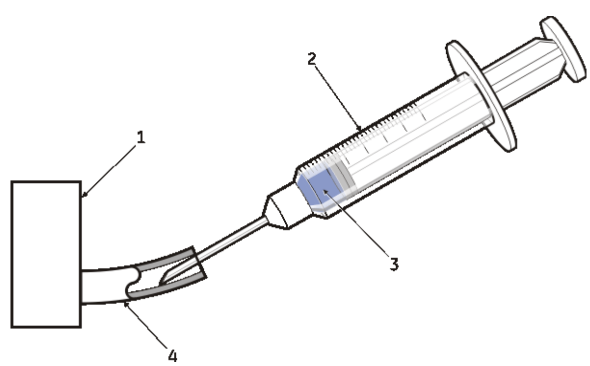
1. Remove the membrane module from the membrane tank and cut off the damaged portion 20 mm (3/4 in.) from the potting material on the ZeeWeed header.



1. Membrane module header
2. (20 mm gap) cut position for single fiber
3. (20 mm gap) cut position for fiber bundle
4. Drawn potting material

Figure 7.14 - Membrane Fiber Cut Positions

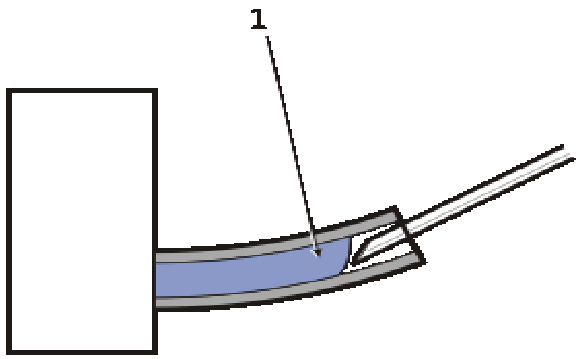
2. Using a hypodermic syringe filled with silicone sealant (available from GE W&PT as part of a Membrane Repair Kit) insert the tip of the needle 10 mm (7/16 in.) into the centre of the membrane lumen.



1. Header
2. Syringe
3. Food-grade silicone sealant
4. Cut lumen

Figure 7.15 - Axial Silicone Injection (One of Four)

3. Apply light pressure when injecting the silicone. Fill the lumen back to the header, as indicated by the darkened zone in *Figure 7.16 - Axial Silicone Injection (Two of Four)*. Filling typically takes 15 - 45 seconds.



1. Darkened (filled) zone

Figure 7.16 - Axial Silicone Injection (Two of Four)

4. Slowly withdraw the needle while still injecting silicone to assure the lumen is completely filled.

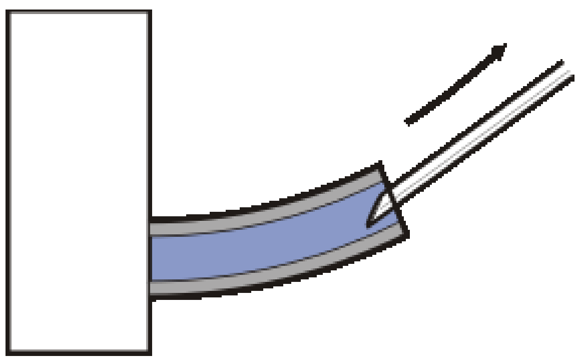


Figure 7.17 - Axial Silicone Injection (Three of Four)

5. While still applying pressure to the syringe, use the tip of the needle to spread silicone over the cut end of the lumen.

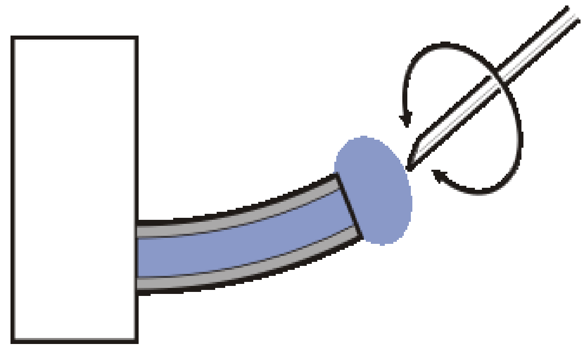


Figure 7.18 - Axial Silicone Injection (Four of Four)

After the repair is complete, place the cassette back into the membrane tank. Allow 10 minutes for curing before performing further membrane testing.

7.6.2 SUBJACENT SILICONE INJECTION

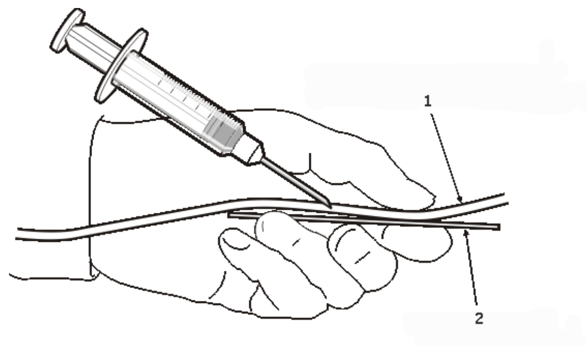
For leaks detected along the middle of the membrane fiber, perform a subjacent-injection repair by completing the following steps:

1. Remove the membrane module from the membrane tank.

⚠ CAUTION

A metal barrier (example: steel ruler) should be used to protect the hand holding the fiber.

2. Using a hypodermic syringe filled with silicone sealant (available from GE W&PT as part of a Membrane Repair Kit), insert the tip of the needle into the lumen. When inserting, hold the syringe at an angle of 5 - 10° to the lumen and insert the tip 5 - 10 mm (3/16 - 7/16 in.) from the leak. Ensure that the needle does not pass through the lumen completely, but only into the hollow centre.

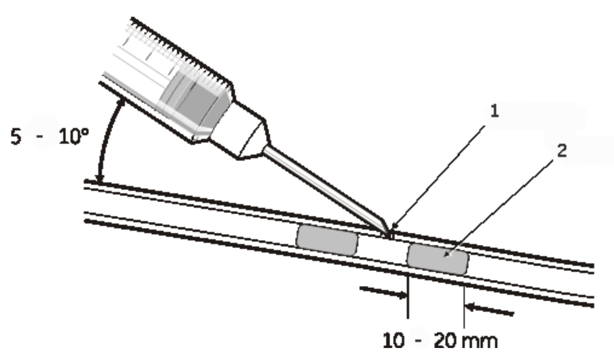


1. Support lumen with fingers placed away from injection point
2. Steel ruler or other protective barrier

Figure 7.19 - Subjacent Silicone Injection (One of Two)

3. Apply light pressure to fill the lumen with silicone. Continue applying pressure while withdrawing the needle from the lumen, ensuring the puncture is sealed.

4. Repeat these steps on the other side of the leak, positioning the needle 5 - 10 mm (3/16 - 7/16 in.) from the leak on the opposite side to the first injection point.



1. Leak
2. Injected silicone

Figure 7.20 - Subjacent Silicone Injection (Two of Two)

After the repair is complete, place the cassette back into the membrane tank. Allow 10 minutes for curing before performing further membrane testing.

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SECTION 8

CLEANING

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8.1 INTRODUCTION

This section provides information regarding the various procedures and chemicals used to clean and maintain the system as a whole.

For information specific to individual components, such as pumps and valves, Refer to *Volume I - Vendor Data Manual*.

8.2 CLEANING SUMMARY

The following table provides key details regarding the chemical cleaning sequences used in this system.

NOTICE

Do not pour chemicals directly onto the membranes.

CAUTION

Sodium hypochlorite cleaning solution generates a corrosive gas that poses a safety risk to those nearby. Adequate ventilation must be provided.

NOTICE

The information provided in the following table is accurate at the time of installation, but is subject to change over time. Contact GE W&PT for up-to-date cleaning information and annotate this table as needed.

Table 8.1 - Typical Cleaning Summary

Chemical	Purpose	Design Concentration	Frequency	Design pH
Maintenance Clean				
Sodium hypochlorite 10.8%	Organic Cleaner	200 mg/L* (Full Tank)	Twice per week	Maximum 10.5
High-pH Recovery Clean				
Sodium hypochlorite 10.8%	Organic Cleaner	1000 mg/L**	Twice per year	Maximum 10.5 at under 30°C (86°F), 10 at 30 - 40°C (86 -104°F)
Low-pH Recovery Clean				
Citric acid 50%	Scale Removal	2000 mg/L**	Twice per year	2.5 - 3.5

NOTES:

- * Backpulse concentration
- ** Soak concentration

8.3 CLEANING CHEMICALS

⚠ WARNING

Allowing certain high-pH and low-pH solutions to mix may create deadly chlorine gas, posing a severe safety hazard to all personnel within the facility. Under no circumstances should these solutions be permitted to come into contact with one another.

TIP: For more severe fouling, GE W&PT offers additional cleaning chemicals designed specifically for use with systems prone to fouling. Contact GE W&PT for more information.

The type of cleaning chemical required depends on the type of fouling that needs to be cleaned. A high-pH (alkaline, caustic, or similar) solution is used to remove biological fouling, while a low-pH (acid) solution is used for precipitative fouling caused by accumulated mineral scales, iron, or other metals.

⚠ CAUTION

Failure to observe all safety precautions outlined in the applicable MSDSs while handling cleaning chemicals may result in injury.

NOTICE

Use of unapproved chemicals during a cleaning procedure may void the warranty.

Safety and handling instructions for all cleaning chemicals which GE W&PT has supplied can be found in the applicable MSDSs.

Contact GE W&PT for more information regarding chemicals that have been approved for use with this system.

For more information on the topics discussed above . . .

- Refer to *Section 15 - Material Safety Data Sheets* for MSDSs.

8.4 Preparing Cleaning Chemicals

NOTICE

The sodium hypochlorite cleaning solution should be limited to a maximum pH of 10.5 at a temperature of less than 30°C (86°F), and a maximum pH of 10 at a temperature between 30 - 40°C (86 - 104°F).

NOTICE

Citric acid solubility is 500 g/L at 10°C (50°F). GE W&PT does not recommend increasing the concentration beyond this amount.

Ensure that the chemical solution has been prepared in sufficient quantity. Use the following calculation to determine the amount of chemical required per liter of solution:

% by weight (as decimal)	×	density	=	amount (kg) required per liter of solution

EXAMPLE: For a 50% by-weight solution with a density of 1.24:

0.5 kg	x	1.24 kg	=	0.62 kg/L solution

If a chemical injection pump will be used to add the solution into the system, ensure that the pump has been set to dose the proper amount when activated. If the solution will be added manually, reconfirm the amount being added before beginning and monitor the addition carefully.

For more information on the topics discussed above . . .

- Refer to *8.3 Cleaning Chemicals* for more on chemicals used in this system.
- Refer to *8.2 Cleaning Summary* for more on cleaning procedures.

8.5 FREQUENCY OF CLEANS

TIP: *Permeability drops if wastewater temperature decreases. This decrease is normal and does not necessarily indicate fouling.*

During normal operation, membranes can become fouled by mineral salts (example: calcium carbonate), iron, insoluble organics (example: oil), and biological matter, all of which can cause a decrease in membrane permeability. How often membranes require cleaning in order to remove these foulants depends on specific operating conditions, including operating time, various flowrates, and wastewater characteristics.

For more information on the topics discussed above . . .

- Refer to *8.2 Cleaning Summary* for more on specific cleaning times.

8.6 CLEANING LOGSHEET

All information gathered during a clean should be recorded on the cleaning logsheet (provided separately in electronic format). This logsheet should be emailed or faxed to GE W&PT so that the effectiveness of cleaning procedures can be verified.

8.7 TYPES OF CLEANS

The following types of cleaning procedures must be performed at regular intervals in order to maintain normal operating parameters.

NOTICE

When performing a Backpulse, never apply pressure greater than 0.55 bar (8 psig) across the membranes, as doing so may decrease membrane lifespan.

BACKPULSE: A Backpulse involves pumping permeate from the backpulse tank back through the membranes and into the membrane tank. This process helps to remove fouling that may have accumulated on the membranes during operation.

RELAX: Relax is an alternative to the Backpulse sequence. If a Backpulse failure occurs and no pump is available, the PLC places the trains into RELAX mode.

MAINTENANCE CLEAN: Fouling that cannot be removed by performing a Backpulse must be cleaned using a chemical solution. This process, known as a Maintenance Clean, involves the use of specialized chemical solutions to dissolve various types of foulants.

RECOVERY CLEAN: A Recovery Clean is performed only to remove substantial amounts of fouling and involves the use of highly concentrated chemical solutions and extended soak periods.

> ***For more information on the topics discussed above . . .***
>
> - Refer to the sections below for more on the cleans outlined here.

8.7.1 BACKPULSE

Backpulse cleans are initiated automatically during the normal production cycle according to setpoint values defined by the operator. Backpulse-related setpoints should be updated periodically to account for changes in operating conditions and wastewater quality.

If necessary, a Backpulse can also be initiated manually by selecting the **Initiate Backpulse** button in the train's Modes pop-up screen. The Backpulse will run for the same duration as an automatically initiated sequence and the Backpulse timer will be reset so that future sequences occur according to the set frequency. A Backpulse cannot be initiated manually if the system is in OFF mode, or if another train is currently undergoing a Backpulse.

When the operator initiates a Backpulse the sequence begins immediately. The selected train becomes the lead train and the system adjusts the production cycle time to maintain a staggered Backpulse schedule.

> ***For more information on the topics discussed above . . .***
>
> - Refer to *Figure 6.5 - Typical UF Modes Pop-up Screen* for an image of this screen.

8.7.2 RELAX

When a train is in RELAX mode, the membranes sit inactive (no permeation) for a duration specified by the operator, after which production resumes. During this time, aeration disperses foulants that have concentrated around the membranes.

A train is placed in RELAX mode either manually (operator selects the **Relax** button) or automatically (PLC triggers the transition to RELAX if a Backpulse sequence fails and no pump is available).

The Relax sequence alone is not enough to prevent gradual foulant accumulation. In cases where a Relax sequence is incapable of restoring adequate membrane permeability, a Backpulse sequence will be initiated instead.

8.7.3 MAINTENANCE CLEAN

TIP: *Cleans should be scheduled during periods when system demand is at its lowest.*

The operator must ensure that there are sufficient cleaning chemicals available and must set the day and time when the Maintenance Clean is to occur for each train.

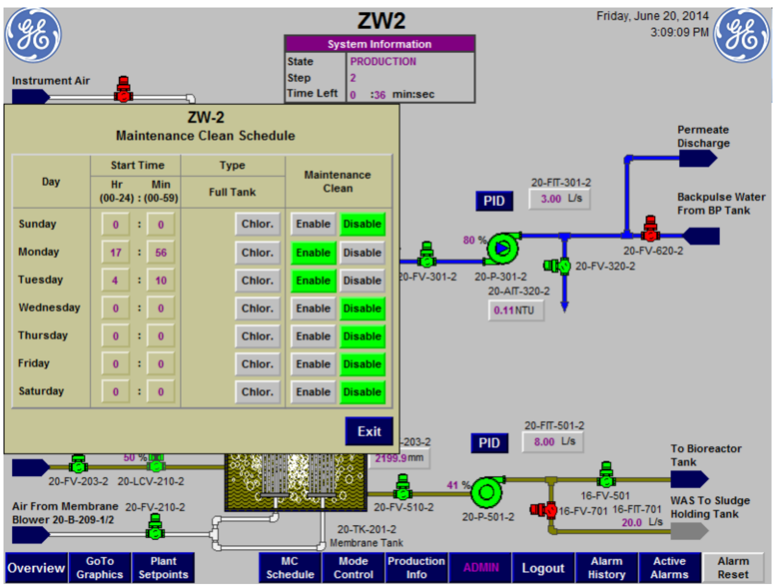

Figure 8.1 - Maintenance Clean Schedule Pop-up Screen

Other chemical cleaners may also be used if approved by GE W&PT. It is recommended that the correct chemicals be selected for each site during the initial operating period.

8.7.3.1 SCHEDULING A MAINTENANCE CLEAN

TIP: *A train cannot undergo a Maintenance Clean if another train has already entered a non-production mode (example: Backpulse, Maintenance Clean).*

To schedule a Maintenance Clean, perform the following steps:

1. In the Maintenance Clean Schedule screen, for days when a clean is to occur, enter the start and end times, and then select the **Enable** button. For days when a Maintenance Clean is not required, select the **Disable** button.

2. In the Maintenance Clean Setpoints pop-up screen, confirm that all setpoint values are properly defined. The factory default values and acceptable ranges for these setpoints are listed in the CLC provided in *Volume III - Controls & Drawings*.

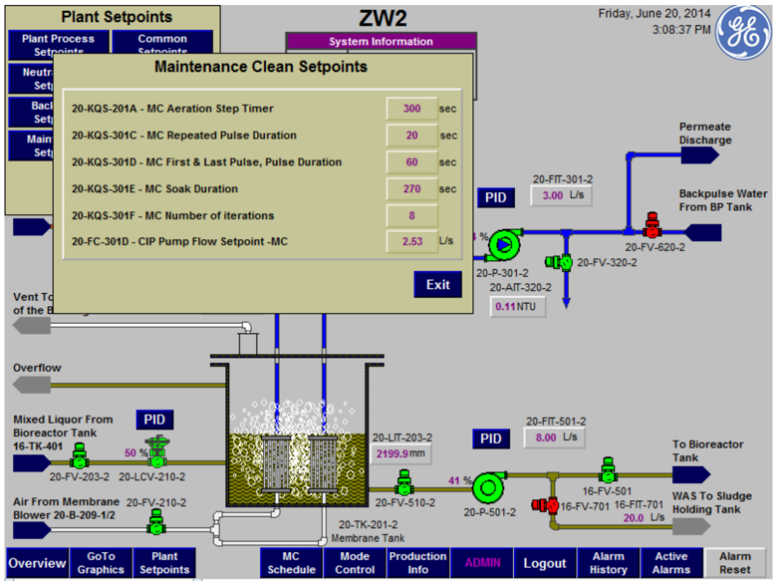

Figure 8.2 - Maintenance Clean Setpoints Pop-up Screen

3. Record all setpoint changes.

8.7.3.2 PERFORMING A MAINTENANCE CLEAN

If necessary, a Maintenance Clean can be initiated manually. Before doing so, read the information provided in this section.

NOTICE

To avoid damaging the membranes during a cleaning sequence, the CIP assembly, including all tanks and piping, must be kept clean at all times (free of debris or other contaminants).

To perform a Maintenance Clean, in the train's Modes pop-up screen, select the **M. Clean Chlorine** button. A clean using the selected chemical is initiated and carried out by the PLC. For more information about the automated steps involved in this sequence, refer to the OSC provided in *Volume III - Controls & Drawings Binder*.

> ***For more information on the topics discussed above . . .***
>
> - Refer to *Figure 6.5 - Typical UF Modes Pop-up Screen* for an image of this screen.

8.7.4 RECOVERY CLEAN

A Recovery Clean should be performed on a regular basis, as well as whenever other, regularly scheduled cleaning sequences fail to restore TMP to the extent required.

A Recovery Clean is operator-initiated and requires that the operator be present during the majority of the clean.

A Recovery Clean can be conducted using ***either*** a high-pH (removes organic fouling) ***or*** low-pH (removes inorganic fouling) solution. If two separate sequences are performed during the same cleaning session, the low-pH clean typically follows the high-pH.

The complete Recovery Clean procedure normally requires approximately 6 - 9 hours per train, per chemical (12 - 18 hours if both cleaning chemicals are used).

8.7.4.1 PREPARING FOR A RECOVERY CLEAN

TIP: *As the Recovery Clean procedure requires that the train be shut down for a minimum of 6 hours, it is recommended that this process be conducted during low-demand periods.*

Recovery Cleans are initiated manually, and so cannot be scheduled through the PLC.

