OPERATION AND MAINTENANCE MANUAL

PURON® Single Header Wastewater Treatment Module

Models: PSH1800, PSH660, PSH330

Prepared for:
SHTANG KM973596

Prepared by:
Koch Separation Solutions, Inc. (KSS)
850 Main Street
Wilmington, MA 01887
Phone: 1-978-694-7000
Fax: 1-978-694-7291
www.kochseparation.com

Approved By: Simone Galluzzi, Project Manager

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1.0 SAFETY INFORMATION

This Manual highlights certain potential hazards related to the handling, operation and maintenance of the Equipment. The intent of this Manual is to enhance and supplement any safety and health standards that are applicable to the facility in which the Equipment is being used. The Manual does not cover the full spectrum of published safety and health standards that are mandated by law. Consequently, users shall not assume that they are responsible only for those standards referenced in this Manual or that those standards quoted are current. The user of this Manual remains at all times responsible for compliance with all applicable safety rules, regulations and standards, for ensuring that its own safety program includes such compliance and for operating and maintaining the Equipment in accordance with prudent industry practice. In the event of a conflict between the provisions of this Manual and applicable local, state or federal safety and health laws, regulations and/or standards, the more stringent shall apply and must be strictly followed.

1.1 Safety Symbols and Guidelines

Failure to follow any of the safety guidelines contained in this Manual, to comply with applicable federal, state and local safety rules, regulations and standards or to operate and maintain the Equipment in accordance with prudent industry practice can result in a potentially hazardous situation. The severity of the potentially hazardous situations highlighted in this Manual has been indicated using the symbols listed below.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

⚠ WARNING

WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

⚠ DANGER

DANGER indicates an imminently hazardous situation, which, if not avoided, **will result** in death, serious injury, or equipment damage.

1.2 Dangers, Warnings, and Cautions

DANGER

DANGER indicates an imminently hazardous situation, which, if not avoided, **will result** in death, serious injury, or equipment damage.

DANGER - PRESSURIZED DEVICE: Improper installation, operation or maintenance of the Equipment, including but not limited to the membrane housings, electrical system, and piping may cause loss of life, severe bodily injury and/or property damage. Read and understand all equipment guidelines given before attempting to open, operate, or service the Equipment. Failure to follow these instructions and observe every precaution may result in malfunction and could result in catastrophic failure. Misuse, incorrect assembly or use of damaged or corroded components can result in high velocity release of hardware.

WARNING

WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

WARNING: Certain operating situations require the use of chemicals and other hazardous substances. Material Safety Data Sheets (“MSDS”) should be provided by chemical suppliers and all instructions therein must be adhered to. Safety briefing of the operating personnel should be carried out by plant health & safety personnel. Always use caution and wear the correct personal protective equipment (“PPE”) when handling any chemical!

WARNING: Comply with all pressure and temperature limits specified in the technical data for the operation of the modules.

WARNING: The use of chemicals that are not approved or in concentrations which are higher than those specified herein can cause premature failure of the Equipment, including the membrane modules.

WARNING: Do not perform any Equipment or membrane maintenance unless the system control power is OFF, the pump starters are OFF, lock out/tag out procedures have been followed and INTERNAL PRESSURE HAS BEEN RELIEVED from the Equipment. Failure to do so may result in serious injury or death.

WARNING: Do not drink treated water. The treated water is NON-POTABLE!

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

CAUTION: The membranes must not be allowed to dry out. The membranes must remain moist any time the Equipment is shut down for any reason, including maintenance. Membrane dry-out will result in irreversible membrane damage.

CAUTION: No anti-foam agents of any kind are to be introduced into the Equipment, without prior review and written approval from KSS. Where such approval is provided, the anti-foam agents may only be introduced in accordance with the conditions specified by KSS as part of the approval.

CAUTION: No silicone-based materials, such as waterproofing sprays, lubricating or cutting fluids, or greases, are to be used in or around the Equipment. Using these materials in the Equipment, in any amount, can cause complete and irreversible membrane fouling.

1.3 "Do"s and "Don't"s

DO – Conduct a site specific safety review before installation and operation of the Equipment.

DO – Install and operate the Equipment following the recommendations in this manual.

DO – Familiarize yourself with this entire Manual and the Equipment, including the controls, before attempting to operate or perform maintenance on the Equipment.

DO – Follow equipment manufacturer recommendations for operation and maintenance.

DO – Wear the appropriate personnel protective equipment.

DO – Routinely inspect for wear and tear on Equipment and perform maintenance when necessary.

DO – Monitor the Equipment's performance and maintain log sheets.

DO – Contact KSS with any questions or concerns related to the Equipment.

DO – Follow all applicable safety practices and precautions.

DON'T – Install or operate the Equipment without knowledge of its operations.

DON'T – Allow unqualified personnel to operate or perform maintenance on the Equipment.

DON'T – Allow unsafe conditions: such as water on the floor, worn equipment, exposed wires, etc. to be tolerated.

DON'T – Exceed the temperature, pressure, chemical limits of the membrane and/or Equipment.

DON'T – Use chemicals without prior review and understanding of their MSDS information and compliance with applicable safety precautions.

DON'T – Use chemicals which have not been approved by KSS in writing.

DON'T – Operate the system for purposes other than those described in this manual.

DON'T – Allow the biomass to die.

FAILURE TO FOLLOW ANY OF THE REQUIREMENTS SET FORTH IN THIS MANUAL WILL INVALIDATE ANY AND ALL WARRANTIES APPLICABLE TO THE EQUIPMENT, INCLUDING THE MEMBRANE MODULES.

1.4 Preconditions to Warranty

The MBR system shall be properly installed, operated, and maintained in accordance with KSS operating instructions as set out in this Operational and Maintenance Manual and with prudent industry practices.

The following preconditions must be met by the Buyer and the System Operator:

A. The Buyer and the System Operator must comply with the requirements of the O&M Manual at all times. Without limiting the general nature of the foregoing statement, Buyer and the System Operator must maintain a log, a copy of which shall be made available to KSS each month of operating, cleaning, maintenance and storage data in a format that is in conformance with the requirements of the O&M Manual.

B. Feed to the MBR system shall meet the critical influent characteristics as described in Appendix I of this manual.

C. There must be no addition of chemicals which cause precipitation on the permeate side of the membrane modules subsequent to filtration.

D. Feed to the MBR system shall not contain silicone based anti-foaming agents or other agents which cause deterioration or structural failure of polymeric plastics (for example organic solvents) or irreversible fouling of the membrane modules.

E. Sharp edged particles like sand, scale or glass can damage the membrane modules. Suitable provisions are to be made to prevent sharp edged particles from entering, forming or accumulating within the MBR system.

F. Wastewater should be screened through a 1-2-mm screen prior to entering the MBR system.

G. All pretreatment processes and the equipment associated with those processes must be in proper working order, adequately sized, and operated and maintained in accordance with manufacturer s instructions and prudent industry practices.

H. The PURON® membranes should be stored per KSS instructions.

I. Membrane warranty only applies to installation of the membranes in the designated system per the design described in Appendix I of this O&M manual.

J. KSS doesn’t warrant membranes subjected to any accident, misapplication, environmental contaminant, corrosion, damage, debris, abuse or misuse.

2.0 GLOSSARY

Aerobic Zone: A zone in the bioreactor that is characterized by high levels of dissolved oxygen. In the aerobic zone, the oxygen level is measured and maintained at an optimal level through the addition of air.

Anoxic Zone: A zone in the bioreactor that is characterized by low levels of dissolved oxygen. In the anoxic zone, no oxygen is added to the digestion process.

Backflush Cycle: An operation used during Process Mode to maintain a low Transmembrane Pressure. Backflush uses permeate which is pumped in the reverse direction, back through the membrane fibers, to lift the fouling layer off the membrane.

Bioreactor System: A system which supports a biologically active environment which is used to treat wastewater. Bioreactor system typically includes Anoxic and Aerobic Zones.

BOD: Acronym for **B**iochemical **O**xygen **D**emand. This quantitative test measures the amount of oxygen the biology consumes during digestion and is proportional to the amount of organics in the sample.

CEB: Acronym for **C**hemically **E**nhanced **B**ackflush.

Cleaning Mode: The operating mode used to remove foulants and restore flux by chemically cleaning and rinsing the membranes. Also called CIP (Clean in Place).

COD: Acronym for **C**hemical **O**xygen **D**emand. This quantitative test measures the oxygen equivalent of the organic material in the wastewater that can be oxidized chemically.

Equipment: The PURON® submerged membrane module(s) and any ancillary equipment provided by KSS as part of its scope of supply.

Feed: The fluid entering a membrane process.

Filtration Mode: The operating mode in which the membranes filter biologically treated water.

Flux: The rate of permeation of the fluid through the membrane pores. Flux is usually expressed in “lmh”, where lmh = liters/square meters of installed membrane area per hour or in “gfd”, where gfd = gallons per square foot of installed membrane area per day.

F_{low}: A flux mode that is characterized by a moderate rate of permeate removal. It is triggered by a moderate level in the bioreactor and normal influent flow.

F_{high}: A flux mode that is characterized by a high rate of permeate removal. It is triggered by a high level in the bioreactor or high influent flow.

Fouling: The accumulation of material at the membrane surface. As MBR systems are operated at a set flux, TMP increases as a result of fouling.

Hollow Fiber Module: The product containing the hollow fiber membrane elements that is physically connected to the permeate manifold of the Equipment.

HMI: Acronym for **H**uman **M**achine **I**nterface. The HMI enables the operator to change PLC inputs from this touch screen.

MBR: Acronym for a **M**embrane **B**ioreactor.

Membrane Bioreactor System: A system which combines membrane filtration with bioreactor technology. The coupling of the two technologies allows for a more efficient process, as the water removed by the membrane system increases nutrient concentrations which will increase digestion.

Maintenance Cleaning: A chemically enhanced backflush cleaning of the membranes, done *in situ* (in the sludge).

Permeate: The fluid that passes through the membrane. Also referred to as filtrate or product water.

Permeate Pressure: The pressure measured on the permeate side of the membrane modules. This pressure is used to calculate the transmembrane pressure.

PLC: Acronym for **P**rogrammable **L**ogic **C**ontroller. This device takes inputs from various devices contained throughout the system, scans them, and according to logic will change the state of various outputs.

Production Mode: The mode that produces permeate water from raw water feed. This operating mode includes Filtration (Process), Backflush, Ventilation and De-aeration steps

Process Mode: The operating mode in which the membranes filter wastewater.

Recovery Cleaning: An intensive cleaning, done with the membranes submerged in a cleaning solution and lasting up to 12 hours per chemical cycle.

Sludge: The solids portion of the biological treatment system.

Transmembrane Pressure (TMP): The difference between the feed side pressure and the permeate pressure. Low TMP indicates a less fouled membrane and High TMP indicates a more fouled membrane.

Traverse: Hanging frame that connects to a PURON module to install it into the membrane tank.

Turbidity: The cloudiness (haziness) of a fluid. Haze is created by the presence of suspended solids.

Ultrafiltration (UF): UF is physical separation process used for the removal of suspended solids and microbiological species ranging in size between 0.001 and 0.05 µm.

3.0 INTRODUCTION

3.1 Ultrafiltration

Ultrafiltration is a process in which semi-permeable membranes are used to separate water and some dissolved solids from a mixture that is submitted for processing.
In a PURON® system, this process stream is typically mixed liquor (wastewater and activated sludge biomass) fed from the aerobic zone of a bioreactor. This mixed liquor is fed into a tank in which a PURON module is submerged.

3.2 The PURON Module

The membrane utilized in a PURON module is a hollow fiber configuration. The nominal pore size of this membrane is 0.03 µm. Larger molecular weight materials (e.g., bacteria and pathogens) are rejected while lower molecular weight materials (e.g., water and dissolved solids) pass through the membrane surface. A braid inside the membrane material gives the fiber high mechanical strength to prevent fiber breakage during operation. A schematic drawing of a single PURON membrane fiber is shown in Figure 3.1.

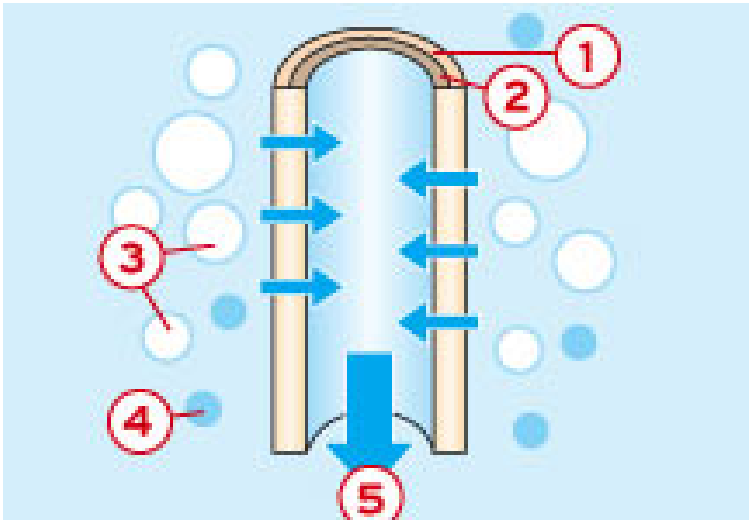


Figure 3.1: PURON Membrane Fiber
Legend: (1) filter surface (2) braid (3) bacteria
(4) viruses (5) filtrate removal

PURON fibers are grouped into fiber bundles as depicted in Figure 3.2. In this configuration, the lower ends of the fibers are potted and the upper ends are individually sealed and free to move laterally. During operation, a vacuum is pulled on the bottom of the fiber bundle. As this happens, permeate is drawn through the membrane surface leaving behind material larger than the membrane pore size. To prevent the fibers from fouling, an aeration stream is directed through the fiber bundle by an aeration nozzle.

Aeration helps to break up the material that does not pass through the membrane and accumulates on its surface.

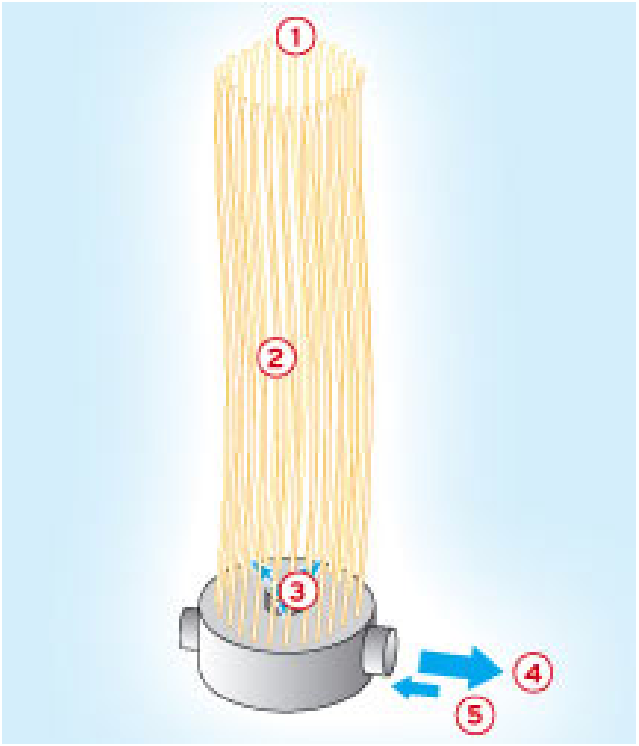


Figure 3.2: PURON Membrane Fiber Bundle

Legend: (1) sealed ends (2) membrane fibers
(3) central aeration (4) filtrate removal (5) backwashing

The fiber bundles are, in turn, arranged in membrane module rows. Lateral fiber supports in the frame of the membrane module row hold the upper ends of the fibers in an upright position during installation.
The membrane module rows are stacked together and enclosed in a stainless steel frame to form a PURON module. The PURON module is specifically suited for use in MBRs where modules are submerged into activated sludge mixed liquor.

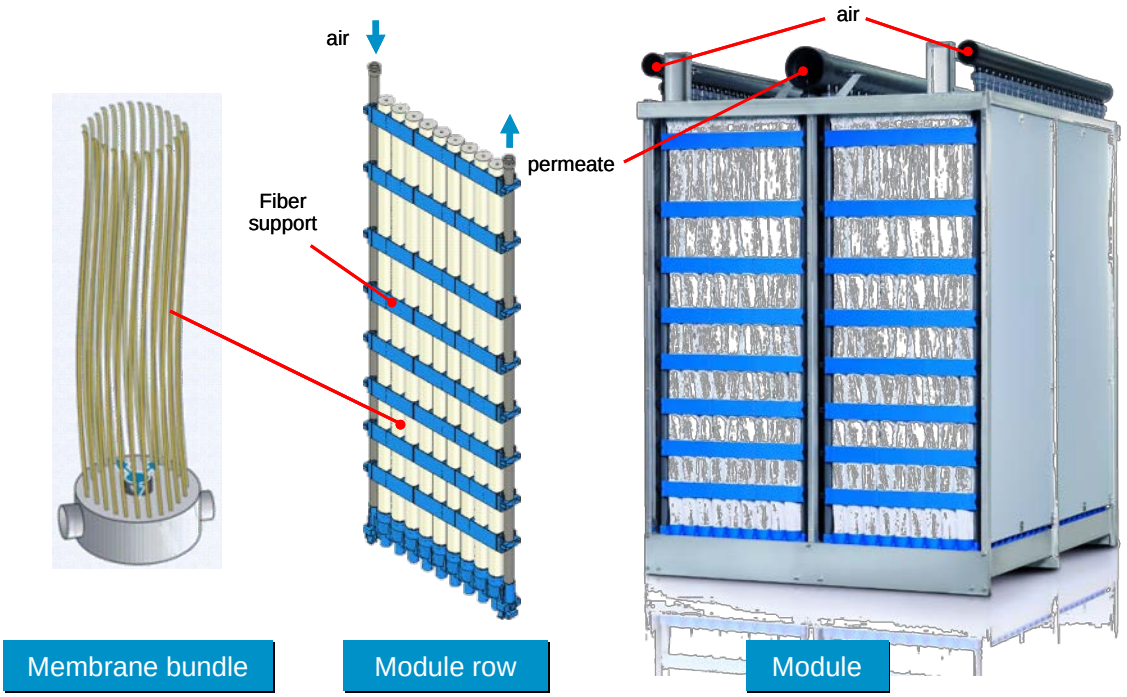


Figure 3.3: PURON bundle, row and module.

The overall area of the PURON module depends on the number of membrane module rows included in the module. KSS has four standard module sizes:

PSH 41 – module row, base unit for the PSH 330, PSH660 and PSH1800 modules
PSH 330 – module comprised of eight (8) PSH 41 rows
PSH 660 – module comprised of sixteen (16) PSH 41 rows
PSH 1800 – module comprised of forty-four (44) PSH 41 rows

Detailed drawings of these modules are available on request.

The main Module dimensions for the PURON modules are indicated in the Product Data Sheet, see Appendix A. The eventual support (hanging frame) dimensions and position of the interfaces (such as pipe flanges) must be determined in conjunction with the planning engineers / designers of the customer.

4.0 PROCESS DESCRIPTION

This Process Description section is focused on the theory of the following operations:

- Pretreatment
- Biological Processes
- Membrane Filtration Unit

4.1 Pretreatment

The water must first pass through a fine screen. Minimally, one based on 2 mm punched holes; wedge wire screens are not allowed in sewage applications. It is necessary to prevent by-pass of the fine screen for proper system operation to prevent hair, rag, plastic, and sanitary deposits in the module.

The membrane modules must be protected from abrasives by clearing the membrane tank of sand, grit or any other abrasive particles prior to membrane installation. Once the modules have been installed, the feed to the modules must be treated to remove any abrasive materials such as rust, scale, flakes, sand, grit and granular abrasive materials. Such materials will damage the membrane.

The pretreatment scheme can be as follows:

- Coarse screening using a 6 to 10 mm moving step screen with round apertures
- Passed through a grit removal system
- Fine screening using a 1 to 2 mm punched hole screen

Other pretreatment schemes are acceptable as long as they provide adequate protection to the membranes. The client shall be responsible to maintain correct function of the screen mechanisms and to promptly remove any accumulated sand from the bottom of the process tanks.

The use of any chemicals added to the wastewater treatment process (e.g.: polymers, coagulants, antifoams) that may come in contact with the membranes must be approved by KSS prior to use.

Fat, Oil and Grease (FOG) concentration shall not exceed 150 mg/L of emulsified FOG in the feed to the bioreactor with no free oil and less than 10 mg/L of mineral or non-biodegradable oil.

4.2 Biological Processes

4.2.1 Anoxic Zone

The primary function of the anoxic process is denitrification or nitrate reduction. In the absence of dissolved oxygen, the biomass oxidizes organics using available oxygen atoms from nitrate (NO_3^-). The reaction reduces nitrate to nitrogen gas which is stripped in the subsequent aerobic step.

Anoxic Reaction:

Nitrate Reduction - NO_3^- + Organic Carbon (e.g., Sucrose) → $N_2 + CO_2 + H_2O + OH^-$

Within the anoxic tank, a mixer blends the screened wastewater with the mixed liquor return from the aerobic tank at a pre-determined recycle rate to achieve optimal bio-reaction.

4.2.2 Aerobic Zone

The denitrified wastewater passes into the aerobic zone. In this zone the biomass is supplied with oxygen by injecting and dissolving air from the process air blower into the mixed liquor through fine bubble diffusers. A properly functioning dissolved oxygen (DO) sensor must be used to ensure that the required level of oxygen is maintained in the tanks for the aerobic digestion. In this oxygen-rich environment, organic materials (as measured by BOD or COD testing) and ammonia are biologically oxidized to carbon dioxide, nitrate and water.

Aerobic Reactions:

BOD Reduction - Organics + O_2 → $CO_2 + H_2O$ + biomass
Ammonia Reduction - $NH_4^+ + 2O_2$ + Alkalinity → $NO_3^- + H_2O$

From the aerobic tank, activated sludge is pumped or gravity fed into the membrane filtration tanks for biomass/water separation. Return activated sludge (RAS) overflows or is pumped from the membrane tanks into the aerobic or anoxic zone of the bioreactor. This circulation flow serves the purpose of maintaining a moderate Mixed Liquor Suspended Solids (MLSS) concentration in the membrane basins.

4.3 Membrane Filtration Unit

The PURON® membranes are immersed in the membrane tanks and use suction pumps (permeate / backflush pumps) to create a vacuum on the permeate side of the membrane. This vacuum is the force which pulls permeate through the membrane.

As permeate is removed through the membrane, solids will tend to build up and form a cake layer that acts as a barrier to flow. To combat this, a coarse bubble aeration stream is applied which helps to scour solids off the surface of the membrane. In addition to aeration, the fibers are periodically backflushed with permeate water. Backflushing forces water from the inside to the outside of the fibers. This reverse flow serves to remove from the membrane surface any accumulated solids that have not been removed by the air scour.

To combat the gradual membrane organic/inorganic fouling, there are two types of chemical clean operations used by the membrane system. Maintenance Cleans (MC) are short cleans with diluted chemical solution back-diffused through membrane fibers that are automatically completed at pre-scheduled intervals. Sodium hypochlorite MCs are typically performed on a more frequent basis while acid MCs are commonly performed on an as needed basis depending on the scaling potential of the water. The purpose of

maintenance cleaning is to maintain a high membrane permeability (i.e. a low transmembrane pressure) on a day to day basis. While MCs are generally effective at maintaining the membrane permeability, some foulants accumulate on the membrane surface over time. Recovery Cleans (RC) are more intensive cleaning operations designed to remove all accumulated fouling material. RCs are typically performed once per year and are initiated manually.

FAILURE TO FOLLOW ANY OF THE REQUIREMENTS SET FORTH IN THIS MANUAL WILL INVALIDATE ANY AND ALL WARRANTIES APPLICABLE TO THE EQUIPMENT, INCLUDING THE MEMBRANE MODULES.

5.0 DESIGN PARAMETERS

Design Parameters

The contract of sale for the PURON submerged membrane modules contains the full details of any warranty provided with the modules and should be consulted in determining your warranty conditions, remedies and obligations. A detailed description of the System design parameters, including design flow rates (average and peak flows), feed specifications, effluent quality, biological design parameters, design flux rates, operating parameters and performance test plan can be found in Appendix I.

FAILURE TO FOLLOW ANY OF THE REQUIREMENTS SET FORTH IN THIS MANUAL WILL INVALIDATE ANY AND ALL WARRANTIES APPLICABLE TO THE EQUIPMENT, INCLUDING THE MEMBRANE MODULES.

6.0 INITIAL STARTUP & PREPARATION

6.1 Requirements

The customer must send KSS written confirmation that it has met the requirements outlined in this Section 6.0 prior to initial startup. Failure to comply will result in startup delays and extra costs, particularly if KSS personnel are sent to the site and are unable to perform services in the absence of such requirements. A sample "Startup Check List" is enclosed in Appendix D.

6.1.1 Drawings

The following system drawings should be available as applicable:

- Piping and Instrumentation Drawings (P&ID)
- General Arrangement (GA)
- Electrical Diagrams
- Mechanical Equipment Documentation
- Electrical Component Documentation

The P&ID and GA are essential to allow startup work to proceed. These drawings should include all system components, including components supplied by others.

6.1.2 Commissioning Water and Air Requirements

The customer or contractor is required to completely clear the system of construction debris, rubbish, dust (in permeate piping), and support materials and tools.

Once the system has been cleared, the customer or contractor is required to supply sufficient potable water to completely flush out all piping and clean the membrane and Backflush/CIP tank. This water should be supplied at a minimum pressure of 3 bar (45 psi).

In addition, the customer or contractor must supply sufficient potable water to fill the permeate system, including the Backflush/CIP tank (if included), and the membrane filtration tank(s).

Proper pneumatic air line filtering is required. Failure to provide clean, dry, instrument quality air to valves will cause problems with actuators. Pneumatic air lines should be purged prior to startup.

6.1.3 Personnel Requirements

In addition to the KSS personnel, the following personnel should be available during the startup:

- Software programmer (in some cases this person will be a KSS representative)
- Certified electrician
- Pipe fitter
- Assigned Customer Representative

To avoid costly delays, these people are required during the startup. If not on-site, the software programmer, pipe fitter and electrician should be available within no more than 2 hours from call out.

6.1.4 Electrical Requirements

The customer or contractor is responsible for supplying the electrical power to the system. The connections must meet all applicable electrical codes.

DANGER

DANGER indicates an imminently hazardous situation, which, if not avoided, **will result** in death, serious injury, or equipment damage.

Before powering up the system, be aware that the PLC automatically stores the last set of settings and equipment states. Ensure that the E-Stop is engaged and all local motor disconnects are shut off before activation.

Startup of a system is critical and the system must be set up correctly before disengaging the E-Stop and turning on the local disconnects. All pumps and valves need to be initially set up to minimize chances of accidental pressure build-up. The actual valve and pump configuration will vary depending on system design.

The customer or contractor is responsible for powering up the system. The customer must confirm to KSS that the system is safe to commission and all local personnel are aware of the commissioning work and will take all appropriate safety precautions.

After the system is powered up, KSS will advise on system default values during startup. KSS will require an engineer status password to control all aspects of the plant. Following the start-up process, KSS will document all operating parameters and set points of the system.

6.2 Site Preparation

This section details the requirements that must be fulfilled before the PURON® modules can be installed. Equipment manufacturer's manuals should be referred to, for proper startup procedures.

6.2.1 Preparation for Membrane System Startup

The following items must be completed prior to the system flushing and membrane installation:

- All input and output signals to the PLC must be checked by an electrician for confirmation of continuity and correct connections.

