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## » Membrane Module User manual

# Evac MBR

## Wastewater treatment

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## 1. Introduction

### 1.1 Evac MBR – Submerged Membrane Module

The Evac Membrane Bioreactor (MBR) is an advanced wastewater treatment process where all wastewater streams can be treated to meet current standard.

Submerged Membrane modules are used for a solid-liquid separation to filter wastewater from biomass. The membranes serve as a physical barrier, preventing passage of particles with diameters larger than their pores while allowing the free passage of treated water.

### 1.2 Manual Overview

This manual provides instructions and notices for the maintenance of the Evac MBR plants membrane modules, as supplied by Evac Oy.

It is important that this manual is reviewed by all relevant personnel and all procedures are fully understood before the maintenance of the membrane modules is performed so that all activities are completed safely and correctly.

The following notices are used in this user's manual:

**! DANGER:** Indicates an imminently hazardous situation, which could result in a fatality or a serious injury if the appropriate precautions are not taken.

**! WARNING:** Indicates a potentially hazardous situation, which could result in serious damage or failure of the equipment if the appropriate precautions are not taken.

**! CAUTION:** Indicates a potentially hazardous situation, which could result in minor damage or failure of the equipment if appropriate precautions are not taken.

**! NOTE:** Indicates that there are important matters related to the process that the operator should be aware of.

## 2. Safety instruction

### 2.1 General

These operating instructions contain the basic procedures to be followed during installation, operation and maintenance of the equipment. Please keep the handbook in a safe and accessible location next to the unit.

Carefully read these instructions before operating the system. Always comply with the safety instructions listed in this document, the existing shipboard accident prevention regulations and any internal Work Health and Safety rules.

Persons could be endangered and damage of the machine may result if the machine is not used for the intended purpose. An inadequately trained personnel and incorrectly performed work may also cause harm.

**! NOTE:           A first aid kit should be available at all times.**

### 2.2 Personnel qualification and training

Ensure that all personnel involved in the installation, commissioning, operation and maintenance of the Evac units are properly qualified and trained to carry out these tasks. Work on the electrical system and equipment of the Evac plants must be carried out by a properly qualified electrician only. Lack of personnel's skills and knowledge of the operation instructions can cause risk to life and damage to the equipment. Evac systems must be used according to the following instructions, and only by authorized personnel who are fully aware of the risks involved in the operation of the unit.

Moreover, the operating company has the responsibility to ensure that personnel fully comprehend the contents of the operating instructions.

The Evac units receives, treats and discharges sewage waste. Personnel must, at all times, observe safety regulations while performing maintenance or repairs which carries certain hazards. Every practical safety feature has been incorporated into the design and manufacture of this equipment; however, personnel must be aware of the potential hazards.

### 2.3 Disease hazard

Sewage is a common mode of transmission for parasitic organisms such as bacteria, fungi, protozoa, viruses and worms. Some of these may be pathogenic; they are capable of causing serious communicable diseases. Most diseases associated with sewage result from hand-to-mouth transfer of the pathogenic organisms. After coming into contact with sewage or any contaminated equipment items, personnel should thoroughly wash themselves with a disinfectant soap solution. This precaution is an absolute requirement before eating, drinking or performing hand-to-mouth functions. Skin abrasions, punctures or any other wounds require immediate and proper medical attention. Also it should be avoided to perform maintenance work on the Evac units if there are any kinds of wounds on the skin in areas that can get into contact with the wastewater or sludge.

## 2.4 Chemical hazard

When using chemicals which are hazardous and/or dangerous for ground water, it is essential to follow the corresponding regulations and laws regarding hazardous substances and water balance. Such dangerous chemicals are, for example, solvents, cleaning agents, care agents etc.

**! CAUTION: ALWAYS refer to official Material Safety Data Sheets (MSDS) provided for hazardous materials when handling chemicals. These should always be provided by the chemical supplier.**

## 2.5 Mechanical hazards

Before maintenance is performed on any motor driven equipment, disconnect the motor's power cord. Prevent the motor from switching on unexpectedly. Motors should also be labelled "OUT OF SERVICE". Only authorized maintenance personnel should make repairs to this equipment.