Before initiating a clean and while the train is still in PRODUCTION mode, record the current water temperature, flux, and TMP level.

> ***For more information on the topics discussed above . . .***
>
> - Refer to *8.2 Cleaning Summary* for more on Recovery Clean frequency and other parameters.

8.7.4.2 PERFORMING A RECOVERY CLEAN

After preparing the cleaning solution, perform a Recovery Clean by completing the following steps:

NOTICE

To avoid damaging the membranes during a cleaning sequence, the cleaning assembly, including all tanks and piping, must be kept clean at all times (free of debris or other contaminants).

***TIP:** The train must be in OFF mode in order for a Recovery Clean to be initiated.*

1. 1. In the Modes of Operation screen, select the **Off** button to turn off the train.

2. Select the type of Recovery Clean to be performed. For a sodium hypochlorite clean, select the **R. Clean Chlorine** button. For a citric acid clean, select the **R. Clean Acid** button.

The PLC advances the clean through an initial aeration and tank drain.

3. After the initial tank drain, manually flush the tank with a hose.

After a set period of time, the PLC advances the clean through the remainder of the procedure.

NOTICE

Do not spray water directly on to the membranes.

For more information about the automated steps involved in this sequence, refer to the OSC provided in Volume III - Controls & Drawings Binder.

⚠ WARNING

Allowing certain high-pH and low-pH solutions to mix may create deadly chlorine gas, posing a severe safety hazard to all personnel within the facility. Under no circumstances should these solutions be permitted to come into contact with one another.

For more information on the topics discussed above . . .

- Refer to *8.4 Preparing Cleaning Chemicals* for more on handling and preparing chemicals.
- Refer to *Figure 6.5 - Typical UF Modes Pop-up Screen* for an image of this screen.

8.7.5 NEUTRALIZATION

Following a chemical clean, the solution must be neutralized before it can be sent for disposal. Acid solutions are neutralized through the addition of sodium hydroxide, whereas sodium bisulfite is required for chlorine removal following an alkaline clean. Because dechlorination decreases the pH, the subsequent addition of sodium hydroxide is also required for complete alkaline neutralization.

The neutralization sequence is semi-automatic and requires the operator to be present during the process.

The chemical cleaning solution must be dechlorinated and neutralized as follows:

1. After the soak duration of the Recovery Clean, when prompted at the HMI, select the **Neutralization** button to proceed to neutralization.

2. When prompted by the HMI, check the chlorine concentration in the membrane tank with the handheld instruments.

   - If the chlorine concentration is below 10 mg/L, select the **Confirm Neutral.** button. The PLC advances the neutralization to the next step.

   - If the chlorine concentration is above 10 mg/L, select the **Resume Neutral.** button. The PLC repeats the soak step of the neutralization.

The PLC advances through the remaining Neutralization steps outlined in OSC. For more information about the Semi-automated steps involved in this sequence, refer to the OSC provided in *Volume III - Controls & Drawings Binder*.

8.8 VENTILATION

If the system is located indoors, the membrane tank must be properly ventilated in accordance with all local regulations.

SECTION 9

MONITORING INTEGRITY & PERFORMANCE

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9.1 INTRODUCTION

TIP: *Data must be normalized before it can be properly evaluated.*

This section provides information regarding the various tools and procedures used to gather performance data and to monitor the physical condition of the system.

This information is essential when assessing long-standing performance issues, establishing trends, and determining the durability of various components.

For more information on the topics discussed above . . .

- Refer to *Section 13 - Calculations* for more on normalizing data.

9.2 MEMBRANE PERMEABILITY

Membrane permeability is a calculated operating parameter (flux divided by TMP) and should be measured at the following points:

- Before and after each membrane clean.
- At least once a day before and after a Backpulse.

The effectiveness of each clean can be verified by comparing the membrane permeability measurements taken before and after the clean is performed.

The Membrane Performance screen displays flow and TMP values before, during, and after a Backpulse.

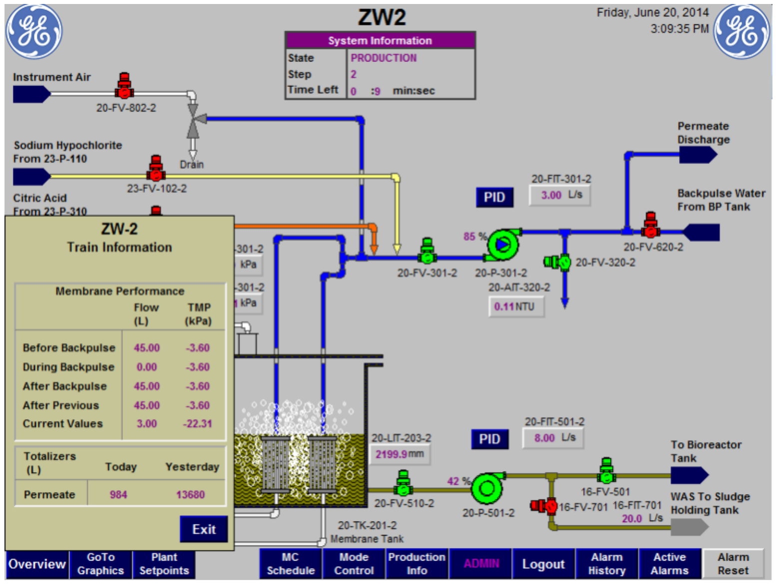

Figure 9.1 - Membrane Performance Screen

Water temperature directly affects water viscosity. Therefore, membrane permeability values must be corrected for temperature fluctuation over time in order to provide a meaningful long-term basis for comparison.

9.3 TURBIDIMETERS

The integrity of the membranes is monitored by observing the turbidity levels of the permeate which they produce.

NOTICE

The sample flowrate is critical to obtaining an accurate measurement with a turbidimeter. To avoid false readings, ensure that the flowrate is within the specified range of the instrument.

For more information about operating and maintaining turbidimeters, refer to *Volume I - Vendor Data Manual.*

9.4 LOGSHEETS

Logsheets, which are provided as electronic copies, are used for manually recording operational data and analytical results.

PERFORMANCE LOGSHEETS: Performance logsheets include those used for recording process data. Electronic copies of these documents will be provided by GE W&PT. Completed performance logsheets should be emailed to GE W&PT on a weekly basis in order to facilitate GE W&PT's ability to provide guidance.

SETPOINT LOGSHEET: The setpoint logsheet is used to record all changes made to setpoints associated with the system or its various components (example: pumps). Because a complete loss of power to the system will cause the PLC to reboot using the original setpoints stored in the E^2PROM, it is essential that this logsheet be updated whenever setpoints are changed so that the most recent values can be reentered.

9.5 INSIGHT

InSight is a powerful remote-monitoring support tool available as an option with most GE W&PT systems. Contact GE W&PT for more information about subscribing to this service.

For more information on the topics discussed above . . .

- Refer to *12.3.1 InSight* for more information about InSight and its features.

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Section 10

Preventive Maintenance

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10.1 INTRODUCTION

The information provided in this section is intended as a general preventive maintenance outline for ZeeWeed membranes and associated components.

10.2 SCHEDULING PREVENTIVE MAINTENANCE

The following table outlines the inspection and maintenance tasks that must be performed regularly in order to maintain optimal performance, and to prevent damage due to wear or corrosion.

For detailed information regarding the inspection and maintenance of specific components (example: pumps, instrumentation), refer to *Volume I - Vendor Data Manual*.

Table 10.1 - Preventive Maintenance Schedule

D	W	M	Q	S	A	Task
X						Complete daily log sheet.
X						Measure pH of wastewater, membrane tank, and permeate samples.
X						Clean any spills or debris and remove any corrosion from piping or instruments.
X						Confirm all components are fitted securely.
X						Check for leaks and excessive condensation.
		X				Check the cassette frame and all associated components for corrosion.
		X				Confirm that aeration is normal by inspecting aeration pattern(s).
		X				Perform ***separate*** acid and base chemical cleans.
		X				Check all couplings for looseness and ensure proper torque values are applied (refer to *Volume I - Vendor Data Manual* for manufacturers' instructions).
			X			Where possible, remove fan covers and clean dust from fans and airways using low-pressure compressed air and/or a dry cloth.
			X			Perform a general inspection on the indicator cassette from each train.
			X			Back up the PLC processor onto the system's EEPROM memory, and copy the PLC ladder logic and operator interface design to an external archive.
				X		Inspect piping for corrosion and repair as needed.
				X		Inspect the inside of the membrane tank for damage. Repair as needed.
					X	Where possible, inspect grounding rods for signs of wear.
					X	Confirm that all cassettes sit level in membrane tank(s).
					X	Check the ground rod. Copper-clad ground rods last longer than galvanized rods. Also, check the clamp or weld connections for corrosion.
					X	Inspect all actuators and replace or repair as needed (refer to *Volume I - Vendor Data Manual* for manufacturers' instructions).
						Every 2 - 4 years, replace the PLC battery.
						Every 5 years, replace the UPS.

NOTE:

- D (daily); W (weekly); M (monthly); Q (quarterly); S (semi-annually); A (annually).

For more information on the topics discussed above . . .

- Refer to *Section 8 - Cleaning* for details regarding how often chemical cleans should be performed.

10.3 GENERAL INSPECTION

The following section outlines the General Inspection procedure used to determine the overall state of the system and its various components.

10.3.1 GATHERING & RECORDING INFORMATION

TIP: Contact GE W&PT regarding templates that can be used to organize information collected during inspection.

Record the following information for each cassette inspected:

- Site name.
- Inspector's name.
- Inspection date.
- Train number.
- Cassette position.
- Cassette serial number.

In addition to collecting the information listed above, take photos at each step of the inspection and file them with the recorded findings.

After completing the inspection, submit all findings, photos, and any updated documents to GE W&PT.

10.3.2 INSPECTION FREQUENCY

Inspections should be carried out every 3 months on a single cassette from each train, using the same cassette during each inspection. This cassette, known as the "indicator cassette," acts as a sample for the entire train, eliminating the need to inspect each individual cassette.

TIP: After the first year of operation, inspection frequency can be adjusted based on past findings and recorded trends in system operation.

For systems with operating temperatures greater than 30°C (86°F), or where there is a high possibility that suspended solids might accumulate within the membrane tanks, it is recommended that the inspection procedure be carried out on a monthly basis, rather than every 3 months.

Contact GE W&PT for assistance with determining the optimum inspection frequency for this system.

10.3.3 BEFORE REMOVING THE CASSETTE

The following information should be recorded before the indicator cassette is removed from the membrane tank.

10.3.3.1 CHECKING AERATION PATTERN

Before the cassette is removed from the membrane tank for inspection, perform a visual examination of the aeration pattern with the water level within the membrane tank 7.62 - 10.16 cm (3 - 4 in.) above the top of the cassette. While the cassette is being aerated, a rectangular bubble pattern should be visible on the surface of the water directly above it. Note any inconsistencies, including insufficient or imbalanced air distribution.

10.3.3.2 CHECKING LINES & CONNECTORS

Examine the following components for signs of damage or wear:

PIPING: Confirm that all piping sections connected to the cassette are in good condition. Note any cracks or discoloration and check that all connections are tight.

CONNECTORS & HOSES: Confirm that all connectors and hoses are securely attached and show no signs of wear or damage.

⚠ WARNING

Failure to tighten a coupling according to the manufacturer's required torque values may result in an explosive rupture or violent release. Following installation, all couplings must be inspected for tightness as part of the regular preventive maintenance process.

10.3.4 REMOVING THE CASSETTE

When removing a cassette with accumulated solids, verify the rated capacity of lifting modules, cranes, and the cassette lifting frame before attempting a lift. As the cassette is removed from the tank, use a weight scale to ensure that components under load are within their design capacity. Ensure that the cassette remains level throughout the lift and inspect the aeration assembly for solids accumulation.

For more information on the topics discussed above . . .

- Refer to *7.3 Lifting & Moving Cassettes* for more on this procedure.

10.3.5 AFTER REMOVING THE CASSETTE

The following information should be recorded after the indicator cassette has been removed from the membrane tank.

SHELLS: Closely examine the cassette and membranes for signs of aquatic life, particularly in the form of shells, which can be as small as 1 mm in length.

Figure 10.1 - Shells

CASSETTE FRAME & HARDWARE: Check the cassette frame welds for signs of leaking or corrosion. Check all connections for loose or missing fasteners.

SOLIDS ACCUMULATION PATTERNS: Take full-length photographs of all four sides of the cassette. Note any solids accumulation on the Inspection Template. Contact GE W&PT if excessive solids accumulation or debris (example: twigs, leaves) is found.

Figure 10.2 - Acceptable (Left) & Unacceptable (Right) Solids Accumulation

MEMBRANE FIBER SLACK: Check the amount of slack exhibited by membrane fibers in the indicator cassette.

For more information on the topics discussed above . . .

- Refer to *7.5 Fiber Slack & Shrinkage* for more on fiber slack.
- Refer to *5.8.15 Leveling Cassettes* for more on leveling pins.

10.4 INSPECTING MODULE INTERCONNECTING STRIPS

The Module Interconnecting Strip (MIS) holds groups of membrane modules together in the cassette. MISs require monthly inspection to ensure proper operation.

To complete this inspection, perform the following steps:

1. Visually inspect all of the MISs and verify that they are firmly attached.

Figure 10.3 - MIS Location

2. Verify that all locking keys are tightly locked in the vertical position.

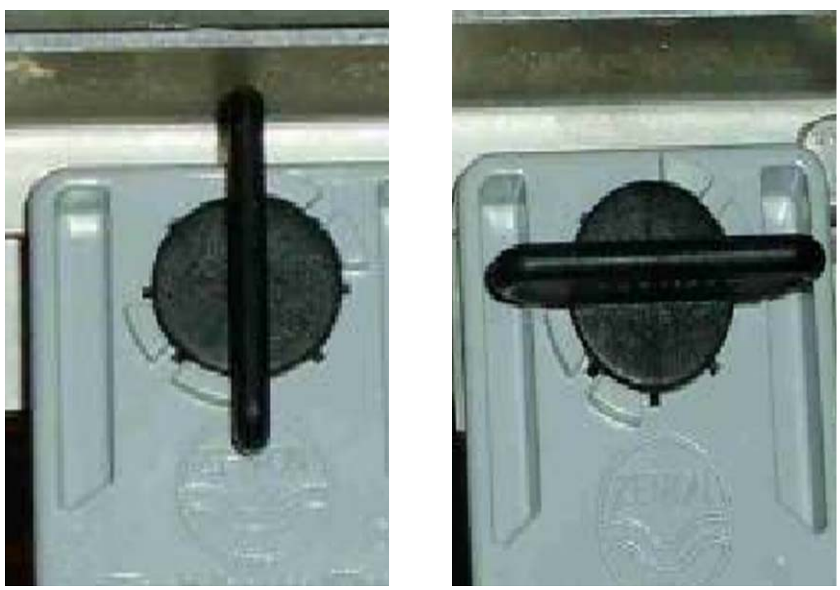

Figure 10.4 - Locking Key Locked (Left) & Unlocked (Right)

3. Inspect the MIS locking pins. The locking pins should be in the vertical (locked) position.

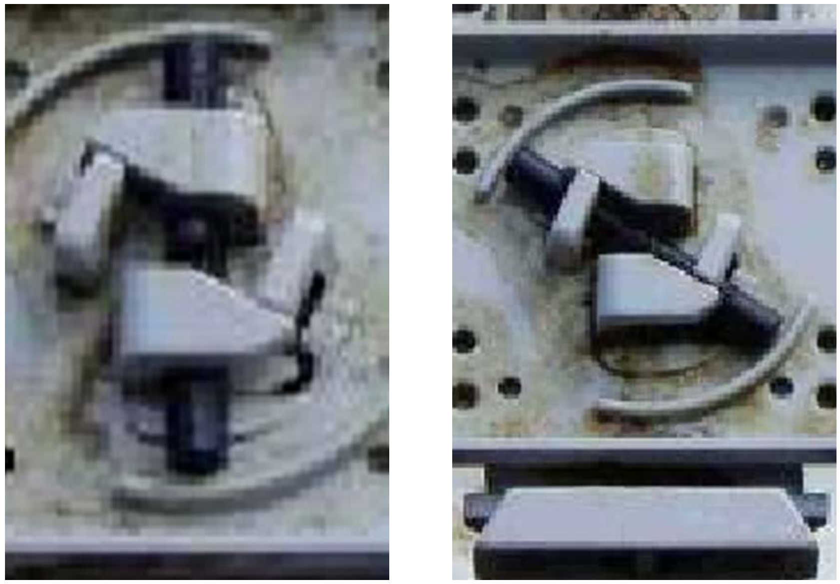

Figure 10.5 - Locking Pin Locked (Left) & Unlocked (Right)

4. Check for wear on the MIS. Each locking pin should lock into position tightly and securely. If the locking pins move freely, the MIS is worn.

5. Check for independent movement between the module and the locking key mechanism.

6. Look for wear on the locking key mechanism.

10.5 Special Requirements for Lifting Module Owners

TIP: These requirements apply only to customers who have purchased one or more lifting modules.

Customers who have purchased a lifting module are subject to the owner's responsibilities outlined under ASME code B30.20-2010. Key duties defined by this code include, but are not limited to, the following:

- Regular inspection of a module which has been altered or repaired.

- Load-testing for modules which have been altered or repaired.
- Creation of a maintenance program.
- Regular recorded service inspections in accordance with frequency of use.
- Creation of training programs for new operators required to work with or around lifting modules.
- Ensuring that modules are operated safely.
- Ensuring that modules are kept in compliance with ASME code B30.20-2010.

TIP: Refer to the relevant ASME regulations for details regarding minimum inspection requirements.

For a full outline of owner's responsibilities, refer to ASME code B30.20-2010.

TIP: The codes listed below have been provided here as an additional reference only. Some are specific to certain regions or industries and may not be applicable to this system.

Additionally, the following table lists other codes and conventions which provide further instruction for owners.

Table 10.2 - Additional Codes for Owners of Lifting Modules

Organization or Governing Body	Code
American Society of Mechanical Engineers (ASME)	(B30.20) Below the Hook Lifting Devices (BTH-1) Design of Below the Hook Lifting Devices
Occupational Safety & Health Administration (OSHA)	(1926.251) Rigging Equipment for Material Handling
Occupational Health & Safety Act/ Regulations (OHSA)	(British Columbia) Reg. 296/97 Part 15 - Rigging (Ontario) O. Reg. 213/91 sec. 111 and Reg. 851, sec. 51
American Welding Society (AWS)	(AWS D14.1) Specification for Welding Industrial and Mill Cranes and Other Material Handling Equipment
Canadian Standards Association (CSA)	(CSA W47.1) Certification of Companies for Fusion Welding of Steel (CSA W59) Welded Steel Construction (Metal Arc Welding)
American National Standards Institute (ANSI)	(Z535.4) Product Safety Signs and Labels

10.6 Preventing Stainless Steel Corrosion

A water treatment system may include various stainless steel components, such as piping and associated fittings and connectors. System operators must follow the preventive maintenance steps provided below in order to prevent corrosion from forming on stainless steel piping and components.

10.6.1 Causes of Corrosion

Surface contamination and chlorine attack are the primary causes of stainless steel corrosion. Both issues can lead to serious degradation if they are not resolved quickly.

Surface Contamination: If stainless steel components are installed with carbon steel tools, or if they are not protected from nearby welding or grinding work, carbon steel particles may embed in stainless steel surfaces. Exposure to water which contains rust particles or to iron-laden dust and dirt can also cause surface corrosion.

Chlorine Attack: Chlorine-induced corrosion can occur when chlorinated water splashes on stainless steel surfaces, or when chlorine vapors condense on these surfaces due to inadequate ventilation or high humidity.