- Instrumentation must be configured and calibrated (records of configuration and calibration must be provided to the KSS authorized representative).
- Automatic Valves
  - Valves must be stroked and timed.
  - Valves must be trigger-tested using the PLC.
- Pumps & Blowers
  - All motors must be dry "bump" tested to ensure correct motor rotation (pump couplings should be removed where appropriate).
  - All pumps that require alignment must be checked and an alignment report must be issued to the KSS authorized representative.
  - All pumps/blowers must be aligned, oiled, etc. and ready for startup.
  - Pumps should be primed if required by the manufacturer.
- Completed Startup Checklist must be returned to the KSS authorized representative.
- All equipment, piping, valves, and instrumentation must be verified with the P&IDs.
- Water drainage system must be verified to be functioning.
- For plastic tanks, all piping and equipment must be verified as properly supported by a frame. Nozzles or bulkhead fittings must not be used to support interconnecting piping.

The following items must be available and accessible prior to the system flushing and membrane installation:

- A lifting device for membrane modules (bridge or road crane)
- Instrument air
- Potable water
- Sodium Hypochlorite (NaOCl) solution for disinfection

6.2.2 System Flushing and Leak Testing

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

No system flushing and leak testing should be carried out until Section 6.2.1 (Preparation for Membrane System Startup has been completed).

Do not install the membranes until system flushing and leak testing is satisfactorily completed.

The following items must be completed prior to the KSS authorized representative arriving on-site:

1. Clean the Backflush/CIP Tank (if applicable):
   - Manually remove all loose material
   - Vacuum to remove all fine material and dust
   - Wash the interior

2. Flush all piping associated with the membrane system:
   - Isolate all individual membrane connections (both air and permeate). Use manual valves if they are present, otherwise use plugs.
   - Flush the piping by pressurizing with potable water and opening manual valves (or removing plugs) as necessary to ensure that all piping is flushed. It is important to be sure that no "dead legs" are left un-flushed. In some cases, pumps must be activated to complete the flushing procedure. Refer to the P&ID to verify all piping is cleaned.
   - Note that the flush flow rate must be greater or equal to the design flow rates through the piping.

3. Check all piping for leaks:
   - During the flush, observe all piping for leaks and repair as necessary.
   - Pressure test the piping.
   - Repair all identified leaks and retest as necessary.

4. Clean the membrane tank:
   - Manually remove all loose material
   - Vacuum to remove all fine material and dust

Finish the system flushing and leak testing process with the assistance of KSS authorized representative:

1. Fill the permeate piping system:
   - Completely fill the permeate system with potable water including the Backflush/CIP tank (if present)
   - Verify that all instrumentation associated with the Backflush/CIP tank is functioning correctly.

2. Flush the permeate piping using the dedicated permeate pumps:
   - Move all manual and automatic valves into the normal backflush position. If permeate reversible pump is used, activate the permeate pump in reverse, or activate the dedicated backflush pump. Do not deadhead the pump.

- Flush out each of the individual module connections by directing the flow through one connection at a time (by moving manual valves or removing plugs).

3. Blow out the membrane aeration lines:

   - Move all manual and automatic valves into the normal aeration position and activate membrane blower.
   - Blow out the aeration lines to each module by directing the flow through one train at a time.

⚠ CAUTION
CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

Use proper protective gear due to possible air and particulate material that may come out of the pipes.

4. Drain and clean the interior of the membrane tank:
   - Drain the tank of any residual water.
   - Manually remove all loose material.
   - Vacuum to remove all fine material and dust.
   - Wash the tank interior and inspect the coating for any damage.

   If lined tanks are used, note that the membrane tank lining is susceptible to damage by impact or abrasion. Use care to ensure that the lining is intact. Safety shoes must be cleaned of stones and burrs before entering tank. Scratches must be reported and repaired.

5. Commission the cleaning chemical dosing systems:
   - Clean the chemical storage tank.
   - Fill the chemical tanks with potable water.
   - Prime the chemical dosing pumps and operate the pumps at full capacity to leak test the dosing lines.
   - Repair any leaks and repeat the test as necessary.
   - Calibrate the dosing pumps for the proper dosing regime.
   - Drain all water from the tanks, pumps, and chemical dosing lines.

6.3 PURON® Module Installation

Membranes are easily damaged by mechanical mishandling and personnel negligence. Below are a number of cautions and tips to help avoid product damage and personnel injury.

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

Avoid contact with the membrane fibers. Always wash your hands before starting any work that potentially brings you in contact with the membrane fibers. Always use the correct gloves.

When working with the membrane modules, always wear safety glasses and safety shoes. Use caution when handling metal parts as they can be sharp. KSS advises that Mechanical resistant gloves be used.

Immediately report any incident or damage to the module to a superior and to KSS. Photos are welcome. It is far easier to fix a problem when the modules are fully accessible prior to being submerged.

The PURON modules are preserved with glycerin to keep the membranes wet. Membranes should not be allowed to dry out. Do not expose them to direct sunlight. Follow KSS' storage procedures after transport as described in the Product Data Sheet, Appendix A.

6.3.1 Getting Started

The procedures outlined in sections 6.1 and 6.2 must be completed and verified before modules can be installed.

The membrane modules can be installed into tanks filled with potable water or into empty tanks as convenient to the start-up process. KSS recommends dry tank installation, but if it is desirable to install the modules into a filled tank, it is important to ensure that there is sufficient water to cover all of the membranes, up to and including the fiber tips. Once the membranes have been immersed in water, they must remain submerged. If the membrane modules are installed into empty tanks, the tanks need to be filled with potable water as soon as possible.

It is a good idea to carefully stage the work area where the modules are to be unpackaged, assembled and installed. Lay out all of the required tools and restrict personnel movement through the area.

With advance planning and correct layout, installation of a single PSH1800 module typically requires two people approximately three hours, from unwrapping the module to the connection of permeate and aeration headers in the membrane tank.

6.3.2 Packaging Information

PURON modules are shipped complete. This means that all membrane rows are installed in the modules before they leave the factory. In addition, they are sealed in plastic to retain moisture and prevent membrane damage (see Figure 6.3.2.1). Some transportation can be done by truck only depending on regional availability.

Figure 6.3.2.1 Standard Packaging Information (PSH1800 shown)

When ocean transport is selected, the modules are protected from mechanical damage by shipping in a container for protection.

If desired by the customer, the modules can be further protected from mechanical damage by wooden crates for an additional crating fee. Please contact KSS before transport to arrange this operation.

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

The PURON Module Crates are not designed to be stacked.

The following table highlights the standard modules from KSS and their crating dimensions.

Table 6.3.2.1: Crating Dimensions

Parameter	PSH330	PSH660	PSH1800
Module Weight	350 kg (771 lbs)	654 kg (1,442 lbs)	1,400 kg (3,090 lbs)
Crate Weight	70 kg (155 lbs)	140 kg (310 lbs)	280 kg (620 lbs)
Total Weight (module + crate)	420 kg (926 lbs)	794 kg (1,752 lbs)	1,680 kg (3,710 lbs)
Crate Height	2,750 mm (9.0 ft)	2,750 mm (9.0 ft)	2,750 mm (9.0 ft)
Crate Length	1,000 mm (3.3 ft)	1,800 mm (5.9 ft)	2,400 mm (7.9 ft)
Crate Width	1,000 mm (3.3 ft)	1,000 mm (3.3 ft)	2,000 mm (6.6 ft)

Figure 6.3.2.2: PSH660 Transport Crate

6.3.3 Required Tools

a. Forklift suitable for safe movement of the module (taking into account its weight and dimensions; **for PSH1800 long forks are needed**).
b. Crane, slings, and lifting brackets – to install the module in the membrane tank. The design load of a PSH1800 module plus traverse with a safety margin is 3,500 kg (7,700 pounds).
c. Four slings or lifting belts and point spreaders.
d. Two crowbars.
e. Electric screwdriver fitted with TORX®, cross- and flat-head bits to open the crate.
f. M16 and M20 spanners and sockets.
g. LOCTITE® thread cement. Use LOCTITE type 271 or 2701.
h. Paper towels, disposal bin.

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

The traverse must be installed before the module is lifted.

6.3.4 Safety

Safety is an integral part of any membrane system installation. Proper planning is essential to ensure safety. It is the responsibility of those installing the membranes to properly prepare the site and to conduct a health & safety meeting prior to the scheduled work.

WARNING

WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

Membrane installation involves working in the vicinity of membrane tanks. As a result, the potential for dangerous falls is always present. Fall protection equipment should be worn when working around or above the membrane tank. Typical equipment requirements include fall arrest harnesses and fall prevention lanyards. Consult with your site safety professional regarding job hazard analysis and the PPE appropriate to this activity. See Figure 6.3.4.1 as an example for fall protection and PPE.

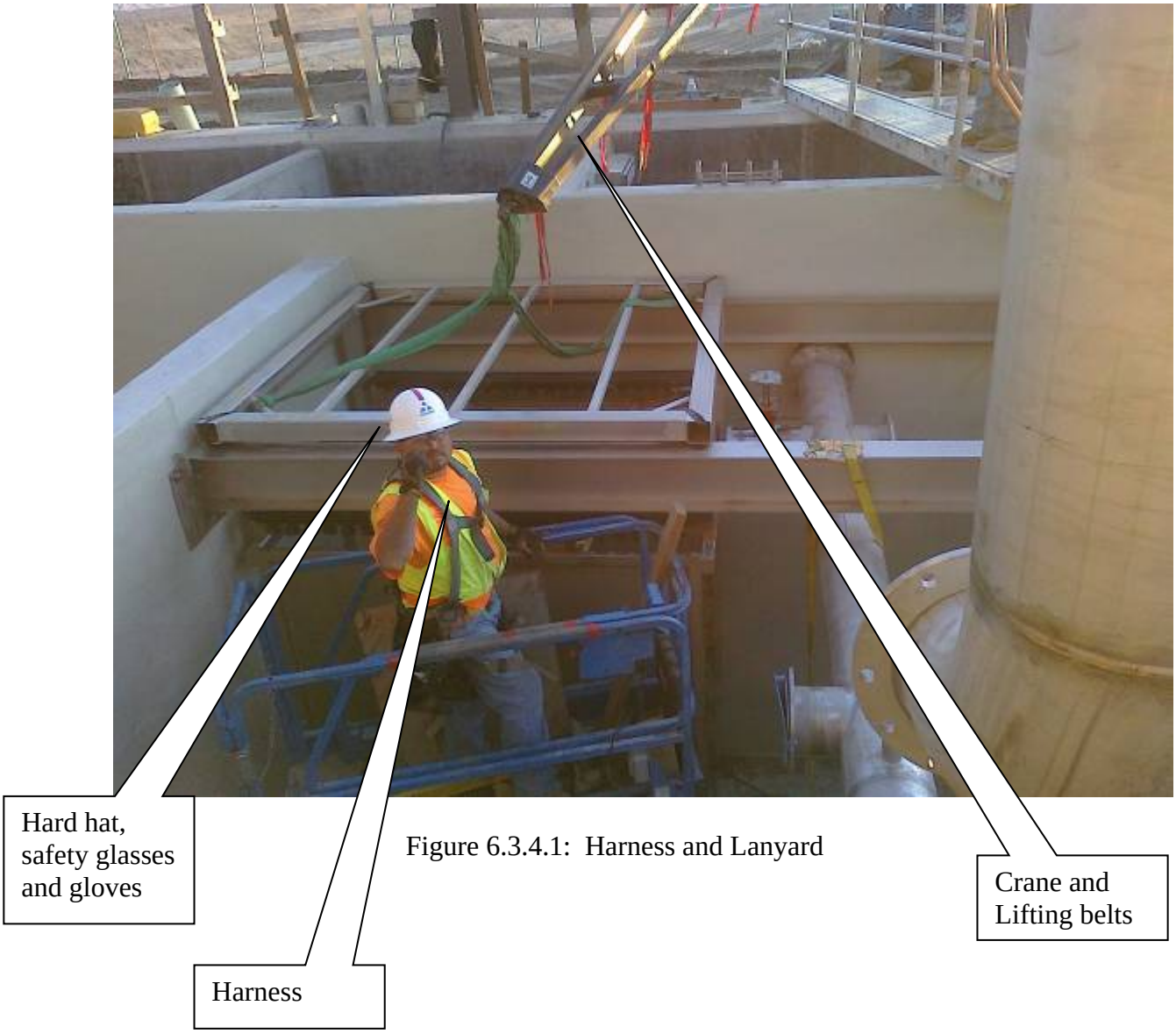


Figure 6.3.4.1: Harness and Lanyard

6.3.5 PURON Module

Modules are supplied complete. No extra work is required on or in the module itself. A KSS representative will inspect the modules during uncrating and take the required action if something adverse is found with the module.

The PURON module is supplied according to customer requirements:

- Module only
- Module and traverse
- Module, traverse and connection kits

It should be noted that if a traverse was not purchased, the customer will need to provide and attach one before hoisting the module as discussed in greater detail below. The

customer will also need to provide the necessary connection kits during installation, if none has been purchased from KSS.

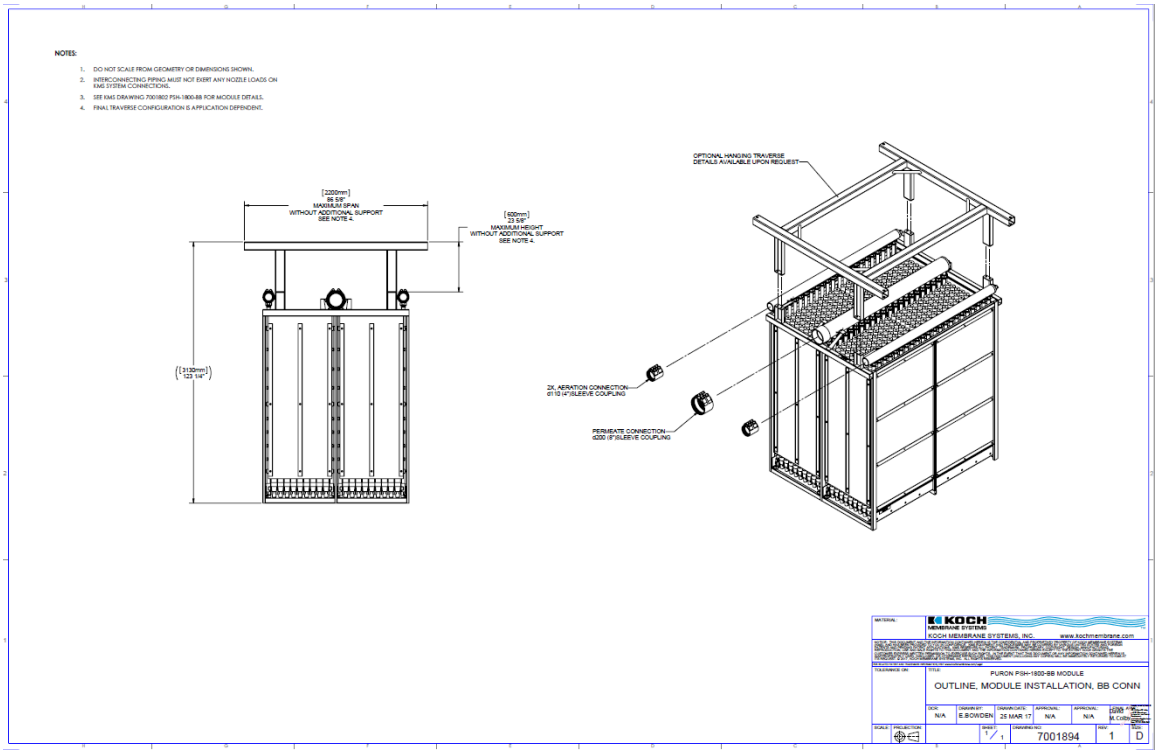


Figure 6.3.5.1: PSH1800 Diagram

6.3.6 Uncrating a Module (if Required)

The modules should be uncrated with an authorized KSS representative present to monitor the process unless otherwise authorized by KSS in writing. A dry, level space is required, preferably out of direct sunlight.

Note that membrane modules are susceptible to mechanical and chemical damage and the membrane area must be protected from activities that could potentially damage the membranes including, but not limited to the following:

- Grinding
- Welding
- Painting
- Drilling/Tapping
- Cutting
- Any other activity that could damage the membranes.

Figures 6.3.6.1 to 6.3.6.3 document the uncrating procedure. Read the instructions in their entirety before attempting to uncrate. Sufficient laydown area and labor, correct tools and proper planning are critical to a safe and successful procedure.

Figure 6.3.6.1: Crate of PSH660 moving with fork truck

1. Inspect the crate for transport damage – document any damage using photos.

Figure 6.3.6.2: Crate Detail Inspection

2. Remove the top of the crate. Once loose, the top weighs ~25 kg (~55 lbs). Once the top has been removed, place it in a safe spot away from the uncrating area. At this point, the four sides of the crate will remain standing without the roof attached.

3. Remove the large front section (labeled as "FRONT") which forms one side of the crate and the top section (labeled as "TOP"). Once these sections are removed, the remaining two sides can be removed as well. Now the module can be lifted out via an attached traverse as further detailed below. A three-sided box remains for disposal.

WARNING

WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

Do not remove front and back or left and right as pairs as the risk of a falling side is high. Sides must always be supported.

Figure 6.3.6.3: Crate after the Side panel has been removed

Next, cut the plastic along round the top and down one vertical side. Also cut around the bottom. Use a small bladed knife with maximum 2.5 cm (1") blade. Once cut, the plastic can be rolled down and removed for direct disposal. To avoid confusion, the "TOP" and "FRONT" sides of the module are labeled.

Figure 6.3.6.4 illustrates the process of plastic removal. Care should be taken when cutting the protective plastic to avoid scratches on the headers.

⚠ CAUTION
CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

Once the protective plastic material is removed, the module must be immersed in water within the next 24 hours to ensure it does not dry out.

Figure 6.3.6.4: Plastic Packing Removal.

6.3.7 Moving Uncrated Modules

The module must have the traverse, lifting frame or hoist rings mounted prior to moving. Never use the four corners of the module or the top headers or frame to hoist the module off the ground.

If hoist rings are being used to move the module (PSH330 and PSH660 modules only), four rings must be used (one in each corner). A hoist ring assembly is shown in Figure 6.3.7.1. The thread is M16 (5/8" - 11) and the hole is 18 mm (3/4"). Tighten the bolt to the recommended torque of 100 ft-lbs. Ensure that the bushing of the hoist ring is sitting flush against the frame. The hoist ring must be free to swivel and pivot in every direction.

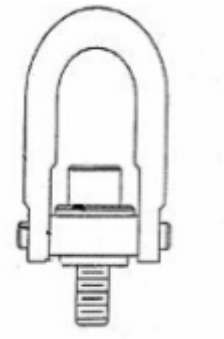


Figure 6.3.7.1: Hoist Ring Assembly

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

Do not swing or drop modules. Modules must be lifted vertically and lowered slowly in a smooth fashion.

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

Because the PURON module is open at the top, debris can fall into the fibers after uncrating and prior to immersion in water. KSS strongly recommends placing a foam plate or a stiff plastic sheet such as a tarp above the fibers prior to module immersion. This will help prevent foreign material from falling into the module and damaging the fibers.

Figure 6.3.7.2: Module fiber protection

6.3.8 Installing Traverse

The traverse is a device that attaches to the module frame, strengthens it and allows the whole structure to be suspended from four points. While the traverse can be supplied by KSS, customers often have traverses custom built by others to fit their filtration tank design. PSH330 and PSH660 modules may be lifted using hoist rings. PSH1800 modules have to use a traverse for lifting. Traverses must be on site to avoid startup delays.

Figure 6.3.8.1 shows a standard KSS traverse.

Figure 6.3.8.1: Standard PSH1800 traverse

Figure 6.3.8.2: Leg connection to PSH 1800 module frame

When a customer elects to purchase traverses from KSS, the traverses are packaged and delivered in a separate crate. The procedure for opening this crate is the same as that for opening a module crate. Each traverse can be simply lifted using a belt and crane. The total weight of each PSH1800 traverse is approximately 75 kg (165 lbs).

Traverse installation:

1. Set the traverse on the ground, standing on its four legs.
2. Attach lifting belts of equal length and rated for the weight of the traverse around the four corner braces.
3. Clear the area and hoist the traverse up and over the module.

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

If the traverse was not supplied by KSS, consult KSS for proper positioning of the traverse. Improper positioning can damage the module.

4. Slowly lower the traverse so the four legs line up with the four frame turrets. If the traverse is a KSS standard traverse, the span arms are symmetrical which makes it easier to line up the legs with the turrets.
5. Fix the traverse to the module frame using 8x M16 bolts (5/8" - 11), rings and nuts. Tighten to the recommended torque of 247 ft-lb (335 N-m).
6. The module is ready for tank installation.

6.3.9 Unloading multiple modules from a road container

Depending on the number of modules to be transported, the location of the customer and customer instructions, modules may be transported in open or closed road-ship worthy containers:

- Iso Container High Cube: 12 m x 2.5 m x 2.9 m (39.5 ft x 8 ft x 9.5 ft) L x W x H
- Iso Container Open Top: 12 m x 2.5 m x 2.5 m (39.5 ft x 8.2 ft x 8.2 ft) L x W x H (Plastic sail cover)
- Open Flat deck truck 12 m x 2.5 m (39.5 ft x 8.2 ft) L x W
- Closed (sail) Flat deck truck 12 m x 2.5 m (39.5 ft x 8.2 ft) L x W

Due to the effects of temperature, vibration, transport duration, climate, seasonal weather and storage conditions on the modules, the transport method must be approved by KSS.

When a container is used, up to five PSH1800 modules can be transported within a single container. Modules are always shipped in a vertical position. The modules are not crated as the modules are protected by the container. However, the modules are fixed to a pallet (same as crating floor) and each module is wrapped in plastic (as inside the crate). Figure 6.3.9.1 shows a module inside a container.

Figure 6.3.9.1: Short distance container transport

The procedure for removal of modules from containers and flat deck trucks is as follows:

1. If the transport container has a removable roof (sail) this should be removed or withdrawn. This gives vertical access to the module frame.
2. The PSH1800 module may be lifted by using a KSS lifting frame (if one has been purchased from KSS) or by using the traverse that is later on used to put the modules into the membrane tank. Modules of the types PSH330 and PSH660 may be lifted with a traverse or using four hoist rings. If a KSS lifting frame has been purchased, it should be secured to the frame and rigged to the lifting device following the procedure set forth in Section 6.3.9. If hoist rings will be used, they should be affixed to the corner posts and rigged to the lifting mechanism as set forth in Section 6.3.8. Once either the lifting frame or hoist rings are properly attached and rigged to the lifting device, the modules can be removed vertically from the transport.

Figure 6.3.9.1a: Module removal with special lifting frame.

In the situation shown in Figure 6.3.10.1a, the truck can pull forward, leaving the module in a suspended position. The module can then be moved to the side for storage prior to module installation in the filtration tank.

3. Once removed from the transport, the module(s) can be either stored in accordance with storage instructions or prepared for installation by removing the plastic wrapping and attaching the traverse(s).

Removal of PSH330 and PSH660 modules from a sealed Iso container is described below:

1. Since the modules are fixed to a crate floor or pallet and are only accessible from the open doors of the container, the modules must be extracted using a forklift, see Figure 6.3.9.1b. PSH330 and PSH660 modules can be slightly lifted using a forklift to pull them out of the container. A different procedure should be used for the PSH1800. For unloading a PSH1800 module, eye screws need to be attached to the wooden

plate below the module. Using these screws the module can be pulled out of the container onto wooden bars that need to be placed in front of the container.

Figure 6.3.9.1b: Module removal from sealed Iso container using forklift.

CAUTION
CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

The modules fit very tightly inside the container. As a result, special care must be taken to make sure that the module is not raised to a height where it might get damaged passing the door frame during extraction.

2. Once the module is removed from the Iso container, it can be either stored in accordance with storage instructions or prepared for installation by removing the plastic wrapping and attaching the traverse(s).

6.3.10 Module Initial Inspection #1

With the module uncrated and the plastic removed, an all-around visual inspection should be carried out prior to installation in the filtration tank. During inspection, the following items should be checked:

- Check tightness of union joints to the aeration and permeate headers. These should all be tight.
- Check for cracks in the union joints or cracks in the headers.
- Check the membrane fibers from the top – look for bending or damage from foreign objects which have fallen into the module.
- Check the plates around the module. Check for scratches and damage to the plates. If damage is seen, remove the plate (as described in the module maintenance section) and inspect the rows located in the vicinity of the damaged plate.
- Check the fastening bolts. Tighten if necessary.
- Check for missing nuts. Where nuts are missing, replace and tighten them according to the KSS product drawing and specification.
- Check the stainless steel frame for rust, damage and bumps.
- Record the serial numbers of each membrane module. KSS has production records of each row number in each module. When placed into the membrane tank, record the location in the tank where the module is placed (a module map is included in Appendix E).

It is highly unlikely to find problems with the module directly after transport but this quick visual inspection is necessary to avoid major time loss once the modules are installed and become far less accessible.

KSS should be informed of any problem detected through inspection using detailed documentation including photos. It is critical to report defects in a timely and accurate manner in the event it becomes necessary to file an insurance claim against the transport company.

KSS may be on site to provide technical support during unloading and uncrating. If so, any defect found after transportation and prior to installation should be shown to the authorized KSS representative on site.

6.3.1 Installation of the Module in the Membrane Tank

Once the above inspection has been performed, there are two methodologies by which to install modules into the filtration tank:

- Dry Membrane Tank Installation
- Wet Membrane Tank Installation

KSS recommends dry tank installation.

Fig 6.3.11.1 shows a photo of a module and standard traverse prior to membrane tank installation.

Figure 6.3.11.1: Module prior to installation in the membrane tank.

Dry membrane tank installation

Remember to record the serial numbers of each membrane module prior to installation!

1. Cordon off the area in which the hoist and installation operation will take place.
2. Verify that the traverse has been properly installed.
3. Lifting belts (designed to bear at least 2500 kg / 5500 lbs each for lifting a PSH1800 module or 1000 kg / 2200 lbs for lifting a PSH660 or PSH330 module) can be hooked around each corner of the traverse and then attached to four chains of at least 3m (10 ft) long and then combined at the crane's lifting hook.
4. During lifting, make sure that the belts do not tangle or touch the headers.

5. Slowly hoist the module.
6. The module must be carefully positioned above its required tank location and then lowered slowly so that the four guiding holes in the traverse line up with the leveling pins. Guide ropes attached to modules are helpful when installing the modules, especially into tight tank configurations.
7. Once the module has been positioned in the tank, the lifting belts can be removed.
8. Record the location in the tank where the module is installed using the applicable serial numbers on the module map included at Appendix E.
9. Level the module(s) and train(s) following the Module/Train Leveling Procedure set forth below.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

Remember to fill the tank with water as soon as possible after installation to avoid drying out the membranes.

Wet filtration tank installation

When a wet filtration tank installation is performed, the same procedure is followed except that all leveling takes place while the tank is filled with water.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

It is important to properly lift the module. Failure to properly handle the module can potentially cause damage or personal injury.

6.3.12 Module Permeate and Aeration Connection and Alignment and Module/Train Leveling

PSH330 and PSH660 modules are always supplied with flange connections. On the PSH1800 the permeate connection can be project-specific depending on specific customer requirements. Flange connections or Straub-Flex are the most common. In principle the PURON module is supplied with a pipe-end connection suitable for a welded plastic butt connection or to facilitate a Straub-Flex connection. KSS standard is Straub-Flex or equivalent quality pipe to pipe connection.