**! CAUTION: Safety devices may only be opened, dismantled or removed when the machine is standstill and safety secured.**

## 2.6 Hazard during installation

Proper placement can extend equipment life time. The Membrane module is to be installed on straight and steady base. The unit is to be levelled horizontally. The machine must be anchored securely to the foundation or supporting structure.

Ensure that in case of a leak any surrounding equipment is not damaged. Before installation, operators should be aware of the contents of this manual. Mechanical installation must be completed before any electrical work commences.

Switching the machine on for operational check, trail run, wet testing, etc. may only be performed by skilled electricians performing the electrical connection work.

**! DANGER: The combination of water and electricity can be fatal.**

## 2.7 Operation and maintenance hazards

Evac plants shall be operated and maintained by authorized and trained personnel only. All work and modifications to the system shall be approved by the manufacturer. Under no circumstances shall the equipment power be switched on, or the equipment be pressurized when work is performed. Be aware of the rotating parts of pumps and screw conveyor.

Before the start-up of the Evac unit, ensure that no one is in danger. Take all necessary measures to ensure that the Evac unit is used only in a safe and reliable state.

Once per day check the Evac unit for obvious damage and defects. In case of damage or a change in the normal operation of the unit, stop the unit immediately and refer to the trouble shooting section. In case of the ship's crew is unable to bring the system to its normal operation, please contact Evac Oy.

The electrical parts of the unit should to be inspected at regular intervals. Defects like loose connections or scorched cables must be repaired without delay. Inspection, servicing and maintenance work is only allowed to be carried out when the machine is at standstill and safety secured. Ensure that the unit is completely switched off before any maintenance and repair work is undertaken.

Restart is only permitted after malfunctions, faults and/or damages have been completely rectified. Never use the Emergency-STOP palm button for normal stopping of the machine, malfunctions/damages may be the result.

**! CAUTION:** The Evac MBR plant is exclusively designed to treat black and grey water and it should not be used for any other purposes. The manufacturer cannot be held responsible for any damage caused by improper use of the plant. The user is totally responsible of risks caused by such misuse.

**! CAUTION:** Before start up, it shall be ensured that no unauthorized persons are close the machine, either working on it or at risk from its start up.

## 2.8 Disposal and Environmental protection

The operator is responsible to disposing of materials which result from maintenance. This may involve, waste water and solid residue, cleaning and care agents, auxiliary material, e.g. lubricants, other waste materials of all sorts, including worn machine components.

Disposal must be performed according to, the law for protection of emission, for waste disposal, for protection of water resources, etc.

## 2.9 Evac component nameplates and tag numbering

All Evac MBR units and components are identified and marked according to NSF1 Group numbering system. Marking equipment and pipes is of the utmost importance to safety at all times. Accidents, injuries and damage to machines and equipment can be caused by ignorance of substances that flow through pipes.

Component tag plates should not be removed during maintenance and if removed must be attached back to correct place after maintenance work. The name plates with equipment tag number, label plates, caution plates, marking notice boards, instruction plates, safety markings and etc. are supplied by Evac and engraved with letters in English language.



### 3. Submerged Membrane Modules

#### 3.1 Specification of Membrane modules

Table 1 Specification of Evac Submerged Membrane Module

Model	Membrane sheet Quantity	Membrane module		Effective Membrane Area [m <sup>2</sup> ]	Diffuser Air Average Supply Rate [m <sup>3</sup> /min]
		Dry weight (kg)	Max weight* (kg)		
MS	200	730	1630	160	2.5
	150	550	1200	120	1.9
	100	370	810	80	1.25
	75	280	600	60	1.25
	50	200	410	40	0.85

\*The Maximum value shows the weight when gaps of Membrane Cartridges are completely filled with sludge. The weight includes that of the Lifting Tool (Optional Parts). If Any other debris or screening pile up on the Membrane module, the total maximum weight could exceed the weight shown in the above table.

**! DANGER:** The weight of Membrane module can change due to sludge adhesion, membrane fouling, etc. When installing ancillary equipment such as hoist rails, check the maximum load of the Membrane module and make sure the equipment is strong enough to meet its dynamic load. Insufficient loading capacity can cause drop accident.