10.6.2 Protecting Against Corrosion

Take the following precautions to reduce instances of stainless steel corrosion:

Clean Regularly: Stainless steel piping and components should be kept clean and dry. Keep potential contaminants (example: solvents, carbon steel tools), away from stainless steel components.

MINIMIZE CONTACT: Protect stainless steel surfaces from contact with chlorinated water, and remove contamination as soon as it is observed. Avoid performing tasks such as welding or grinding near stainless steel components. If this sort of work must be done near a stainless steel surface, ensure that it is properly protected.

HANDLING AND INSTALLING COMPONENTS: Properly weld and passivate new or repaired piping. Avoid the use of different metal fasteners and joining components. Ensure that the interior and exterior surfaces of new components are thoroughly cleaned before installation.

If excessive condensation appears on piping surfaces, adjust the ventilation system or add dehumidification measures.

10.6.3 DETECTING, CLEANING & REPAIRING CORROSION

The following sections include recommendations on detecting, cleaning, and repairing corroded or contaminated components.

10.6.3.1 DETECTING EMBEDDED IRON

The simplest test for free, embedded iron is to wash down the stainless steel part with clean water, allow it to dry (or drain), and wait 24 hours. If there are rust streaks on the surface of the stainless steel, iron is present.

The ferroxyl test is a more sensitive indicator of embedded iron. To perform this test, apply a ferroxyl solution with a spray bottle, and then check for a blue stain within 15 seconds of the application. A blue stain will indicate iron contamination.

Table 10.3 - Ferroxyl Test Solution Ingredients

Ingredient	Amount
Distilled Water	1,000 mL
Nitric Acid, 60-67%	20 mL
Potassium Ferricyanide	30 g

CAUTION

When handling this test solution, wear rubber gloves, protective clothing, and a face shield. Avoid inhaling the atomized spray.

Prepare the solution specified in the table above by first adding the nitric acid to the distilled water, mixing well, and then adding the potassium ferricyanide.

10.6.3.2 Cleaning & Repairing Surface Corrosion

NOTICE

Do not allow cleaning compounds to fall into tanks or other vessels.

Any corrosion found on a stainless steel surface can be removed by scrubbing with the appropriate wire brush. After the oxidized areas have been brushed clean, apply a pickling paste to the affected area to chemically clean the surface and remove any embedded contaminants.

Table 10.4 - Effective Cleaning Methods

Task	Cleaning Agents	Comments
Routine cleaning	Warm water, soap, ammonia, and detergent	Apply with a sponge or soft cloth.
Smears and fingerprints	3M Stainless Steel Cleaner and Polish, Arcal 20, Lac-O-Nu, Lumin Wash, Stainless Shine	Provides a barrier film to minimize fingerprints.
Stubborn stains and discoloration	3M Stainless Steel Cleaner and Polish, Twinkle, Liquid Nu Steel, Household Cleaners	Using a dry or damp cloth, rub lightly in the direction of the polish lines of the stainless steel.
Grease and oil	Any good commercial detergent or caustic cleaner.	Apply with a sponge or soft cloth in the direction of the polish lines of the stainless steel.

There are various protective coatings that can be used as an added precaution to help prevent stainless steel contamination and corrosion. Clear lacquers are preferred over the colored lacquers and paints, as they allow the operator to check the condition of the stainless steel surface below the coating.

SECTION 11

TROUBLESHOOTING

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11.1 INTRODUCTION

This section provides information regarding some of the most common issues and frequently asked questions related to this system and its associated components.

Several training courses related to troubleshooting techniques and skills are available upon request. For more information, contact GE W&PT.

CAUTION

To avoid injury or property damage while performing the troubleshooting procedures outlined in this section, adhere to the following points.

- When working with a pressurized system, ensure that all associated components and piping have been fully depressurized before beginning work. In the case of valves connected to compressed air lines, the line must be fully disconnected from the valve before work may begin. Simply actuating the valve will not sufficiently depressurize the line.
- All routine troubleshooting must be carried out according to the safety regulations and instructions specified by the supplier of the component. Read all relevant safety information provided in *Volume I - Vendor Data Manual* before attempting repairs.
- Wear suitable protective equipment when working with pumps, piping, or other components that may have contained caustic or acidic chemicals.

11.2 TROUBLESHOOTING QUICK-REFERENCE

The following table provides solutions for common issues related to system components and is intended only as a brief summary. Refer to the sections below and to *Volume I - Vendor Data Manual* for more detailed troubleshooting information regarding specific components.

In the event of a contradiction between information provided in this section and that supplied by the manufacturer, the manufacturer's information will always take precedence.

If problems discussed in this section persist or other difficulties arise, contact GE W&PT. Completed operating logsheets will be necessary in order for GE W&PT representatives to determine the cause of the issue.

Troubleshooting procedures involving mechanical or electrical components should be performed only by qualified personnel. All operators must familiarize themselves with the applicable safety information before performing any of the procedures outlined here.

Table 11.1 - Troubleshooting Quick-Reference Sheet

Problem	Cause	Corrective Action
Low flow shutdown	Flow valve or solenoid valve downstream of pump discharge is closed	Check valves for correct operation
	Hand valves on pump discharge are throttled or closed	Verify correct position of hand valve, as per P&IDs
High TMP shutdown (low pressure)	Hand valve upstream of pump inlet is throttled or closed	Verify correct position of hand valve, as per P&IDs
	System recovery has drifted to higher than designed limit	Compare current with design system recovery
	Membranes require cleaning	Perform Recovery Clean
	PID tuning overshooting the flow or pressure control setpoints after backpulse	Contact GE W&PT
	Permeate header pressure transmitter or any of the membrane tank level float switches malfunctioning	Check instrument calibration; check readings on HMI
High-pressure shutdown (backpulse)	Hand valve upstream of pump inlet is throttled or closed	Verify the correct position of hand valves, as per P&IDs
	System recovery has drifted to higher than designed limit	Compare current with design system recovery
	Timers for pressure shutdowns too quick	Contact GE W&PT
Level problems (analog)	Failed 24 V DC power supply	Verify power supply outlet
	Problems with moisture in probe	Check probe seals
Level problems (digital)	Switch compromised by chemicals	Inspect switch
	Blown fuse	Inspect fuses, replace as needed
	Switch programmed incorrectly	Verify switch input to PLC compared to program
Leaking or cut fiber	Damaged fiber	Repair fiber

For more information on the topics discussed above . . .

- Refer to 8.7.4 *Recovery Clean* for more on performing a Recovery Clean.
- Refer to 7.6 *Repairing Fibers* for more on performing fiber repairs.

11.3 Permeate Quality

Several issues may result in reduced permeate quality, though the most common are damaged membranes and a leak in the cassette seal. The following information can be used to address both of these problems.

11.3.1 Membrane Damage

To determine if membrane fibers have been damaged, examine the permeate from each membrane cassette. If the permeate does not meet acceptable standards, it is likely that a module within that cassette contains one or more damaged fibers. After identifying the cassette, locate the damaged module by either visual fiber inspection or by conducting a Bubble Test. Inspect and repair or replace any damaged modules to bring the overall system performance up to appropriate levels.

For more information on the topics discussed above . . .

- Refer to *5.9.1 Bubble Test* for more on performing a Bubble Test.
- Refer to *7.6 Repairing Fibers* for more on inspecting and repairing fibers.

11.3.2 Cassette Seal Leakage

A leak in a cassette seal may be the result of either improper installation or gradual loosening during operation. Check these connections periodically to ensure that they are properly installed and to avoid permeate contamination by wastewater.

11.4 PROCESS PUMPS

Certain types of pumps will lose their prime if excessive amounts of air enter the flow. Water in contact with air at atmospheric pressure naturally contains dissolved gases. After the water crosses the membrane boundary, the lower pressure encountered within the membranes reduces the solubility of these gases, creating bubbles in the permeate flow.

This system includes an air-extraction assembly designed to remove entrained air from the permeate flow before it encounters the process pump. However, if a leak has developed, or if TMP levels are too high, this may not always prevent air from disrupting the pump's operation.

PROBLEM: The process pump will not achieve prime due to air inside permeate header or pump intake line.

Possible causes include the following:

- Air leaks along piping.
- Cracks or missing seals along permeate piping.
- Failed check valves.
- Valves which may allow air to enter the permeate header (example: permeate sample valves) are not closed properly.
- Excessive TMP.

Recommended solutions include the following:

- Close all valves which may allow air to enter the permeate header.
- If a leak is suspected, use a spray bottle to coat fittings and piping along the permeate header with a soap solution and watch for soap bubbles formed during a Backpulse sequence (when the header is positively pressurized). After locating the leak(s), repair or replace damaged connectors, fittings, or piping as needed.

- Ensure that the backpulse tank volume is well above the discharge point on the tank.
- Determine if the air release valve rubber seat has become stuck. If so, it will prevent air from being vented from the permeate header.
- The higher the TMP, the greater the likelihood of air being pulled across the membranes. If high TMP is suspected of causing excessive entrained air within the permeate header, initiate a chemical clean to restore TMP to an optimal level.
- Request a program change to ensure that flow valves remain open in STANDBY.

11.5 Aeration Components

Proper aeration is essential for normal operation. To avoid aeration problems, ensure that air filters are replaced in accordance with manufacturer instructions provided in *Volume I - Vendor Data manual*, and regularly inspect all air connections and piping for damage. Immediately repair any damaged or worn aeration components found during inspection.

11.6 Chemical Metering Pumps

⚠ WARNING

Use extreme caution when working with or around chemical pumps and associated piping, as significant pressure can build within a blocked discharge line. Proper protective equipment must be worn at all times (goggles, gloves, and a suitable splash apron at minimum).

Problem: The chemical metering pump has lost pressure.

Possible causes include the following:

- Associated valves are malfunctioning.
- Pump is malfunctioning.

Recommended solutions include the following:

- After ensuring that the pump is deactivated and that all associated lines are depressurized, remove the foot valve from the pump inlet and ensure that no blockage has formed around it or the inlet. After reinstalling the foot valve, perform the same check on all ball valves associated with the chemical skid.
- After inspecting the valves, if the pump still does not operate properly, consult the associated manufacturer's instructions provided in *Volume I - Vendor Data Manual*.
- If the manufacturer's instructions do not provide a solution, contact GE W&PT for further assistance.

11.7 General Component Failure

If a component has failed and cannot be repaired by performing maintenance and troubleshooting procedures as outlined in *Volume I - Vendor Data Manual*, ensure that the component has been locked out (if applicable), and then record the make, model, part number, and tag number.

After isolating and documenting the component, check the RSPL for parts availability and contact GE W&PT to order a replacement.

For more information on the topics discussed above . . .

- Refer to *Section 14 - Recommended Spare Parts List* for the RSPL.

11.8 BIOREACTOR FOAM

Increased foaming conditions in the bioreactor may be caused by a foaming agent in wastewater or a limit on one of the required components for biological oxidation. Limiting feed COD, insufficient DO or limiting nutrients may decrease organism activity. Each of these conditions should be evaluated if foaming becomes an issue.

If foaming becomes excessive, ensure that the foam control sprayer is operating properly to prevent foam from spilling out of the bioreactor. If extreme foaming is occurring and the sprayer cannot control it, contact GE W&PT for assistance.

Foam escaping from the bioreactor may release biomass, reducing the bioreactor's TS and VS levels. Depending on the extent of the foam spill, this may reduce the system's ability to treat wastewater.

Following a foam spill, the bioreactor TS and permeate COD should be measured to determine the extent of the biomass loss and the impact on permeate quality. If the effluent quality is unacceptable and the bioreactor TS concentration has decreased significantly, the feed rate should be reduced, if possible, to maintain normal operating parameters.

Strategies for minimizing bioreactor foam generation include the following:

CONTROLLING BIOREACTOR TEMPERATURE: Maintaining an optimum temperature within the bioreactor is an effective way of controlling foam production. The bioreactor is designed with an ideal operating range of 20 - 35°C (68 - 95°F). Allowing temperatures to exceed 35°C (95°F) may contribute to foaming and should be avoided.

REMOVING SLUDGE FROM TOP OF BIOREACTOR: Foam-generating substances created during production may concentrate near the surface of the bioreactor. If this occurs, sludge wasting from the top of the bioreactor using a vacuum to collect material will assist in reducing the effect these substances have on foam buildup. Ensure that collected waste is stored and disposed of properly.

REDUCING SLUDGE AGE: Foam is more likely to develop as sludge ages. If the TSS level is used as a measure of sludge age, the MLVSS concentration must also be checked regularly (monthly at minimum). TSS indicates the level of both organic and inorganic solids, whereas MLVSS measures only organic solids. Therefore, the MLVSS level is the true measurement for sludge age. A reduced MLVSS level indicates a higher likelihood that foam will develop.

PROBLEM: Foam.

Possible causes include the following:

- Anaerobic bacteria are reacting to aeration or presence of filamentous bacteria.
- Aerobic bacteria are stressed or dying.
- Detergents are present.
- Grease or floating material is present.

Recommended solutions include the following:

NOTICE

Never reduce the ZeeWeed membrane aeration level.

- Reduce bioreactor aeration. After stable operation is achieved at a lower aeration, slowly return the aeration to normal levels.
- Attempt to knock down the foam.
- Address any obvious process problems.

The preferred method of foam control in MBR systems is through the use of design features that provide continuous or periodic foam removal, typically as part of the waste sludge system. In some cases, these design features are not included in the plant design, or are insufficient. In these situations, foam is controlled through the use of a chemical antifoam product. The wastewater flow is dosed with antifoam by antifoam pump (15-P-201).

Antifoam products must meet the following criteria:

- Effective for the specific type of foam that has developed.
- Compatible with system components downstream (example: ZeeWeed modules).
- Must not foul the ZeeWeed membranes.

The following antifoam products are approved for use with ZeeWeed MBR systems:

NOTICE

Consult GE W&PT before using antifoam products not included in the following list.

- GE FoamTrol AF2050 (maintain mixed liquor pH of less than 8).
- GE FoamTrol AF3031.
- GE FoamTrol AF3552.
- GE FoamTrol AF3560 (maintain mixed liquor pH of less than 8).
- GE FoamTrol AF3562 (maintain mixed liquor pH of less than 8).
- GE FoamTrol AF4039.
- GE FoodPro FAF9806.
- GE FoodPro FAF9807.

11.9 BIOREACTOR PERFORMANCE

Bioreactor Dissolved Oxygen (DO) and Oxygen Uptake Rate (OUR) can be used as indicators when determining the cause of a change in bioreactor performance. Factors contributing to changes in bioreactor performance are outlined in the following sections.

11.9.1 Increased Dissolved Oxygen & Decreased Oxygen Uptake Rate

The most likely cause of an increase in bioreactor DO and a decrease in OUR is a sudden decrease in the Chemical Oxygen Demand (COD) loading.

- Check the F:M ratio to confirm that it is within typical limits.
- Check the bioreactor pH and temperature. If the pH is not within 7.0 - 8.5, the pH should be adjusted by adding an approved acidic or caustic chemical as needed.
- Verify the pH controller and sensor.
- Check the temperature of the bioreactor. Low temperatures outside the ideal operating range will slow biological activity and increase the DO level.
- To verify the system is receiving sufficient nutrients, check the UF permeate for residual ammonia (TKN) and phosphorus. If there is less than 2 mg/L of either substance, increase nutrient dosage.

If OUR remains low, check wastewater composition. Some substances (example: sodium hypochlorite) will inhibit or destroy the biological population. If such substances are found within wastewater, additional pretreatment measures may be required to remove them before wastewater enters the bioreactor. Contact GE W&PT for more information.

11.9.2 Decreased Dissolved Oxygen & Increased Oxygen Uptake Rate

A decrease in DO and increase in OUR could be caused by an increase in F:M ratio, microbial activity, and oxygen demand.

- Increase the aeration rate to maintain the average DO and meet the higher oxygen demand.

- Determine the F:M ratio. If poor permeate quality persists and the F:M ratio has increased, decrease the F:M ratio by reducing the wastewater flowrate, if possible, or allow the bioreactor Volatile Suspended Solids (VSS) or Volatile Solids (VS) concentration to increase.

11.9.3 Bioreactor pH

An unsuitable bioreactor pH (outside the range of 7.0 - 8.5) could reduce permeate quality. If the pH is outside of this range and/or the effluent COD is significantly increased, the pH sensor should be checked and recalibrated. If the pH controller is malfunctioning and the source of the problem cannot be rectified, the bioreactor pH can be adjusted manually by slowly adding an approved acid or base to the bioreactor until the desired pH is achieved.

11.9.4 Bioreactor Temperature

An extreme temperature change (example: increase or decrease of 6.7°C (20°F) could reduce permeate quality. If the temperature is outside of the normal range 29.4 - 40.5°C (85 - 105°F) and/or the permeate COD has increased significantly, corrective action must be taken. Contact GE W&PT for more information.

11.9.5 Bioreactor Dissolved Oxygen

The bioreactor DO should always remain under 1.0 mg/L. However, if the DO level is less than 0.5 mg/L and the effluent quality is acceptable, the aeration rate should be increased to maintain a DO level of between 0.5 - 1.0 mg/L to inhibit the growth of anaerobic bacteria. If the DO has increased or decreased significantly and permeate quality has become unacceptable, corrective action must be taken to return the DO level to this range.

11.9.6 Bioreactor TSS

The maximum bioreactor TSS concentration is application-specific. If the bioreactor TSS concentration is above 12,000 mg/L and problems associated with high TSS levels are occurring, reduce the TSS levels to 8,000 mg/L by removing bioreactor contents.

If the bioreactor TSS has decreased significantly and no clear cause can be identified, other sources of biomass loss should be investigated (example: process pump seal or piping leak).

11.9.7 Bioreactor Nutrients

Soluble nutrients, particularly nitrogen and phosphorus, are required for biological growth. To ensure that sufficient nutrients are available, examine permeate for ammonia, TKN, and soluble phosphorus. If permeate contains more than 1 mg/L of each of these substances, sufficient nutrients are available for biological growth. If not, nutrient addition rates should be increased.

If permeate contains these substances in greater quantities than 10 mg/L, nutrient addition rates should be reduced. This is particularly important if there are criteria regarding the amounts in which these substances can be present in permeate.

11.9.8 Bioreactor Recovery Following an Upset Condition

An upset condition is defined as any phenomenon which inhibits, destroys, or removes the biological population such that it can no longer function properly and achieve the COD or BOD discharge criteria. Many of the upset conditions are outlined above and include extreme pH or temperature shifts, the presence of microbial inhibitory or toxic compounds, or the loss of significant quantities of biomass through foam spills or other means.

If an improper operating condition is present (example: extreme pH or temperature), the condition must be corrected. After the situation has been rectified, the biological population will generally return to normal operation in a short period of time. Recovery time will depend on the severity of the upset condition, and can vary from hours to days.

During the upset condition, the effluent COD and BOD may increase. In the recovery period, the wastewater flowrate could be reduced, if feasible, to assist in maintaining acceptable COD and BOD levels.

In cases where the upset has resulted in the destruction or loss of biomass, longer recovery period will be required to allow the microbial population to multiply and return to normal levels. If feasible, the feed rate could be reduced in the recovery period to maintain the normal F:M ratio.

11.10 Backpulse Tank Alarm

Problem: Backpulse tank level low alarm. Plant alarm does not respond to system reset or full restart.

Possible cause is:

- Backpulse tank liquid level is at or below the low low setpoint.

To resolve this issue, perform the following steps:

1. At the onscreen interface, record the current value for each backpulse tank level setpoint (example: LAH, LAL).
2. Record the current level within the backpulse tank and compare with the setpoints shown on the onscreen interface.
3. If the current backpulse tank level is at or below the LAL setpoint, at the onscreen interface, lower the LAL setpoint to a value below the actual tank level. If this is not possible, bring the tank level above the LAL setpoint by filling it with permeate or water of comparable quality from an external source.