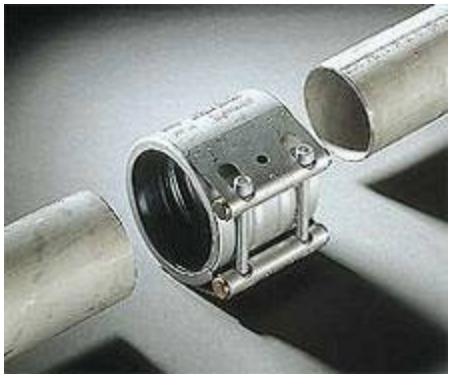


Figure 6.3.12.1a: Straub-Flex fitting.

When compression joints such as Straub-Flex (see Figure 6.3.12.1a) are used, a stainless insert must be placed inside the plastic header, see Figure 6.3.12.1b. Connection kit, including the Straub-Flex coupling and the insert is available from KSS.

Figure 6.3.12.1b: Header Insert for Straub-Flex.

Some installations have horizontal permeate header connection and remain submerged in the process fluid, others have extension pipes to above the process fluid to allow the operator to operate the module isolation valve. The aeration pipes are always above water level to avoid water siphoning back into the supply pipe and eventually to the blower.

The system in Figure 6.3.12.2 has a horizontal Straub-Flex connection with an extension pipe to above water level for the aeration pipes and a flanged connection with extension pipe for the permeate header.

Figure 6.3.12.2: Permeate Header Connection.

Systems with extension pipes have slightly more flexibility in build dimensions and can be modified if found not to fit exactly. Systems with direct through-wall connection must be aligned to ± 3 mm (⅛") and modifications are not easily made.
In case of a system with both extension pipe and through-wall connection, the following procedure should be used for header alignment and module/train leveling:

A construction laser with an accuracy of ± 2mm is recommended in order to ensure that the required tolerances are achieved. These tolerances are tight, especially for concrete construction. The design engineer and contractors must coordinate closely to ensure these tolerances can be achieved.

Each membrane module must be properly leveled as part of the installation procedure.

⚠ CAUTION
CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

Module leveling is critical to ensure proper aeration distribution. Failure to properly level the membrane modules can lead to significant operational problems.

PURON module installations include pins to allow for module leveling during installation. There are two types of leveling pins used in module installation: smooth pins with safety clip and shims or threaded pins with hex nut.

1. Using a laser, set the leveling pins at the required height across all trains.
2. Lower each module slowly onto the leveling pins – do not fix the level at this time.
3. Align the permeate header with the module permeate header and slide the Straub-Flex across the joint or locate the flange and counter-flange. Do not tighten at this time.
4. Align the aeration headers with the modules aeration headers and slide the Straub-Flex across the joint or locate the flange and counter-flange. Do not tighten at this time.
5. Use the laser to check all modules in the system. Within a train, each module must be leveled within a tolerance of ±1 cm (⅜"). Across the system, each module must be leveled within a tolerance of ±1 cm (⅜").
6. Make minor adjustments if the pipes do not line up exactly – target tolerance should be 5 mm ($^{3}/_{16}$") but absolutely not more than 15 mm ($^{5}/_{8}$") when using Straub-Flex coupling. In any event, the modules must remain within their required tolerances across the system.
7. Once all modules have been leveled in this manner, the level can be fixed.
8. The Straub-Flex connections can now be tightened taking great care not to over-tighten thereby causing damage to the module headers.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

KSS recommends dry leveling. While wet leveling can be done, personnel and equipment will get wet, tools will get slippery and the chance of accidents will increase due to the presence of water.

More often than not the permeate pipework is constructed using fixed, rigid pipework. In some cases with the PSH660 module the permeate pipe is made of flexible hose.

In most cases the aeration pipework is also fixed but flexible hose can also be used. Figure 6.3.12.5 below shows a system with fixed permeate pipework and flexible hose aeration pipework.

Figure 6.3.12.3: Alternative Module Connections.

6.3.13 Membrane Tank Work

The header connections for the module are often inside the membrane tank.

DANGER

DANGER indicates an imminently hazardous situation, which, if not avoided, **will result** in death, serious injury, or equipment damage.

Working inside the membrane tank presents safety risks. When the tank contains water, risk of drowning exists. Consult with your site safety professional regarding job hazard analysis, safety procedures and the PPE appropriate to this activity.

A working platform such as shown in Figure 6.3.12.1 may be used in order to lower the operator into the filtration tank inside the traverse to fix the header connections, inspect the module, check for leakages and other maintenance related activities.

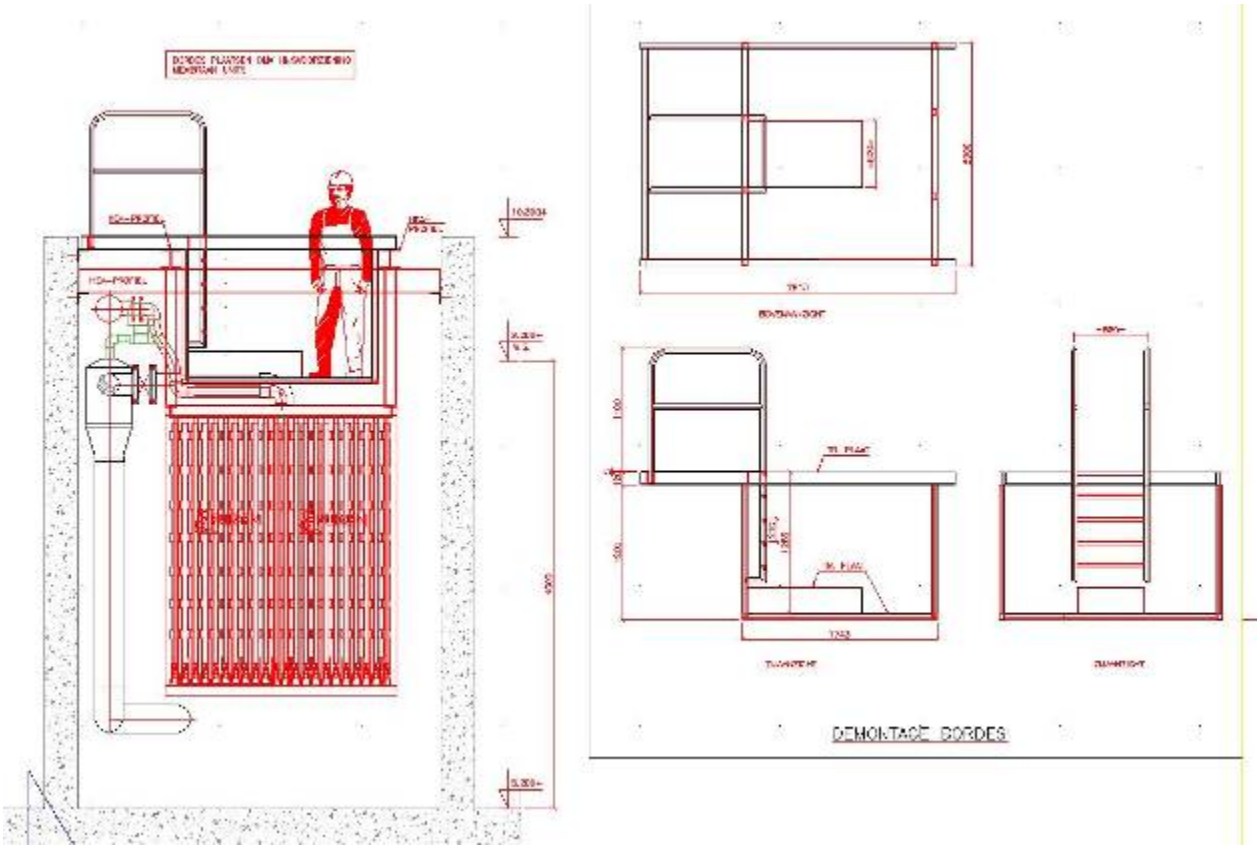


Figure 6.3.13.1: Working Platform

6.3.14 Module Immersion Depth

The immersion depth (liquid level above the membranes) should be set as follows:

PSH330 and PSH660

Minimum 300 mm (or 8 inches), maximum 1000 mm (or 40 inches). Typical immersion depth is between 300 and 400 mm (12 and 16 inches).

PSH1800

Minimum 400 mm (or 16 inches), maximum 1000 mm (or 40 inches). Typical immersion depth is between 400 and 500 mm (16 and 20 inches).

As a rule, water leveling is carried out to control the overflow-weir at the exit of each filtration tank. An extra adjustable weir can be installed if necessary.

6.3.15 Membrane Installation Documentation

All serial numbers and membrane locations should be recorded on the membrane map form, see Appendix E. This form is provided by the authorized Representative. The document is part of the official project documentation.

FAILURE TO FOLLOW ANY OF THE REQUIREMENTS SET FORTH IN THIS MANUAL WILL INVALIDATE ANY AND ALL WARRANTIES APPLICABLE TO THE EQUIPMENT, INCLUDING THE MEMBRANE MODULES.

7.0 OPERATING THE PURON® MEMBRANES

7.1 PURON Operation

This section highlights the PURON technology basic operating procedures, including startup, automatic operation, membrane cleaning and temporary storage. Regarding the process automation, KSS has or will supply a separate control narrative as part of the engineering package that describes in detail the operation of the submerged membrane system for incorporation into the PLC code. This control narrative also specifies all setpoints and timers with default values and allowable ranges.

7.2 Aeration System Guidance

As stated earlier, the aeration system is critical to the correct and stable operation of the submerged membrane system.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

Never operate the filtration system without aeration or with constant (non-stop) aeration. This can cause serious blockage and clogging of the membrane and render the system unusable.

Automatic interlocks should be included in the controls code to prevent permeate extraction without an active aeration mode. This interlock is not present in manual operating mode.

This section will guide the operator or engineer in early aeration system problem diagnostics.

KSS aeration philosophy has flux-related aeration protocols:

1. *Standby Mode* is set up with one of the two following options:
   a. Low flux aeration (see point 2).
   b. Sleep mode aeration (60 second Air ON every 15-30 minutes Air OFF for tank mixing).
2. *Low Flux Mode*: < 23 l/m^{2}h gross (13 gfd) flux filtration (depending on temperature and MLSS level in membrane tank) – intermittent aeration of >120 second aeration cycle with 25%, 33% or 50% aeration at **maximum** specific aeration density. (33 second Air ON; 99 second Air OFF = 25% aeration)
3. *High Flux Mode*: > 23 l/m^{2}h gross (13 gfd) flux filtration – intermittent aeration of >120 second aeration cycle with 85% aeration at **minimum** specific aeration density. (105 second Air ON; 20 second Air OFF = 85% aeration). Minimum specific aeration density can be down to 50% of maximum specific aeration density.

DO NOT MODIFY THE AERATION CYCLE WITHOUT THE EXPRESS WRITTEN PERMISSION OF KSS.

The PURON aeration system is a reliable and robust aeration device; but also like any aeration device can be compromised. The following items can compromise the correct aeration performance:

Table 7.2.1: Trouble-Shooting Guide for Correcting Poor Module Aeration

SYMPTOM	PROBLEM	CORRECTIVE ACTIONS
Hair and debris clogging the aeration system or the fiber bundles. Serious by-passing will be seen easily in the module aeration pattern.	Poor pretreatment of the raw wastewater entering the bioreactor.	Membranes may require mechanical cleaning or replacement.
Aeration pressure increases	Aerators are blocked with sludge or. Insufficient aeration	1. increase power flush frequency; if aeration pressure is not decreasing point 2 is required. 2. The module will require removal and the aeration system must be flushed free of all sludge. The module can be returned and aerated until the bundles become sludge free – this may take 1 to 3 days.
Uneven module aeration pattern.	Blocked bundles.	Implement the remedies described in Section 7.2.4.
Decreasing air flow is delivered to the aeration system.	Worn out blowers.	Replace blowers.
No air supply.	The MCC and SCADA function as if the blower is running but the belts could be broken or slipping and hence little or no air supply to the modules.	Replace blower belts.
Aeration pattern changes.	Sludge is too viscous or too high TSS is too high.	Check the operation and operating parameters of the bioreactor, WAS and feed characteristics.

Most of the problems set forth in Table 7.2.1 can be avoided by operator visual inspection of the modules on a regular basis and implementation of the remedial activities set forth in this manual. KSS recommends a simple module plan as part of a daily or weekly surface inspection. Figure 7.2.1 below illustrates a system plan with sample comments. The operator can use the initially completed line up protocol as a template.

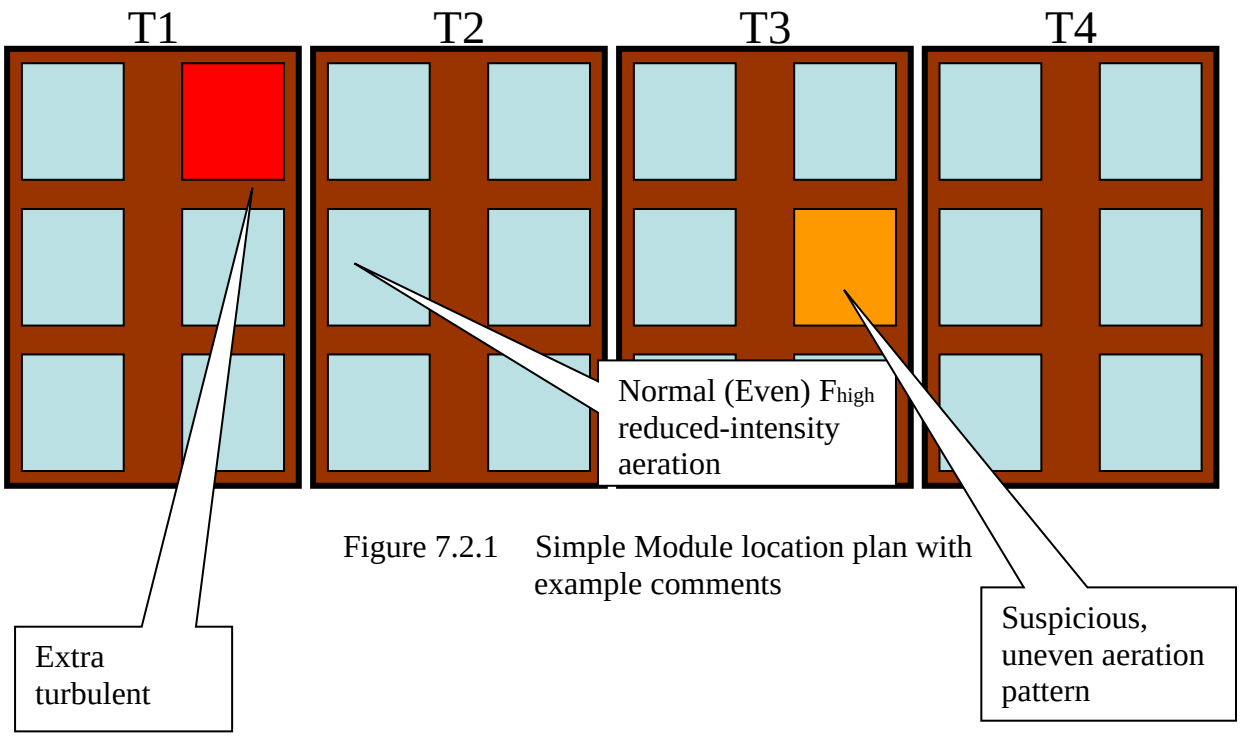


Figure 7.2.1 Simple Module location plan with example comments

The following section defines what the operator should look for during such visual inspections.

7.2.1 Early Signs of Poor Aeration and Consequences

Because it is very difficult to automatically detect an oncoming problem with the aeration system, the best way to anticipate and prevent aeration problems is operator visual inspection.

7.2.2 Automation

As illustrated below, automation can only suggest a potential problem and then only after significant blockage of the aeration system has occurred.

Important points about the automation of the aeration control:

1. The blower system is recommended to have a pressure indicator transmitter of 0-600 mbar (0 – 8.7psi) and preferably also with an air flow indicator.
2. The air pressure should be trended on the SCADA (supervisory control and data acquisition) system and the information during intermittent aeration on the relevant train controlled.
3. High flux (F_{high}) aeration is not possible to assess via the computer as the flow is fixed and thereafter distributed to all available trains.

4. During low flux (F_{low}) or standby aeration the individual train is aerated and therefore the measured pressure is directly related to that train (or trains in multiple train systems) being aerated.
5. The air pressure will vary slightly between trains despite being leveled to within 6mm (1/4”).
6. Under normal conditions the air pressure will be 270 - 280 mbar (3.9 - 4.1 psi) plus the submergence pressure, for a total air pressure of approximately 320-330 mbar (4.6 – 4.8 psi) for a submergence depth of 0.5m (1.6 ft). Each train can have its own normal value input and an Alarm and Warning value. The Warning value is about base value plus 50-100 mbar (0.7-1.4psi) and the Alarm value at plus 100-150 mbar (1.4- 2.1psi).
7. The Warning will cause a banner to be displayed on the screen. An Alarm may put the train to Safe Mode.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

An increase in aeration system pressure is a sign of aerator blockage and must be investigated as soon as possible. It must be noted that the pressures given are equivalent to approximately 10% blocked aerators (40 bundles for PSH1800), which is excessive.

Figure 7.2.2.1 is an Air Pressure Graphic of a seriously blocked aeration system and Figures 7.2.2.2 and 7.2.2.3 show its subsequent Power Flush recovery:

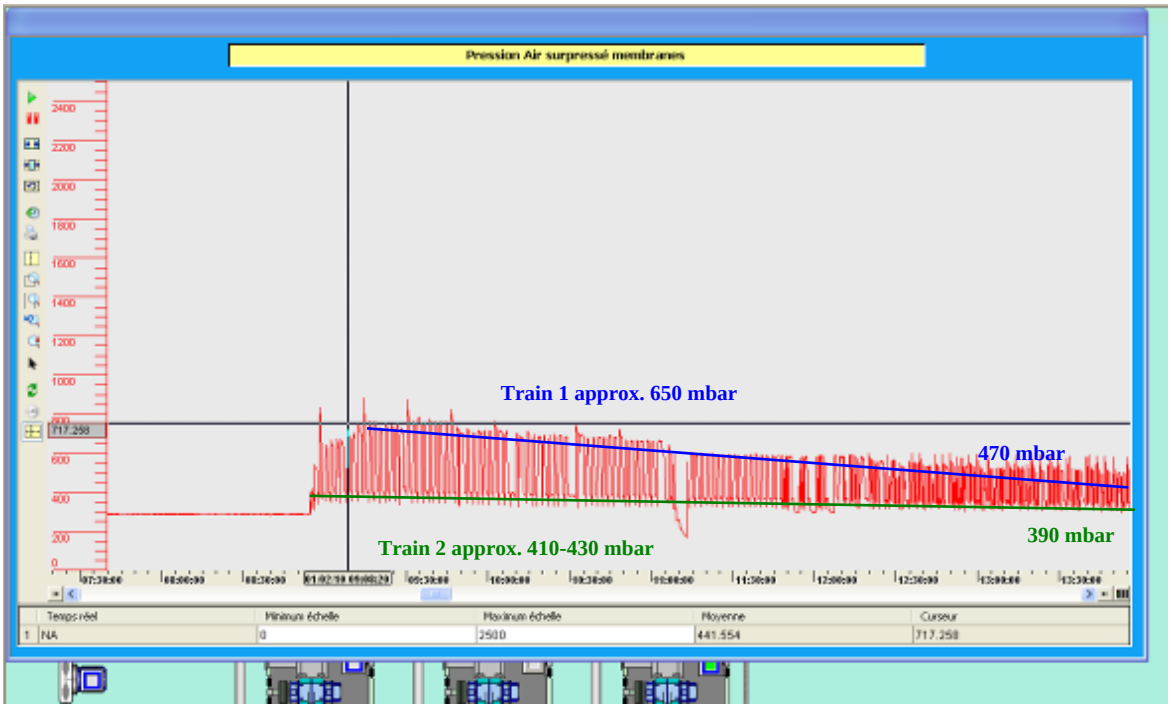


Figure 7.2.2.1 Blocked Aerator Automatic Recovery with Power Flush

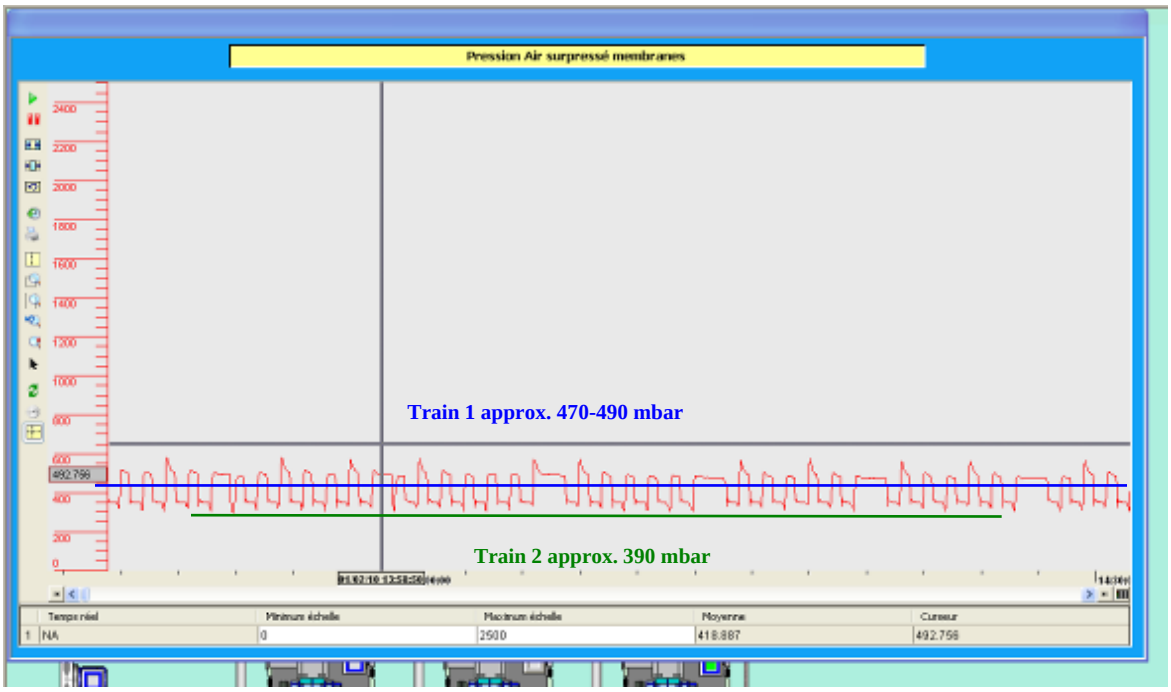


Figure 7.2.2.2 Blocked Aerator Automatic Recovery with Power Flush Improving

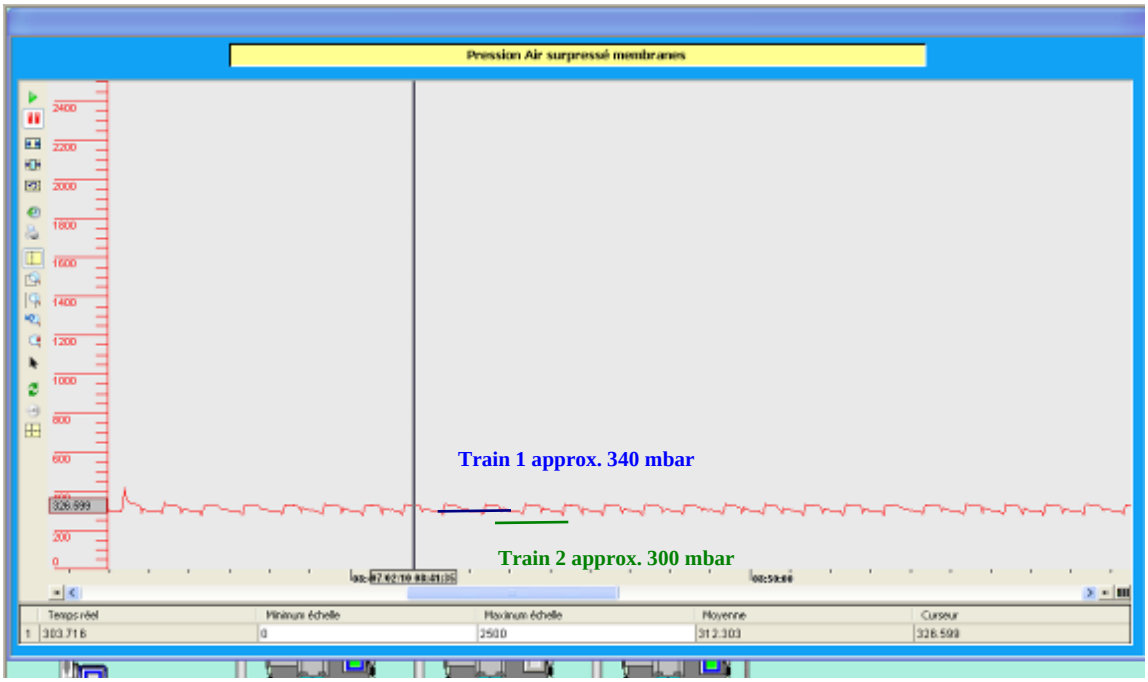


Figure 7.2.2.3 Blocked Aerator Automatic Recovery with Power Flush Final

7.2.3 Visual Inspection

By contrast to relying on automation, visual inspection by the operator is far more accurate and can detect single bundles that are not aerating. Removal of any gratings is the first step in a proper visual inspection. Figure 7.2.3.1 shows a module that has been earmarked by the operator as having an imperfect aeration pattern after removal of the gratings.

In order to be performed properly, any obstructions to visual inspection must be removed. Figures 7.2.3.2 and 7.2.3.3 provide examples of such obstructions.

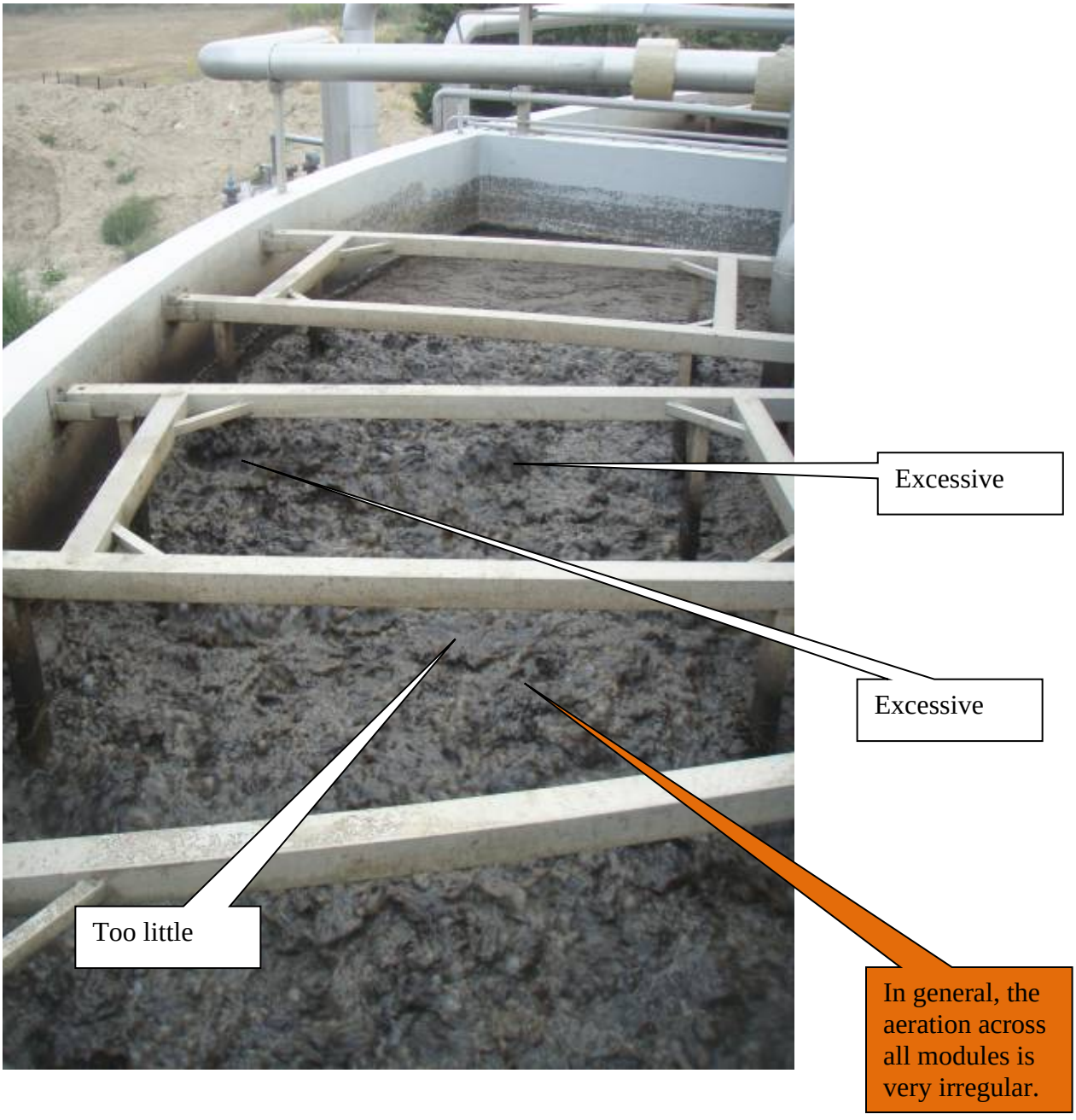


Figure 7.2.3.1 Poor aeration pattern – earmarked by Operator

Figure 7.2.3.2 Aeration pattern – masked by vapor

Figure 7.2.3.3 Aeration pattern – masked by grating

The next step for the operator is to lower the water level in the tank to the top of the fibers (see Figure 7.2.3.4) while leaving the aeration on. Under these conditions individual bundles can be seen and blocked bundles are easy to identify.

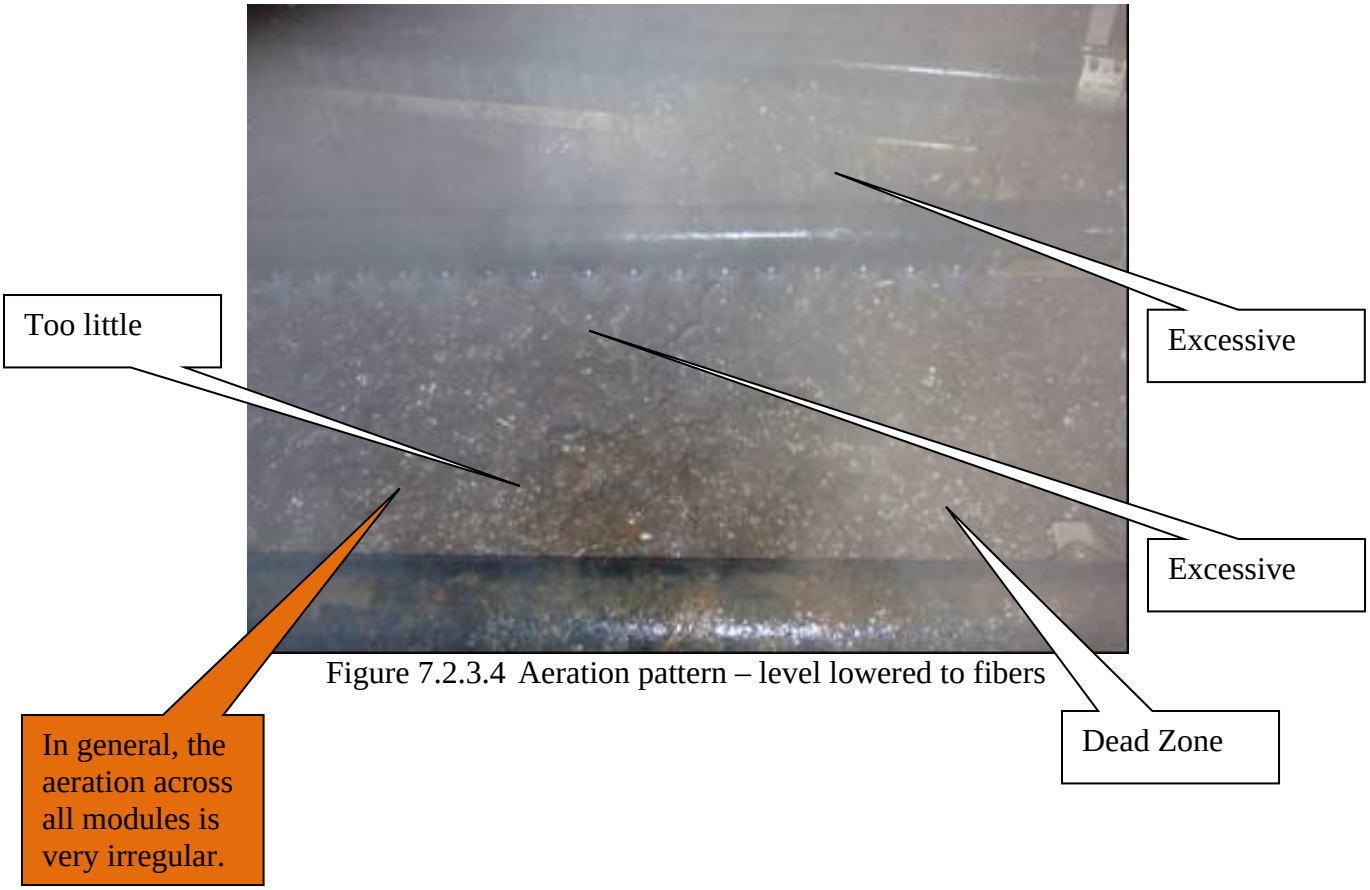


Figure 7.2.3.4 Aeration pattern – level lowered to fibers

Once a problem area has been detected, the level can be dropped further to expose the fibers. Figure 7.2.3.5 displays free bundles and blocked bundles.

Figure 7.2.3.5 Clear and blocked bundles

7.2.4 Automatic actions/remedies

If blocked bundles are detected, increase the frequency of Aeration System Power Flush described in Section 7.2.6. Repeat this procedure until the air pressure returns to normal values. This process can take several hours.

If the air pressure still does not decrease to the normal range, the module must be removed, and aeration system manually flushed (see procedure in Section 10.4.1). It is more difficult to power flush a whole train to correct a problem on a single module – in this case it is better to remove the problematic module.

After the power flush reduces the air pressure, the modules should be aerated for 1-3 days without filtration to remove built up sludge from the bundles. If this procedure does not recover the bundles, it may be necessary to remove the module and carry out manual mechanical cleaning. If a mechanical clean is necessary, please contact KSS.

7.2.5 Aeration Rules

Operator training on proper visual inspection is critical.

In most cases the cause of the problem is very easy to find. There are four main reasons for poor aerator / module aeration.

- Pre-treatment (mostly fine screen) by-passing and subsequent clogging in module
- Filtration without air or insufficient air

- Constant aeration, thus no regularly flooding of aerators
- Leaking aeration valve due to worn-out seals, leading to operation without defined flooding of aerators.

In all cases of aeration system blockage, KSS must be provided with detailed information. KSS can analyze data files and recommend actions to remedy many issues. The operator should take the following steps:

- Log all actions
- Inform KSS
- Save screen shots
- Save data files
- Follow the instructions set forth in this O&M manual

Failure to provide KSS with detailed information will invalidate any warranty. If a warranty claim is made and, after due investigation, it is determined not to be covered by warranty, any site visits will be charged at KSS' then current technical service rates.

KSS can support the client in module recovery if so required. A jointly performed module recovery is often a good learning exercise for the client and operators. Such site visits will be charged according to KSS' current technical service rates.

7.2.6 Aeration System Power Flush

The power flush is a simple procedure that allows complete flooding of the modules' aeration manifold to just under the top aeration headers. The volume of sludge is significantly more than that used during a standard flooding that occurs every time the air cycle valve is closed. This extra sludge volume is forced through the aeration manifold at great velocity and forces any sludge buildup to be dissipated. Power flushing is an excellent tool for removing sludge from aeration systems and to maintain the performance of aeration system.

The Aeration System Power Flush is not an independent aeration mode – it only acts to open and close the Train Aeration Flood Valves during the normal aeration mode as appropriate to flux and operation conditions.

Power flush mode is triggered by the power flush frequency timer. This timer runs while any train is online and is in the normal Process Mode or Stand-By Mode. When the timer times out, the power flush flag is set for each individual train, and the power flush frequency timer resets.

Once the train power flush flags are set, they remain loaded and idle until two conditions are met:

- The aeration mode becomes low flux aeration

- The Train Aeration Cycling Valve closes

Once these conditions are met, the train opens the Train Aeration Flood Valve for the input Open Timer and then closes it.

The power flush cycle completes the next time aeration is applied to the train through normal aeration cycling.

Note: The Train Aeration Flood Valve is interlocked with the Train Aeration Cycling Valve such that the flood valve will close if the cycling valve opens.

The Aeration System Power Flush Mode is suspended when high flux Aeration Mode is active.

7.3 Cleaning PURON Membranes

7.3.1 Cleaning Chemicals

Depending on the type of cleaning required and the fouling on the membranes, either a sodium hypochlorite (NaOCl) (oxidizing conditions) solution or a citric acid (acidic conditions) solution may be required. Sodium hypochlorite is used to remove organic and biological fouling from the membrane. Citric acid is used to remove fouling due to mineral scaling such as iron, other metal salts, or removal of calcium salt and other surface scaling compounds. Safety and handling instructions for these cleaning chemicals are located in Section 2: Safety. Sample generic MSDS sheets are included in Appendix B: Material Safety Data Sheets. It is recommended that MSDS are supplied for the specific chemicals used at the MBR plant.

For more severe fouling, KSS can be contacted for more rigorous chemical solutions and alternative chemical solutions. These approved cleaning chemicals and procedures should be used along with the maintenance clean and recovery clean procedures provided in this manual.

WARNING

WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

Wear appropriate personal protective equipment ("PPE") including face mask, rubber apron, and rubber gloves when handling chemicals. For more information, see Appendix B: Sample Material Safety Data Sheets.

General guidelines for PURON membrane cleaning are summarized in Table 7.3.1.1.

Table 7.3.1.1 Standard Operating Conditions (SOP) for Membrane Cleaning

Chemical	Function	Target values	Flux	Duration
Maintenance Cleaning *in Situ* (biomass)				**Standard**
Sodium Hypochlorite, 12%	Organic Cleaner & bio fouling	125 mg/l pH 8.0 to 10.5	6 L/m^2/h (3.5 gfd)	30 minutes, daily to weekly; without aeration
Citric Acid, 50%	Inorganic fouling & scaling	pH 2.0 to 3.0 (min 1000 mg/l, often ~1000-2000 mg/l; pH adjustment may be required with HCl)	6 L/m^2/h (3.5 gfd)	30 minutes, Up to 1x/week; without aeration
Recovery Cleaning				**Standard**
Sodium Hypochlorite, 12%	Organic Cleaner & bio fouling	1000-2000 mg/l pH 8.0-10.5 (1) 15°C < T < 25°C (59°F < T < 77°F) (2) 25°C < T < 40°C (77°F < T < 104°F)	N/A	(1) 8 - 12 hours (2) 4 - 8 hours Occasional aeration
Citric Acid, 50%	Inorganic fouling & scaling	pH 2.0 to 3 (min 1000 mg/l, often ~1000-2000 mg/l; pH adjustment may be required with HCl) (1) 15°C < T < 25°C (59°F < T < 77°F) (2) 25°C < T < 40°C (77°F < T < 104°F)	N/A	(1) 6-10 hours (2) 4 - 6 hours Intermittent aeration

7.3.2 Frequency of Cleanings

The frequency of cleaning is dependent on numerous factors, including:

- Operating temperature
- Wastewater type
- Pretreatment efficiency
- Particular chemistry of the fluid being filtered
- Completeness of biological degradation
- Permeate flux rates
- Scaling potential of the wastewater
- The membrane condition (new vs. old)

During normal operation, the membrane surface can become fouled with particulate material including biomass, salt precipitates and insoluble organics (such as oil). These

deposits can build up if not adequately controlled via backflushing and aeration and eventually cause loss of membrane performance – a decline in process permeability. It should be noted that the permeability can also drop if the process temperature drops, this decrease does not necessarily indicate membrane fouling.

KSS recommends a daily to weekly maintenance clean at low NaOCl concentrations of 125 mg/l and occasional polishing with a citric acid maintenance clean at a frequency of up to once per week. It should be noted that citric acid maintenance cleans are often not required for municipal installations with low scaling potential. This cleaning regime helps maintain a sanitized permeate system, avoids excessive "after growth" of bacteria and fouling in the permeate distribution system.

KSS maintenance clean (MC) procedures alone cannot maintain the permeability permanently. As a result, the permeability will slowly decline over time. KSS recommends one to four recovery clean (RC) cycles per year to boost the permeability back to more acceptable levels. Assuming two recovery cleans are performed per year, the first recovery clean should be carried out prior to the onset of winter conditions, when permeate temperature is still high (before November in the Northern Hemisphere) to give the system the most flexibility during the cold season, and the second recovery clean at the onset of warmer weather (April in Northern Hemisphere) to recover the membranes after a long winter period. The warmer permeate water in the summer months will boost the effect of the maintenance clean.

KSS has developed a wealth of cleaning experience on various types of membranes since the 1970's. KSS representatives are readily available to advise the client on cleaning strategies and procedure optimization.

7.3.3 Types of Cleanings

There are four hierarchies of membrane cleaning, each of which has to be optimized for the process conditions:

- Mechanical Cleaning via Backflushing (Section 7.3.5)
- Mechanical Cleaning via Aeration scouring (Section 7.2)
- Chemical Cleaning via MC (Section 7.3.6)
- Chemical Cleaning via RC (Section 7.3.7)

To maximize the performance and life of the membrane, the system must be set up to accommodate all of the cleaning hierarchies in an optimized philosophy. KSS can assist in the set-up of the system according to past experience or pilot work.

The client must optimize the cleaning parameters according to the environmental conditions to which the system is exposed. The settings for cleaning on Day 1 may vary greatly for what is needed on Day 1,000.

It is important to maintain a cleaning log book where the performance of each clean can be compared with the prior clean and trend of several cleaning cycles can be analyzed over longer time periods.

A common mistake is to fail to document performance and to adjust and optimize the original set up. Where a membrane guarantee has been provided, it must be supported via process optimization and system performance documentation.

7.3.4 Cleaning Log Book

All Recovery Cleaning data for each train should be recorded in the Cleaning Log Book (CLB), see Section 8.1 – Performance Monitoring. If a membrane guarantee has been provided, maintaining this data is part of the guarantee requirements. In any event, such data must be made available to KSS in order to assist with trouble-shooting and optimization. The data can be faxed or emailed to the KSS representative.

7.3.5 Backflush

The backflush cleaning uses permeate produced during the production mode and is returned either from a permeate collection manifold or directly from a CIP / backflush reservoir. The permeate is pumped back through the membranes at low pressure and high flow rates, equivalent to a fixed 30 L/m^2/h.

During a backflush cycle water is forced up the inside of each of the fibers in each membrane bundle contained in the module. The water is forced out of the fiber through the pores of the membrane and effectively cleans the membrane surface of particles that have accumulated to the surface. Backflush cycle should be performed for at least 15 seconds at the required flux of 30 L/m^2/h.

Backflushing occurs automatically during a normal process mode cycle. The duration and frequency is input by the operator. The duration can be fine-tuned by the operator to address varying operational conditions.

General Backflush settings are shown in Table 7.3.5.1:

Table 7.3.5.1 Backflushing Standard Operating Conditions

Flow/Flux	Time ON	Frequency	Aeration
30 L/m^2/h (18 gfd)	25 to 30 seconds	400 to 600 sec	Independent of BF

The backflush has a major effect on the system efficiency as produced permeate is returned into the process fluid and must be re-extracted. The operator must maintain an efficiency of no less than 75%. Efficiency of 85% is typical and efficiency levels of up to 95% may be attained on easy to filter processes.

Any change to the backflush settings must be recorded.

7.3.5.1 Initiating a Backflush

The backflush is part of the process mode and will be repeated indefinitely until the cycle is interrupted for maintenance clean, Standby mode or an alarm.

If necessary, the operator can force a backflush cycle by selecting Manual Backflush on the HMI. Depending on the specific programming of each project, trains may be

interlocked to prevent backflush cycles from occurring simultaneously or backflush may occur irrespective of other train operations.

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

Never apply backflush pressures of greater than 600 mbar across the membrane (TMP). Higher pressures could damage the membrane integrity.

7.3.6 Maintenance Clean

The maintenance clean (MC) procedure is documented as part of the Control Narrative. The MC is performed regularly to ensure the performance of the PURON membranes. Regular MC helps maintain and sustain higher flux rates and extends membrane life by increasing the time between recovery cleans (RC).

PURON systems have an *in-situ* MC. The *in-situ* MC can be performed in biomass/process fluid or in clean water/permeate.

Each train can perform a number of MC procedures in a single day – the normal single chemical cycle is 30-45 minutes long and can be repeated by manually initiating MC procedure on the Train Screen. The PLC counts the number of MC cycles and the type of chemical used. The analysis of this data can isolate cleaning differences between multiple train designs. The operator must log the data in the cleaning logbook – see Section 7.3.4

The primary chemical of choice for MC is sodium hypochlorite (NaOCl). Citric acid is periodically used if metal or hardness scaling is an issue.

It is good operating practice to give the trains an MC after the full flow to the system has passed and the system can handle the reduced flow capacity with fewer trains in production.

7.3.6.1 Scheduling a Maintenance Clean

The schedule of the MC procedure is typically input via the Train Setup Screen. Each train usually has a dedicated MC input window to allow making choices such as:

- First chemical – NaOCl default or citric acid
- Second chemical – citric acid default or NaOCl
- Setting dosing timers setpoints
- Water purging times
- MC flux – 6 L/m^{2}h (default)
- Frequency of MCs (Timer for first chemical and counter for second chemical)

KSS will setup the initial MC procedures during plant commissioning. Based on the data tracked in the cleaning logbook (Section 7.3.4), the settings can be optimized to improve

the performance of the MC or to reduce chemicals and improve system efficiency. KSS can advise on MC optimization.

If a train is consistently not cleaned via MC or if the cleaning data cannot be made available to KSS on request, any membrane guarantee shall be voided.

7.3.6.2 Verification of Chlorine concentration

The chlorine concentration in the MC has to be regularly verified as stock solutions degrade with time and temperature. The concentration should be verified once per month in temperate regions and once per week in warmer climates (the standard MC chlorine concentration is typically 125 ppm).

Chlorine test kits are available from MERCK or HACH.

7.3.7 Recovery Clean

After a period of time, the automatic backflushing, air scouring and MC procedures will be insufficient to maintain workable membrane permeability and the system operation will become limited to the maximum TMP. This maximum is set between 0.4 and 0.6 bar (6 and 9 psi). KSS recommends the performance of Recovery Clean (RC) procedures when TMPs exceed 0.4 bar (6 psi) and the performance of RC procedures is mandatory at TMP of 0.6 bar (9 psi).

Operation of the membrane system at a TMP above 0.6 bar (9 psi) will void any membrane guarantee. KSS must be informed in writing if a membrane system is operating near the maximum TMP.

There are two types of RC: sodium hypochlorite soak and citric acid soak. KSS recommends that they be carried out one directly after the other without first returning to production. If this is not possible, the half-cleaned train must not exceed 15 L/m^{2}h (9 gfd) in production or else the first RC cleaning step will have to be repeated.

As with the MC procedure, the sodium hypochlorite is used for organic fouling removal and the citric acid is used to remove scaling and metal salts.

The recommended RC procedure which involves soaking in sodium hypochlorite followed by soaking in citric acid takes between 12 and 24 hours in total. The water temperature is an important factor that affects the soaking time. See table 7.3.1.1 for general guidelines.

See Appendix G for log sheets to record the membrane performance of the train going through RC procedure.

7.3.7.1 Preparing for a Recovery Clean

It is recommended to plan the RC procedure well in advance. Due to the nature of the soaking clean and the time it takes to complete, a train may be out of operation for up to a day or two. While the RC procedure can be interrupted at any stage in case the train needs to be brought back on line to handle extra hydraulic loading to the system, it should be noted that in some plants the disposal of large volumes of weak NaOCl solution can be problematic. Municipal systems are particularly at risk due to unexpected rain and storms when extra water will need to be processed. Industrial systems must use all the equalization capacity available to bridge the time of the "out of service" train.

The RC procedure should be performed when the process water is >15°C (>59°F). Cleaning at temperatures of 25 to 35°C (77 to 94°F) is optimal for an RC procedure. The chemical efficiency is high and the duration can be reduced to several hours. Some systems have hot water tanks to increase the RC efficiency.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

In temperate climates, KSS recommends that one RC procedure be performed in fall (October – November in the Northern Hemisphere) and, if required, that a second be performed in the Spring (April – May in the Northern Hemisphere). In tropical climates where the process water is always >20°C, the RC can be carried out independent from the season.

In planning for an RC procedure, KSS recommends that the operator does the following:

1. Check the local weather for the period in which the RC procedure is planned. If any rain is predicted, it may be wise to delay the RC until drier periods.
2. Check there are enough chemicals on site to conduct the RC.
3. Procure and make available proper safety equipment (including PPE).
4. Make a work plan.

7.3.7.2 RC Safety & Warnings

Safety is an important issue during RC procedures and in particular during the oxidizing step using sodium hypochlorite.

⚠ WARNING

WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

As stated in Table 7.3.1.1 – Cleaning Chemicals, the chemical volumes used in RC procedures are considerable and extra safety measures may need to be taken.

Sodium hypochlorite cleaning solutions generate vapor that is both a health and safety concern and corrosive in nature. Ventilation is essential in the work area and the correct PPE must be made available for personnel.

Negligence by inexperienced operators can also cause damage to the membranes. NEVER pour concentrated chemicals directly onto the membranes or in the area of the membrane in the tank. Product damage will be caused.

In many systems the RC procedure is largely automated, and the operator only needs to initiate the sequence and follow the various prompts. When performing the RC procedure manually, and when chemicals are being added to the top of the membrane tanks, the operator should add the chemicals into a well-mixed zone and use more than one addition point. Aeration of the membranes will mix the tank very quickly.

7.3.7.3 RC Visual Inspection

Before draining the filtration tank, a visual inspection of the aeration pattern should be performed as outlined below:

1. Visually inspect the aeration pattern of the modules at high flux (F_{high}) aeration rate while the plant is still in operation. The aeration must be even on all modules. If areas of low aeration intensity are identified, the operator must stop the automatic operation of the train and manually conduct several “power flushes” (see Section 5.4.1).
2. After conducting these power flushes, aeration valve must remain open for 10 minutes to remove sludge that might have accumulated in non-aerated bundles. If possible, maximum specific aeration capacity should be used. During this time the other membrane trains may need to be stopped (put in stand-by mode) and blower operated manually to ensure 100% air flow into the train in RC.
3. Return all trains to normal operation. Repeat the visual inspection at high flux (F_{high}) aeration, repeat step 2 if required.

7.3.7.4 RC Filtration Tank Draining

Once the operator has verified that aeration is even on all modules, the filtration tank may be drained as outlined below:

1. Using the HMI, stop the train which has to be cleaned (set train Off-Line).
2. Close isolation valve for sludge supply to the filtration tank (may be automatic or manual).
3. Drain the filtration tank as appropriate to the site configuration (gravity, pumped, etc.).

4. Once drained, be sure that all valves are in the correct position and then start a manual backflush to remove sludge from inside the module. The backflush should be approximately 120 seconds in duration.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

During the backflush, make sure that the other filtration lines deliver enough water to the permeate tank or manifold.

5. Hose down residual sludge from tank walls and module covering plates. Ensure that sludge that has settled in the corners of the filtration tank is completely removed. Residual sludge remaining in the tank will consume excessive sodium hypochlorite for membrane cleaning.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

Do not direct the water from the hose onto the top of the membranes! This might damage the membranes. Ignore any foam that may have accumulated on top of the membranes.

6. In a system with a sloped floor, the filtration tank isolation valve can be cracked open for a few seconds to flush the tank floor to the lowest point. This can save a lot of time compared to performing the same task with only a fire-hose.
7. Draining/tank cleaning procedure is finished when the water on the tank floor and inside the pumping pit (sump) is free of sludge.
8. Check that the filtration tank is fully isolated before proceeding to the next step.

7.3.7.5 RC NaOCl Cleaning

Once the filtration tank has been drained and isolated, the RC cleaning using an NaOCl soak may begin as outlined below:

1. Connect the chemicals to the chemical pumps.
2. Calibrate and set the NaOCl chemical pump to the correct dosing rate to achieve a minimum in-tank concentration of 1000 mg/l (any adjustment to this concentration

should be done only after consultation with KSS). The dosing rate must be tuned to the wash water/permeate pump filling rate.

3. Some systems have a separate wash water pump used to facilitate the MC procedure at flux rate of 6 L/m^{2}h (3.5 gfd). If such a pump exists, this same pump is often used to fill the filtration tank. In other systems, the chemicals are dosed directly into the permeate line while relying on the reversible permeate pump to provide the backflush supply water. KSS' preferred way to add chemicals into the filtration tank is to dose the concentrated chemicals into the discharge side of this wash water pump or reversible permeate/backflush pump. The operator can control this pump in manual mode. This will causes an interlock for MC procedures on the other trains as this pump services all trains. The flow settings can be adjusted via the HMI. If the wash water pump is small and cannot reach recommended filling flux of 20-30 L/m²h, the backflush pump can be used in addition to wash water pump. Dosing pumps need to be set to reach required minimum 1000 mg/L after mixing with water from wash water and the backflush pump.

   Some systems do not have a wash water pump. In this case, the filtration tank can be filled with process water from another pumped source or filled via a 20-30 L/m^2/h (12-18 gfd) manual backflush. The chemicals are either added into the top of the tank by the operator or dosed directly into the tank via separate chemical distribution systems.

⚠ CAUTION
CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

The tank must be filled to cover the fibers within 1 hour of draining in order to avoid drying out of the fibers. If it is not possible to fill within this time, then the membrane must be backflushed (20-30 L/m^2/h / 12-18 gfd) to fill the tank and to keep the fibers wet. If the fibers are allowed to dry out, any membrane warranty will be voided.

4. Open the automatic valve of cleaning pipe to the specific train, double check that all needed manual valves are open.

5. In the SCADA/HMI:

   - Set all valves in the NaOCl piping to the required Open position.
   - Start the NaOCl chemical dosing pump.
   - Start wash water pump to required flow to fill tank in shortest possible time or use the backflush pump.

6. After sufficient chemicals are added to the tank and water level covering the top of the membranes by ~15cm (or 6 inches):
    - Stop the NaOCl chemical dosing pump.
    - Stop the RC water supply.
    - Set all valves in the NaOCl piping to the Closed position.
7. The RC train aeration can now be started. Typical aeration frequency during hypochlorite cleaning is 1-2 times per hour for duration of 0.5 - 1 minute. If an MBR system goes to F_{high} operation the train in RC mode will not receive air. If an MBR system with a maximum of 4 trains operates in low flow with alternating membrane aeration, the train in RC mode will receive air. When the hypochlorite clean is first initiated, the train may foam (white fluffy foam) which may need to be suppressed with water from a hose. After a while the foam will die down. The aeration mixes the tank, oxidizes sludge and fouling, dislodges sludge from between the fibers and aids the RC efficiency.