4. Reset the alarm.
5. Activate the system.

PROBLEM: The backpulse tank level low low alarm has triggered. The pump is set in STOP mode.

Possible cause is:

- Backpulse tank level is at or below the low low setpoint.

To resolve this issue, perform the following steps:

1. Check the level in the backpulse tank. If the level is not low, then the transmitter is not functioning correctly. Refer to *Volume I - Vendor Data Manual* for troubleshooting procedures.

TIP: For detailed information regarding a particular valve's location or natural state, refer to Volume III - Controls & Drawings. For operation and maintenance information, refer to Volume I - Vendor Data Manual.

2. Ensure that all valves associated with the backpulse tank are functioning correctly by confirming the following points for each valve:
   - The valve actuates correctly when triggered.
   - The valve returns to its natural state when the system is deactivated.
   - The valve shows no obvious signs of damage or wear.
3. When the level of the backpulse tank returns to the operating level, switch the pump back to AUTO.

For more information on the topics discussed above . . .

- Refer to *6.6 Resuming Operation Following an Alarm Shutdown* for more on resetting alarms.
- Refer to *6.3 Starting Up the System* for more on activating the system.

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Section 12

Service & Support

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12.1 INTRODUCTION

This section provides information regarding the various support services offered by GE W&PT. All service bulletins associated with this system are to be inserted at the end of this section.

12.2 CONTACTING GE W&PT

Upon subscribing to GE W&PT's 24/7 technical support service and activating your customer account, a four-digit security code will be issued. Provide this code when contacting the Service Department, which can be reached by phone or email:

PHONE (TOLL-FREE WITHIN NORTH AMERICA): 1-866-271-5425.

PHONE (WORLDWIDE): 1-905-469-7723.

EMAIL: gewater.technicalsupport@ge.com.

Contact the regional lifecycle manager for additional information about the 24/7 technical support service and other services provided by GE W&PT.

When calling to request technical assistance, have the following information ready:

- System model and serial number.
- The date on which the system was installed.
- A detailed description of the issue.
- Recently completed Daily Logsheets and a list of current performance parameters (example: flowrates, pressure readings, pH levels).
- The date on which a chemical clean was last performed (if applicable).

For inventory enquiries and purchases, contact GE W&PT's Inside Sales Department, which can be reached by either phone or email:

PHONE: 1-866-439-8272.

EMAIL: gewater.parts@ge.com

12.3 AVAILABLE SERVICES

GE W&PT delivers a comprehensive range of services beyond system design and installation. Contact the Service Department to enquire about the following services:

- InSight remote-monitoring support and data analysis.
- Site visits and component audits.
- Training programs.
- 24/7 technical support.
- Emergency call-out support.
- OEM components and consumable products inventory.
- Operation & Maintenance agreements.
- Plant commissioning, optimization, and upgrades.
- System controls support.
- Component calibration and preventive maintenance planning.

12.3.1 InSight

InSight is a powerful plant support tool available to those system owners who choose to subscribe. It provides fully automated process data monitoring and trend analysis, and stores information in a centralized database. This information is then presented to the client in regular reports and is also readily available to GE W&PT support personnel.

With InSight, operators can assess trends, solve process problems quickly, improve plant productivity, reduce the impact of operator turnover, and manage continuous software enhancements.

For additional information regarding InSight, or to subscribe to this service, contact GE W&PT.

12.3.2 Site Visits

GE W&PT service professionals are on-hand for both emergency service calls (call-outs) and planned service visits. Areas of plant operation that they can assist with include instrument calibration, preventive maintenance planning, process monitoring, and DCS code modifications. Contact the Service Department and ask them to develop a service plan tailored to this system.

Emergency call-outs are invoiced based on the Field Services Labor Rate Sheet, which can be obtained by contacting GE W&PT.

12.3.3 Training

Training for all operators is provided at the time of plant commissioning. Customized training packages are available. Contact GE W&PT for more information.

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SECTION 13

CALCULATIONS

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13.1 INTRODUCTION

This section provides calculations used in various aspects of system operation and maintenance, such as evaluating performance data and determining chemical requirements.

Additional information may be provided by GE W&PT personnel during the initial startup and commissioning stages.

13.2 UNIT CONVERSION

TIP: *Multiply a value in US gpm by 3.785 to get the equivalent in lpm. Multiply a value in lb/ft^3 by 0.016 to get the equivalent in kg/L.*

Convert all values to metric equivalents before performing the calculations provided in this section.

To find the corresponding value in kg/L for a known solution density, look up the density in the following table.

Concentrations are given as weight percentages. To create a solution using a dry chemical, use [x]/(1-[x]) kg of chemical for every liter of water, where [x] is the solution concentration written as a decimal.

EXAMPLE: To make a 35% calcium chloride solution, 0.35/(1-0.35) = 0.538 kg of calcium chloride for every liter of water used to make the solution.

Table 13.1 - Solution Concentrations and Densities

Chemical	Solution Concentration (Weight%)	Solution Density (kg/L)
Aluminum sulfate	48.50	1.335
Ammonium chloride	10.00	1.080
Calcium chloride (35% soln.)	35.00	1.250
Calcium chloride (15% soln.)	15.00	1.150
Calcium hydroxide	5.00	1.050
Ferric chloride	35.00	1.360
MC-1	50.00	1.240
Phosphoric acid (75% soln.)	75.00	1.582
Phosphoric acid (85% soln.)	85.00	1.694
Polyaluminum chloride	33.00	1.205
Potash	25.00	1.150
Potassium permanganate	3.00	1.030
Powdered activated carbon slurry	5.00	1.025
Sodium aluminate (10% soln.)	10.00	1.090
Sodium aluminate (32% soln.)	32.00	1.300
Sodium bicarbonate	3.50	1.035
Sodium bisulfite	40.00	1.370
Sodium carbonate	10.00	1.110
Sodium hydroxide (25% soln.)	25.00	1.260
Sodium hydroxide (50% soln.)	50.00	1.520
Sodium hypochlorite (12% soln.)	12.00	1.168
Sodium hypochlorite (6% soln.)	6.00	1.076
Sulfuric acid (77.67% soln.)	77.67	1.704
Sulfuric acid (93.19% soln.)	93.19	1.834
Sulfuric acid (98% soln.)	98.00	1.836
Urea	23.00	1.000
ZenoTreat 150 (antiscalant)	100.00	1.150
ZenoTreat 450 (antiscalant)	100.00	1.080

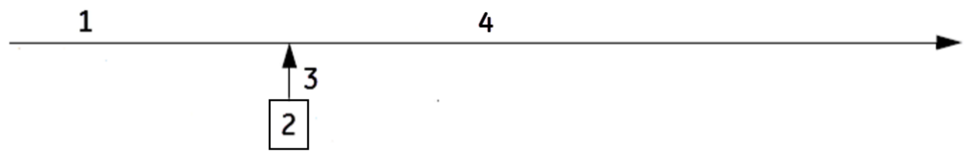
NOTES:

- Before mixing solution, consult the applicable MSDS for chemical purity.

13.3 GENERAL DOSING CALCULATION

To determine the amount of chemical(s) required when dosing the subsystem, use the following calculation:

Calculate the flow rate of 35% ferric chloride solution to dose to 60 ppm in a 100 lpm stream.



1. Wastewater flowrate (Q_f)
2. Chemical stock solution concentration (C_c) and density (ρ_c)
3. Chemical flowrate (Q_c)
4. Chemical concentration in wastewater (C_f)

Figure 13.1 - Dosing Calculation Diagram

Wastewater flow rate	Q_f = 100 lpm
Chemical concentration in wastewater stream	C_f = 60 ppm (60 mg/L)
Stock solution concentration	C_c = 35% by weight
Stock solution density	ρ_c = 1.36 kg/L

The mass flow rate of ferric chloride in the wastewater stream equals the mass flow rate of ferric chloride dosed.

In the equations below, Q_f and Q_c are in lpm, C_f is in mg/L, ρ_c is in kg/L, and C_c is weight percent written as a decimal (example: 35% as 0.35).

$$Q_c = \frac{Q_f \times C_f}{\rho_c \times C_c \times 10^6}$$

Example:

$$\frac{100 \times 60}{1.36 \times 0.35 \times 10^6} = 0.0126 \text{ lpm}$$

$$100\,\frac{\text{L feed}}{\text{minute}} \times 60\,\frac{\text{mg FeCl}_3}{\text{L feed}} = Q_c\,\frac{\text{L FeCl}_3\text{ soln.}}{\text{minute}} \times \frac{1.36\text{ kg soln.}}{\text{L soln.}} \times \frac{35\text{ kg FeCl}_3}{100\text{ kg soln.}} \times \frac{10^6\text{ mg}}{\text{kg}}$$

If the required nutrient concentration (nitrogen or phosphorus) in the wastewater stream (C_f) is given in mg/L (or ppm), then an extra calculation step must be included.

Calculate the chemical flowrate according to the general example above, and then divide this flowrate by the mass percent nitrogen or phosphorus in the chemical being used (refer to *Table 13.2 - Mass Percent Nitrogen or Phosphorus in Chemical*.

Table 13.2 - Mass Percent Nitrogen or Phosphorus in Chemical

Chemical	Mass Percent Nitrogen or Phosphorus in Pure Chemical
Ammonium chloride	26.1%
Urea	46.6%
Phosphoric acid	31.6%

13.4 Calculating Membrane Permeability

To gauge the effectiveness of a cleaning session, calculate the overall permeability of the membranes before versus after the session has been performed.

Refer to the example below when calculating membrane permeability.

Example: A system has a typical operating temperature of 20°C (68°F) (T_1) and an actual (observed) operating temperature of 15°C (59°F) (T_2). The permeate flowrate was recorded at 3,285.4 lpm (868 gpm) at a membrane pressure of 0.414 bar (6 psi), while total membrane surface area equals 4,548.53 m^2 (48,960 ft^2).

1. Calculate the membrane area:

Membrane area per train	=	Number of modules per cassette	×	Number of cassettes per train	×	Surface area per module

48 modules per cassette	×	3 cassettes per train	×	340 ft^2 per module	=	48,960 ft^2 per train

2. Convert flow rate to flux at the observed temperature:

$$\text{Flux at 59°F} = \frac{\text{Flow}}{\text{Membrane surface area per train}} \times \text{Number of minutes per day}$$

$$\frac{868 \text{ gpm}}{48{,}960 \text{ ft}^2 \text{ per train}} \times 1{,}440 \text{ minutes per day} = 25.5 \text{ gfd}$$

3. Correct the flux value from the observed temperature (15°C (59°F)) (T_2) to the reference temperature (20°C (68°F)) (T_1). Viscosity values required for this calculation can be found in *Table 13.3 - Water Viscosity*.

Table 13.3 - Water Viscosity

Temperature		Viscosity	Temperature		Viscosity	Temperature		Viscosity
°C	°F	cP	°C	°F	cP	°C	°F	cP
1	34	1.7311	23	73	0.9356	45	113	0.5988
2	36	1.6736	24	75	0.9142	46	115	0.5884
3	37	1.6192	25	77	0.8935	47	117	0.5782
4	39	1.5677	26	79	0.8736	48	118	0.5683
5	41	1.5188	27	81	0.8544	49	120	0.5587
6	43	1.4723	28	82	0.8359	50	122	0.5494
7	45	1.4281	29	84	0.8180	51	124	0.5403
8	46	1.3860	30	86	0.8007	52	126	0.5315
9	48	1.3459	31	88	0.7840	53	127	0.5229
10	50	1.3077	32	90	0.7679	54	129	0.5145
11	52	1.2712	33	91	0.7523	55	131	0.5064
12	54	1.2362	34	93	0.7372	56	133	0.4984

Table 13.3 - Water Viscosity

13	55	1.2029	35	95	0.7225	57	135	0.4907
14	57	1.1709	36	97	0.7084	58	136	0.4832
15	59	1.1403	37	99	0.6946	59	138	0.4758
16	61	1.1109	38	100	0.6813	60	140	0.4687
17	63	1.0828	39	102	0.6685	61	142	0.4617
18	64	1.0558	40	104	0.6560	62	144	0.4549
19	66	1.0298	41	106	0.6438	63	145	0.4482
20	68	1.0049	42	108	0.6321	64	147	0.4418
21	70	0.9809	43	109	0.6207	65	149	0.4355
22	72	0.9578	44	111	0.6096			

$$\text{Flux at } T_1 = \text{Flux at } T_2 \times \frac{\text{viscosity at } T_1}{\text{viscosity at } T_2}$$

$$25.5 \text{ gfd} \times \frac{1.0049}{1.1403} = 22.47 \text{ gfd}$$

4. Using the recorded membrane pressure, convert the temperature-corrected flux to membrane permeability.

$$\text{Membrane permeability} = \frac{\text{Corrected flux}}{\text{Membrane pressure}}$$

$$\frac{22.47 \text{ gfd}}{6 \text{ psi}} = 3.7 \text{ gfd per 1 psi}$$

In order to accurately assess the effectiveness of a cleaning procedure, measure and record the membrane permeability immediately before and after each cleaning session is performed.

13.5 Analytical Techniques for Bioreactors

This section outlines procedures for measuring the various characteristics of bioreactor tank contents. Refer to *Volume I - Vendor Data Manual* for information regarding the operation and maintenance of meters, measurement kits, and other equipment mentioned below.

Information in this section has been adapted from *Standard Methods for Examination of Water & Wastewater 20th ed.* (American Public Health Association Publications, 1998).

13.5.1 Dissolved Oxygen

Measuring the dissolved oxygen (DO) level within the bioreactor will determine whether there is enough oxygen available within the tank to allow organisms to effectively break down pollutants in wastewater.

DO readings typically range from 1 - 14 mg/L, with readings above 9 mg/L being common for samples taken from near the bottom of the tank, where gases have a higher level of solubility.

Tanks with a DO level of below 1 mg/L may operate at reduced efficiency due to insufficient oxygen. This can be resolved by either increasing aeration or decreasing wastewater flow into the tank until the DO level rises above 1 mg/L.

13.5.1.1 Collecting Samples

The DO level can be measured using either a mounted or portable meter. If using a portable meter, a sample can be taken using one of the following methods:

In-situ (inside the bioreactor): To obtain the most accurate reading, insert the probe directly into the bioreactor in an area of relatively high turbulence.

CAUTION

Wear protective gloves and safety glasses when collecting from a sample valve, and do not allow the beaker to overflow.

INLINE (AT THE SAMPLING VALVE): To take a reading using a sample, partially open the sample valve on the return line and collect a sample using a beaker. Return any biomass released during collection to the bioreactor.

GRAB SAMPLE (AT THE LAB BENCH): Testing a sample that has been taken directly from within the bioreactor tank requires a calibrated DO meter, a BOD bottle, and a magnetic stirrer. If the DO probe has a built-in stirrer, a magnetic stirrer is not required.

13.5.1.2 MEASURING DO LEVELS

The DO concentration can be read from the meter after allowing the probe to stabilize for 1 - 2 minutes. If the in-situ method is being used, subsequent measurements should be taken from the same area in the bioreactor as the first.

Take multiple measurements and compare results. If the meter does not produce the same result (that is, if the second reading is not within 0.2 mg/L of the first) without calibration or adjustment, the meter has drifted during the test and the probe membrane should be replaced.

Always refer to the manufacturer's instructions provided in *Volume I - Vendor Data Manual* when maintaining the meter. However, as a general rule, the probe membrane should be replaced approximately every 3 weeks.

13.5.2 BIOLOGICAL OXYGEN UPTAKE RATE

The oxygen uptake rate (OUR) is the rate at which the biological population within the tank is consuming oxygen. The more active the bacteria, the higher the oxygen uptake rate.

Results of an OUR measurement are typically expressed as the amount of oxygen in mg consumed per liter of bioreactor contents per hour. Typical results will range between 10 - 60 mg oxygen per L/hr. Various factors affect the OUR, including wastewater flowrate, solids concentration, aeration rate, nutrient levels, and temperature.

This measurement can be performed using either the grab sample or in-situ method, both of which are described below.

13.5.2.1 OUR Grab Sample Method

The following equipment is required to perform this test:

- DO meter.
- Probe with oxygen-sensitive electrode.
- BOD bottle sized to contain the DO probe.
- Magnetic stirrer.
- Stop watch or other timing device.

To measure the OUR within a bioreactor using the grab sample method, perform the following steps:

1. Calibrate the oxygen probe and meter according to the manufacturer's instructions.

TIP: The longer it takes to collect a sample and take a DO measurement, the less accurate the results will be.

2. As quickly as possible, collect a 500 ml sample and transport it to the lab bench, and then measure the DO.
3. If the DO is greater than 4 mg/L, proceed to step 3. If not, increase the DO concentration before proceeding by shaking the sample in a partially filled container or by bubbling air through it for 3 - 5 minutes. The DO should be greater than 4 mg/L before the OUR is measured.
4. Pour the sample into the BOD bottle containing the magnetic stirrer.

5. Insert the probe into the top of the BOD bottle to displace enough bioreactor contents to fill the bottle entirely and isolate the contents from the atmosphere. Air bubbles should not be present in the top of the BOD bottle.

6. Turn on the magnetic stirrer and allow the sample to mix well before proceeding.

7. Measure the DO level, and then start the stop watch as soon as the meter registers (this provides the "time zero" DO level).

8. Continue to measure the DO level at least once every 15 - 30 seconds, depending on the rate of consumption. Record the data until the DO level is less than 1 mg/L.

9. Mark each reading on graph paper as DO (mg/L) versus time (minutes) and determine the slope of the line of best fit. This line is the oxygen consumption rate in mg per lpm. Multiply the result by 60 to obtain the OUR in mg per lph.

13.5.2.2 OUR In-situ Method

The following equipment is required to perform this test:

- DO meter.
- Probe with oxygen-sensitive electrode.
- Stop watch or other timing device.

To measure the OUR within a bioreactor using the in-situ method, perform the following steps:

1. Calibrate the oxygen probe and meter according to the manufacturer's instructions.

2. Submerge the end of the probe in the bioreactor tank.

TIP: Ideally, the DO level within the tank should be 4 - 6 mg/L.

3. If the DO level is below 2 mg/L, increase aeration until this level is achieved.

4. After the DO level has risen above 2 mg/L, turn off aeration.

5. Measure the DO level again, and then start the stop watch as soon as the meter registers (this provides the “time zero” DO level).

6. Continue to measure the DO level at least once every 15 - 30 seconds, depending on the rate of consumption. Record the data until the DO level is less than 1 mg/L.

7. Mark each reading on graph paper as DO (mg/L) versus time (minutes) and determine the slope of the line of best fit. This line is the oxygen consumption rate in mg per lpm. Multiply the result by 60 to obtain the OUR in mg per lph.

13.5.3 Total & Volatile Suspended Solids

Analyzing the total suspended solids (TSS) and volatile suspended solids (VSS) will determine the amount of particulate material (that is non-dissolved solids) contained in a sample.

Using the TSS and VSS values, operators can estimate the microbial concentration within the membrane tank, which is necessary when establishing a schedule for wasting sludge.

Whereas the TSS test simply measures the total amount of suspended solids, the VSS test measures the amount of organic suspended solids. The difference between these values is the amount of inert (that is, non-organic) suspended solids in a sample.

Typical TSS values measured at various points throughout a system include the following:

Wastewater Flow: 100 - 500 mg/L.

Permeate Flow: Below the minimum detection limit (less than 1 - 3 mg/L).

Bioreactor Tank: 8,000 - 10,000 mg/L (with a fully developed biomass population).

Before a TSS or VSS measurement can be taken, the sample must be filtered in order to separate suspended solids from dissolved solids. This is usually a simple process with wastewater or permeate samples, but can be quite complex for bioreactor samples containing more than 10,000 mg/L. In such cases, it is better to perform a total solids (TS) or volatile solids (VS) test instead of measuring TSS and VSS.