7.3.7.6 RC Chemical - Tank Draining

Once the NaOCl soak has completed, the tank should be drained using the standard procedure described below. This procedure involves pumping the NaOCl chemical solution either back to the system feed line or directly to the process tank / bioreactor:

1. After the NaOCl soak has finished, drain the tank.
2. Clean the chemical piping by flushing with permeate (by starting the wash water pump, or the backflush pump if wash water pump does not exist).
3. Hose down the outside of the module and the tank walls and conduct a manual backflush for 5 minutes at 20 $L/m^2/h$ (12 gfd) to remove residual NaOCl from the tank and permeate system.

The residual NaOCl will oxidize some very small percentage of the biomass but should have no significant effect on the total operation of the plant.

Note: In discharge areas where Absorbable Organic Halide (AOX) is a discharge criterion, the residual NaOCl will have to be neutralized with sodium meta-bisulphite ($Na_2S_2O_5$) and then sent to the process tank. KSS suggests a 1 to 1 ratio based on the initial NaOCl concentration. This will result in an excess of sodium meta-bisulphate as some NaOCl would have been used in the RC process or stripped from the filtration tank. (neutralization of chlorine with sodium metabisulfite may lower the pH and caustic addition may be required).

7.3.7.7 RC Citric Acid Cleaning

Once the tank is drained and any residual NaOCl removed from the tank and permeate system, RC cleaning using a citric acid soak may continue as outlined below:

WARNING
WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

Any residual NaOCl will react with the citric acid and produce noxious vapors. All NaOCl must be flushed out of the system before initiating the citric acid clean. The operator should not enter the filtration tank or filtration tank area until the tank is completely full with water. In addition, the operator should wear a gas mask at the onset of citric acid dosing.

1. Connect the chemicals to the chemical pumps.
2. Calibrate and set the citric acid chemical pump to the proper dosing rate to achieve a tank concentration of 2000 mg/l (any adjustment to this concentration should be done only after consultation with KSS). If a wash water pump is used, the dosing rate must be tuned to the pump filling rate.
3. Some systems have a separate wash water pump used to facilitate the MC procedure at flux rate of 6 L/m^{2}h (3.5 gfd). If such a pump exists, this same pump is often used to fill the filtration tank. In other systems, the chemicals are dosed directly into the permeate line while relying on the reversible permeate pump to provide the backflush supply water. KSS' preferred way to add chemicals into the filtration tank is to dose the concentrated chemicals into the discharge side of this wash water pump or reversible permeate/backflush pump. The operator can control this pump in manual mode. This will cause an interlock for MC procedures on the other trains as this pump services all trains. The flow settings can be adjusted via the HMI. If the wash water pump is small and cannot reach recommended filling flux of 20-30 L/m²h backflush pump can be used in addition to wash water pump. Dosing pumps need to be set to reach required min. 2000 mg/L after mixing with water from wash water and backflush pump.

   Some systems do not have a wash water pump. In this case, the filtration tank can be filled with process water from another pumped source or filled via a 20-30 L/m^2/h (12-18 gfd) manual backflush. The chemicals are either added into the top of the tank by the operator or dosed directly into the tank via separate chemical distribution systems.

WARNING
WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

The tank must be filled to cover the fibers within 1 hour of draining in order to avoid drying out of the fibers. If it is not possible to fill within this time, then the membrane must be backflushed (20-30 L/m^2/h / 12-18 gfd) to fill

the tank and to keep the fibers wet. If the fibers are allowed to dry out, any membrane warranty will be voided.

4. Open the automatic valve of the cleaning pipe to the specific train, double check that all required manual valves are open.
5. In the SCADA/HMI:
    - Set all valves in the citric acid piping to the required Open position.
    - Start the citric acid chemical dosing pump.
    - Start the wash water pump and set to the required flow to fill the tank in shortest possible time or use the backflush pump to fill the tank.
6. When sufficient chemicals are added to the tank and the water level covers the top of the membranes by ~15 cm (6 inches):
    - Stop the citric acid chemical dosing pump.
    - Stop the RC water supply.
    - Set all valves in the citric acid -piping to the required Closed position.
7. The RC train aeration can now be started. Typical aeration frequency during citric acid cleaning is 1-2 times per hour for duration of 0.5 - 1 minute. If an MBR system goes to F_{high} operation the train in RC mode will not receive air. If an MBR system with a maximum of 4 trains will be operated in low flow with alternating membrane aeration, the train in RC mode will receive air.
8. Using a properly calibrated pH meter, periodically check the pH value in the filtration tank to make sure it remains between 2.0 and 3. To reach a pH value between 2.0 and 3 some hydrochloric acid (HCl) may need to be added.

    Note: The amount of HCl required will be dependent on the water alkalinity.

    If addition of HCl is required:

    - Add the needed HCl gradually. Do NOT add all HCl in one step.
    - Add a portion of the HCl during an aeration period and thereafter check the tank pH.
    - Repeat the procedure and stop HCl dosing when the required pH-value is achieved.

The duration of the citric acid cleaning step is dependent on the water temperature. The soaking step shall be at least 4 hours with a temperature of ~15°C (59°F).

Neutralization of citric acid is typically not required. Citric acid is a biological nutrient and can be mixed with mixed liquor biomass where it will be consumed.

7.3.7.8 RC Ending

Once the citric acid soak has been completed, the RC procedure shall be concluded as outlined below:

1. Open the filtration tank isolation (feed) valve.
2. Start the sludge circulation system and wait for 30 minutes to dilute residual citric acid solution.
3. Set aeration to normal mode – this will depend on plant capacity.
4. Carry out a manual backflush for 1-5 minutes at 20 L/m^{2}h (12 gfd) to remove residual citric acid from within the membrane fibers.
5. Carry out a manual de-aeration followed by ventilation. See Section 7.4 for further details.
6. Return the train to Standby Mode.

The membrane requires a stabilization period before maximum fluxes can be applied. The cleaned train will not be allowed to go directly to high flux (F_{high}) conditions (flux limited to 20 L/m^{2}h (12 gfd) for a period of 15-30 minutes.

7.3.7.9 RC Guidance

After completion of an RC, it is important that the RC data be evaluated to determine the effectiveness of the RC and the condition of the membrane.

The effectiveness of an RC is dependent on the status of the membrane, its age, the manner in which they have been used and maintained and whether mistakes were made in carrying out the RC procedure:

- As the membrane gets older, irreversible fouling begins to take place. As a result, it will eventually become more difficult to recover permeability and the membrane may need to be replaced.
- Wear and tear also influences membrane performance and operator interaction can, in some cases, be detrimental to membrane operation.
- Some of the most common mistakes in carrying out RC procedures which lead to poor recovery of permeability are listed below:
  - Old chemicals – such as inactive NaOCl
  - Water is too cold for suitable RC procedure <10°C (50°F)
  - Contact time with chemicals is too short
  - Incorrect planning
  - No aeration during RC
  - Incorrect flushing of filtration tanks prior to RC
  - Incorrect calculated dosing rates of chemicals

KSS can take fiber samples and carry out laboratory-based controlled cleaning experiments. These tests help diagnose the fouling and identify a procedure to recover the membrane, including the use of alternative chemicals.

7.4 De-Aeration, Standby and Safe Mode

De-Aeration

During operation, especially at lower flux rates, air can get entrained in the tips of the PURON fibers. These air pockets reduce the active membrane area and can increase the operational trans-membrane pressure. The system will routinely perform automatic De-Aeration cycles to eliminate these air pockets.

A De-Aeration cycle pulls permeate from the fibers at a minimum flux rate of 20-30 l/m^2h (12-18 gfd) for a specified duration of between 60 and 120 seconds, thus removing entrapped air from the fiber tips. De-Aeration cycles are initiated based upon a frequency which is set for each flux condition and is adjustable from the Train Set-up Screen (see Section 3.2.15). The cycle duration is also set from the same Train Set-up Screen. When the De-Aeration cycle has been completed, the system will return to the production mode.

De-Aeration is usually initiated every 6 hours to 24 hours and is automatically available in low flux (F_{low}) modes. High flux modes (F_{high}) may not require de-aeration as the applied flux is sometimes high enough to continuously extract air from the fibers.

The operator can initiate a manual De-Aeration cycle from the HMI or SCADA system. KSS can help optimize the de-aeration of a system. It is wise to carry out process data collection regarding permeability and membrane performance after carrying out a De-Aeration cycle as the fiber surface area is then fully available for filtration.

Standby

The Standby Mode is initiated manually or automatically. Automatic initiation is typically initiated by a low level in the controlling basin (most commonly an aeration basin level or a return activated sludge - RAS basin level). During Standby Mode the trains are available to produce permeate but are not actively producing as there is no demand to process water. Sludge still circulates through the trains and aeration is applied.

Safe Mode

The Safe Mode is like Standby mode, with the difference that Safe mode is triggered by an alarm condition and a manual reset is required to exit the mode.

7.5 Bioreactor Operation

The membrane bioreactor (MBR) technology is an integrated biological-filtration process. Experience has shown that a poor biological design or improper system operation seriously harms the membrane performance. Because the biological system is the key to successful operation of the membranes, operators should give at least the same

level of care and attention to the bioreactor part of the MBR as they do to sedimentation tanks (primary/secondary clarifiers) in conventional treatment.

Since conventional systems rely on sludge settleability, one of the operator's main tasks was to condition the biomass in such a way that it was easy to settle. In conventional treatment, the operator attempted to keep the sludge volume index (SVI) as low as possible. Set forth below is the sludge quality associated with a range of SVI values:

- SVI <100 ml/g Sludge is easy to settle; plant operation is easy.
- SVI >100 ml/g Good sludge to settle but fine tuning of process is required.
- SVI >150 ml/g Poor sludge to settle and much process attention is required.
- SVI >200 ml/g Bad sludge to settle and plant has TSS problems at discharge.
- SVI >300 ml/g Process is losing its sludge via bulking or pin floc; plant has serious operation problems.

These conditioning rules also apply to MBR sludge except that instead of a settling process we have a filtration process in which lower SVI's translate to lower TMP's and better membrane performance and higher SVI's translate to higher TMP's and worse membrane performance.

Note: Since MBRs often operate at higher MLSS concentrations, the SVI test MLSS concentration may need to be diluted with permeate water to 4g/l (DSVI – Diluted SVI).

The Time-to-filter (TTF) test is another way to quantify the sludge health and filterability. TTF is determined by Standard Method 2710H (Standard Method for the Examination of Water & Wastewater 2012, 22nd Edition, jointly published by the APHA, AWWA, and WEF.).

Set forth below is the sludge quality associated with a range of TTF values:

- TTF < 100 seconds Sludge is easy to filter. Plant operation is easy.
- 100 < TTF < 200 seconds Good sludge to filter
- 200 < TTF < 300 seconds Moderate sludge to filter. The operation of the bioreactor should be reviewed and optimized.
- TTF > 300 seconds Difficult sludge to filter. The operation of the bioreactor should be corrected.

7.5.1 Biological Configurations:

While there are numerous biological processes and system configurations, one thing remains constant – the sludge must be separated from the water phase.

KSS appreciates the diversity in biological systems and can work with a variety of systems provided they result in a good working bioreactor. Good membrane performance cannot be achieved in the absence of a good working bioreactor. The following is a list of the sludge characteristics typical of a good working bioreactor:

1. The MLSS must be between 1,000 and 10,000 mg/l in the bioreactor. For best results the MLSS should be between 6,000 to 8,000 mg/l in the bioreactor.
2. The MLSS must be no higher than 14,000 mg/l in the membrane tank. For best results the MLSS should be between 8,000 to 10,000 mg/l in the membrane tank.
3. The supplied sludge should have a minimum dissolved oxygen (DO) concentration of 0.5 mgO_2/L. For best results the DO concentration should be at least 1 mgO_2/L.
4. The supplied sludge should have a minimum Redox Potential of -50 mV. For best results the Redox Potential should be positive (> 0 mv).
5. The supplied sludge should have a SVI or DSVI of <200 mL/g. Preferably <150 mL/g. Values higher than 300 mL/g will require biological optimization and values higher than 400 mL/g will temporarily void the capacity guarantee.
6. The supplied sludge should have a TTF of <200 seconds. Preferably <150 seconds. Unless the PURON® sale contract specifically defines the sludge TTF, values higher than 300 seconds will require biological optimization and will temporarily void the capacity guarantee.
7. The feed must be aerobically biodegraded until all residual BOD is removed and only a residual COD is present as hard COD in the permeate.
8. While complete nitrification and de-nitrification processes are not required for membrane operation, better membrane performance is seen in systems with complete nitrification and de-nitrification.
9. The sludge age SRT must be between 10 and 30 days. A sludge age of 10 days is acceptable for tropical systems with complete nitrification and de-nitrification. A sludge age of between 16 to 22 days is recommended for systems located in moderate climates.
10. SVI or DSVI values must be achieved without addition of special polymers. These polymers should only be used if the biological process is deteriorating.
11. Free oil must not be present in the feed to the membrane tanks (<1 mg/L).
12. Sand and coarse material/debris must be removed via extensive pre-treatment. **All screening to 2 mm punched holes with absolutely no by-pass.** By-pass will void the guarantee.
13. Proof of proper operation is required by KSS to support any long-term guarantees.

FAILURE TO FOLLOW ANY OF THE REQUIREMENTS SET FORTH IN THIS MANUAL WILL INVALIDATE ANY AND ALL WARRANTIES APPLICABLE TO THE EQUIPMENT, INCLUDING THE MEMBRANE MODULES.

8.0 PERFORMANCE MONITORING

In order to assess performance, it is necessary to monitor the results from the system and compare them with the original design values. Monitoring and information exchange are essential to the control of membrane performance and the assessment of the duty life of the PURON® MBR product.

Most modern systems have data logging systems as part of the SCADA system. While these data loggers permit some data files and reports to be generated automatically, continuous operator monitoring and operator system assessment are also critical to maintaining a successful operating system.

For contracts where workmanship and / or performances warranties have been included, records of the following data must be maintained for the entire warranty duration and be made available to KSS upon request:

1. Automatic data logging in the SCADA system with automatic CSV file generation
2. Manual data recording for external Lab analyses results
3. Manual data recording for on-site analyses and tests

as further specified in the following paragraphs.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

Since any assessment is only as good as the data on which it is based, all instruments should be regularly maintained and calibrated per vendor specifications. Records must be kept by the operator and made available to KSS as set forth in this manual.

The operator has to check the data logging on a regular basis to ensure that the data logger is working properly.

8.1 Standard Analysis (On/Offline)

Unless otherwise specifically agreed in writing, the required parameters listed in Table 8.1 must be measured and recorded using the methods specified in Table 8.1. These records must be maintained for the entire warranty duration and be made available to KSS upon request. Every effort should be made to forward the records to KSS on a monthly basis; however, KSS acknowledges that this may not always be practical and occasional lapses will not be cause for voiding the warranty.

Table 8.1 Analytical Requirements

Recordable parameter	Method and frequency of testing	Required /Preferred
Influent		
COD/BOD	Once per week on site and once per month by external lab	Preferred
Ammonia	Once per week on site and once per month by external lab	Preferred
Effluent		
COD/BOD	Twice per week on site and once per month by external lab	Preferred
Ammonia	Twice per week on site and once per month by external lab	Preferred
TSS	Once per month by external lab	Required
Turbidity	Once per week manually on site	Required
Biomass		
MLSS	Online (provided that MLSS is measured once per week manually to verify online measurement) or twice per week manually	Required
MLVSS	Once per month	Preferred
TTF	Once per week	Required
SIEVE TEST	Once per week	Required
Operation		
Permeate Flowrate per train	Online (+ archive datalog)	Required
Recirculation Flowrate per train	Online (+ archive datalog)	Required
Cumulative Flowrate	Online (+ archive datalog)	Preferred

Recordable parameter	Method and frequency of testing	Required /Preferred
(all inlet and outlet flows)		
Permeate Pressure per train	Online (+ archive datalog)	Required
Pressure Module air scouring	Online (+ archive datalog)	Required
Temperature in Biology	Online (+ archive datalog) or once per week manually on site	Required
Permeate Turbidity per train	Online (+ archive datalog) AND once per week manually on site	Required
Operating Hours per train (on permeate pump)	Online (+ archive datalog)	Preferred
Timers	Any changes in timers like filtration time, backflush time, etc. have to be reported	Required
Set-points	Any changes in set-points have to be reported	Required
Maintenance Cleaning	Online + archive datalog (frequency, flow rate, and TMP); pH and Cl concentration need to be checked on a monthly basis	Required
Maintenance Cleaning	Frequency (flow rate, and TMP); pH and Cl concentration need to be checked on a monthly basis	Required
Recovery Cleaning	Manual log; needs to be transmitted within 4 weeks after Recovery Cleaning execution	Required
- KSS shall have the right but not the obligation to measure and record each of the above-mentioned parameters using its own personnel or laboratory in order to verify system performance or to perform troubleshooting activities. KSS shall be given reasonable access to the system in order to perform such measurements. - All on-line instrumentation shall be calibrated according to manufacturer recommendations. - It is recommended that all manual samples should be taken at same time and day of the week.		

The external laboratory must be a third-party laboratory duly qualified to perform the testing in accordance with all applicable requirements and prudent industry practice.

8.2 Analytical Techniques, External Analyses

Many standard analytical techniques can be carried out on site using simple analytical tools. Analyses generally conducted by an external lab include BOD, ammonia-N, nitrate-N, nitrite-N, total phosphorous, total fats, oil and grease (TFOG), and hydrocarbon fats, oils & grease (HFOG), metals, pesticides, biocides, viruses, specific bacteria colonies, as well as any other parameters necessary to ensure compliance with sewer discharge requirements.

The following analytical methods are taken from the *Standard Methods for Examination of Water and Wastewater 21st Ed (APHA, AWWA & WEF, 2005),* which should be used for the commonly required analyses:

Table 8.2: Analytical Methods

Analyzed Parameter	Analysis Methods
BOD	Standard method 5210
COD	Standard method 5220 or HACH® COD Analysis Method 8000 (approved by EPA)[1]
Ammonia	Standard method 4500 or HACH® NH_3-N Analysis Method 10200 (approved by EPA)
Turbidity	Standard method 2130 or HACH® Low Range Turbidimeter On-line Reading
Nitrates	Standard method 4110 or HACH® NO_3^--N OD Analysis Method 8039
Nitrites	Standard method 4110 or HACH® NO_2^--N Analysis Method 8507 (approved by EPA)
Total Suspended Solids (TSS)	Standard method 2540
Volatile Suspended Solids (VSS)	Standard method 2540

1. *HACH® manufactures analytical instruments and reagents used to test water quality*

Procedures for the external analyses are not included in this manual but should be conducted by the external laboratory according to documented standard laboratory procedures.

8.3 Log Sheets for Manually Collected Data

The system shall have a number of separate log books. Except as noted, each of the log books must be maintained on site for the entire duration of the warranty period and shall

be submitted to for inspection by KSS upon request. Appendix G shows an example of acceptable log sheet for recording recovery cleaning effectiveness.

Log books include the following:

1. Operator log book – Any operator may write notes or comments regarding the system operation in the log book. The operator should note the maintenance and calibration of data-gathering equipment in this log. Such activity should be performed in accordance with manufacturer recommendations.
2. Cleaning Log book – This book shall record train Backflush, Maintenance Clean and Recovery Clean procedures with before and after data points. Any operator may add to the log book regarding such cleaning procedures.
3. Lab & Site log book – This book records any testing carried out on site (membrane specific tests like TTF, Sieve Test results, etc.) and / or in the on-site laboratory. Daily analyses, site test results and operational changes must be noted.
4. Materials log book – This book records all material usage and disposal related to the system, e.g., sludge disposal, chemical deliveries and spare parts usage.
5. Visitors log – This books records all persons admitted to the site. It should note the visitors name and employer and include a sign in time and date and a sign out time.

Most plant data can be input directly into an excel worksheet and sent to KSS for assessment. KSS has vast experience in analyzing system data and trends. If it is provided with accurate data in a timely fashion, it can advise the client in advance of potential system problems and assist in averting them. Because of the critical nature of the information to be captured in these logs, failure to maintain the logs in the manner set forth in this manual shall invalidate any warranty that has been provided.

8.4 Set point Log Sheet

The set points are saved in the memory of the PLC. Even during brown- or black-outs, the set points are kept. When an operator changes a set point (for whatever reason), the new set point overwrites the previous value. After the system outage, the set points are automatically reloaded to the parameter pages.

KSS recommends taking screen shots of the original set up of the system. These screen shots will assist in restoring the original set up. It should be noted that it is possible in curtain conditions for the PLC to lose system memory where the code has to be download and all the parameters need to be checked. These screen shots will be beneficial.

KSS requires that any set point change be logged by the operator or engineer. The change should be noted either in the Operator Log-book or in a separate Set Point Log Book.

The automation narrative (sequence of operation) contains the startup default values for safe system initiation.

8.4.1 Data Analysis and Training

Analytical results have to be evaluated to understand what they mean for the system. Operator training and experience are crucial to assess the system performance.

KSS recommends that any MBR operator have basic biological training in their own language via a qualified organization. Training courses are available for Sewage Plant operators throughout Europe, North America and other countries and at levels which include:

- Basic Operator
- Full Operator
- Supervisor Operator
- Plant Manager

KSS recommends that the operator be trained to at least the Full System Operator level on Conventional Activated Sludge treatment with Biological Nutrient Removal (BNR).

KSS' scope of work specifies the operator training on membrane filtration and the interaction between the biological system and the filtration system that is included in the purchase price for KSS equipment. Additional training may be arranged upon request.

FAILURE TO FOLLOW ANY OF THE REQUIREMENTS SET FORTH IN THIS MANUAL SECTION (PERFORMANCE MONITORING) WILL INVALIDATE ANY AND ALL WARRANTIES APPLICABLE TO THE EQUIPMENT, INCLUDING THE MEMBRANE MODULES.

9.0 FIBER LEAK DETECTION AND REPAIR

9.1 Bubble Test

If the permeate quality is not meeting the expected value and it is suspected that membrane integrity is compromised, a bubble test is used to locate the leaks in the membranes.

To bubble test a module, the following steps should be followed:

1. Carry out a pressure decay by slowly opening the pressure regulating valve to evacuate the liquid from the permeate side of the membrane into the membrane tank. Adjust the applied air pressure to just under the required pressure (200 mbar or 3 psi). Wait 5 minutes to ensure the air has purged the water and then increase the air pressure to the required pressure (275-350 mbar or 4-5 psi).
2. Observe the module.
3. Once a leak has been found, analyze the bubbles as described in Section 9.1.1: Bubble Types. The module can be repaired using the fiber repair methods detailed in Section 9.2. In cases where few leaks are present in a given module, and none of the leaks are serious, the repairs should be made on site. If a module requires difficult or numerous repairs, please contact KSS for further information.

9.1.1 Bubble Types

The size or type of bubble indicates the type of leak. Bubbles are classified into four types, as shown in Figure 9.1.1:

- Type 1 bubbles appear as steady streams of large bubbles, typically 10 mm (⅜”) diameter or greater. If the stream appears to come from the permeate header, it is most likely caused by an improperly installed O-ring. Otherwise, it is likely a broken fiber.
- Type 2 bubbles are characterized by steady streams of moderate sized bubbles (>1 mm and <10 mm (>1/32” and <⅜”)). This category may indicate damaged fibers or “pin holes” in the membrane. Bubbles of this type indicate a minor leak that may or may not need repair. If larger leaks are found in the module or sub-group of modules, these larger leaks should be repaired first and then another bubble test performed to determine whether these smaller leaks need repair.
- Type 3 bubbles appear as an intermittent stream of small bubbles (<1 mm (<1/32”)). This type of bubble is typically due to air passing through unwetted pores. Unwetted pores allow passage of air, but not water, and they do not need to be repaired.
- Type 4 bubbles are those that gather at the top of the modules and release when the bubble is sufficiently large. Typically, type 2 or type 3 bubbles gather to form this type of bubble.

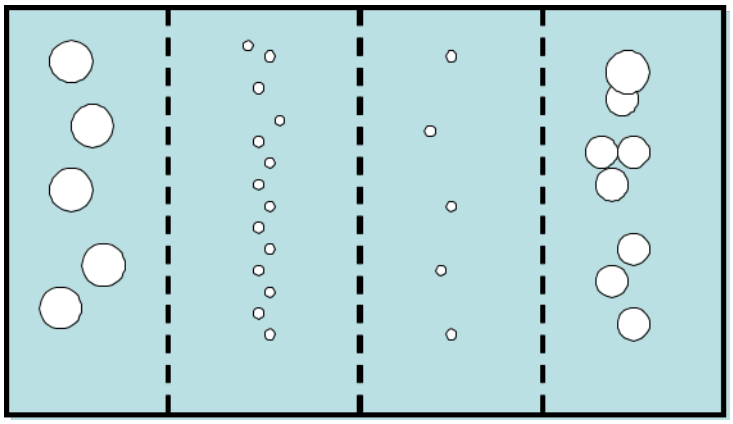


Figure 9.1.1: Bubble Sizes

Type 4 bubbles are very common if the aeration system of the module has been commissioned ahead of protocol. This makes bubble size analysis very difficult as process air gets trapped within the module and is periodically released. In MBR applications type 2 and 3 bubbles are rarely fixed as they will plug during process operation.

9.2 Membrane Fiber Damage and Repair

9.2.1 Membrane Fiber Damage

If damage to one or more of the membrane modules in the train is suspected, a damaged module may be located by examining the permeate from each module to see if it is acceptable. If a damaged module is identified, the damaged row can then be found by visual fiber inspection or bubble test. Any damaged row should be inspected and repaired or replaced to bring the overall system performance up to desired levels.

A leaking row can be located by a bubble test (see Section 9.1: Bubble Test). Streams of bubbles identify the location of possible leaks in the module. After the module has been removed from the filtration tank, and the plates removed, the leak can be located in the row.

In most cases, the module does not require complete disassembly to locate and repair leaking fibers.

If the damage is extensive and local to one row, for example a sharp object has fallen into the module, it is advisable to replace the row completely.

Other sections in this O&M describe how to dismantle the module, replace a row, re-build it and commission it (see chapter 6.0 and chapter 10.0).

9.2.2 Membrane Fiber Repair

The following equipment is needed:

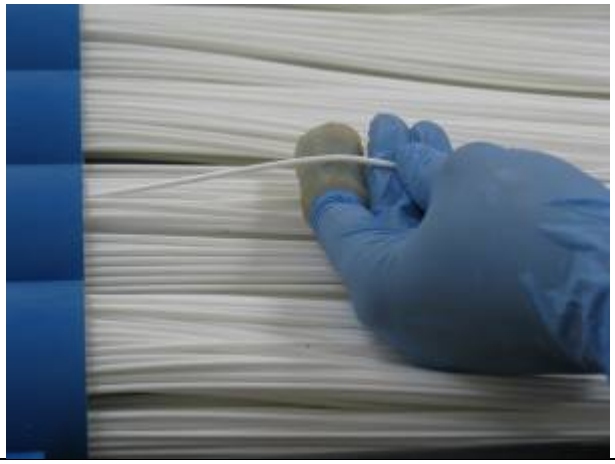
1. Silicon Kit – acid stable, anti-bacterial, high viscosity, fast drying (available in any hardware store)
2. Syringe with 1 mm needle
3. Hard plastic thimble
4. Rubber gloves

There are two possible ways to seal a fiber:

1. Via side wall insertion
2. Via end hole of cut fiber

A membrane fiber repair kit, containing items 1-3, can be ordered from KSS.

While side wall insertion renders the fiber length above the insertion point redundant, its advantage is that the fiber length below the point of insertion will still function as a membrane. This method is used to seal off pinholes located near the top of the fiber. This method is illustrated in Figure 9.2.2 below.