The following equipment is required to measure the TSS and VSS values in a sample:

TIP: *The muffle furnace and crucibles are only required for the VS test. If only the TS analysis is being performed, any suitable container that can be accurately weighed may be used.*

- 25 ml ceramic crucibles (2).
- glass-fiber filter disks (GF/C) and filtration apparatus.
- suction flask.
- drying oven.
- muffle furnace.
- desiccator.
- analytical balance.

To measure the TSS and VSS in a sample, perform the following steps:

1. Measure the TSS value by performing the following steps:

   a. Ignite the crucibles in the muffle furnace at 500 - 600°C (932 - 1,112°F) for 15 minutes, and then store them in the desiccator until cool.

   b. Place a filter in each crucible.

   c. Assemble the filtration apparatus.

   d. Using a well-mixed sample, begin filtering until between 2.5 - 200 mg (0.007 oz) of dried residue has been produced. If filtration takes more than 10 minutes to complete, either increase the filter size or decrease the sample volume.

   e. Weigh the crucible and record the weight (B in the calculation below).

f. Carefully remove the filter paper with residue from the filtration apparatus and transfer to one of the crucibles.

g. Dry the crucible and filter paper with residue for at least 1 hour in an oven heated to 103 - 105ºC (217.4 - 221ºF), and then cool in the desiccator to the temperature of the analytical balance, and weigh.

h. Repeat the cycle of drying, cooling, desiccating, and weighing until a constant weight is obtained, the weight loss is less than 4% of the previous weight, or a weight of 0.5 mg is obtained, whichever occurs first. (The resulting weight is A in the calculation below.)

i. Where A equals the combined weight of the crucible, filter, and dried residue (mg), while B equals the combined weight of the crucible and the filter (mg), calculate the TSS value as follows:

$$\text{TSS (mg/L)} = (A - B) \times \frac{1000}{\text{sample volume (ml)}}$$

j. Repeat this procedure 1 - 2 times and determine the final TSS value by averaging the results.

2. Measure the VSS by performing the following steps:

   a. Perform steps d to f in the TSS measurement procedure above using the crucible that was not used for the TSS measurement.

   b. Ignite the crucible and filter paper with residue within the furnace at a temperature of 500 - 600ºC (932 - 1,112ºF), and then cool in the desiccator to the temperature of the analytical balance, and weigh.

   c. Repeat the cycle of heating, cooling, desiccating, and weighing until a constant weight is obtained or until the weight loss is less than 4% of the previous weight, whichever occurs first. (The resulting weight is C in the calculation below.)

d. Where A equals the combined weight of the crucible, filter, and dried residue (mg) before ignition, while C equals the combined weight (mg) after ignition, calculate the VSS value as follows:

$$\text{VSS (mg/L)} = (A - C) \times \frac{1000}{\text{sample volume (ml)}}$$

e. Repeat this procedure 1 - 2 times and determine the final TSS value by averaging the results.

3. After determining the TSS and VSS values, calculate the percentage of TSS that is VSS as follows:

$$\%\ \text{VSS} = \text{average VSS} \times \frac{100}{\text{average TSS}}$$

13.5.4 Total & Volatile Solids

***Tip:** A bioreactor's TS level will usually be within the 10,000 - 15,000 mg/L range after 3 - 4 months of operation.*

When the solids content within the bioreactor is greater than 10,000 mg/L, it is much more practical to perform a TS or VS test than one for TSS and VSS. The results of this test can be used as a reasonable approximation of the TSS value.

To measure the TS and VS in a sample, use the suspended solids procedure and calculations outlined in this manual, but without the use of filtration equipment or filter paper. Instead, pour a liquid sample estimated to yield between 2.5 - 200 mg (0.007 oz) of dry residue into the crucible. The liquid portion of the sample will be evaporated during the drying (TS) or heating (VS) process.

For more information on the topics discussed above . . .

- Refer to *13.5.3 Total & Volatile Suspended Solids* for more on measuring the TS and VS values.

13.5.5 Specific Oxygen Uptake Rate

The bioreactor TSS or TS concentration is an approximate measure of the microbial population within the tank. Because this concentration can vary, the specific OUR is often calculated to determine the OUR per unit mass of bacteria.

To calculate the specific OUR, perform the following steps:

1. Measure the OUR within the bioreactor.
2. Measure either the TSS or TS level within the bioreactor.
3. Using the following calculation, determine the specific OUR.

$$\text{Specific OUR (mg oxygen per g of TSS (or TS) per hour)} = \frac{\text{OUR (mg per L/hr)}}{\text{TSS (or TS) g per L}}$$

For more information on the topics discussed above . . .

- Refer to *13.5.2 Biological Oxygen Uptake Rate* for more on measuring OUR.
- Refer to *13.5.3 Total & Volatile Suspended Solids* for more on measuring TSS values.
- Refer to *13.5.4 Total & Volatile Solids* for more on measuring TS values.

13.5.6 pH

To ensure proper operation, pH levels within the bioreactor should remain between 7 - 8.8 and must be checked daily. The pH analysis can be performed with a pH meter and probe as described in the following procedure:

1. Calibrate the pH meter and probe as per the manufacturer's instructions provided in *Volume I - Vendor Data Manual*.
2. Collect a sample from the bioreactor and stir gently before inserting the pH probe.
3. Record the registered reading.

13.5.7 Chemical Oxygen Demand

Measuring the chemical oxygen demand (COD) of a sample will indicate the amount of organic material it contains.

The COD in wastewater entering the bioreactor represents the amount of food available to the organism contained there, while the COD in permeate represents the amount of non-biodegradable (recalcitrant) material in the permeate.

In the case of the bioreactor contents, only the soluble COD is measured and the sample must be filtered prior to analysis.

13.5.8 Total Phosphorus

The COD to total phosphorous (TP) ratio should be kept above 170:1. The typical minimum allowable TP concentration is 5 mg/L. Allowing the TP level to fall below this point will limit the number of organisms within bioreactor and reduce overall efficiency.

13.5.9 Nitrogen (Ammonia)

Nitrogen is provided to organisms within the bioreactor in the form of ammonia. The COD to Total Kjeldahl Nitrogen (TKN) ratio should be kept above 170:3. The typical minimum allowable nitrogen concentration is 15 mg/L. As with TP, Allowing the nitrogen level to fall below this point will limit the number of organisms within bioreactor and reduce overall efficiency.

13.5.10 Calculating Nutrient Densities

The following procedure is used to calculate the requirements for aerobic biological waste treatment.

In order for biological degradation to take place, nitrogen and phosphorus must be present in the bioreactor in specific amounts. If the required levels are not met by nutrients contained in the wastewater, they will need to be added to the tank on a regular basis.

Before starting up the bioreactor, measure the following wastewater characteristics:

TIP: *COD will always be greater than BOD.*

- BOD and COD.
- Filtered TKN.
- Filtered TP.
- Magnesium.
- Manganese.
- Calcium.
- Iron.

Magnesium, manganese, calcium, and iron are generally present in trace amounts in wastewater. However, if they are not present in the following ratio, contact GE W&PT.

Table 13.4 - Wastewater Requirements

Requirement	Amount
COD	1,000
Magnesium	8.9
Manganese	3.3
Calcium	2
Iron	0.2

In general, biological systems require 5 mg/L of nitrogen and 1 mg/L of phosphorus for every 100 mg/L of BOD in the wastewater. Therefore, ensure that there is a COD-nitrogen-phosphorus ratio of 100:5:1 (unless system-specific parameters dictate otherwise) before starting up the bioreactor. Because COD is always greater than BOD, this ratio will ensure sufficient nutrients are available.

After the bioreactor has been started up and is operating in stable condition, nitrogen and phosphorus analyses can be performed on effluent to determine if the amount of nutrients being added should be adjusted.

13.5.11 CALCULATING NUTRIENT REQUIREMENTS

To calculate the amount of nitrogen and phosphorus required to ensure normal operation, perform the following steps:

1. Determine wastewater COD (mg/L).

2. The ratio of COD to nitrogen must be 20:1. To calculate the amount of nitrogen needed, divide the COD (mg/L) by 20 (example: if COD equals 5,000 mg/L, the nitrogen nutrient requirement equals 250 mg per liter of wastewater added to the bioreactor).

3. The ratio of COD to phosphorus must be 100:1. To calculate the amount of phosphorus needed, divide the COD (mg/L) by 100 (example: if COD equals 5,000 mg/L, the phosphorus nutrient requirement equals 50 mg per liter of wastewater added to the bioreactor).

For both nitrogen and phosphorus, if the amount of nutrient contained in the wastewater is ***greater than or equal to*** the nutrient requirement, it is not necessary to add additional amounts of that nutrient to the bioreactor. If wastewater content is ***less than*** the nutrient requirement, subtract the amount of nutrient contained in the wastewater from the calculated nutrient requirement to determine the amount that must be added.

EXAMPLE: When calculating the nutrient requirement, if TKN equals 50 mg/L and TP equals 10 mg/L:

- The actual nitrogen amount required equals the calculated nitrogen requirement minus TKN:

250 mg of nitrogen per liter - 50 mg/L	=	200 mg of nitrogen per liter of wastewater added to the bioreactor

- The actual phosphorus amount required equals the calculated phosphorus requirement minus TP:

50 mg of phosphorus per liter - 10 mg/L	=	40 mg of phosphorus per Liter of wastewater added to the bioreactor

13.5.12 Calculating Dosing Rates & Concentrations

TIP: For the purposes of these calculations, ammonium chloride will be used as the nitrogen source and phosphoric acid as the phosphorus source. Other chemicals can be used.

After the actual nitrogen and phosphorus nutrient requirements have been calculated, the required dosing rates for each can be determined.

Calculate the amount of 99% ammonium chloride (assume pure) needed to supply the actual nitrogen requirement. The molecular weight of ammonium chloride is 54 while that of nitrogen is 14. Therefore, 54 mg of ammonium chloride contains 14 mg of nitrogen.

EXAMPLE: When determining the amount of ammonium chloride required, if the actual nitrogen requirement equals 200 mg of nitrogen per liter of wastewater added to the bioreactor:

$$\text{200 mg of nitrogen} \times \frac{\text{54 mg of ammonium chloride}}{\text{14 mg of nitrogen}} = \text{771 mg of ammonium chloride required per liter of wastewater added to the bioreactor}$$

Calculate the amount of 85% phosphoric acid solution needed to supply the actual phosphorus requirement. The molecular weight of phosphoric acid is 98, while that of phosphorus is 31. Therefore 98 mg of phosphoric acid contains 31 mg of phosphorus.

EXAMPLE: When determining the amount of phosphoric acid required, if the actual phosphorus requirement equals 40 mg of phosphorus per liter of wastewater added to the bioreactor:

$$\text{40 mg of phosphorus} \times \frac{\text{98 mg phosphoric acid}}{\text{31 mg phosphorus}} \times \frac{\text{1 mg of 85\% phosphoric acid}}{\text{0.85 mg of phosphoric acid}} = \text{149 mg of 85\% phosphoric acid for each liter of wastewater added to the bioreactor}$$

Because an 85% phosphoric acid solution has a specific gravity of 1.7 (1,700 mg/ml):

$$\frac{\text{149 mg of phosphoric acid}}{\text{1,700 mg/ml}} = \text{0.0876 ml of 85\% phosphoric acid}$$

Therefore, 149 mg of phosphoric acid is contained in 0.0876 ml of 85% phosphoric acid, meaning that 0.0876 ml of 85% phosphoric acid must be added for each liter of wastewater added to the bioreactor.

With the dosing rates determined, the stock solution concentration for each nutrient can be calculated. Both the wastewater and nutrient solution flowrates must be known in order to perform this calculation.

EXAMPLE: Based on the example above, with a wastewater flowrate of 1 lpm, 771 mg of ammonium chloride and 0.0876 ml of 85% phosphoric acid must be added to the bioreactor every minute. If the nutrient flowrate is 20 ml per minute, then a nutrient stock solution concentration of 771 mg of ammonium chloride and 0.0876 ml of 85% phosphoric acid is required per 20 ml of nutrient stock solution.

$$\frac{\text{771 mg of ammonium chloride}}{\text{20 ml}} \times \frac{\text{1,000 ml}}{\text{1 L}} = \text{38,550 mg (38.55 g) of ammonium chloride}$$

Therefore, 38.55 g of ammonium chloride are required per liter of nutrient stock solution.

$$\frac{\text{0.0876 ml at 85\% phosphoric acid}}{\text{20 ml}} \times \frac{\text{1000 ml}}{\text{1 L}} = \text{4.38 ml of 85\% phosphoric acid}$$

Therefore, 4.38 mL of phosphoric acid is required per liter of nutrient stock solution.

Section 14

Recommended Spare Parts List

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General Notes

Pumps

Chemical metering pumps	Certain parts, such as diaphragms and check valves, are prone to wear and will require periodic replacement. Most suppliers recommend that these parts be replaced annually. A complete spare parts kit should be purchased annually for every type of metering pump in this system.
General pump repair	For rotating pumps of any kind, seals, bearings, and other parts prone to wear will require periodic replacement. These parts generally do not suffer catastrophic and immediate failure under normal operating conditions.

Valves

Automatic valves	Automatic valves are critical to system operation. Without properly functioning valves, the system may not operate in AUTO mode, or may become totally inoperable. Valves are unlikely to experience catastrophic and immediate failure unless exposed to conditions such as frozen lines or a contaminated air supply.
Angle-seat solenoid valves	Solenoid valves are critical components which control valve operation and, therefore, the process flow sequences for the entire system. Malfunctioning solenoid valves will prevent the system from being operated in AUTO mode and will adversely effect system operation overall.

Instrumentation

Pressure and temperature gauges	Gauges are non-critical components. It is recommended that at least one spare gauge of each size, range, and mounting-style be kept in inventory at all times.
Diaphragm seals for pressure gauges	It is recommended that one spare diaphragm seal for each pressure gauge be kept in inventory at all times.
Pressure, level, flow, and temperature switches and indicators	Switches and indicators are critical components which monitor and/or control system operation. Attempting to operate a system with malfunctioning switches or indicators may damage the system, compromise product quality, and expose operators to possible injury.
Meters, analyzers and other monitoring components	Analytical instrumentation provides valuable process data that is critical to maintaining production and safety. Control logic and alarms rely on these signals to keep the system operating within specific ranges, to notify operators of developing problems, and to trigger preventive actions when necessary.
Reagents and maintenance kits for meters and analyzers	Most analytical instruments require regular maintenance to ensure proper performance. As a result, most suppliers provide maintenance packages which include spare parts, cleaning solutions and calibration equipment. Typically, kits will need to be replenished or replaced every 2 - 3 years.
Turbidimeters	It is highly recommended that operators follow manufacturers' instructions in detail when working with turbidimeter calibration solutions.

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Criticality Ratings:
C - Critical (failure will halt operation. Average 1 - 3 year lifespan)
R - Recommended spare
M - Maintenance (example: parts kits)
CS - Consumables

* Quantities may vary depending on system specifications. Update as needed.

Recommended Spare Parts List for U-500615 GOVT OF NUNAVUT

Item	Description	Part Number	Skid	Unit Type	Unit Price	Recommended Qty*	Criticality Rating
AIR FILTER	A FLTR,AIR,CMPRSD,1/4",40MICRON ,	3086200	500615ZZ500615BOM	Replacement filters	Email gewater.parts@ge.com for an up-to-date quote.	Minimum of one (1) per unit, per year	CS
ANGLE-SEAT VALVE	A vlve,angle-seat,Asse,0.5"FNPT	3090988	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type (including actuator, if applicable)	R
ANGLE-SEAT VALVE	A VLVE,ANGLE-SEAT,1"FNPT,SS	3086434	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type (including actuator, if applicable)	R
ANGLE-SEAT VALVE	VALVE-ANGLE,0.50,F.C.,24VDC,BURKERT	500615-MA-41	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type (including actuator, if applicable)	R
BACK PRESSURE VALVE	A BPV,0.5"FNPT,PVC	3083847	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BALL CHECK VALVE	A VALVE-CHK,BALL,0.5",THD,PVC/VITON	3090250	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R

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Recommended Spare Parts List for U-500615 GOVT OF NUNAVUT

Item	Description	Part Number	Skid	Unit Type	Unit Price	Recommended Qty*	Criticality Rating
BALL CHECK VALVE	A CV,BALL,0.5",SW,PVC/VITON	3090239	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BALL VALVE	A VLVE,BALL,1.5",316SS,2PC,THD	3088955	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BALL VALVE	A VALVE-BALL,1",316SS,3PC,SW	3067286	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BALL VALVE	A VALVE,BALL,0.75",TU,PVC/EPDM	3090184	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BALL VALVE	A VALVE,BALL,0.5",TU,PVC/EPDM	3090183	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BALL VALVE	A VALVE-BALL,FV,0.5",PVC/EPDM,SRFC,24V	3089339	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BALL VALVE	A VALVE,BALL,2",TU,PVC/EPDM	3090187	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R

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Criticality Ratings:
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R - Recommended spare
M - Maintenance (example: parts kits)
CS - Consumables

* Quantities may vary depending on system specifications. Update as needed.

Recommended Spare Parts List for U-500615 GOVT OF NUNAVUT

Item	Description	Part Number	Skid	Unit Type	Unit Price	Recommended Qty*	Criticality Rating
BALL VALVE	A VALVE,BALL,0.5",TU,PVC/VITON	3087942	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BALL VALVE	A VLVE,BALL,0.25",316SS,2PC,THD	3067269	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BALL VALVE	A VALVE-BALL,CV,0.5",SW,PVC/EPDM	3090233	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BALL VALVE	A VLVE,BALL,1",FNPT,316SS,2-WAY	3067272	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BALL VALVE	A VALVE,BALL,0.5",TU,PVC/VITON	3090189	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BALL VALVE	VALVE-BALL,PVC,2.00,F/C,SOC,GF	500615-MA-16	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BALL VALVE	A VLVE,BALL,0.5",316SS,1PC,THD	3067260	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R

GE Power and Water
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Criticality Ratings:
C - Critical (failure will halt operation. Average 1 - 3 year lifespan)
R - Recommended spare
M - Maintenance (example: parts kits)
CS - Consumables

* Quantities may vary depending on system specifications. Update as needed.

Recommended Spare Parts List for U-500615 GOVT OF NUNAVUT

Item	Description	Part Number	Skid	Unit Type	Unit Price	Recommended Qty*	Criticality Rating
BALL VALVE	A VALVE-BALL,FV,0.5",PVC/FPM,SRFC,24V	3089341	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
BLOWER	BLOWER-PD,10HP,600/60/3,AERZEN,GM 10S DN	500615-MA-01	500615ZZ500615BOM	Maintenance/parts kit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) complete parts kit for each type	M
BLOWER	BLOWER-PD,30HP,600/60/3,AERZEN,GM 25S DN	500615-MA-02	500615ZZ500615BOM	Maintenance/parts kit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) complete parts kit for each type	M
BUTTERFLY VALVE	VALVE-BTFLY,DI,4.00,F/C,LUG,BRAY,24V	500615-MA-07	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type (including actuator, if applicable)	R
BUTTERFLY VALVE	A FCV,BF,8",LUG,NYL,50PSI,DA,PO	3090383	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type (including actuator, if applicable)	R
BUTTERFLY VALVE	VALVE-BTFLY,DI,3.00,S/A,LUG,LS,BRAY,24V	500615-MA-04	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type (including actuator, if applicable)	R

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Criticality Ratings:
C - Critical (failure will halt operation. Average 1 - 3 year lifespan)
R - Recommended spare
M - Maintenance (example: parts kits)
CS - Consumables

* Quantities may vary depending on system specifications. Update as needed.