	Locate pinhole or leak using the detection methods described in this manual. If the fiber is accessible, then the row does not need removal (plates must be removed). If the leak is near the middle of the row, then the module will need dismantling. In the photo: a leak or pin-hole is located 5 cm (2”) to the right of the index finger protection.

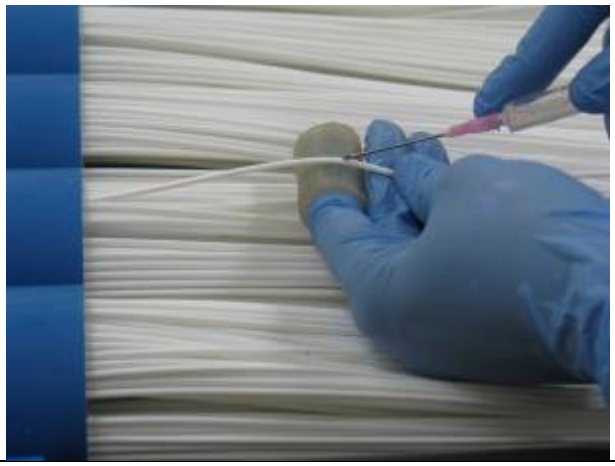
	Carefully insert the needle through the side wall of the fiber away from the located leak. The syringe is pre-filled with the sealing agent (sucked into syringe).
	Push the needle 5 cm (2”) into the lumen of the fiber to the butt-of the needle as shown left. Inject the sealant by pressing the syringe plunger slowly and at the same time withdrawing the needle slowly. Wait 10 minutes for the sealant to harden.
	The repair appears as shown left. The fiber can be left in the row or removed 5 cm (2”) above the injection point.

Figure 9.2.2: Fiber repair

DANGER

DANGER indicates an imminently hazardous situation, which, if not avoided, **will result** in death, serious injury, or equipment damage.

Consult with your site safety professional regarding the required safety procedures and the PPE appropriate to this activity.

Sealing the end hole of a cut fiber is done where fibers are taken as samples or if the pin hole is located within 50 cm (20”) of the bottom header. This method is performed as follows:

1. The fiber is cut at least 5 cm (2”) from the bottom header.
2. The needle is inserted into the open end of the fiber.
3. The sealant is injected into the fiber at the same time as slowly withdrawing the needle.
4. Wait 10 minutes for sealant to harden.
5. The repair is complete.

For module tracking purposes, a lineup protocol should be followed. Refer to Appendix E for more information.

FAILURE TO FOLLOW ANY OF THE REQUIREMENTS SET FORTH IN THIS MANUAL WILL INVALIDATE ANY AND ALL WARRANTIES APPLICABLE TO THE EQUIPMENT, INCLUDING THE MEMBRANE MODULES.

10.0 MODULE ASSEMBLY AND DISASSEMBLY

10.1 Module Disassembly

The following sections on module disassembly, assembly, row replacement and mechanical cleaning are presented using a chronological photo-session with explanatory text.

This section (10.1) deals with complete module disassembly. For module inspection the headers do not need to be removed. Generally, only a couple of side plates need to be removed for adequate module inspection and usually rows are not removed. As modules are disassembled, it is important that all hardware, especially manifolds, is set aside carefully and protected until reinstallation.

Complete disassembly of the module is typically required due to three possible causes:

1. Membranes need replacement after lifetime has expired.
2. Membrane rows require mechanical clean.
3. Problem has been found and a row needs replacement.

10.1.1 Manpower Requirement

⚠ CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

It requires two people to carry out module disassembly safely. Before commencing disassembly, keep the following reminders in mind:

- Good housekeeping is a must to avoid loss of parts
- Always have reserve material available
- Always use the correct tools
- Never force the plastic joints
- Always use the correct protective equipment – gloves, safety shoes, and safety glasses.

Figure 10.1.2 shows the tools required for module work.

10.1.2 Tools Required

	LOCTITE®: for all threaded SS material Ratchet screwdriver with 10 & 13 mm sockets Torque wrench Utility knife
	10 mm extension socket 10 mm spanner 13 mm spanner PVC 50-100 mm union pliers Socket set with 10 and 13 mm sockets

Figure 10.1.2: Tools Required for Module Work

10.1.3 Header disassembly

Figure 10.1.3a shows the steps of header disassembly and Figure 10.1.3b shows the module after the headers have been removed.

Release the Aeration header from its metal support bracket.

Loosen all the union joints using the correct tool – these are hand tight plus ¼ turn.

All rows have a gasket (check all are present). Only use specified O-rings from GF.

If a union is broken or cracked it will need replacement. Use only GF 40 mm unions.

 Release the Permeate header support bolts from the metal brackets.		 Loosen all unions as with aeration header using the correct tool. Two people are required to remove the permeate header safely.

Figure 10.1.3a: Header Disassembly

Figure 10.1.3b: Module after headers have been removed

Figure 10.1.3c shows Plate Removal and Figure 10.1.3d shows the module after plate has been removed.

<table>
<tr>
<td>  </td>
<td> 
Release the lock nut first</td>
<td>  </td>
</tr>
<tr>
<td>  </td>
<td> 
Remove the nut – make note of LOCTITE® usage (green residue)</td>
<td>  </td>
</tr>
</table>

Remove the nuts and metal plates and store in a safe location.

Remove the plate and store in a safe location.

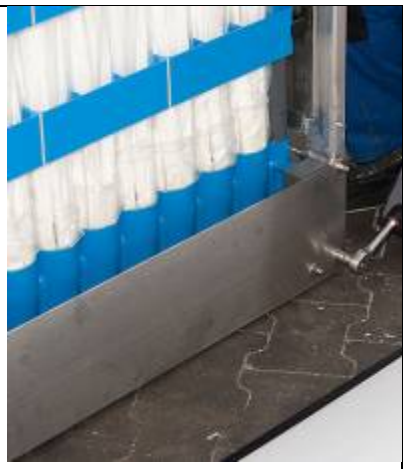
It makes no difference which plates are removed first or the subsequent order. Please note for replacement that the front plates are a different size than the side plates.

Figure 10.1.3c: Module Plate Removal

Figure 10.1.3d: Module without Headers and Plates

Figure 10.1.4a shows removal of a row from a module. Figure 10.1.4b shows the module frame after all rows have been removed.

The rows are located in a metal guide-rail and held in place by front plates and spacers.











Note the PVC spacer – this must be used during assembly.

Note the guide-rail and the way the foot element is located in the rail.

Note the hole in first row at front side

Row removal requires two people to support the row sides. Remove the row by sliding the foot element out of the rail.

Note:
Long PVC pipe = Air
Short PVC pipe = Permeate

Figure 10.1.4a: Module Row Removal

Figure 10.1.4b: Module Frame

10.2 Module Assembly

Module assembly is in principle the opposite of disassembly. There are, however, a number of detailed procedures that must be followed to secure the module does not lose component parts once returned to process.

Figure 10.2.1.1 shows the steps of assembly of a module.

10.2.1 Detailed Procedures for Assembly

		 All SS threads MUST be fixed using Loctite®. Use torque wrench at 1.2 Nm for first nut
 Loosely fit the plate so that all side space is the same – approximately 5mm around plate.	 Also use LOCTITE® for lock nut.	 Make sure the first nut does not turn during locking with lock-nut.

When installing the headers use a wooden plate to bridge the module and allow easy access to the unions.

This also prevents tools and debris from falling into the module.

Install permeate header first then aeration headers.

Torque wrench at 17 to 20Nm

The standard permeate header has a metal insert to allow use of a Straub-Flex coupling. This metal sleeve must line up correctly and sit smoothly in the pipe. (metal piece is not contained in module scope of supply, but in separately available connection kit)

Figure 10.2.1.1: Detailed Assembly Procedures

10.2.2 Final Checks

Visual inspection is necessary; however, some problems cannot be identified even in a thorough visual inspection. Such problems may include:

1. Unions are not tightened correctly
2. LOCTITE® is not used
3. Headers have been put on a wrong way
4. Foot plates not installed
5. Foot element spacers missing

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

All the above are caused by not following the assembly procedures. The only reliable way to verify good module assembly quality is to follow these instructions carefully and then to carry out a clean water leak test after the module has been returned to the filtration tank. Any problems must be remedied according to the procedures described in this manual.

10.2.3 Returning Damaged Membranes

Before returning membranes to KSS, it is imperative that they be properly cleaned, preserved, and that a "Returned Material Authorization" (RMA) number be obtained prior to shipping it. Contact KSS Technical Support for information on the RMA procedure. Return of fiber samples should also be done following the RMA procedure.

10.2.4 Disposal of Old Rows

Old rows that cannot fulfill their required duty can be disposed of. The row is made up of various plastics with SS metal fixings. Although the operator should check applicable local regulations, the rows can normally be disposed of to landfill as plastic or incinerated in specialized central waste incinerators.

10.3 Laying module on side

In the case of aeration system blockage, it is sometimes necessary to remove the module from the filtration tank so that the aeration caps are accessible. The latter is achieved by setting the module on its side.

Stainless Steel brackets can be obtained from KSS as well as a special tilting traverse. These are shown below.

The following procedure describes the recommended approach to module handling when it is necessary to place the module on its side.

Table 10.3.1: Setting module on side for bottom access

	Action	Information
1	Module has been removed from tank and stands vertically on pallets or wooden spacers.	
2	Remove standard hanging traverse and any pipes supported by the traverse.	While it is possible to tilt the module using the standard traverse, this may cause steel deflection with extremely heavy modules. Accordingly, KSS advises using the tilting traverse. 
3	Prepare the tilting traverse or use hoisting rings. This traverse makes tilting easier because it does not have legs. Also prepare the header support frame – this protects the header connection during tilting.	

4	Install the header support frame. The support frame is mounted against the permeate header unions and fixed with clamps. This support is essential when tilting heavy modules. Note the direction of the tilt is dictated by the position of the support frame. When in a tilted position, the support frame must be closest to the ground and the permeate header must be horizontal.	
5	Install the lifting traverse	

6	Connect two belts to the corners opposite to where the support frame is mounted. The crane can then slowly lift the module until the balance point is reached and then allow the module to tilt slowly to the ground. The traverse is designed to allow contact with the ground while supporting the weight of the module while laid on its side. Use wood as a convenient spacer.	
7	The module is on its side and ready for inspection / maintenance or aeration system flushing / maintenance	

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

Failure to follow the foregoing procedure can result in equipment damage or personal injury.

10.4 Repair of Aeration Nozzle

The following equipment is needed to repair an aeration nozzle:

1. ABS adhesive
2. Over-cap ring
3. Aeration cap removal tool

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

During routine aeration cap maintenance or inspection, the operator may apply excessive force by accident and damage the plastic retaining lips on the cap or on the housing itself.

Figure 10.4 illustrates the proper procedure for repair of an aeration nozzle.

 Repair Cap Ring	 Element with possible damaged lips	 Locate cap ring over foot element
 Insert aeration cap	 Locate the position of the cap ring to hold the aeration cap. Mark position.	 Glue the cap ring according to the marked position – check the aeration cap can still be removed.

Figure 10.4: Aeration Cap Repair

Note: If plastic retaining lip is completely broken the membrane row needs to be replaced.

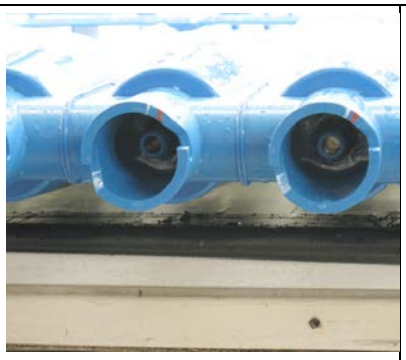
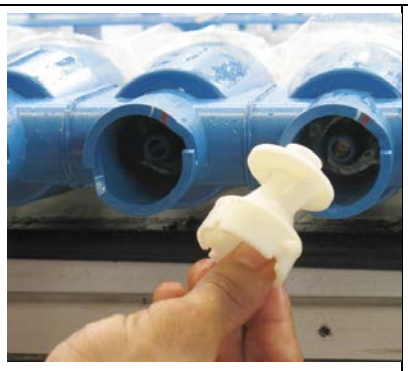
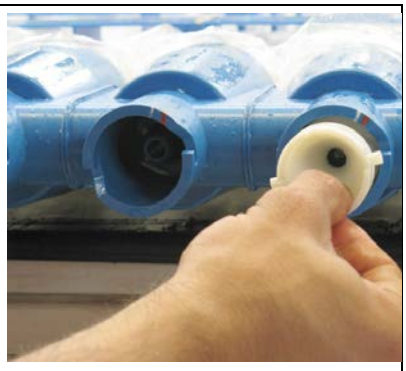
10.4.1 Mechanical Cleaning of Aeration System

If the aeration system is blocked and cannot be recovered by power flushing, it is necessary to remove the affected module from the membrane tank. Using a crane and a tilting traverse, the module has to be laid on its side as described in section 10.3 (KSS can be contacted if assistance is required). In this position, all aeration caps are removed with the special tool available from KSS. The aeration system should be flushed with a water hose to remove residual biomass and debris that might have entered the aeration system. When horizontal channel and vertical aeration tubes are free of sludge, the aeration nozzles should be replaced according to following procedure shown in Figure 10.4.1:

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

Use the dedicated aeration nozzle removal tool from KSS. Do not attempt to remove the aeration cap with a screw-driver or pliers. KSS recommends that a supply of spare caps be available during a cleaning procedure as the caps contain plastic ears that are easily broken off. Spare caps can be ordered from KSS.

	 Check the small hole is opposite the aeration supply header.	 Locating the hole is critical to correct aeration of the membrane.

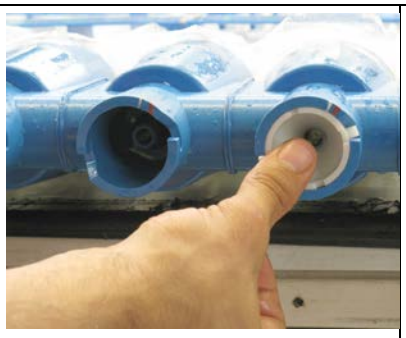
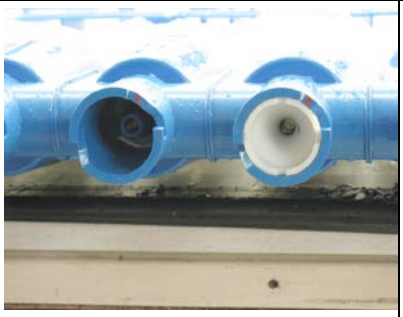
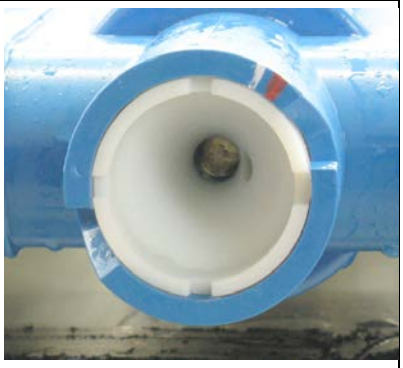
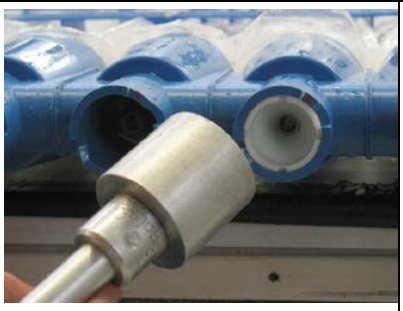
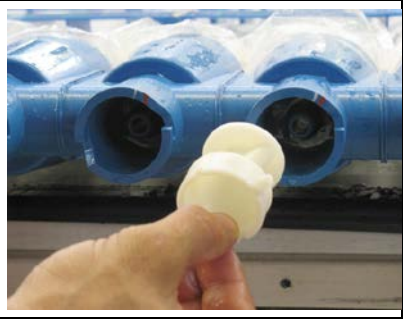
	 Check the tool alignment with the cap key.	 Carefully locate tool so that the tool and cap are joined correctly.
 Turn the tool 10° to the right. Remove the tool	 The aeration cap is correctly placed	
 Note the pins in the removal tool.		
		

Figure 10.4.1: Replacing an Aeration Cap

10.5 Membrane Storage

To preserve the membranes when not in operation, leave them submerged in biomass and aerate. This should be programmed into the PLC to ensure that it is done automatically.

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

The membranes must always be kept moist and not allowed to freeze! For more information refer to Appendix F.

The membranes cannot be exposed to air at a temperature below 5°C (41°F) at any time. This means that the membrane tank can only be drained to expose the membrane if the air temperature is above 5°C (41°F). Membranes can only be lifted out of the biology (for inspection, transfer to another tanks, etc.) when the ambient air temperature is higher than 5°C (41°F).

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11.0CHEMICAL COMPATIBILITY

Certain chemicals may have potentially destructive effects on the membrane. These chemicals can coat the membrane and reduce the flux by blocking the pores, or they may degrade the membranes due to incompatibility with the membrane material. Also, the modules are comprised of various metal and plastic parts which may be adversely affected by certain chemical compounds. The following table contains a list of chemicals and their compatibility with the PURON® module.

DANGER

DANGER indicates an imminently hazardous situation, which, if not avoided, **will result** in death, serious injury, or equipment damage.

The reference information in the Table below is based on compatibility with individual compounds. Interactions can occur when multiple compounds are present. Excessive exposure, elevated temperature or high concentrations of even the chemicals listed as compatible can harm the membrane or the module. Please contact KSS with specific questions regarding duration, concentration and temperature when using these chemicals in your application.

Table 11.1: PURON MEMBRANE MODULE CHEMICAL COMPATIBILITY

Compound	Affiliation (Group of chemicals)	Usage (cleaning/influent compounds)	Compatibility	
			Yes	No
Acetic Acid *	7		(X)	
Acetone	3			X
Acetonitrile	6			X
Aluminum sulfate	12		X	
Ammonia*	10	Typical MBR concentration range is acceptable. Contact KSS for your application.	(X)	
Aniline	4			X
Anionic polymer	13			X
Benzene	4			X
Butylacetate	3			X
Cationic polymer	13			X
Citric Acid*	7	Cleaning chemical, apply according to product data sheet.	(X)	
Dibutylphthalate	3, 4			X
Dichloromethane (DCM)	5			X

Compound	Affiliation (Group of chemicals)	Usage (cleaning/influent compounds)	Compatibility	
			Yes	No
Dicyclohexylamine	4			X
N,N-Dimethylacetamide	6			X
N,N-Dimethylaniline	4			X
N,N-Dimethylformamide	6			X
Esters	3			X
Ethanol*	1		(X)	
Ethylbenzene	4			X
Ferric chloride	12		X	
Ferric sulfate	12		X	
Formalin*	3		(X)	
Gasoline	4			X
Glycerin	1		X	
Halogenated Hydrocarbons	5			X
Hexamethyldisiloxane	13			X
Hydrochloric Acid*	11	Cleaning chemical, at pH according to product data sheet	(X)	
Hydrogen Peroxide*	11	Cleaning chemical, when applied according to concentrations given for NaOCl in product data sheet	(X)	
Hypochlorite*	11	See Sodium hypochlorite	(X)	
Isopropyl alcohol*	1		(X)	
Kerosene	4			X
Ketones	3			X
Lime [Kalk]	12		X	
Metals	15		X	
Methanol*	1		(X)	
N-Methylpyrrolidinone	6			X
Mono Ethylene Glycol (MEG)	1		X	

Compound	Affiliation (Group of chemicals)	Usage (cleaning/influent compounds)	Compatibility	
			Yes	No
Nitric Acid*	9	Cleaning chemical, at pH according to product data sheet. For strong $CaSO_4$ or $MgSO_4$ fouling.	(X)	
Oxalic Acid*	7	Cleaning chemical, at pH according to product data sheet. For strong ferric or manganese fouling.	(X)	
Ozone	11			X
Phenol*	4	Contact KSS for more inform.	(X)	
Phosphoric Acid*	9	Cleaning chemical, at pH according to product data sheet. Sometimes applied in food applications.	(X)	
Potassium Hydroxide*	10	Cleaning chemical, at pH according to product data sheet	(X)	
Seawater	15		X	
Silicone	13			X
Soda	12		X	
Sodium Hydroxide*	10	Cleaning chemical, at pH according to product data sheet	(X)	
Sodium Hypochlorite*	11	Cleaning chemical, at concentrations according to product data sheet	(X)	
Sulfolane	14			X
Sulfamic Acid*	9	Contact KSS for use in cleaning		X
Sulfuric Acid*	9	Cleaning chemical, at pH according to product data sheet	(X)	
Tetrahyrofuran	2			X
Toluene	4			X
Triethylamine	8			X
Ultrapure Water	15		X	

Compound	Affiliation (Group of chemicals)	Usage (cleaning/influent compounds)	Compatibility	
			Yes	No
Xylene	4			X

* - (X) indicates chemical is compatible at limited concentrations or exposure for cleaning

Groups of Chemicals

1. Alcohols
2. Ether
3. Ester, Aldehydes, Ketones
4. Saturated, aromatic and non-saturated Hydrocarbons
5. Chlorinated hydrocarbons
6. Aprotic polar organic solvents
7. Organic acids
8. Organic base solutions
9. Inorganic acid solutions
10. Inorganic alkaline solutions
11. Oxidative compounds
12. Inorganic salts
13. Polymers
14. Organic sulfones
15. Others

The following list describes the general chemical categories and is for reference only. Please consult KSS for your specific application.

1. Alcohols

Low molecular weight alcohols, e.g. methanol, ethanol, and propanol can cause swelling of the membrane material, but do not cause chemical deterioration of the membrane.

2. Ether

Low molecular weight ethers cause swelling and cause membrane or/and module elements deterioration and/or loss of rejection.

3. Ester, Aldehydes, Ketones

Low molecular weight aliphatic esters cause deterioration of the membrane when present in high concentrations.

4. Saturated and non-saturated Hydrocarbons

Although these compounds cause no chemical deterioration to the membrane, some of these chemicals may affect the module elements. Generally, aromatic hydrocarbons are more destructive than aliphatic ones. They may plug the membrane pores causing membrane fouling which is not easy to clean by chemical cleaning.

5. Chlorinated hydrocarbons

Similar to the non-chlorinated hydrocarbons, they may cause severe membrane fouling or, in some cases, deteriorate the membrane. Generally, halogenated hydrocarbons are more destructive than non-halogenated hydrocarbons.

6 Aprotic polar organic solvents

These solvents cause swelling of the membrane material resulting in decrease in rejection. In higher concentrations, they can severely damage the membrane.

7. Organic acids

Low molecular weight acids (such as formic acid or acetic acid) cause swelling (of the membrane material and/or the components of the module. In higher concentrations, they can also damage the membrane by dissolving the membrane matrix. Low concentrations are typically safe.

8. Organic bases solutions

In higher concentrations, these solutions (e.g., triethylamine) may damage the module components.

9. Inorganic acid solutions

Pure nitric acid and sulfuric acid can deteriorate the module components and/or the membrane.

The deterioration effect increases with concentration, contact time and temperature. The pH limits, as shown in the membrane data sheet should not be exceeded to ensure membrane compatibility.

10. Inorganic alkaline solutions

Caustic soda is generally tolerated during cleaning in low concentrations (≤0.1N). The pH limits, as shown in the membrane data sheet should not be exceeded to ensure membrane compatibility.

11. Oxidizing compounds (NaOCl, H_2O_2, O_3, peracetic acid)

In higher concentrations, all oxidizing compounds cause deterioration of the membrane and can cause embrittlement by degradation of the carbon chains of the polymer molecules. Because oxidizing compounds are destructive in **any** concentration, compounds such as NaOCl and H_2O_2, which are used for regular chemical cleaning of the membranes, must be used strictly in accordance with KSS cleaning instructions. NaOCl and H_2O_2 can be tolerated with up to 1,000,000 ppm-h when the KSS PURON operating and maintenance instructions are followed.

12. Inorganic salts

While direct negative effects have not been observed, the ions, when dissolved in water, may significantly shift the pH towards alkaline values (Na_2CO_3, “Soda”) or towards acid values (NH_4Cl “ammonium chloride“). As long as the normal pH operating range (5 to 10 pH) is not exceeded, there is no adverse chemical effect on the membrane material.

In addition, salts with low solubility in water (such as $CaCO_3$, Lime) can precipitate in the (aerated) environment around the membrane. When they precipitate directly onto the membrane surface, they may create fouling due to pore blockage and/or lime scaling

(which is reversible to a certain extent with acid cleanings). They may also form sharp-edged crystals which may mechanically abrade the membrane surface.

13. Polymers

While polymers do not cause deterioration of the membrane, they do adhere to the membrane material and block the membrane pores mechanically. In some cases (such as in the case of silicones), this blocking may be irreversible.

14. Organic sulfones

The module components are typically not compatible with organic sulfones, e.g. sulfolane.

15. Others

Metals, glass splinters, sand and grit are abrasive and will damage the membrane.

Important note:

This section describes the effect of single chemicals being dissolved in water on the membrane material and matrix. It should be noted that, in the context of a well-designed wastewater treatment system using mechanical pretreatment (including oil, fat and grease removal) and a membrane bioreactor system (MBR), the membranes, which are at the end of the process, should not often come in contact with the chemicals found at the inlet of the plant because they have already been properly treated by the upstream process steps.

In this regard, various considerations need to be taken into account by the engineer/OEM in the design of the upstream process steps. These considerations include the following:

- A well designed and operated aerated grit chamber with combined oil, fat and grease removal will remove most of the non-soluble hydrocarbons.
- Acids and alkalis may neutralize each other. The acid buffer capacity of a huge bioreactor with activated sludge is considerable, so the pH is generally stable around 7 – 8.5. This also reduces the potential of precipitation of inorganic salts in the system.
- Oxidizing compounds are typically exhausted in the activated sludge before coming into contact with membranes.
- Dissolved hydrocarbons will get biologically degraded in the bioreactor to a certain extent.
- Hydrocarbons and nutrients are typically incorporated into the bacteria cell mass.
- Adhesion of some chemical compounds (macromolecules) to the structure of sludge floc may prevent their direct contact with the membrane as they are withdrawn out of the system with the excess sludge.

These types of effects make the overall wastewater treatment system much more stable, and membranes used in an MBR system much less vulnerable than when a membrane used for direct filtration alone.

It is the responsibility of the system designer and of the system builder to weigh and account for these effects and evaluate the extent to which the different chemical compounds may get through the system and lead to potentially detrimental effects on the membranes.

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12.0 APPENDICES

APPENDIX A: PURON® MODULES DATA SHEET

DATASHEET

KOCH SEPARATION SOLUTIONS

PURON® Hollow Fiber Modules

Hollow Fiber Submerged Membrane Modules for MBR Applications

PRODUCT DESCRIPTION	
Membrane Chemistry:	Proprietary PVDF
Membrane Type:	Braided hollow fiber for outside-in operation
Fiber Support Chemistry:	Polyester
Nominal Pore Size:	0.03 µm
Outside Fiber Diameter:	0.1 inch (2.6 mm)
Regulatory Information:	Accepted by California Department of Public Health (CDPH) for compliance with California Water Recycling Criteria (Title 22)
Potting Material:	Proprietary epoxy compound
Module Frame Material:	316 Stainless Steel
Permeate Collection Tube Material:	ABS, PVC, PE manifolds
Storage Solution:	Glycerin

PRODUCT SPECIFICATIONS		
Model	**Membrane Area ft² (m²)**	**Rows per Module**
PSH 330	3,552 (330)	8
PSH 660	7,104 (660)	16
PSH 1800	19,375 (1,800)	44

OPERATING AND DESIGN INFORMATION*	
Temperature Range:	41 - 104°F (5 - 40°C)
Maximum Filtration Transmembrane Pressure:	9 psi (0.6 bar)
Maximum Backflush Transmembrane Pressure:	9 psi (0.6 bar)
Allowable pH Range for Cleaning:	2.0 - 10.5
Maximum Allowed Total Chlorine @ 95°F (35°C) or Lower:	1,000 ppm @ pH 8 or higher during maintenance clean
Maximum Allowed Total Chlorine @ 95°F (35°C) or Lower:	2,000 ppm @ pH 8 or higher during recovery clean
Maximum Allowed Total Chlorine Contact:	500,000 ppm-hrs cumulative

*Consult KSS Process Technology Group for specific applications.

NOMINAL DIMENSIONS								
	L		W		H		Dry Weight	
Model	**inches**	**(mm)**	**inches**	**(mm)**	**inches**	**(mm)**	**Pounds**	**(kg)**
PSH 330	35.67	(906)	35.16	(893)	98.25	(2,496)	771	(350)
PSH 660	65.43	(1,662)	35.16	(893)	99.61	(2,530)	1,442	(654)
PSH 1800	88.35	(2,244)	69.10	(1,755)	99.61	(2,530)	3,434	(1,570)

*See Outline drawings for details

CONNECTIONS				
	Permeate		Air	
Model	**Type**	**Size**	**Type**	**Size**
PSH 330	Grooved Coupling	2” IPS	Grooved Coupling	2” IPS
PSH 660	Grooved Coupling	3” IPS	Grooved Coupling	3” IPS
PSH 1800	Pipe	Ø 200 mm	Pipe	Ø 110 mm (2x)

Koch Separation Solutions, Inc. 850 Main Street, Wilmington, MA 01887
Main: +1-978-694-7000 • Fax: +1-978-657-5208 • Toll Free: +1-888-677-5624

For complete contact information and listing of our global locations, visit www.kochseparation.com

09/15 Rev 15-4

APPENDIX B: SAMPLE MATERIAL SAFETY DATA SHEETS (MSDS) OF CLEANING CHEMICALS

SIGMA-ALDRICH

MATERIAL SAFETY DATA SHEET

Date Printed: 06/28/2004
Date Updated: 04/15/2004
Version 1.4

Section 1 - Product and Company Information

Product Name	SODIUM HYPOCHLORITE, SOLUTION, AVAILABLECHLORINE 10-13%
Product Number	425044
Brand	ALDRICH
Company	Sigma-Aldrich
Street Address	3050 Spruce Street
City, State, Zip, Country	SAINT LOUIS MO 63103 US
Technical Phone:	314 771 5765
Emergency Phone:	414 273 3850 Ext. 5996
Fax:	800 325 5052

Section 2 - Composition/Information on Ingredient

Substance Name	CAS #	SARA 313
SODIUM HYPOCHLORITE	7681-52-9	No

Formula	NaOCl
Synonyms	Antiformin * B-K liquid * Carrel-dakin solution * Chloros * Chlorox * Clorox * Dakins solution * Deosan * Hyclorite * Hypochlorite solution containing >7% avaliable chlorine by wt. (UN1791) * Javex * Klorocin * Milton * Neo-cleaner * Neoseptal CL * Parozone * Purin B * Sodium chloride oxide * Sodium hypochlorite * Sodium oxychloride * Surchlor
RTECS Number:	NH3486300

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Corrosive.

Contact with acids liberates toxic gas. Causes burns.

HMIS RATING

HEALTH: 3
FLAMMABILITY: 0
REACTIVITY: 0

NFPA RATING

HEALTH: 3
FLAMMABILITY: 0
REACTIVITY: 0

For additional information on toxicity, please refer to Section 11.

Section 4 - First Aid Measures

ORAL EXPOSURE

If swallowed, wash out mouth with water provided person is conscious. Call a physician. Do not induce vomiting.

INHALATION EXPOSURE
If inhaled, remove to fresh air. If not breathing give artificial respiration. If breathing is difficult, give oxygen.

DERMAL EXPOSURE
In case of skin contact, flush with copious amounts of water for at least 15 minutes. Remove contaminated clothing and shoes. Call a physician.

EYE EXPOSURE
In case of contact with eyes, flush with copious amounts of water for at least 15 minutes. Assure adequate flushing by separating the eyelids with fingers. Call a physician.

Section 5 - Fire Fighting Measures

FLASH POINT
N/A

AUTOIGNITION TEMP
N/A

FLAMMABILITY
N/A

EXTINGUISHING MEDIA
Suitable: Carbon dioxide, dry chemical powder, or appropriate foam.

FIREFIGHTING
Protective Equipment: Wear self-contained breathing apparatus and protective clothing to prevent contact with skin and eyes.
Specific Hazard(s): Emits toxic fumes under fire conditions.

Section 6 - Accidental Release Measures

PROCEDURE TO BE FOLLOWED IN CASE OF LEAK OR SPILL
Evacuate area.

PROCEDURE(S) OF PERSONAL PRECAUTION(S)
Wear self-contained breathing apparatus, rubber boots, and heavy rubber gloves.

METHODS FOR CLEANING UP
Absorb on sand or vermiculite and place in closed containers for disposal. Ventilate area and wash spill site after material pickup is complete.

Section 7 - Handling and Storage

HANDLING
User Exposure: Do not breathe vapor. Do not get in eyes, on skin, on clothing. Avoid prolonged or repeated exposure.

STORAGE
Suitable: Keep tightly closed.
Store at 2-8°C

Section 8 - Exposure Controls / PPE

ENGINEERING CONTROLS

Safety shower and eye bath. Use only in a chemical fume hood.

PERSONAL PROTECTIVE EQUIPMENT
Respiratory: Government approved respirator.
Hand: Compatible chemical-resistant gloves.
Eye: Chemical safety goggles.
Other: Faceshield (8-inch minimum).

GENERAL HYGIENE MEASURES
Wash contaminated clothing before reuse. Discard contaminated shoes. Wash thoroughly after handling.

Section 9 - Physical/Chemical Properties

Appearance — Physical State: Liquid

Property	Value	At Temperature or Pressure
Molecular Weight	74.44 AMU	
pH	N/A	
BP/BP Range	111 ˚C	760 mmHg
MP/MP Range	-30 - -20 ˚C	
Freezing Point	N/A	
Vapor Pressure	17.5 mmHg	20 ˚C
Vapor Density	N/A	
Saturated Vapor Conc.	N/A	
SG/Density	1.25 g/cm3	
Bulk Density	N/A	
Odor Threshold	N/A	
Volatile%	N/A	
VOC Content	N/A	
Water Content	N/A	
Solvent Content	N/A	
Evaporation Rate	N/A	
Viscosity	N/A	
Surface Tension	N/A	
Partition Coefficient	N/A	
Decomposition Temp.	N/A	
Flash Point	N/A	
Explosion Limits	N/A	
Flammability	N/A	
Autoignition Temp	N/A	
Refractive Index	N/A	
Optical Rotation	N/A	
Miscellaneous Data	N/A	
Solubility	Solubility in Water:Miscible.	

N/A = not available

Section 10 - Stability and Reactivity

STABILITY
Stable: Stable.
Materials to Avoid: Strong acids, Organic materials, Finely powdered metals, Forms explosive mixtures with:, Amines, Ammonia, Methanol.

HAZARDOUS DECOMPOSITION PRODUCTS
Hazardous Decomposition Products: Chlorine.

HAZARDOUS POLYMERIZATION
Hazardous Polymerization: Will not occur

Section 11 - Toxicological Information

ROUTE OF EXPOSURE

Skin Contact: Causes burns.
Skin Absorption: May be harmful if absorbed through the skin.
Eye Contact: Causes burns.
Inhalation: Material is extremely destructive to the tissue of the mucous membranes and upper respiratory tract. May be harmful if inhaled.
Ingestion: May be harmful if swallowed.

SIGNS AND SYMPTOMS OF EXPOSURE

Material is extremely destructive to tissue of the mucous membranes and upper respiratory tract, eyes, and skin.
Inhalation may result in spasm, inflammation and edema of the larynxand bronchi, chemical pneumonitis, and pulmonary edema.
Symptoms of exposure may include burning sensation, coughing, wheezing, laryngitis, shortness of breath, headache, nausea, and vomiting.

TOXICITY DATA

Oral
Mouse
5800 mg/kg
LD50
Remarks: Behavioral:Change in motor activity (specific assay).
Gastrointestinal:Other changes.

IRRITATION DATA

Eyes
Rabbit
10 mg
Remarks: Moderate irritation effect

CHRONIC EXPOSURE - CARCINOGEN

Result: This product is or contains a component that is not classifiable as to its carcinogenicity based on its IARC, ACGIH, NTP, or EPA classification.

IARC CARCINOGEN LIST

Rating: Group 3

CHRONIC EXPOSURE - MUTAGEN

Species: Human
Dose: 100 PPM
Exposure Time: 24H
Cell Type: lymphocyte
Mutation test: Cytogenetic analysis

Species: Human
Dose: 149 MG/L
Cell Type: Embryo
Mutation test: Sister chromatid exchange

Species: Hamster
Dose: 100 MG/L
Cell Type: lung

Mutation test: Cytogenetic analysis

Mutation test: Histidine reversion (Ames)

Section 12 - Ecological Information

No data available.

Section 13 - Disposal Considerations

APPROPRIATE METHOD OF DISPOSAL OF SUBSTANCE OR PREPARATION
Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber. Observe all federal, state, and local environmental regulations.

Section 14 - Transport Information

DOT
Proper Shipping Name: Hypochlorite solutions
UN#: 1791
Class: 8
Packing Group: Packing Group III
Hazard Label: Corrosive
PIH: Not PIH

IATA
Proper Shipping Name: Hypochlorite solution
IATA UN Number: 1791
Hazard Class: 8
Packing Group: III

Section 15 - Regulatory Information

EU DIRECTIVES CLASSIFICATION
Symbol of Danger: C
Indication of Danger: Corrosive.
R: 31 34
Risk Statements: Contact with acids liberates toxic gas. Causes burns.
S: 26 36/37/39 45
Safety Statements: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. Wear suitable protective clothing, gloves, and eye/face protection. In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

US CLASSIFICATION AND LABEL TEXT
Indication of Danger: Corrosive.
Risk Statements: Contact with acids liberates toxic gas. Causes burns.
Safety Statements: After contact with skin, wash immediately with plenty of soap-suds. In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

UNITED STATES REGULATORY INFORMATION
SARA LISTED: No
TSCA INVENTORY ITEM: Yes

CANADA REGULATORY INFORMATION

WHMIS Classification: This product has been classified in accordance with the hazard criteria of the CPR, and the MSDS contains all the information required by the CPR.
DSL: Yes
NDSL: No

Section 16 - Other Information

DISCLAIMER

For R&D use only. Not for drug, household or other uses.

WARRANTY

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Inc., shall not be held liable for any damage resulting from handling or from contact with the above product. See reverse side of invoice or packing slip for additional terms and conditions of sale.

SIGMA-ALDRICH

MATERIAL SAFETY DATA SHEET

Date Printed: 10/05/2007
Date Updated: 05/19/2006
Version 1.10

Section 1 - Product and Company Information

Product Name	SODIUM HYDROXIDE, 50% SOLUTION IN WATER
Product Number	415413
Brand	SIAL
Company	Sigma-Aldrich
Address	3050 Spruce Street SAINT LOUIS MO 63103 US
Technical Phone:	800-325-5832
Fax:	800-325-5052
Emergency Phone:	314-776-6555

Section 2 - Composition/Information on Ingredient

Substance Name	CAS #	SARA 313
SODIUM HYDROXIDE SOLUTIONS (>5%)	1310-73-2	No

Ingredient Name	CAS #	Percent	SARA 313
WATER	7732-18-5	<= 95	No
SODIUM HYDROXIDE	1310-73-2	>= 5	No

Formula NaOH

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Corrosive.
Causes burns.
Exothermic in contact with water

HMIS RATING

HEALTH: 3
FLAMMABILITY: 0
REACTIVITY: 2

NFPA RATING

HEALTH: 3
FLAMMABILITY: 0
REACTIVITY: 2

For additional information on toxicity, please refer to Section 11.

Section 4 - First Aid Measures

ORAL EXPOSURE

If swallowed, wash out mouth with water provided person is conscious. Call a physician. Do not induce vomiting.

INHALATION EXPOSURE

If inhaled, remove to fresh air. If not breathing give artificial respiration. If breathing is difficult, give oxygen.

DERMAL EXPOSURE
In case of skin contact, flush with copious amounts of water for at least 15 minutes. Remove contaminated clothing and shoes. Call a physician.

EYE EXPOSURE
In case of contact with eyes, flush with copious amounts of water for at least 15 minutes. Assure adequate flushing by separating the eyelids with fingers. Call a physician.

Section 5 - Fire Fighting Measures

FLASH POINT
N/A

AUTOIGNITION TEMP
N/A

FLAMMABILITY
N/A

EXTINGUISHING MEDIA
Suitable: Dry chemical powder.
Unsuitable: Do not use water.

FIREFIGHTING
Protective Equipment: Wear self-contained breathing apparatus and protective clothing to prevent contact with skin and eyes.
Specific Hazard(s): Emits toxic fumes under fire conditions.

Section 6 - Accidental Release Measures

PROCEDURE TO BE FOLLOWED IN CASE OF LEAK OR SPILL
Evacuate area.

PROCEDURE(S) OF PERSONAL PRECAUTION(S)
Wear self-contained breathing apparatus, rubber boots, and heavy rubber gloves.

METHODS FOR CLEANING UP
Absorb on sand or vermiculite and place in closed containers for disposal. Ventilate area and wash spill site after material pickup is complete.

Section 7 - Handling and Storage

HANDLING
User Exposure: Do not breathe vapor. Do not get in eyes, on skin, on clothing. Avoid prolonged or repeated exposure.

STORAGE
Suitable: Keep tightly closed. Store in a cool dry place.
Incompatible Materials: Do not allow contact with water

Section 8 - Exposure Controls / PPE

ENGINEERING CONTROLS
Safety shower and eye bath. Use only in a chemical fume hood.

PERSONAL PROTECTIVE EQUIPMENT
Respiratory: Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN

(EU). Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator.
Hand: Compatible chemical-resistant gloves.
Eye: Chemical safety goggles.
Other: Faceshield (8-inch minimum).

GENERAL HYGIENE MEASURES

Wash contaminated clothing before reuse. Discard contaminated shoes. Wash thoroughly after handling.

EXPOSURE LIMITS

Country	Source	Type	Value
USA	OSHA.	PEL	2 mg/m3
USA	ACGIH	TLV	2 mg/m3

Section 9 - Physical/Chemical Properties

Appearance: Physical State: Liquid

Property	Value	At Temperature or Pressure
Molecular Weight	40 AMU	
pH	N/A 14	
BP/BP Range	105.0 - 140.0 °C	
MP/MP Range	- 12.0 - 10. °C	
Freezing Point	N/A	
Vapor Pressure	< 18 mmHg	20 °C
Vapor Density	> 1 g/l	
Saturated Vapor Conc.	N/A	
SG/Density	1.327 g/cm3	25 °C
Bulk Density	N/A	
Odor Threshold	N/A	
Volatile%	N/A	
VOC Content	N/A	
Water Content	N/A	
Solvent Content	N/A	
Evaporation Rate	N/A	
Viscosity	N/A	
Surface Tension	N/A	
Partition Coefficient	N/A	
Decomposition Temp.	N/A	
Flash Point	N/A	
Explosion Limits	N/A	
Flammability	N/A	
Autoignition Temp	N/A	
Refractive Index	N/A	
Optical Rotation	N/A	
Miscellaneous Data	N/A	
Solubility	Solubility in Water:Miscible. Soluble.	

N/A = not available

Section 10 - Stability and Reactivity

STABILITY

Stable: Stable.
Conditions of Instability: Absorbs carbon dioxide from air. Heat of solution is very high, and with limited amounts of water, violent boiling may occur

Conditions to Avoid: Air sensitive.
Materials to Avoid: Water, Acids, Organic materials, Chlorinated solvents, Aluminum, Phosphorus, Tin/tin oxides, Zinc.

HAZARDOUS DECOMPOSITION PRODUCTS
Hazardous Decomposition Products: Sodium/sodium oxides.

HAZARDOUS POLYMERIZATION
Hazardous Polymerization: Will not occur

Section 11 - Toxicological Information

ROUTE OF EXPOSURE
Skin Contact: Causes burns.
Skin Absorption: May be harmful if absorbed through the skin.
Eye Contact: Causes burns.
Inhalation: Material is extremely destructive to the tissue of the mucous membranes and upper respiratory tract. May be harmful if inhaled.
Ingestion: May be harmful if swallowed.

SIGNS AND SYMPTOMS OF EXPOSURE
Material is extremely destructive to tissue of the mucous membranes and upper respiratory tract, eyes, and skin. Inhalation may result in spasm, inflammation and edema of the larynxand bronchi, chemical pneumonitis, and pulmonary edema. Symptoms of exposure may include burning sensation, coughing, wheezing, laryngitis, shortness of breath, headache, nausea, and vomiting. To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

IRRITATION DATA
Skin
Rabbit
500 mg
24 HR
Remarks: Severe irritation effect
Eyes
Rabbit
0.5 mg
24 HR
Remarks: Severe irritation effect

Section 12 - Ecological Information

No data available.

Section 13 - Disposal Considerations

APPROPRIATE METHOD OF DISPOSAL OF SUBSTANCE OR PREPARATION
Contact a licensed professional waste disposal service to dispose of this material. Observe all federal, state, and local environmental regulations.

Section 14 - Transport Information

DOT
Proper Shipping Name: Sodium hydroxide solution
UN#: 1824
Class: 8
Packing Group: Packing Group II

Hazard Label: Corrosive
PIH: Not PIH

IATA
Proper Shipping Name: Sodium hydroxide solution
IATA UN Number: 1824
Hazard Class: 8
Packing Group: II

Section 15 - Regulatory Information

EU DIRECTIVES CLASSIFICATION
Symbol of Danger: C
Indication of Danger: Corrosive.
R: 35
Risk Statements: Causes severe burns.
S: 26-37/39-45
Safety Statements: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. Wear suitable gloves and eye/face protection. In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

US CLASSIFICATION AND LABEL TEXT
Indication of Danger: Corrosive.
Risk Statements: Causes burns.
Safety Statements: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. Wear suitable protective clothing, gloves, and eye/face protection. In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
US Statements: Exothermic in contact with water

UNITED STATES REGULATORY INFORMATION
SARA LISTED: No

CANADA REGULATORY INFORMATION
WHMIS Classification: This product has been classified in accordance with the hazard criteria of the CPR, and the MSDS contains all the information required by the CPR.
DSL: No
NDSL: No

Section 16 - Other Information

DISCLAIMER
For R&D use only. Not for drug, household or other uses.

WARRANTY
The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Inc., shall not be held liable for any damage resulting from handling or from contact with the above product. See reverse side of invoice or packing slip for additional terms and conditions of sale.

SIGMA-ALDRICH

MATERIAL SAFETY DATA SHEET

Date Printed: 12/19/2005
Date Updated: 05/03/2004
Version 1.4

Section 1 - Product and Company Information

Product Name	CITRIC ACID, 99%
Product Number	C83155
Brand	SIAL
Company	Sigma-Aldrich
Street Address	3050 Spruce Street
City, State, Zip, Country	SAINT LOUIS MO 63103 US
Technical Phone:	314 771 5765
Emergency Phone:	414 273 3850 Ext. 5996
Fax:	800 325 5052

Section 2 - Composition/Information on Ingredient

Substance Name	CAS #	SARA 313
CITRIC ACID ANHYDROUS	77-92-9	No

Formula: $C_6H_8O_7$

Synonyms: Aciletten * Anhydrous citric acid * Citretten * Citric acid, anhydrous * Citro * 2-Hydroxy-1,2,3-propanetricarboxylic acid * beta-Hydroxytricarballylic acid * Kyselina citronova (Czech) * Kyselina 2-hydroxy-1,2,3-propantrikarbonova (Czech) * NSC 30279 * 1,2,3-Propanetricarboxylic acid, 2-hydroxy-

RTECS Number: GE7350000

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Irritant.
Risk of serious damage to eyes.
Possible sensitizer.

HMIS RATING

HEALTH: 2
FLAMMABILITY: 0
REACTIVITY: 0

NFPA RATING

HEALTH: 2
FLAMMABILITY: 0
REACTIVITY: 0

For additional information on toxicity, please refer to Section 11.

Section 4 - First Aid Measures

ORAL EXPOSURE

If swallowed, wash out mouth with water provided person is conscious. Call a physician.

INHALATION EXPOSURE
If inhaled, remove to fresh air. If not breathing give artificial respiration. If breathing is difficult, give oxygen.

DERMAL EXPOSURE
In case of contact, immediately wash skin with soap and copious amounts of water.

EYE EXPOSURE
In case of contact, immediately flush eyes with copious amounts of water for at least 15 minutes.

Section 5 - Fire Fighting Measures

FLASH POINT
N/A

EXPLOSION LIMITS
Lower: 8 %

AUTOIGNITION TEMP
N/A

FLAMMABILITY
N/A

EXTINGUISHING MEDIA
Suitable: Water spray. Carbon dioxide, dry chemical powder, or appropriate foam.

FIREFIGHTING
Protective Equipment: Wear self-contained breathing apparatus and protective clothing to prevent contact with skin and eyes.
Specific Hazard(s): Emits toxic fumes under fire conditions.

Section 6 - Accidental Release Measures

PROCEDURE(S) OF PERSONAL PRECAUTION(S)
Wear respirator, chemical safety goggles, rubber boots, and heavy rubber gloves.

METHODS FOR CLEANING UP
Sweep up, place in a bag and hold for waste disposal. Avoid raising dust. Ventilate area and wash spill site after material pickup is complete.

Section 7 - Handling and Storage

HANDLING
User Exposure: Do not breathe dust. Avoid contact with eyes, skin, and clothing. Avoid prolonged or repeated exposure.

STORAGE
Suitable: Keep tightly closed.

Section 8 - Exposure Controls / PPE

ENGINEERING CONTROLS
Safety shower and eye bath. Mechanical exhaust required.

PERSONAL PROTECTIVE EQUIPMENT

Respiratory: Government approved respirator.
Hand: Compatible chemical-resistant gloves.
Eye: Chemical safety goggles.

GENERAL HYGIENE MEASURES
Wash thoroughly after handling.

Section 9 - Physical/Chemical Properties

Appearance — Physical State: Solid

Property	Value	At Temperature or Pressure
Molecular Weight	192.12 AMU	
pH	N/A	
BP/BP Range	N/A	
MP/MP Range	155.0 - 157.0 °C	
Freezing Point	N/A	
Vapor Pressure	N/A	
Vapor Density	N/A	
Saturated Vapor Conc.	N/A	
SG/Density	N/A	
Bulk Density	N/A	
Odor Threshold	N/A	
Volatile%	N/A	
VOC Content	N/A	
Water Content	N/A	
Solvent Content	N/A	
Evaporation Rate	N/A	
Viscosity	N/A	
Surface Tension	N/A	
Partition Coefficient	N/A	
Decomposition Temp.	N/A	
Flash Point	N/A	
Explosion Limits	Lower: 8 %	
Flammability	N/A	
Autoignition Temp	N/A	
Refractive Index	N/A	
Optical Rotation	N/A	
Miscellaneous Data	N/A	
Solubility	N/A	

N/A = not available

Section 10 - Stability and Reactivity

STABILITY
Stable: Stable.
Materials to Avoid: Oxidizing agents, Bases, Reducing agents, Nitrates.

HAZARDOUS DECOMPOSITION PRODUCTS
Hazardous Decomposition Products: Carbon monoxide, Carbon dioxide.

HAZARDOUS POLYMERIZATION
Hazardous Polymerization: Will not occur

Section 11 - Toxicological Information

ROUTE OF EXPOSURE
Skin Contact: May cause skin irritation.
Skin Absorption: May be harmful if absorbed through the skin.

Eye Contact: Causes severe eye irritation.
Inhalation: Material may be irritating to mucous membranes and upper respiratory tract. May be harmful if inhaled.
Ingestion: May be harmful if swallowed.

SENSITIZATION
Sensitization: Prolonged or repeated exposure may cause allergic reactions in certain sensitive individuals.

SIGNS AND SYMPTOMS OF EXPOSURE
To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated. Dermatitis. Damage to tooth enamel. Diarrhea. Vomiting. Exposure can cause:

TOXICITY DATA

Oral
Rat
3000 mg/kg
LD50

Intraperitoneal
Rat
290 MG/KG
LD50

Subcutaneous
Rat
5500 MG/KG
LD50
Remarks: Other changes Lungs, Thorax, or Respiration:Other changes.

Oral
Mouse
5040 mg/kg
LD50
Remarks: Lungs, Thorax, or Respiration:Other changes. Other changes

Intraperitoneal
Mouse
903 MG/KG
LD50

Subcutaneous
Mouse
2700 MG/KG
LD50
Remarks: Other changes Lungs, Thorax, or Respiration:Other changes.

Intravenous
Mouse
42 MG/KG
LD50
Remarks: Behavioral:Convulsions or effect on seizure threshold. Lungs, Thorax, or Respiration:Cyanosis. Gastrointestinal:Changes in structure or function of salivary glands.

Intravenous

Rabbit
330 MG/KG
LD50
Remarks: Behavioral:Convulsions or effect on seizure threshold. Lungs, Thorax, or Respiration:Cyanosis. Gastrointestinal:Changes in structure or function of salivary glands.

IRRITATION DATA

Skin
Rabbit
500 mg
24H
Remarks: Mild irritation effect

Eyes
Rabbit
0.75 mg
24H
Remarks: Severe irritation effect

Section 12 - Ecological Information

No data available.

Section 13 - Disposal Considerations

APPROPRIATE METHOD OF DISPOSAL OF SUBSTANCE OR PREPARATION
Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber. Observe all federal, state, and local environmental regulations.

Section 14 - Transport Information

DOT
Proper Shipping Name: None
Non-Hazardous for Transport: This substance is considered to be non-hazardous for transport.

IATA
Non-Hazardous for Air Transport: Non-hazardous for air transport.

Section 15 - Regulatory Information

EU ADDITIONAL CLASSIFICATION
Symbol of Danger: Xi
Indication of Danger: Irritant.
R: 41
Risk Statements: Risk of serious damage to eyes.
S: 26-39
Safety Statements: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. Wear eye/face protection.

US CLASSIFICATION AND LABEL TEXT
Indication of Danger: Irritant.
Risk Statements: Risk of serious damage to eyes.
Safety Statements: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. Wear

suitable protective clothing.
US Statements: Possible sensitizer.

UNITED STATES REGULATORY INFORMATION
SARA LISTED: No
TSCA INVENTORY ITEM: Yes

CANADA REGULATORY INFORMATION
WHMIS Classification: This product has been classified in accordance with the hazard criteria of the CPR, and the MSDS contains all the information required by the CPR.
DSL: Yes
NDSL: No

Section 16 - Other Information

DISCLAIMER
For R&D use only. Not for drug, household or other uses.

WARRANTY
The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Inc., shall not be held liable for any damage resulting from handling or from contact with the above product. See reverse side of invoice or packing slip for additional terms and conditions of sale.

APPENDIX C: PURON® PSH COMMISSIONING PROTOCOL

PURON® PSH Commissioning Protocol

Before the commissioning procedure is carried out, please make sure that all items on the Plant Start-up checklist provided by KSS are completed prior to the arrival of our Field Service Engineer(s). Sign the bottom of the form email a copy of it to the assigned Field Service Engineer. For contact information, see Appendix J.