Recommended Spare Parts List for U-500615 GOVT OF NUNAVUT

Item	Description	Part Number	Skid	Unit Type	Unit Price	Recommended Qty*	Criticality Rating
BUTTERFLY VALVE	VALVE-BTFLY,FV,3",LUG,NYL,50PSI,DA,24V	3103256	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type (including actuator, if applicable)	R
BUTTERFLY VALVE	A HV,BF,6",LUG,NYL,LEV	3090288	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type (including actuator, if applicable)	R
BUTTERFLY VALVE	VALVE-BTFLY,FV,4",LUG,NYL,50PSI,DA,24V	3103178	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type (including actuator, if applicable)	R
BUTTERFLY VALVE	A HV,BF,3",LUG,NYL,LEV	3090286	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type (including actuator, if applicable)	R
BUTTERFLY VALVE	VALVE-BTFLY,DI,3.00,S/A,LUG,TS,BRAY,24V	500615-MA-05	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type (including actuator, if applicable)	R
BUTTERFLY VALVE	VALVE-BTFLY,DI,4.00,S/A,LUG,TS,BRAY,24V	500615-MA-06	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type (including actuator, if applicable)	R

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R - Recommended spare
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CS - Consumables

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Recommended Spare Parts List for U-500615 GOVT OF NUNAVUT

Item	Description	Part Number	Skid	Unit Type	Unit Price	Recommended Qty*	Criticality Rating
CHECK VALVE	A CV,WFR,BRAY,3",SWG,CI/SS	3088538	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
CIRCUIT BREAKER	B BREAKER-CIRC,0.5A,250/65 VAC/VDC	3091555	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	Three (3) sets of each type, size, and rating	C
CIRCUIT BREAKER	B BREAKER-CIRC,1A,250/65 VAC/VDC	3091556	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	Three (3) sets of each type, size, and rating	C
CIRCUIT BREAKER	B BREAKER-CIRC,2A,250/65 VAC/VDC	3091557	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	Three (3) sets of each type, size, and rating	C
COUPLING	A CPLG,4",316LSS,1 PC, VACUUM	3084139	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity	R
COUPLING	A CPLG,3",316LSS,1 PC,VACUUM	3084138	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity	R
COUPLING	A COUPLING,PVC,S80,FPT,0.50	1110340	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity	R
COUPLING	B COUPLING-RDCR,PVC,S80,SOC,3.00X2.00	1260535	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity	R
DIAPHRAGM PUMP	A P,AIR DIA,900L/HR,PVDF	3086061	500615ZZ500615BOM	Maintenance/parts kit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) complete parts kit for each type	M

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Recommended Spare Parts List for U-500615 GOVT OF NUNAVUT

Item	Description	Part Number	Skid	Unit Type	Unit Price	Recommended Qty*	Criticality Rating
DIAPHRAGM PUMP	PUMP-DIAPH,DLTA0730,120/60/1,PROM	500615-MA-28	500615ZZ500615BOM	Maintenance/parts kit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) complete parts kit for each type	M
DIAPHRAGM PUMP	PUMP-DIAPH,GALA1601,120/60/1,PROM	500615-MA-27	500615ZZ500615BOM	Maintenance/parts kit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) complete parts kit for each type	M
DIAPHRAGM PUMP	PUMP-DIAPH,DLTA0450,120/60/1,PROM	500615-MA-26	500615ZZ500615BOM	Maintenance/parts kit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) complete parts kit for each type	M
DIAPHRAGM PUMP	PUMP-DIAPH,DLTA0450,120/60/1,PROM	500615-MA-25	500615ZZ500615BOM	Maintenance/parts kit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) complete parts kit for each type	M
DISSOLVED OXYGEN SENSOR	SENSOR-DO,316,1.00,MNPT,HACH	500615-MA-17	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	One (1) maintenance kit per unit (replace unused kits every three (3) years)	C
EJECTOR	A EJECTOR ASS, PIAB,1",SS	3088902	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	One (1) complete parts kit for each type	M
EJECTOR	A P,VACM,EJECTOR,0.8SEC/FT3TO-9"	3085593	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	One (1) complete parts kit for each type	M
ELECTRICAL FUSE	FUSE,2A,FAST,CERAMIC,BUSSMAN N,ABC-2	3060755	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	Three (3) sets of each type, size, and rating	C

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CS - Consumables

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Recommended Spare Parts List for U-500615 GOVT OF NUNAVUT

Item	Description	Part Number	Skid	Unit Type	Unit Price	Recommended Qty*	Criticality Rating
ELECTRICAL FUSE	B FUSE-HOLDER,CHCC1,BUSSMANN,1P,30A,600V	3097937	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	Three (3) sets of each type, size, and rating	C
ELECTRICAL FUSE	A FUSE,1A,FAST ACTING,CERAMIC,ABC-1-R	3055154	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	Three (3) sets of each type, size, and rating	C
ELECTRICAL FUSE	FUSE,10AMP,600V,LP-CC-10	3010561	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	Three (3) sets of each type, size, and rating	C
FLOAT SWITCH	SWITCH-FLOAT,PVDF,2-STAGE,PROM	500615-MA-29	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each type or 10% of original quantity, whichever is greater	C
FLOW SWITCH	SWITCH-FLOW,0.50MNPT,3.3-66'/SEC,KOBOLD	500615-MA-18	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each type or 10% of original quantity, whichever is greater	C
FLOW SWITCH	A FS,6' PVDF,2-STAGE	3084212	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each type or 10% of original quantity, whichever is greater	C
FLOW TRANSMITTER	A TRANS,SENSOR-FLOW,E&H,2",PBTN,PU	3085437	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each size and type	C
FOOT VALVE	A CV/STR,PVC/VTN,0.75"MNPT CONN	3081347	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R

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Criticality Ratings:
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R - Recommended spare
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CS - Consumables

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Recommended Spare Parts List for U-500615 GOVT OF NUNAVUT

Item	Description	Part Number	Skid	Unit Type	Unit Price	Recommended Qty*	Criticality Rating
FOOT VALVE	A VLVE,FOOT,1",PVC/EPDM	3096273	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
GASKET	B GASKET-COLLAR,Z-POD,ZW500DS,DUAL	3093229	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity	C
GASKET	B GASKET-DOOR,SILICONE,Z-POD,ZW500DS	3093224	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity	C
LEVEL SWITCH	SWITCH-LEVEL,PVC,120VAC,MJK,W/WEIGHT	500615A-MA-03	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each type or 10% of original quantity, whichever is greater	R
LEVEL SWITCH	A LSF,20'CABLE,PVC JACKET	3084450	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each type or 10% of original quantity, whichever is greater	R
LEVEL SWITCH	A LS,HORIZ,0.5"NPT,CPVC	3082338	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each type or 10% of original quantity, whichever is greater	R
LEVEL TRANSMITTER	TRANS-LEVEL,316,3.00,FLG,0-3700MM,E+H	500615-MA-12	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each size and type	C
LEVEL TRANSMITTER	TRANS-LEVEL,316,3.00,FLG,0-5000MM,E+H	500615-MA-08	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each size and type	C

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R - Recommended spare
M - Maintenance (example: parts kits)
CS - Consumables

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Recommended Spare Parts List for U-500615 GOVT OF NUNAVUT

Item	Description	Part Number	Skid	Unit Type	Unit Price	Recommended Qty*	Criticality Rating
LEVEL TRANSMITTER	TRANS-LEVEL,316,3.00,FLG,0-2100MM,E+H	500615-MA-09	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each size and type	C
NEEDLE VALVE	A VLVE,NDL,0.5",FNPT,PVC	3081844	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity for each size and type	R
PH SENSOR	SENSOR-PH,PTFE,0.75,MNPT,PROM	500615-MA-22	500615ZZ500615BOM	Maintenance/parts kit (or complete unit if kit is not available)	Email gewater.parts@ge.com for an up-to-date quote.	One (1) maintenance kit per unit (replace unused kits every three (3) years)	R
PLC PROCESSOR	PLC-AB,1794-OF4I,FLEX,ANLG,4-20 MA,4OUT	1261180	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) spare unit, unless advised otherwise during commissioning	C
PLC PROCESSOR	B PLC-AB,1794-TB2,FLEX,2 WIRE TERMINAL	1162578	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) spare unit, unless advised otherwise during commissioning	C
PLC PROCESSOR	C PLC-AB,1794-IB16,FLEX,24 VDC,16 IN	1162582	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) spare unit, unless advised otherwise during commissioning	C
PLC PROCESSOR	A PLC-AB,1794-AENT,FLEX,ENETADAPTER	3028091	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) spare unit, unless advised otherwise during commissioning	C

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R - Recommended spare
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CS - Consumables

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Recommended Spare Parts List for U-500615 GOVT OF NUNAVUT

Item	Description	Part Number	Skid	Unit Type	Unit Price	Recommended Qty*	Criticality Rating
PLC PROCESSOR	B PLC-AB,1794-TB3,FLEX,3 WIRE TERMINAL	1162579	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) spare unit, unless advised otherwise during commissioning	C
PLC PROCESSOR	C PLC-AB,1794-OB16,FLEX,24 VDC,16 OUT	1162583	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) spare unit, unless advised otherwise during commissioning	C
PLC PROCESSOR	D PLC-AB,1794-IE8,FLEX,ANLG,4-20 MA,8 IN	1162587	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) spare unit, unless advised otherwise during commissioning	C
PLUG	A PLG,125V,15A,WOODHEAD	3080786	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity	R
POWER SUPPLY	B POWEP-SUP,FLEXLOGIX,24VDC,1.3A	3085138	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each type, size, and rating	M
POWER SUPPLY	A POWER-SUP,24VDC,2.5A,2866268,PHOENIX	3059354	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each type, size, and rating	M
PRESSURE GAUGE	A PI,160PSI with Diaphram Seals	3090155	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each size, range, and mounting style	R
PRESSURE GAUGE	A PI,30"HG,30PSI,2.5",SS,GF	3081158	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each size, range, and mounting style	R

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Recommended Spare Parts List for U-500615 GOVT OF NUNAVUT

Item	Description	Part Number	Skid	Unit Type	Unit Price	Recommended Qty*	Criticality Rating
PRESSURE REGULATOR	REGULATOR-PRESS,40MICRON FLTR,WATTS	500615-MA-34	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity	R
PRESSURE REGULATOR	A PRECISION REGULATOR	3091001	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	10% of original quantity	R
PRESSURE SWITCH	SWITCH-PRESS,H100,483KPA INCREASING,U.E.	500615-MA-35	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each type or 10% of original quantity, whichever is greater	C
PRESSURE SWITCH	SWITCH-PRESS,J6X,276KPA INCREASING,U.E.	500615-MA-33	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each type or 10% of original quantity, whichever is greater	C
PRESSURE TRANSMITTER	TRANS-PRESS,0.50,FNPT,-100TO100KPA,E+H	500615-MA-11	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each size and type	C
PUMP	PUMP-CENT,0.75HP,600/60/3,RC200,PRICE	500615-MA-21	500615ZZ500615BOM	Maintenance/parts kit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) complete parts kit for each type	M
RELAY	RELAY,SPDT,24VDC,10A,FINDER,40.31	3040656	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	Three (3) sets of each type, size, and rating	C
RELAY	RELAY,BASE,FINDER,95.03	3040657	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	Three (3) sets of each type, size, and rating	C
RELAY	A RELAY,RETAINING CLIP,FINDER	3056595	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	Three (3) sets of each type, size, and rating	C

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Recommended Spare Parts List for U-500615 GOVT OF NUNAVUT

Item	Description	Part Number	Skid	Unit Type	Unit Price	Recommended Qty*	Criticality Rating
RELAY	B RELAY-CNTRL,40.31.8.120.0000,FINDER,120V	3083867	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	Three (3) sets of each type, size, and rating	C
ROTARY LOBE PUMP	PUMP-PD,7.5HP,600V,BOERGER PL200,Z-MOD L	3104268	500615ZZ500615BOM	Maintenance/parts kit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) complete parts kit for each type	M
SOLENOID VALVE	VALVE-SOL,0.50,N.C.,24VDC,BURKERT	500615-MA-37	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) valve of each size and type	C
TEMPERATURE TRANSMITTER	TRANS-TEMP,316,0.75,MNPT,0 TO 40C,E+H	500615-MA-13	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	One (1) of each size and type	R
TURBIDIMETER	A AE/AIT,TURB,1720E,CONTROLLER	3084195	500615ZZ500615BOM	Maintenance/parts kit, including spare lamp, calibration column, and calibration solution	Email gewater.parts@ge.com for an up-to-date quote.	One (1) maintenance kit per unit (replace unused kits every three (3) years)	M
TURBIDITY CONTROLLER	A CONTROLLER,2INPUT,HACH,SC200	3090984	500615ZZ500615BOM	Complete unit	Email gewater.parts@ge.com for an up-to-date quote.	10% of Original quantity	C

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SECTION 15

MATERIAL SAFETY DATA SHEETS

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MSDS Number: **G4774** * * * * * *Effective Date:* ***05/25/05*** * * * * * *Supercedes:* ***08/10/04***

MSDS *Material Safety Data Sheet*

From: Mallinckrodt Baker, Inc.
222 Red School Lane
Phillipsburg, NJ 08865

Mallinckrodt CHEMICALS

J.T.Baker

24 Hour Emergency Telephone: 908-859-2151
CHEMTREC: 1-800-424-9300

National Response in Canada
CANUTEC: 613-996-6666

Outside U.S. and Canada
Chemtrec: 703-527-3887

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

GLYCEROL

1. Product Identification

Synonyms: 1,2,3-propanetriol; glycerin; glycol alcohol; glycerol, anhydrous
CAS No.: 56-81-5
Molecular Weight: 92.10
Chemical Formula: C3H5(OH)3
Product Codes:
J.T. Baker: 2135, 2136, 2140, 2142, 2143, 2988, 4043, M778
Mallinckrodt: 0564, 5092, 5093, 5100

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Glycerin	56-81-5	90 - 100%	Yes

3. Hazards Identification

Emergency Overview

CAUTION! MAY CAUSE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT. MAY AFFECT KIDNEYS.

SAF-T-DATA$^{(tm)}$ Ratings (Provided here for your convenience)

Health Rating: 2 - Moderate (Life)
Flammability Rating: 1 - Slight
Reactivity Rating: 0 - None
Contact Rating: 1 - Slight
Lab Protective Equip: GOGGLES; LAB COAT; VENT HOOD; PROPER GLOVES
Storage Color Code: Green (General Storage)

Potential Health Effects

Inhalation:
Due to the low vapor pressure, inhalation of the vapors at room temperatures is unlikely. Inhalation of mist may cause irritation of respiratory tract.
Ingestion:
Low toxicity. May cause nausea, headache, diarrhea.
Skin Contact:
May cause irritation.
Eye Contact:
May cause irritation.
Chronic Exposure:
May cause kidney injury.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems or impaired liver or kidney function may be more susceptible to the effects of the substance.

4. First Aid Measures

Inhalation:
Remove to fresh air. Get medical attention for any breathing difficulty.
Ingestion:
Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention.
Skin Contact:
Immediately flush skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention if irritation develops.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get medical attention if irritation persists.

5. Fire Fighting Measures

Fire:
Flash point: 199C (390F) CC
Autoignition temperature: 370C (698F)
Slight fire hazard when exposed to heat or flame. Slight fire hazard when exposed to heat or flame.
Explosion:
Above flash point, vapor-air mixtures may cause flash fire.
Fire Extinguishing Media:
Use any means suitable for extinguishing surrounding fire. Water spray may be used to extinguish surrounding fire and cool exposed containers. Water spray will also reduce fume and irritant gases.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

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6. Accidental Release Measures

Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Contain and recover liquid when possible. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer!

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7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Isolate from incompatible substances. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

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8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
For Glycerin Mist:
- OSHA Permissible Exposure Limit (PEL):
Total Dust: 15 mg/m3 (TWA);
Respirable Fraction: 5 mg/m3(TWA).
- ACGIH Threshold Limit Value (TLV):
10 mg/m3

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.
Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded and engineering controls are not feasible, a half facepiece particulate respirator (NIOSH type P95 or R95 filters) may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest.. A full-face piece particulate respirator (NIOSH type P100 or R100 filters) may be worn up to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency, or respirator supplier, whichever is lowest. Please note that N filters are not recommended for this material. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.
Skin Protection:
Wear protective gloves and clean body-covering clothing.
Eye Protection:
Use chemical safety goggles. Maintain eye wash fountain and quick-drench facilities in work area.

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9. Physical and Chemical Properties

Appearance:
Clear oily liquid.
Odor:
Odorless.
Solubility:
Miscible in water.
Specific Gravity:
1.26 @ 20C/4C
pH:
(neutral to litmus)
% Volatiles by volume @ 21C (70F):
0
Boiling Point:
290C (554F)
Melting Point:
18C (64F)
Vapor Density (Air=1):
3.17
Vapor Pressure (mm Hg):
0.0025 @ 50C (122F)
Evaporation Rate (BuAc=1):
No information found.

10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage.
Hazardous Decomposition Products:
Toxic gases and vapors may be released if involved in a fire. Glycerin decomposes upon heating above 290C, forming corrosive gas (acrolein).
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Strong oxidizers. Can react violently with acetic anhydride, calcium oxychloride, chromium oxides and alkali metal hydrides.
Conditions to Avoid:
Heat, flames, ignition sources and incompatibles.

11. Toxicological Information

Oral rat LD50: 12,600 mg/kg. Investigated as a mutagen, reproductive effector.

```
--------\Cancer Lists\------------------------------------------------------
                                       ---NTP Carcinogen---
Ingredient                             Known    Anticipated    IARC Category
------------------------------------   -----    -----------    -------------
Glycerin (56-81-5)                      No          No             None
```

12. Ecological Information

Environmental Fate:
When released into the soil, this material is expected to readily biodegrade. When released into the soil, this material is not expected to evaporate significantly. When released into water, this material is expected to readily biodegrade. This material is not expected to significantly bioaccumulate. When released into the air, this material may be moderately degraded by reaction with photochemically produced hydroxyl radicals. When released into the air, this material may be removed from the atmosphere to a moderate extent by wet deposition.
Environmental Toxicity:
This material is not expected to be toxic to aquatic life.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Not regulated.

15. Regulatory Information

```
--------\Chemical Inventory Status - Part 1\---------------------------------
Ingredient                                       TSCA  EC   Japan  Australia
-----------------------------------------------  ----  ---  -----  ---------
Glycerin (56-81-5)                                Yes  Yes   Yes      Yes

--------\Chemical Inventory Status - Part 2\---------------------------------
                                                          --Canada--
Ingredient                                       Korea  DSL   NDSL  Phil.
-----------------------------------------------  -----  ---   ----  -----
Glycerin (56-81-5)                                Yes   Yes   No     Yes

--------\Federal, State & International Regulations - Part 1\----------------
                                           -SARA 302-    ------SARA 313------
Ingredient                                 RQ    TPQ     List  Chemical Catg.
-----------------------------------------  ---   -----   ----  --------------
Glycerin (56-81-5)                         No    No      No         No

--------\Federal, State & International Regulations - Part 2\----------------
                                                      -RCRA-    -TSCA-
Ingredient                                 CERCLA     261.33     8(d)
-----------------------------------------  ------     ------    ------
Glycerin (56-81-5)                         No         No         No


Chemical Weapons Convention:  No     TSCA 12(b):  No     CDTA:  No
SARA 311/312:  Acute: Yes      Chronic: Yes  Fire: No  Pressure: No
Reactivity: No          (Pure / Liquid)
```

Australian Hazchem Code: None allocated.
Poison Schedule: None allocated.
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

NFPA Ratings: Health: **1** Flammability: **1** Reactivity: **0**
Label Hazard Warning:
CAUTION! MAY CAUSE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT. MAY AFFECT KIDNEYS.
Label Precautions:
Avoid breathing mist.
Avoid contact with eyes, skin and clothing.
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.
Label First Aid:
If inhaled, remove to fresh air. Get medical attention for any breathing difficulty. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. Get medical attention if irritation develops or persists.
Product Use:
Laboratory Reagent.
Revision Information:
MSDS Section(s) changed since last revision of document include: 3.
Disclaimer:
****

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SECTION 16
GLOSSARY

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16.1 INTRODUCTION

The following sections define acronyms, abbreviations, and terms used within this manual and the water treatment industry in general.