Once all requirements on the Plant Start-up checklist have been completed, please proceed with the commissioning protocol provided below. A KSS Field Service Engineer will guide you through the entire process. All necessary comments should be documented in the available space.

☐ System is ready for the installation of the PURON membranes. The control software has been installed post Factory Acceptance Test (FAT) and the I/O check has been completed.

_____

_____

_____

_____

☐ On location a KSS person will check the issued P&ID as per contractual description against the “as built” system. Comments will be made if necessary. KSS will sign off if the as built P&ID installation is correct. If system is not suitable or corrections must be made, the work and time frame will be assessed. Sign off and membrane commissioning will be suspended until the system is suitably configured.

_____

_____

_____

_____

☐ KSS will check the software as part of a Site Acceptance Test (SAT). The KSS engineer will wet test the basic program structure with help from the client or their designated engineer. If the basics are present according to the KSS supplied software

description, this will be officially communicated. Software issues can suspend commissioning if the builder cannot show the basic functionality of the plant.

_____

_____

_____

_____

☐ KSS will provide technical support during the flushing of all permeate pipe work and the purging of all aeration pipe work and will inspect for debris.

_____

_____

_____

_____

☐ KSS will provide technical support during the unpacking of the membrane modules. An inspection will be made of every KSS component as delivered to site. Any damage will be documented with photos.

_____

_____

_____

_____

☐ KSS will provide technical support during the assembly of the traverse (hanging device) to the module frame. Please consider the designated mounting locations on that frame highlighted in the customer approved outline drawing. Adhere to recommended torque values for the appropriate bolts. Now carefully remove the plastic jackets of each individual fiber bundle (may also be completed after membrane installation).

_____

_____

_____

_____

☐ KSS will provide technical support during the assembly of all installation kits to the designated aeration and permeate connections on the headers.

_____

_____

_____

_____

☐ KSS will provide technical support during the lifting and placement of the modules into the filtration tank or filtration zone. The modules will be mechanically fixed and the necessary permeate and air pipes mounted and checked. If non-KSS personnel are involved in the work, they must not stand on the headers or use the headers to lever connections. The modules may now be submerged up to the required working depth of the tank.

_____

_____

_____

_____

☐ The aeration system will be tested first. The aeration must be balanced and correct. KSS will specify the initial aeration scheme. In separate filtration tanks the sludge distribution line and tank hydrodynamics will also be tested (or tested directly on sludge at a later time if bioreactor is already seeded).

_____

_____

_____

_____

☐ The permeate system will be the next tested item. The system will be de-aerated and purged. The KSS representative will provide technical support during the various process, backflush and ventilation modes in order to fully prime the membranes. This may take 2-3 hours. Any leaks or trapped air will be eliminated (see next item). After running for at least 2 hours, the hoses and connections should be re-tested.

_____

_____

_____

_____

☐ Once the permeate system is purged and fully de-aerated, a leak test will be performed. This will be performed on each train of modules and on individual modules where allowable (depending on valving or blanks). Supply compressed and oil-free air at max. 0.3 bar (4.5 psi) to the permeate system (for instance at sample or drain connections of the pipe) so that leaks can instantly be detected and eliminated.

_____

_____

_____

_____

☐ Once the system is primed and the glycerin is removed, clean water permeability (CWP) test will be carried out. This will be performed on each train of modules and on individual modules where allowable (depending on valving or blanks). The target value per module is 400-500 L/m^2/h/bar (16-20 gfd/psi) @ flux of 20 L/m^2/h (12 gfd). The train CWP may be lower due to inherent pressure losses. The CWP is correlated to 20˚C. The formula will be communicated by KSS.

_____

_____

_____

_____

☐ Once all modules have met the quality criteria, the system will be run in automatic at the first possible convenience. During this step, the system will be operated at the design flow rate and the set points will be programmed to yield the correct net flow according to the contract requirements. The MC software will be tested, and training of operators will commence. The KSS engineer will define the moment that the system is ready for production.

_____

_____

_____

_____

Summary / Open Issues

The commissioning is complete once the KSS commissioning engineer has handed the system over after water testing. All parties must agree that this moment has been reached. Any open issues will be documented here. Both parties will sign off this checklist if done.

_____

_____

_____

_____

_____

_____

_____
Customer's Name (please print)

_____ _____
Date Customer's Signature

_____
KSS Commissioning Engineer (please print)

_____ _____
Date KSS Commissioning Engineer Signature

APPENDIX D: STARTUP CHECKLIST

Plant Start-up Check off Sheet

TO: _____ **FAX:** _____

COMPANY: _____ **DATE:** _____

LOCATION: _____

SYSTEM TYPE: _____ **INDEX** _____

PLEASE ALLOW TWO TO THREE WEEKS TO SCHEDULE THE FIELD SERVICE ENGINEER.

The KSS Field Service Group would like your start-up to go smoothly, on schedule, and without any additional cost or delays to you. To help us ensure a successful start-up for you, please complete the following checklist of items, ***prior to the arrival*** of our Field Service Engineer(s).

Please check off the items as they are completed, sign the bottom of the form and fax it to our Field Service Department (see Appendix J for contact information in your region). The document should be faxed to the attention of **Field Services Administrative Assistant** or emailed to the assigned **Field Service Engineer**. A Field Service Engineer will not arrive at your site until we receive your completed, signed checklist. Please complete and return this form to us at least three (3) days before your scheduled start-up date.

==========

1. All piping is 100% complete and in agreement with flow schematic ☐
2. All electrical and field wiring is 100% complete ☐
3. Customer supplied items, such as, tanks, pumps, level controls, etc. are in place and operational. ☐
4. Pump rotations have been checked. ☐
5. Alignment of pump(s) to motor(s) has been checked. ☐
6. Cleaning chemicals have been ordered and are on-site for start-up. ☐

   The cleaning chemicals for your system are:

   _____NaOCl _____
   _____Citric Acid_____
   _____

7. System operators have been selected and have received a copy of the PURON® operating manual for review. ☐

8. Water for clear water membrane start up is available ☐

9. Process fluid is available in sufficient quantity to operate the system. ☐

==========

I, the undersigned, have verified that each item checked off on this list has been completed. I further understand that any items not completed upon the arrival of the Field Service Engineer could result in delays with the start-up. If additional days or extra flights are required because the system is not ready, we understand that we are responsible for the purchase of these items.

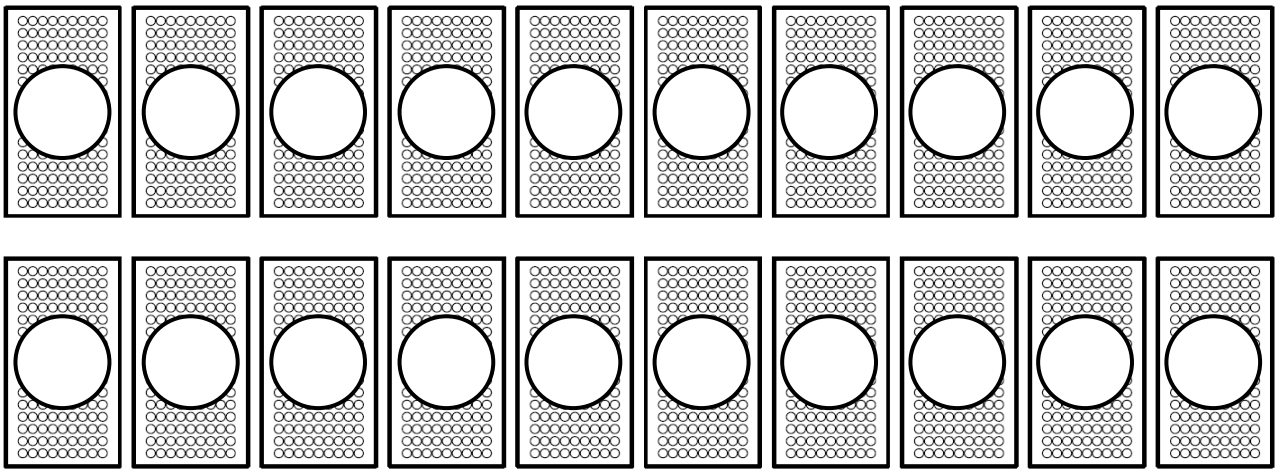
Customer's Name (please print)

Customer's Signature **Date**

APPENDIX E: MODULE LINE UP PROTOCOL / MODULE MAP

Module Line-up Protocol

The drawing below is an overhead view of the membrane tank (not drawn to scale). Place the module position numbers on the appropriate module position below.



Plant Name and Location: _____

Recorded by (Name): _____ Date: _____

Faxed to KSS (see contact information in Appendix J) on Date: _____

Note: To maintain any warrantees and guarantees, this form must be updated and sent to KSS within seven calendar days whenever any modules or module rows are moved, replaced or put into service.

Module Position #	Module Serial #	Annotations
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

_____
Customer's Name (please print)

_____ _____
Date Customer's Signature

APPENDIX F: MEMBRANE PRESERVATION

PURON MEMBRANE TRANSPORT AND STORAGE CONDITIONS

Storage of PURON Modules

Storage of PURON modules should be carried out at ambient temperature (41 to 77°F / 5 to 25°C). Extended exposure to UV source must be avoided. The PURON modules must not be stored for longer than 3 months on site.

Transport of PURON Modules

Transport of PURON modules should be carried out at ambient temperature (23 to 113°F / -5 to 45°C).

When the PURON modules are being transported by ship , the PURON module should be placed in seaworthy packaging and stored at ambient temperature, provided that such temperature is between 23 and 113°F (-5 and 45°C).

Dry-up Protection

Once the PURON hollow fiber module has been commissioned with an aqueous medium, it should never be stored dry. If the membrane plant is not operated for 7 days or less, the module may be kept wet by keeping it submerged in the biomass, provided the following conditions are met:

The biomass is healthy and is aerated and the recirculation of biomass over the membrane chamber is functioning properly.

The module is fully submerged in the biomass.

The module aeration is switched on every 30 minutes for a period of 1 minute to assure mixing of sludge inside the module.

Storage of Used Modules

If the idle period is longer than 7 days, immersion in a storage solution is required. Proceed as follows:

Submerge the module fully in potable water. Start the aeration for at least 3 to 4 hours, drain the tank and finally refill with fresh water again.

Add sodium hypochlorite to form a solution of concentration of 10 mg/l total chlorine at pH between 5.5 and 7.5.

Check the chlorine concentration daily. If the concentration of total chlorine drops below 5 mg/l additional dosage of sodium hypochlorite is necessary.

Long-term Storage

If a dry-up cannot be avoided due to transport or if the idle period is longer than 21 days, the module has to be conditioned. Please consult KSS for more details.

Proper Handling

Utmost care at any time should be taken when handling the module. Collisions, impact or hitting the ground in a rough manner may damage modules or connections.

Precautions When Working Near the Hollow Fiber Module

Keep the hollow fiber modules free from contact with sharp objects or exposure to heat sources. Actions that may cause sparks (e.g. welding, grinding) should be strictly prohibited.

WARNING

WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

WARNING: Use caution when handling the chemicals mentioned above. This is an environmentally hazardous substance. Read and follow the chemical supplier's MSDS sheets.

APPENDIX G: RECOVERY CLEAN LOG SHEET

PURON® PSH RECOVERY CLEANING PROTOCOL

Plant Name and Location: _____

Recorded by (Name): _____ Date: _____

Faxed/Emailed to KSS on: Date: _____

Note: To maintain any warrantees and guarantees, this form must be completed and sent to KSS within seven calendar days whenever any modules or module rows are cleaned to restore the original permeability.

Module Serial # / Train in service for Recovery Cleaning:

_____

Date and Time	Temperature Biomass [°C / °F]*	Static Head in Standby mode [mbar / psi]*	Pressure in Filtration mode [mbar / psi]*	Flow in Filtration mode [L/h / gpm]*	Comments
Before Recovery Cleaning					
After Recovery Cleaning					

* - circle one

_____
Operator's Name (please print)

_____ _____
Signature Date

APPENDIX H: WATER QUALITY GUIDELINES

KSS WATER QUALITY GUIDELINES FOR CLEANING

Influent Cleaning and Diafiltration Water Parameters for All Polymeric Membrane Applications

Influent Parameter	MF/UF	NF/RO
Turbidity	< 1.0 NTU	< 1.0 NTU
Suspended Solids (see Note 1)	< 5 mg/l	< 1 mg/l
Calcium (Ca)	< 10 mg/l	< 5 mg/l
Total Hardness (as $CaCO_3$)	< 60 mg/l	< 30 mg/l
Iron (Fe)	< 0.05 mg/l	< 0.05 mg/l
Zinc (Zn)	< 0.3 mg/l	< 0.05 mg/l
Copper (Cu)	< 0.1 mg/l	< 0.05 mg/l
Manganese (Mn)	< 0.05 mg/l	< 0.02 mg/l
Aluminum (Al)	< 0.05 mg/l	< 0.05 mg/l
Silica, Reactive (as SiO_2)	< 10 mg/l	< 10 mg/l
Silica, Colloidal (as SiO_2)	< 1 mg/l	< 0.1 mg/l
Silicone	0 mg/l	0 mg/l
Total Bacteria Count (TBC)	< 1000 per ml	< 1000 per ml
E-Coli Count	0 per 100 ml	0 per 100 ml
Chlorine (as NaOCl)	< 1 mg/l	0 mg/l
D-Limonene (citrus applications only)	< 5 mg/l	0 mg/l
Fats, Oils and Grease	0 mg/l	0 mg/l
Total Organic Carbon (TOC)	< 1 mg/l	< 1 mg/l
pH (standard units) (see Note 2)	6.5 – 7.5	6.5 – 7.5

1. The water supply must be free from particulate matter such as rust, scale, flakes, sandy and granular material, slurries, scum, algae and any chemical constituents that could foul or damage the membranes.
2. The water pH may need to be adjusted with acid or alkali depending on application and local conditions.

GENERAL NOTE

KSS membranes are available in many configurations and materials that may be affected differently by various water constituents. Softened water or evaporator condensate is generally acceptable for cleaning and flushing of polymeric membranes. Please consult with the KSS Process Group for the particular membrane in question.

APPENDIX I: SYSTEM DESIGN PARAMETERS

DESIGN PARAMETERS

Koch Separation Solutions has provided PURON® submerged membrane modules for installation into the following system:
System name: Afula (Israel)
Customer: SHTANG CONSTRUCTION and ENGINEERING COMPANY LTD
Application: Municipal WWTP for domestic sewage treatment

General System Design

The system was designed to treat wastewater from the municipality of Afula (Israel)

The system includes 8 trains, each containing 4 PURON modules, model PSH 1800-38.

Design Parameters and Warranty Requirements

The contract of sale for the PURON submerged membrane modules contains the details of any warranty associated with the project and should be consulted in determining your warranty terms, remedies and obligations. For PURON® modules where all O&M manual recommendations and preconditions have been met, the MBR system in which the PURON modules have been installed shall have the capacity and effluent quality set forth in Tables 1.1 and 1.2.

The performance specified in Tables 1.1 and 1.2 in terms of capacity and effluent quality is dependent on operation of the MBR system in such a way that the requirements of feed water quality, pretreatment efficiency, biological and process parameters and flux rates as specified in Tables 1.3, 1.4 and 1.5 are met at all times.

The system design flows and effluent quality are shown in Tables 1.1 and 1.2 below.

Table 1.1: System Design Capacity

Design Flow Rates (inlet to biological treatment)	Units	Flow	Maximum duration per event
Annual Average Daily Flow (AADF)	m^3/day	36000	Not Applicable
Maximum Month Daily Flow (MMDF)	m^3/day	36000	
Maximum Week Daily Flow (MWDF)	m^3/day	36000	
Maximum Daily Flow (MDF)	m^3/day	36000	
Peak Hourly Flow (PHF)	m^3/day	36000	

Table 1.2: System Effluent Quality[1]

Parameters	Units	Acceptable Limit or Range
TSS	mg/L	< 10 (19/20 consecutive samples)
Turbidity	NTU	< 1 (19/20 consecutive samples)

The quality of the feed to the MBR system containing the PURON modules must be maintained as per the following table for waste treatment systems:

Table 1.3: Feed (to Biology) Water Quality Basis:

Parameter	Units	Acceptable Limit or Range
Temperature	°C (°F)	18 - 32
COD	mg/L	≤ 1200
BOD_5	mg/L	≤ 600
TKN Nitrogen	mg/L	≤ 120
pH	Standard pH units	6 - 8

The following process parameters and acceptable operating ranges must be met:

Table 1.4: Process Parameters

Parameter	Units	Acceptable Limit or Range
Mixed Liquor Suspended Solids (MLSS)[2] in the feed to the membrane tank	g/L	≤ 8
Dissolved Oxygen in the feed to the membrane tank	mg/L	≥ 1
Mixed Liquor Temperature in the feed to the membrane tank	°C	18 - 32
Soluble BOD_5	mg/L	< 10
Ammonia as Nitrogen (NH_4-N) in the feed to the membrane tank	mg/L	< 2
pH in the feed to the membrane tank	Standard pH units	6 - 8
Oil and Grease in the feed to the membrane tank	mg/L	< 1

[1] This quality statement specifically excludes TSS and turbidity resulting from post membrane filtration precipitation and microbiological growth downstream of the membrane or within the membrane lumen.

[2] The MLSS concentration in the membrane filtration tanks shall not be maintained any higher than 4 g/l above the MLSS concentration in the bioreactor feeding the membrane filtration tanks. For example, if the MLSS in the bioreactor tank is 6,000 mg/L then the MLSS in the membrane filtration tank shall be limited to ≤ 10,000 mg/L.

Solids Retention Time (SRT)[3]	days	15 - 25
Time-to-filter test (in accordance with Standard Method 2710H[4]) on membrane tank sludge	seconds	≤ 200
Sieve Test (in accordance with Appendix J) on membrane tank sludge	g/100L	≤ 1

The filtration section of the MBR system shall be installed per the following design:

Table 1.5: System Design

Parameter	Units	Value
Membrane Module Type	-	PSH1800
Number of Installed/Full Rows per Module	No.	38/44
Membrane Surface Area per Module	m^2	1560
Number of Membrane Tanks	No.	8
Number of Installed Modules Per Tank	No.	4
Number of Total Module Space Per Tank	No.	6
Total Number of Modules Installed in the Plant	No.	32
Membrane Surface Area per Filtration Line	m^2	6240
Total Installed Membrane Surface Area	m^2	49920

The following operating and design parameters must be met:

Table 1.6 Design Flux Rates and Expected TMP Values

Parameter	Units	Design Value[5]	Accepted Operating Range
ADF Net Flux	$L/m^2/h$	30	15 - 30
MMDF Net Flux	$L/m^2/h$	30	15 - 30
MWDF Net Flux	$L/m^2/h$	30	15 - 30
PDF Net Flux	$L/m^2/h$	30	15 - 30
PHF Net Flux	$L/m^2/h$	30	< 40
Maintenance Cleaning (MC) Gross Flux	$L/m^2/h$	6	5 - 8
Backflush Gross Flux	$L/m^2/h$	30	28 - 32

[3] The sludge retention time takes the following volumes into consideration: aerobic volume, anoxic volume and membrane tank volume.

[4] According to Standard Method for the Examination of Water & Wastewater 2012, 22nd Edition, jointly published by the APHA, AWWA, and WEF. Standard Method 2710H as approved by the SM committee 2004.

[5] The design values for net flux rates consider that all membrane trains are in service

Instantaneous Membrane Airflow per Module	Nm^3/h	760	740 - 780
Average expected Membrane Airflow per Module	Nm^3/h	380	370 - 390
Expected TMP at average flux	bar	0.15	0.05 – 0.3
Expected TMP at peak flux	bar	0.4	0.2 – 0.5
Maximum Filtration TMP	bar	0.6	Not applicable
Maximum Backflush TMP	bar	0.6	Not applicable

Membrane Performance Guarantee

A performance test shall be conducted on the MBR System (the initial **"Performance Test"**) in order to demonstrate that the PURON® Membrane System meets its performance criteria. The Initial Performance Test shall have a duration of 24 consecutive hours and shall be conducted as defined here below.

Scope of Performance Guarantee

Subject to the Conditions of Warranty, the PURON® Membrane System shall satisfy the performance criteria **("Performance Criteria")** defined in Table 1.7. during the Performance Test (summarized below). The **Initial Performance Test** will take place as soon as possible after the commissioning – to verify that the membrane system complies with the warranty parameters targeted in the contract. Afterwards, additional performance test(s) can be performed by the customer to verify that the membrane section is performing as designed, at any time during the duration of the warranty period.

Table 1.7 System Performance Criteria during Performance Test:

Parameter	Units	Value
System capacity - average daily permeate flow	m^3 / day	36000 (1)
System capacity - maximum daily permeate flow	m^3 / day	36000 (1)
Maximum system permeate capacity (N-1 condition) allowed max 24 hours continuously	m^3/h	7 trains x 214 m^3/h per train
Permeate Turbidity (19 out of 20 consecutive samples)	NTU	≤ 1
Permeate TSS (19 out of 20 consectutive samples)	[mg/l]	≤ 10

Table Notes:

1. *To confirm the MBR system satisfies the Performance Criteria (with respect to MBR system capacity) sufficient feed water shall be made available to feed the MBR system. The MBR plant shall be operated with the maximum number of available membrane filtration lines at all times.*
2. *The biological system must be operated in conformance with standard industry practice (i.e. recycle flow rates, DO and SRT control, carbon dosing, etc.).*
3. *The PURON® MBR Performance Guarantee specifically excludes TSS and turbidity resulting from post membrane filtration precipitation and microbiological growth downstream of the membranes or within the membrane lumen. The methods for measurement and the cycle time / location of the effluent sample are to be mutually agreed upon. Effluent samples must be free from small bubbling and are to be taken at the end of the filtration cycle and cannot be taken within the first hour after a membrane cleaning.*

Buyer Obligations with respect to the Performance Test:

1. The **Initial Performance Test** should be performed within 3 calendar months after Initial Conditioning, or 6 calendar months from KSS' delivery of the goods, whichever occurs first. The assistance from KSS is included in the sales contract for the Initial Performance Test execution.
2. For all subsequent Performance Test(s) that might be required during the warranty period, KSS must be notified at least 3 weeks prior to the scheduled date and the customer will be charged for the visit based on the attached Field Service daily rate sheet.
3. The Initial Performance Test shall not start before the biological treatment system feeding the membrane tanks has reached steady state operation as demonstrated by analytical testing of the bioreactor effluent to ensure compliance with the process parameters according to Table 3 with no downward trend in the wastewater quality parameters (immediately prior to commencement of the Performance Test) over a period of 48 consecutive hours of 24-hour composite samples.
4. The filtration system will be operated by the Buyer's personnel and all analytical testing will be the responsibility of the Buyer.
5. If the Initial Performance Test is not completed within the time frame mentioned at point n.1 – due to no fault of KSS – the system shall be deemed accepted by the customer and to have met the Performance Guarantee.
6. Upon successful completion of the Initial Performance Test, the performance obligations under this Agreement have been fulfilled and the Buyer shall promptly give notice of such fulfillment to KSS.
7. In case further Performance Test are required to be conducted all over the warranty period, upon successful completion of any of those, the Buyer shall promptly give notice that the performance obligations under this Agreement have been fulfilled by KSS.
8. If, after the Initial Performance Test, no further PT are requested with KSS supervision – the system shall be deemed to have met the Performance Guarantee during the whole period where no PT have been carried out.

Handling a Warranty Claim

If the Buyer has satisfied the requirements and preconditions set out herein, but it appears based on test results that the MBR system is not meeting the Performance Criteria as set forth above, KSS shall have thirty days (the **"Investigation Period"**) to investigate the cause of such failure, including the right to have the system operated at such conditions as it may deem necessary or advisable for purposes of determining the nature or cause of the

failure of the MBR system to meet the Performance Criteria, provided such operating conditions (1) are in accordance with good operating practice and (2) do not violate the Buyer's safety rules enforced at the site. At the end of such 30-day period, KSS shall have the option to provide a written plan of modifications to the MBR system to achieve compliance.

For avoidance of doubt, KSS shall have no liability to provide ancillary equipment or make site modifications, supply overhead crane, other equipment/materials, or labor required for inspection, removal, and/or installation of membrane modules.

KSS at its discretion will repair or replace any failed membrane in accordance with the terms of this membrane warranty. Any repair done to a membrane will not compromise either the quality or output of the membrane system.

Replacement membranes provided under this warranty shall be warranted for the remaining balance of the Membrane Warranty Period only. KSS reserves the right to provide redesigned or improved membranes for any replacement membrane.

The Performance Guarantee applies to the membranes only and does not extend to any other part or component. This Membrane Performance Guarantee will not apply to any membranes supplied after the expiration of the Performance Guarantee Period.

FAILURE TO MEET THE CONDITIONS OF WARRANTY AND THE REQUIREMENTS OF THIS OPERATION AND MAINTENANCE MANUAL MAY HAVE AN ADVERSE EFFECT ON SYSTEM PERFORMANCE, MODULE INTEGRITY AND MEMBRANE LIFE AND WILL VOID THE WARRANTY.

KOCH SEPARATION SOLUTIONS CONTACT INFORMATION

For questions about your PURON® system please contact the KSS Field Service office in your region:

USA:
Phone: +1 978-694-7000 or toll free 1-888-677-5624
Fax: +1 978-657-5208

EUROPE:
Phone: +49 (0)241 41326 0
Fax: +49 (0)241 93688256

KOCH™
SEPARATION SOLUTIONS

SIEVE TEST PROCEDURE

The Sieve Test is used to determine the amount of coarse material that is contained in the mixed liquor of an activated sludge wastewater treatment plant. It is very often used in MBR plants, where the good performances of the pretreatment fine screen are very strictly connected with the good operation of the membranes installed after the biotreatment.

Koch Separation Solutions always recommends to install fine-screen from 1mm to max 2mm as maximum dimension (circular shape) for the pre-screening of the inlet wastewater. Depending on the punched holes size selected in the plant's pre-screening stage, a different sieve will be used for the test:

- Either ASTM n.10 (2mm)
- or ASTM n.18 (1mm)

The sieve test requires a relatively large sample volume of mixed liquor (typically 100 L) to pass through the Sieve tray of the same size as the pre-screen equipment installed.

1. Take 10L bio-sludge sample by means of a 10L graduated bucket, in a representative mixed liquor sampling point.
2. Get the sample passing through the sieve tray and gently wash through with clean water to rinse away the biomass and to clean the collected screenings.

3. Repeat the previous actions for 10 times in order to get a final sieved mixed liquor volume of 100L

4. Separately collect the screenings from the sieve, and transfer to pre-weighed aluminum trays.

5. Dry collected screenings material in an oven at 105°C for a minimum of 8 hours, until constant weight is reached.

6. Weight the aluminum tray and subtract the initial pre-weighted value to determine the net dry weight of the screenings. Record the weight in grams, this result will be referred as STR (Sieve Test Result)

7. Compare the result with the following table to assess the pre-screening performances:

TRAYS	SIEVE TEST GOOD RESULT (100L sample)	SIEVE TEST MEDIUM RESULT[1] (100L sample)	SIEVE TEST POOR RESULT[2] (100L sample)
ASTM n.10	STR < 1 g/100L	1 ≤ STR ≤ 3 g/100L	STR > 3 g/100L
ASTM n.18	STR < 2 g/100L	2 ≤ STR ≤ 5 g/100L	STR > 5 g/100L

[1] Immediate actions have to be taken in order to mitigate the coarse material accumulation in the mixed liquor (most common: sludge extra screening)

[2] Bad pretreatment performances evidence, possible bypass or installation leaking points have to be verified. Membrane operation could be compromised and restored only after manual cleaning