This glossary is intended to address all aspects of the products and services offered by GE W&PT, and may include some information that does not apply to this system.

16.2 ACRONYMS & ABBREVIATIONS

The following table defines some of the most common short-hand terms, acronyms and abbreviations used within the industry.

Table 16.1 - Acronyms & Abbreviations

Acronym	Definition	Acronym	Definition
BBD	Brine Blowdown	MLSS	Mixed Liquor Suspended Solids
BMU	Brine Make-up	MLVSS	Mixed Liquor Volatile Suspended Solids
BOD	Biological Oxygen Demand	MMF	Multi-Media Filtration
c/w	complete with	MMI	Man Machine Interface (see HMI)
$CaCO_3$	Calcium Carbonate	MOV	Motor Operated Valve
CBD	Concentrate Blowdown	NaOCl	Sodium Hypochlorite
CEB	Chemically Enhanced Backwash	NaOH	Sodium Hydroxide
CFS	Cubic feet per second	ng/L	nanograms per liter
CIP	Clean In Place	NH_3	Ammonia
CLC	Controls Logic Chart	NO_2	Nitrite
COD	Chemical Oxygen Demand	NO_3	Nitrate
CPU	Central Process Unit	NTU	Nephelometric Turbidity Unit
CMU	Concentrate Make-Up	O_2	Molecular Oxygen
CN	Control Narrative	OI	Operator Interface
CR	Concentrate Recycle	OIT	Operator Interface Terminal
DCS	Distributed Control System	ORP	Oxidation reduction potential
DF	Dilute Feed	OSC	Operations Sequence Chart

Table 16.1 - Acronyms & Abbreviations

Acronym	Definition	Acronym	Definition
DO	Dissolved Oxygen	OSP	Off-Spec Product
EBCT	Empty bed contact time	OUR	oxygen uptake rate
ECIP	Electrode Clean In Place	PAC	Powdered Activated Carbon
ED	Electrodialysis	P&ID	Piping & Instrumentation Diagram
EDI	Electrodeionization	PDT	Pressure Decay Test
EDR	Electrodialysis Reversal	PC	Personal Computer
EF	Electrode Feed	PFD	Process Flow Diagram
EW	Electrode Waste	PID	Proportional Integral Derivative
ESD	Emergency Shutdown	PLC	Programmable Logic Controller
E^2PROM	Electronically Erasable Programmable Read Only Memory	POV	Pneumatically Operated Valve
$FeCl_3$	Ferric Chloride	ppb	parts per billion
GAC	Granular activated carbon	ppm	parts per million
GFD	Gallons per ft^2 per Day	psi	pounds per square inch
gpm	gallons per minute	psid	pounds per square inch differential
HCl	Hydrochloric acid	psig	pounds per square inch gauge
HCO_3	Bicarbonate	RAS	Return Activated Sludge
H_2S	Hydrogen sulfide	RO	Reverse Osmosis
H_2SO_4	Sulfuric Acid	SCADA	Supervisory Control & Data Acquisition System
H_3PO_4	Phosphoric Acid	scfm	standard cubic feet per minute
HMI	Human Machine Interface	SDI	Silt Density Index
kg/L	kilograms per litre	TDS	Total Dissolved Solids
kPa	kilo pascals	TKN	Total Kjeldahl Nitrogen
L	Litre	TMP	Transmembrane Pressure
LMH	Litres/m^2 of Membrane Area per Hour	µg/L	Micrograms per liter
LRV	Log Removal Value	USgpm	US gallons per minute
$FeCl_3$	Ferric Chloride	UV	Ultraviolet
LSI	Langelier Saturation Index	VFD	Variable Frequency Drive
MCC	Motor Control Center	VS	Volatile Solids
mg/L	milligrams per liter	VSS	Volatile Suspended Solids
MIT	Membrane Integrity Test	ZW	ZeeWeed

16.3 DEFINITIONS

AC MOTOR	A motor which consists primarily of a rotating cylinder called a rotor surrounded by a stationary part called a stator. Coil windings in the stator produce an alternating magnetic field which causes the rotor to turn. The rotor spins at a speed proportional to the frequency of the applied alternating current.
ACID	A solution which has an excess of hydrogen ($H^{\pm}$) ions and a pH of less than 7.0.
ACTIVATED SLUDGE	Particulates formed in unfiltered or settled wastewater due to the growth of bacteria and other organisms in the presence of dissolved oxygen (DO).
ACTUATED VALVE	Any valve that has been fitted with an actuator controlled by an external command.
ADSORPTION	Non-permanent attachment of a particular molecule to a solid substrate.
ADVISORY ALARM	A process alarm which notifies an operator that action is needed to prevent an impending shutdown, or to restore a component to a normal state.
AEROBIC BACTERIA	Any bacteria which require oxygen in order to survive.
AEROBIC ZONE	An environment that is completely devoid of oxygen.
AIR COMPRESSOR	Air compressors provide oil-free, pressurized air required for various aspects of system operation.
AIR DIAPHRAGM METERING PUMP	Air diaphragm metering pumps allow the operator to dispense chemical solutions at measured rates. Dosing rates are set manually and are regulated by adjusting either the pump's backpressure value or the amount of compressed air which drives a pump.
AIR DRYER	Air dryers protect pneumatic devices from damage by removing condensation from a compressed air flow.
AIR FLOW SWITCH	Air flow switches are used to indicate when a specific flowrate has been reached within a line supplying compressed air or other gas.
AIR RELEASE VALVE	Air release valves allow air to escape from fluid streams, thus preventing air locks and other issues related to entrapped air.

ALARM	A visual or auditory indicator which notifies the operator that he or she must take action to rectify or prevent an abnormal situation. An alarm may take the form of an illuminated warning light, an onscreen notice, a horn or other visual or auditory indicator.
ALARM BEACON	A visual indicator which notifies the operator that a component or process requires attention (example: a flashing light).
ALERT	A warning which informs the operator that a process or component is operating outside of acceptable limits and requires attention to prevent the occurrence of an alarm. An alert may take the form of an illuminated warning light, an onscreen notice, or other visual or auditory indicator.
ALTERNATION	A control scheme used when two or more components, such as pumps or blowers, are operated in parallel. Using this method, the unit that has been running for the longest time is stopped first, and the unit that has been in STANDBY for the longest time is started first.
ALKALINE	A solution which has an excess of hydroxyl (OH) ions and a pH of greater than 7.0.
ALKALINITY	A measure of the capacity of water to neutralize an acid. Alkalinity in water helps to resist changes in pH caused by the addition of acids.
ANAEROBIC BACTERIA	Bacteria which can survive in the partial or complete absence of free oxygen by using molecular oxygen found in nitrates and sulfates.
ANAEROBIC ZONE	An environment where there is an absence of free oxygen.
ANALOG	An electrical signal which is proportional to the size of the variable being monitored or controlled.
ANION	A negatively charged ion.
ANTISCALANT	A compound added to feedwater to increase the concentration at which scalants will precipitate, thereby increasing the efficiency of the membranes.
ANOXIC ZONE	An environment where there is a lack or absence of oxygen.
AUTOMATIC FLOW VALVE	Automatic flow valves are used when regular changes are required in the state of the valve, such as fully open or fully closed.

BACKPULSE	A mode of operation in which the usual (production) flowpath across a membrane is reversed. During a Backpulse, solids which have accumulated on the membrane surface are repelled, thus improving membrane permeability.
BACKWASH TMP TRIGGER	The TMP level at which a Backwash sequence becomes necessary in order to ensure normal production levels.
BACKWASH TROUGH	The trough on the side of the membrane tank that collects water during a Backwash and discharges it to the backwash channel.
BIOCHEMICAL OXYGEN DEMAND (BOD)	The amount of oxygen required by microorganisms to break down the organic matter in a water sample.
BIOCIDE	A chemical used to prevent biological growth.
BIOLOGICAL OXYGEN DEMAND (BOD)	*See* Biochemical Oxygen Demand.
BIOMASS	The mixture of bacteria, biosolids, and other biodegradable material present in a biological wastewater treatment system.
BIOSOLIDS	A byproduct resulting from the biodegradation of organics by bacteria.
BLOWER	Blowers are used to introduce air into certain tanks and other vessels. Depending on the application, this air may be used to recirculate influent within the tank, to scour membranes and prevent fouling, or to create an aerobic environment.
CASSETTE (ZEE-WEED)	A reinforced steel or plastic framework that provides structure and support for membrane modules and associated permeate and aeration piping. Regardless of the number of modules it contains, a cassette is typically considered a single unit in terms of monitoring and testing performance. Not all ZeeWeed systems include cassettes, but instead feature membrane modules supported directly within the membrane tank.

CHEMICAL OXYGEN DEMAND (COD)	A test in which a strong oxidizing agent is added to a sample in order to determine the amount of oxidizable organic matter within the sample (measured in mg/L). A sample's COD value is generally higher than its BOD value because more compounds can be chemically oxidized than can be biologically oxidized. Generally, a sample's BOD/COD ratio varies from 0.4 to 0.8.
CHEMICAL FEED REQUIREMENTS	The specific parameters, such as concentration and volume, for any pretreatment, cleaning, or other chemical solutions used in a system.
CHEMICALLY ENHANCED BACK-WASH (CEB)	A Backwash sequence during which a chemical cleaning solution is added to the reversed flow.
CHLORINE CON-TACT CHAMBER	A tank or other vessel wherein chlorine is added to water for the purpose of disinfection.
CIP MODE	The operating mode in which the system undergoes a Clean-In-Place (CIP) sequence.
CLEAN-IN-PLACE (CIP)	A cleaning method which involves exposing membranes to a chemical cleaning solution without removing them from the system or adjusting their position or orientation. A CIP sequence is typically accomplished by circulating cleaning solutions through the same feed and/or permeate lines used during production.
COAGULANT	A chemical agent which causes dissolved or fine impurities to group together (coagulate). Commonly used coagulants include ferric chloride and alum.
COAGULATION	The aggregation or "clumping" of dissolved or very fine impurities in water. Coagulation is usually achieved through the addition of a coagulant and is performed as a pretreatment step prior to filtration.
CO-CURRENT FLOW	A flow configuration in which the various production flows move in the same direction and parallel to the membrane surface.
COLOR	A notable tint or hue in water, often the result of decaying organic material or other impurities.
COMPOSITE MEMBRANE	A membrane with two or more distinct layers.

CONCENTRATE	The portion of the feed flow that does ***not*** pass through the membrane, and which contains an increased concentration of solids and ions. Also known as the reject, brine, or retentate flow.
CONCENTRATE RECYCLE (CR)	A method in which overall system recovery is increased by reusing a fraction of the concentrate flow. Also refers to the portion of the concentrate flow that exits the membrane stack before being repressurized by the concentrate recycle pump and returned to the stack concentrating flow.
CONCENTRATE FLOW	The process flow which passes through the concentrate chambers of an EDI stack.
CONCENTRATE BLOWDOWN (CBD)	The portion of a concentrate flow which is displaced by concentrate makeup and sent to waste.
CONCENTRATE MAKEUP (CMU)	The portion of the feed flow which is added to the concentrate recycle flow in order to control that flow's ionic concentration.
CONCENTRATION FACTOR	The amount of a given compound which is present in the concentrate flow compared to the amount which is present in the feed flow.
CONDUCTIVITY SENSOR	A device which measures the conductivity of aqueous solutions, primarily as a means of determining total ionic concentrations (example: dissolved compounds).
CONTACTOR	The component within a motor starter which protects the PLC by isolating it from the strong electrical currents necessary to run most motors.
CONTROLS LOGIC CHART (CLC)	Part of a system's Control Strategy. The CLC lists the control logic elements of a system, such as process variables, motors, valves, PID controls, alarms, and operator selections. For each control element, the CLC defines attributes such as tag number, description, unit of measure, range, setpoint, and control actions.
CONTROL NARRATIVE (CN)	Part of a system's Control Strategy. The CN describes the high-level functions of programmable controllers and operator interfaces, as well as various other control system details.
CONTROL STRATEGY	Documentation which defines the function of the various programmable controllers and operator interfaces used to control the system.

CONTROL VALVE Either a self-actuated valve or a valve with a positioning actuator (as opposed to an open/closed actuator). Generally used to adjust flow settings throughout the system.

CORROSION The attack upon metals by chemical agents, converting them to non-metallic products. Stainless steel has a passive film created by the presence of chromium (and often other alloying elements) that resists this process.

CRITICAL ALARM An alarm condition which notifies an operator to take immediate action in order to maintain production, preserve product quality, or to avoid a potentially unsafe situation.

CRITICAL FAILURE A condition which triggers an alarm and an immediate system shutdown in order to avoid endangering operators or damaging the system.

CROSS-FLOW FILTRATION A flowpath across and through a membrane where the feed and reject streams flow parallel to the membrane while the permeate stream flows perpendicular.

CROSS LEAK The hydraulic transfer of water between chambers in the EDI stack, moving from the dilute flow to the concentrate flow.

CURRENT The movement of electrons through a wire or other conductor. Current is measured in Amperes (A) or milliAmperes (mA). The current direction can be either direct (DC) or alternating (AC). The current draw of a motor is stamped on the unit's nameplate. This is the tested maximum ampere draw for the motor under full load conditions (FLA).

CURRENT DAY TOTAL A totalized value that is reset to zero at midnight.

CYCLIC AERATION VALVE Cyclic aeration valves control air flow to the ZeeWeed membrane cassettes. The PLC controls the operation of cyclic aeration valves according to setpoints defined by the operator.

DECHLORINATION The process of removing residual chlorine from water.

DECONCENTRATION A sequence during which the membrane tank is drained in order to reduce the average solids concentration when permeation is stopped.

DEMAND	A dynamic setpoint that is typically used for controlling a system with multiple process trains or units in parallel (example: an integer setpoint for the number of trains or pumps that should be running, or a flow setpoint for the desired system production rate).
DEMINERALIZATION	The process of reducing the quantity of minerals or salts in an aqueous solution.
DEMINERALIZING FLOW	The process flow which passes through the demineralizing compartments of the membrane stack.
DENITRIFICATION	The biological process by which nitrate is converted to nitrogen gas. This process occurs in the absence of free oxygen.
DIGITAL SIGNAL	A digital (discrete) electrical signal is either on or off. This type of signal is used for relaying simple on/off control signals related to specific devices, such as those triggered by alarm setpoints.
DILUTE FEED	The flow which serves as the feed source for deionization.
DISSOLVED OXYGEN (DO)	The amount of free oxygen dissolved within a fluid. DO is normally expressed in mg/L, ppm, or percent of saturation.
DISTRIBUTED CONTROL SYSTEM (DCS)	A centralized electronic monitoring and control system used to oversee the operation of multiple components and processes.
DRY CONTACT	An electrically isolated relay contact that is not directly connected to a power source. Dry contacts are typically used to send a contact closure to a remote control circuit where the circuit power comes from a remotely located controller.
EDUCTOR	A jet pump typically used to extract a fluid or powdery substance from a space.
EFFLUENT	The treated flow which emerges from a filtration system or other process. Also known as product.
EJECTOR	A device used to remove air from a tank, piping or other vessel.
ELECTRICAL POWER	The rate at which electrical energy is consumed by a process. Electrical power is calculated by multiplying the current by the voltage, and is generally expressed in watts (W), kilowatts (kW), or horsepower (Hp).
ELECTRICAL STAGE	Cell pairs bounded by two electrodes.

ELECTROMAGNETIC FLOWMETER (MAG METER) Electromagnetic flowmeters (mag meters) measure liquid flowrate.

ELEMENT The smallest replaceable membrane unit in a membrane filtration system.

EMERGENCY STOP A manually initiated system shutdown performed as quickly and safely as possible, usually by removing direct electrical power to the system.

ENGINEERED UNITS A numerical value that is correct for its unit of measure, and so does not need to be scaled for use or display.

EVENT An occurrence that is notable, but does not constitute an alarm condition.

FAULT An abnormal condition that affects a device's ability to perform its normal function. "Fault" should generally be used instead of "failure," "failed," or "faulted," and should not be used where "alarm" would be applicable.

FEED A flow which is directed into a filtration system or other process for the purpose of treatment.

FILTRATE A flow which has passed through a filtration process and now contains a reduced amount of solids or other contaminants. Also known as permeate if the filtration process involved the use of membranes.

FILTRATION CYCLE A repeated series of steps or sequences performed during a filtration process. Generally, the system's PLC oversees the status of the filtration cycle and the transition between stages as it progresses.

FLOC A mass of clumped solids or precipitates formed in feedwater by biological or chemical activity.

FLOCCULANT Materials that can precipitate into aggregates or flocs from finely suspended particles. After flocculants have formed, they can then be separated from the fluid which contains them using a filtration process.

FLOCCULATION The creation of aggregates or flocs from finely suspended particles that can later be separated from the fluid in which they are contained. Flocculation is often aided by the addition of a coagulant.

FLUX	The rate at which permeate passes through the filtration membrane, per unit of membrane surface area (calculated as permeate flowrate divided by membrane surface area). Flux is usually measured in GFD (gallons per square-foot per day) or LMH (liters per square-meter per hour).
FOOD-TO-MICROORGANISM RATIO (F:M)	The mass (kg) of organic matter fed to the bioreactor each day per unit mass of microorganism.
FOULANT	Unwanted materials that deposit on the surface of a membrane.
FOULING	The buildup of unwanted materials on the surface or within the pores of a membrane. Fouling reduces the active surface area of the membrane, and thus lowers permeability.
GLYCERIN (GLYCEROL)	Glycerin is the impure commercial form of glycerol. Glycerin is used to preserve membranes, specifically to prevent them from drying out or freezing during storage or transportation.
GLYCEROL	*See* glycerin.
HAND VALVES (FLOW CONTROL)	Flow control hand valves are used to control flow in situations where regular changes in flow are not required, with the valve either fully open or fully closed.
HAND VALVES (ISOLATION)	Isolation hand valves are used in situations where the valve is required only to be either fully open or fully closed, and where there is no need for regular adjustment. Common types of isolation hand valves include ball valves, butterfly valves, and gate valves.
HARDNESS	A measure of the amount of calcium and magnesium in water, both of which will cause scale to form on membranes if present in large enough quantities.
HEADLOSS	The drop in pressure experienced as water flows through a resin bed.
HIGH	A condition in which a process variable is greater than its normal value or range of values. This condition is typically used for control purposes and may trigger an advisory alarm if reached.
HIGH-HIGH	A condition in which a process variable is greater than a high setpoint. If reached, this condition typically triggers an automated shutdown.

HUMAN-MACHINE INTERFACE (HMI) An electronic operator interface which allows the operator to monitor and control the various components and processes in a system. Common examples of an HMI include a panel-mounted touchscreen with proprietary software, or an industrial computer workstation running a SCADA program.

HYDRAULIC RETENTION TIME (HRT) The time required for the feedwater flow to displace the working volume of a bioreactor in a continuous flow system.

HYDROMETER Measures the specific gravity of fluids.

HYDROXYL The anion of a water molecule. The chemical formula is OH^-.

IMMEDIATE SHUTDOWN ALARM A shutdown alarm condition that causes the process unit to stop immediately without performing the usual shutdown sequence, as continued operation would put operators and/or the system at risk.

INFLUENT A flow which enters a system, a process, or a tank or other vessel.

INPUTS/OUTPUTS Inputs/outputs refer to the direction of the electronic signal in reference to the PLC. Inputs are signals that come into the PLC via an external device. Outputs are signals that are sent from the PLC to an external device. Inputs/outputs can be either digital or analog signals.

INSIGHT GE W&PT's powerful plant process support tool, which provides fully automated process data monitoring and trend analysis.

INTERLOCK A control scheme which prevents a mechanism or action from being set in motion when another mechanism or action is in operation.

ION An electrically charged particle with a positive or negative charge, formed by the dissociation of a salt, mineral, or acid in water.

ION EXCHANGE The process by which cations and anions are removed from water through the use of resins to replace undesirable ions of a certain charge with desirable ions of the same charge.

ION EXCHANGE REGENERATION The process of restoring ion exchange resin to its fully charged state.

LANGELIER SATURATION INDEX (LSI) A measure of the tendency of water to dissolve or deposit calcium carbonate (scaling).

LEVEL SWITCH Level switches are placed in tanks to indicate changes in tank levels.

LEVEL TRANSMITTER Level transmitters measure the liquid level in a tank or other vessel.

LOW A condition in which a process variable is less than its normal value or range of values. This condition is typically used for control purposes and may trigger an advisory alarm if reached.

LOW-LOW A condition in which a process variable is lower than a low setpoint. If reached, this condition typically triggers an automated shutdown.

LUMEN The internal cavity within a hollow-fiber membrane through which air and permeate flow.

MAINTENANCE CLEAN (MC) A chemically enhanced cleaning procedure which may be performed using either a high-pH or low-pH chemical solution, depending on system requirements. MC sequences are generally automated and include aeration, Backpulse, and soak stages, however, specific details regarding this procedure tend to vary between systems.

MANIFOLD A flow which feeds several other flows.

MAN-MACHINE INTERFACE (MMI) *See* Human-Machine Interface (HMI).

MC-1 (CITRIC ACID) A proprietary cleaning chemical available from GE W&PT and designed to remove inorganic foulants from membranes.

MEMBRANE Thin barriers or films of material with many small pores of a predetermined size. These pores allow solvents and other smaller molecules, ions, or particles to pass through while preventing the passage of larger materials. Fluid which passes through a membrane is separated from the feed flow and is known as permeate.

MEMBRANE AERATION A process in which air is introduced into the feedwater in order to create bubbles (turbulence) which scour the membrane surface and dislodge foulants which may have accumulated there during production, thus improving permeability.

MEMBRANE BIOREACTOR (MBR) A biological wastewater treatment system that uses a membrane to separate water from biomass.

MEMBRANE BLOWER The air provided by membrane blowers is used to recirculate influent and to provide turbulence which helps scour accumulated foulants from membrane surfaces.

MEMBRANE INTEGRITY TEST (MIT)	A test used to determine the overall integrity of ZeeWeed membranes and to detect the presence of damaged fibers. The MIT procedure involves introducing pressurized air into the interior of the membrane fibers, and then measuring the rate at which that air escapes (depressurization). A rate of depressurization which is notably higher than what is seen when air naturally escapes across intact membranes is a strong indicator that broken, leaking fibers are present.
MEMBRANE PERMEABILITY	The ratio of the flux value and the transmembrane pressure at that flux value. Usually expressed in $L/m^2/h/kPa$ or GFD/psi.
MEMBRANE SURFACE AREA	A measurement of the effective surface area of a membrane.
METERING PUMP	An electronically-controlled, solenoid- or motor-driven diaphragm pump used for metering fluids, such as chemical solutions.
MHO	A measure of conductance, representing the ratio of the current flowing through a conductor, measured in amperes, to the potential difference between the end to the conductor, measured in volts. A mho is a unit of conductance equal to the reciprocal of the ohm, expressed as amperes/ volt.
MICROMHO (μMHO)	One millionth of a mho.
MICROSIEMENS (μS)	A measure of conductance equivalent to a micromho.
MIXED LIQUOR	The liquid mixture present in the aeration tank of an activated sludge system. The liquid is a mixture of activated sludge and water containing organic matter undergoing activated sludge treatment. The mixed liquor is a living “soup” of microorganisms that requires food, oxygen, nutrients, proper pH, and correct solids retention time.
MIXED LIQUOR SUSPENDED SOLIDS (MLSS)	A measure of the quantity of suspended solids in the aeration tank of an activated sludge treatment system. Mixed Liquor Suspended Solids (MLSS) is usually measured in milligrams per liter (mg/L).
MIXED LIQUOR VOLATILE SUSPENDED SOLIDS (MLVSS)	The portion of the Mixed Liquor Suspended Solids (MLSS) that vaporizes when heated to 550°C ± 50°C (1022°F ± 122°F). This volatile portion is mainly organic material and thus indicates the biomass present in the aeration tank. The portion of solids that does not vaporize is mostly inorganic substances.

MODULE (MEMBRANE, ZEEWEED)	A filtration device consisting of membrane fibers, top and bottom headers, and connection ports for air and permeate lines. A module is the smallest distinct portion into which a cassette can be divided.
MODULE FLOWRATE	The fluid flowrate through the module, which is normally equal to the sum of the permeate and concentrate flowrates. Measured in US gpm or liters/minute.
MOLECULAR WEIGHT CUT-OFF (MWCO)	The size of the pores in a membrane. The smaller the MWCO, the smaller the pore-size
MOTOR CONTROL CENTER (MCC)	The control panel which holds the motor starters and breakers for the motor-driven components in a system.
MOTOR FUNDAMENTALS	Key requirements which must be met in order to ensure a motor operates safely and at peak performance. These requirements will vary depending on the type of motor in question.
MOTOR ROTATION CHECK	The three-phase motors typically installed in large pumps can run either clockwise or counter-clockwise, depending on how they are wired. If a pump's three-phase power is disconnected, it is ***essential*** that the rotation of a pump's motor be verified before the pump is activated, as a pump may be severely damaged if started in reverse rotation. Also, always uncouple a pump prior to checking its rotation.
MOTOR STARTER	A starter allows the PLC to operate a motor while remaining electrically isolated from the motor circuit.
NAVIGATION	The process of moving from one graphic or pop-up screen on an operator interface to another.
NEPHELOMETRIC TURBIDITY UNIT (NTU)	A measurement of the turbidity (opacity) of water.
NITRATE	Nitrate (NO_3^-) is the most highly oxidized form of nitrogen found in wastewater. Total Kjeldahl Nitrate (TKN) is converted to nitrate during nitrification, and nitrate is converted to nitrogen gas during denitrification.
NITRIFICATION	The biological process by which ammonia is converted to nitrite and then to nitrate.

NITRITE	Nitrite (NO_2^-) is the middle step of nitrification, where ammonia is converted to nitrite and then to nitrate. Nitrite is relatively unstable and easily oxidized.
NO VERSUS NC SWITCH	A circuit which is either open (off) or closed (on). The circuit is considered closed if an electrical current is flowing through it, and open if there is no current.
NON-CRITICAL ALARM	An alarm condition which must be addressed in a timely fashion, but which does not require immediate attention.
NON-CRITICAL FAILURE	A process alarm condition which triggers an orderly shutdown of the system (that is, not an immediate stop).
NORMALLY OPEN (NO) SWITCH	An electrical configuration wherein the circuit is open when no forces are acting upon the switch.
NORMALLY CLOSED (NC) SWITCH	An electrical configuration wherein the circuit is closed when no forces are acting upon the switch.
OFF-SPEC PRODUCT (OSP)	Any portion of the product flow which does not meet product quality standards. Typically, off-spec product is either diverted back to the feed flow for retreatment or is sent to waste.
OPERATOR INTERFACE (OI)	An electronic display through which the system can be monitored and controlled. Also referred to as a Human-Machine Interface (HMI) or Man-Machine Interface (MMI).
OPERATOR INTERFACE TERMINAL (OIT)	*See* operator interface.
ORGANIC LOADING RATE	The mass of organic matter fed into a bioreactor each day per unit volume. Expressed as kg of COD/m^3 of nitrification reactor/d or kg of BOD_5/m^3 of nitrification reactor/d. The organic loading rate can be reported using the units of mg/L/min.
OPERATIONS SEQUENCE CHART (OSC)	Part of a system's Control Strategy. The OSC outlines the various sequences and steps involved in each operating mode. For each step in a sequence, the chart defines attributes such as pump states, valve actuations, step times, interlocks, and control actions.
OVERLOAD	A mechanism which causes a motor to shut down if the motor begins to overheat while drawing a higher current than its full load amperage (FLA) for an extended period.

OXYGEN UPTAKE RATE (OUR) The rate at which the microorganisms in a bioreactor use oxygen while consuming biodegradable materials. OUR can be a direct indicator of biological activity within the reactor, and is measured in mg of O_2 consumed per liter of biomass per minute.

PANELVIEW HMI (HUMAN-MACHINE INTERFACE) Provides an interface between the operator and the PLC. The PanelView screen enables the operator to monitor the system's operation. The touch-screen controls allow the operator to control the system.

PARTICLE COUNT The number of particles per 100 ml of water. Water can be microscopically examined using a particle counter, which classifies suspended particles by number and size.

PARTICLE COUNTER Particle counters are placed in piping to measure the particle count within a flow, verify membrane integrity, and ensure the quality of the permeate.

PARTICULATE Very small suspended solids in water. They vary in size, shape, density, and electrical charge, and can be gathered together by coagulation and flocculation.

PASSIVATION A chemical treatment used to expedite the natural passive quality of stainless steels. When exposed to air, stainless steels passivate naturally due to the presence of chromium. The rate of natural passivation varies. To ensure that a passive layer forms rapidly after pickling, a solution of nitric acid and water is applied to the metal surface. Passivation does not remove embedded surface contamination. Thorough water rinsing must follow all passivating treatments.

PASSIVE A characteristic condition of stainless steels which impedes normal corrosion tendencies and renders the steel passive to its environment.

PERMEATE The portion of the feed flow that passes through a membrane.

PERMEATE FLOWRATE (FLUX) The permeate flowrate per unit of membrane area. Permeate flowrate is typically expressed in gallons of permeate per square foot of membrane area per day (GFD) or in liters of permeate per square meter per day (LMH).

PERMEATE HEADER The piping which connects to the permeate manifolds and combines the permeate from these manifolds into a single flow.

PERMEATE MANIFOLD The piping which collects permeate from the membrane modules and transfers it to the permeate header.

PICKLING After stainless steel has been heated, such as during welding, an oxide scale which can lead to contamination will form on the surface if it is not cleaned with a pickling solution or paste, which removes oxides and loosely embedded iron.

PH The measure of the acidity or alkalinity of a solution, based on the concentration of hydrogen ions which it contains. pH values are expressed as numbers on a scale of 0 (highly acidic) to 14 (highly basic).

PH ANALYZER pH analyzers measure the pH levels within a flow or vessel.

POP-UP SCREEN A screen which is displayed on the onscreen interface when the corresponding button or symbol is selected. The pop-up screen overlays a portion of the primary graphical screen from which it was opened. Pop-up screens are typically used to access specific functions, such as controlling a component directly or entering setpoints.

POWER SUPPLY A device that converts an AC input to a DC output.

PORE SIZE The size of the holes in a membrane.

PPM Parts per million. 1 ppm is equal to 1 mg/L (assuming a specific gravity of 1.0).

PRESSURE DROP A loss of pressure due to friction or flow restriction.

PRESSURE DECAY TEST (PDT) *See* Membrane Integrity Test.

PRESSURE GAUGE A device used to measure the pressure of a gas or liquid.

PRESSURE TRANSMITTER Pressure transmitters relay the current pressure level within a tank, pipe, or other vessel to the PLC. The signal sent from a pressure transmitter is often associated with a setpoint which will trigger an alarm if the pressure level moves outside an acceptable range.

PROCEDURE A set of properly defined actions which must be performed in order to achieve a specific goal, such as activating the system or resolving an alarm issue.

PRODUCT *See* effluent.

PROGRAMMABLE LOGIC CONTROLLER (PLC) A microprocessor-based controller which uses programmable memory to store the instructions for performing a specific process. The main components of a PLC include the power supply, processor, memory, input interface, and output interface.

PROPORTIONAL CONTROL A control scheme in which the controller output is adjusted in order to maintain a required ratio between two process variables. (Example: proportional control is used to vary the speed of a chemical dosing pump in proportion to the flowrate of the stream into which the chemical is being added.)

PROPORTIONAL INTEGRAL DERIVATIVE (PID) CONTROL LOOP Feedback control with proportional, integral, and derivative control action. This control method allows the PLC to manipulate a physical device (control variable) to achieve a setpoint by constantly observing the response (process variable).

RATE The tuning parameter for the derivative control action of a PID controller.

RECOVERY The amount of feed recovered as product divided by the total amount of feed supplied to the system. High recovery ratios mean that a large percentage of feed is collected as product, whereas a low recovery results in most of the feed exiting the system as reject.

RECOVERY CLEAN (RC) A chemically enhanced cleaning procedure which may be performed using either a high-pH or low-pH chemical solution, depending on system requirements. RC sequences are generally semi-automated and involve highly concentrated cleaning solutions and extended soak periods. This sequence is typically performed only when fouling has become extensive, or when other cleaning sequences have failed to adequately restore membrane permeability.

RECTIFIER An electrical device which changes AC power to DC power.

REDOX/ORP ANALYZER The redox analyzer measures the ability of a solution to act as an oxidizing or reducing agent. Positive readings indicate an oxidizing agent, while negative readings indicate a reducing agent.

REINFORCED FIBER A hollow-fiber membrane which consists of an outer (membrane) layer supported by an underlying braided support structure.

RESET The process of using a manual reset button to clear an alarm condition after it has been resolved. The tuning parameter for the integral control action of a PID controller.

RESIDUAL CHLORINE ANALYZER	Residual chlorine analyzers measure the level of chlorine present in a flow or within a tank or other vessel. The signal sent from an analyzer is often associated with a setpoint which will trigger an alarm if the chlorine level moves outside an acceptable range.
RETENTATE	*See* reject.
REJECT	The portion of the feed flow that does not pass through the membrane. Also known as brine, concentrate, or retentate.
RUNTIME METER	A runtime counter for a motor or other process unit.
SCALE	A type of fouling which forms on the surface of a membrane due to the accumulation of calcium carbonate or calcium sulfate.
SCALING	*See* scale.
SEQUENTIAL CONTROL	A control function in which the states of pumps, valves, and other control devices are adjusted according to a series of operational steps.
SETPOINT	An adjustable value related to a specific process variable, such as a target flowrate or temperature. After an operator has defined a setpoint, the PLC will oversee all related operations in accordance with the value which the operator has provided.
SHUTDOWN ALARM	An alarm which notifies an operator that action is needed to allow a stalled or disrupted component to resume operation, or to resolve a condition which makes continued operation unsafe or otherwise undesirable.
SILICA ANALYZER	A device which measures the silica concentrations in a liquid.
SLUDGE WASTING RATE	The volume of excess biological sludge which is removed (wasted) from the bioreactor.
SODIUM HYPOCHLORITE (NAOCL)	A strong oxidant and disinfectant chemical commonly used in cleaning solutions intended to remove biological fouling from membranes, piping, tanks, and other vessels.
SOLENOID VALVE	Valves which are overseen by the PLC and which provide on/off control for low flow volume locations, such as the air line connected to a pneumatically operated valve.

SOLIDS RETENTION TIME (SRT) The time required to remove the working volume of the bioreactor's mixed liquor according to the average flowrate of sludge being wasted from the system.

SOLUTE Material, such as salt, which can be dissolved by a solvent, such as water.

SOLVENT Any material which can be used to dissolve another (example: water). The solvent constitutes the dissolving medium, or liquid portion, of a solution.

STRAINER A perforated sieve or filter used to trap debris and other particles contained in a flow.

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) A computer system which collects and records process data and provides a graphical user interface through which the operator can monitor and control the system. The center of the system's control structure and the link between the PLC and the operator.

SWITCH A device which produces a binary signal in response to an operator action or other physical stimulus. (Example: a level switch converts a change in tank level into a binary signal which may be compared with the associated level setpoint(s).

SYSTEM RECOVERY *See* recovery.

TANK HEATER A heating unit which allows operators to adjust the temperature of the contents of a tank or other vessel.

TEMPERATURE TRANSMITTER Temperature transmitters monitor temperature levels at various locations throughout the system. The signal sent from a transmitter is often associated with a setpoint which will trigger an alarm if the temperature level moves outside an acceptable range.

TOTAL DISSOLVED SOLIDS (TDS) The concentration of all solids dissolved in a solution (normally expressed in ppm).

TOTAL KJELDAHL NITROGEN (TKN) The total concentration of nitrogen present in a sample as ammonia or bound in organic compounds (usually expressed in mg/L).

TOTAL ORGANIC CARBON (TOC) A measure of the amount of organic materials suspended or dissolved in a liquid sample.

TOTAL SOLIDS (TS) A measure (by weight) of the amount of material that is dissolved or suspended in a liquid sample. TS is determined by allowing a known volume to evaporate, and then weighing the remaining residue.

TOTAL SUSPENDED SOLIDS (TSS) A measure of the solids contained in a liquid sample which can be removed by filtration (normally expressed in ppm).

TRAIN (ZEEWEED) A series of membrane tanks or cassettes arranged as a single unit and connected to a common header through which permeate is drawn. A system may consist of a single train or may include multiple trains arranged in parallel. The number of tanks or cassettes included in a train can vary depending on system type and requirements.

TRANSMEMBRANE PRESSURE (TMP) The difference in pressure across a membrane (that is, between the outer and inner surface of membrane). TMP is the driving force behind cross-membrane filtration, and is created by either increasing pressure or by creating a partial vacuum on one side of the membrane.

TRIGGER Allows a change in operation. A trigger is a normal event which can clear an alarm or be one of several points in a sequence of events.

TURBIDITY A measure of the extent to which light penetrates a liquid, as a means of determining the amount of sediment or other particles suspended in the fluid. Turbidity is expressed in Nephelometric Turbidity Units (NTU).

TURBIDITY METER (TURBIDIMETER) Turbidity meters monitor the turbidity of a flow or of the contents of a tank or other vessel. The signal sent from a turbidity meter is often associated with a setpoint which will trigger an alarm if the turbidity level moves outside an acceptable range.

ULTRAFILTRATION (UF) A filtration method used to remove suspended solids, bacteria, and viruses from water or other liquids. Ultrafiltration systems typically operate at comparatively low pressures and use hollow-fiber or rolled membrane elements.

ULTRAVIOLET (UV) A form of radiation (light) which is lethal to most forms of bacteria, viruses, and parasites. As a result, UV is often used as a treatment step in potable water applications.

UNREINFORCED FIBER A hollow-fiber membrane which does not include an underlying support braid.

VACUUM DEGASIFIER A vertical tank within which a vacuum is created and through which water droplets descend to remove dissolved gas.

VACUUM PUMP Vacuum pumps remove entrained air from within piping and other vessels containing liquid.

VALVE TEST A procedure for manually testing the condition of motor-operated valves.

VARIABLE FREQUENCY DRIVE (VFD) An electrical device which automatically adjusts the speed of a motor in response to an external signal. A VFD controls motor speed by changing the frequency of the alternating current used to power the motor.

VOLATILE SOLIDS (VS) The total amount of suspended and dissolved solids contained in a liquid sample which are volatile at 550°C (1,022°F).

VOLATILE SUSPENDED SOLIDS (VSS) Suspended solids which can be filtered from a liquid sample and which are volatile at 550°C (1,022°F).

VOLTAGE The difference in electrical potential across two points. Voltage is measured in volts (V).

WATER HAMMER Instantaneous surges in liquid pressure caused by sudden interruptions in the flow.

WATER SOFTENING The exchange of sodium through ion exchange.

ZENOGEM GE W&PT’s patented process wherein ZeeWeed membrane technology is used to treat effluent from a bioreactor.

ZEEWEED GE W&PT’s immersible hollow-fiber UF technology.