**! NOTE:** Aeration equipment (e.g. Blower) capacity must be within the indicated range. Insufficient air supply may cause fouling and excess air supply may cause damage to Membrane sheets.

#### 3.2 Evac MBR units and Membrane modules

Three different membrane module types are used in the Evac MBR 7K – 45K plants. The different Evac MBR plants and the amount and type of corresponding membrane modules are listed in table below. The MS25 module has 25 membrane cartridges, the MS50 has 50 membrane cartridges and the MS75 has 75 membrane cartridges.

Table 2 Number of membrane modules in different MBR plants

Evac MBR	7K	15K	22K	30K	45K
Module type	1x MS25	1xMS50	1x MS75	2x MS50	2x MS75

The total amount of membrane sheets per Evac MBR plant type is listed below:

Table 3. Membrane sheet amounts in MBR units

Evac MBR	7K	15K	22K	30K	45K
Sheets	25	50	75	100	150

### 3.2.1 Evac Large MBR units

Evac Large MBR units, i.e MBR units that are larger than MBR 70K are always custom made and Membrane modules are always selected by size and use of the MBR units.

### 3.3 Membrane module structures

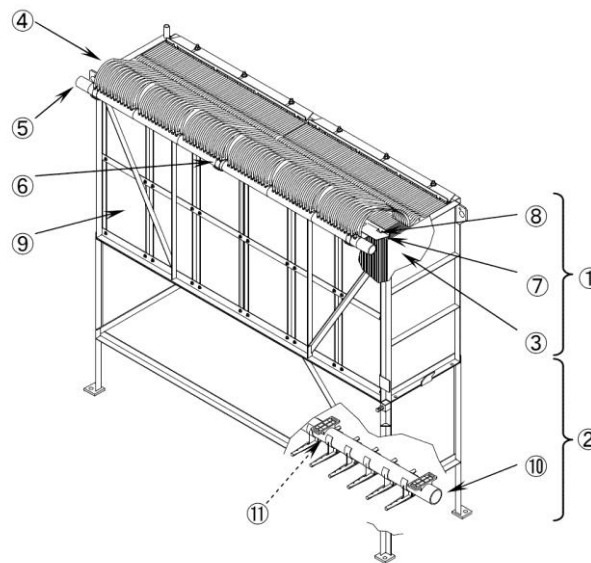


Figure 1 Schematic of Submerged Membrane Module

Table 4 Parts list

	Parts	Instructions
1	Membrane module	Membrane Cartridges are set inside
2	Diffuser Case	Diffuser is installed
3	Membrane Cartridge	Enable solid-liquid separation
4	Tube	Connects Manifold and each membrane cartridge
5	Manifold	Piping to collect permeate
6	Manifold Saddle	Fix manifold to the manifold support
7	Retaining Rubber	Fix each Membrane Cartridge in equal distance
8	Retaining Plate	Fix the retaining rubber
9	Panel	Support each Membrane Cartridges equally from the side
10	Diffuser	Air from the blower is diffused to each Membrane Cartridge
11	Diffuser Branch Pipe	Air from the blower is diffused to each Membrane Cartridge

### 3.4 Usage conditions

Membrane modules are installed in the MBR tank. The Membranes are used solid-liquid separation of active sludge or mixed liquor. The Pump sucks the wastewater through the Membranes.

- Operating Trans-Membrane pressure(TMP): between 0 and -250 mbar
- Chemical Injection Pressure for Chemical Cleaning of Membrane cartridge:
  - Continuous 10 kPa or lower (1 m water head by gravity)
  - Maximum instantaneous: 20 kPa or lower (2 m water head by gravity)
- Chemicals for In-situ Chemical Cleaning
  - Effective chlorine concentration of sodium hypochlorite: 1.0 % or less
  - 0.25 to 0.6 % of effective chlorine concentration of sodium hypochlorite is recommended for in-situ chemical cleaning.
  - Oxalic acid: 1.0% or less
  - When there is calcium carbonate precipitation in tanks, this chemical cleaning method should not be conducted.
- Water Temperature: 5 to 40 °C
- pH: 5 to 10

**! DANGER:** Never mix sodium hypochlorite and oxalic acid (or other acid). Doing so will produce toxic chlorine gas, which may cause severe accident.

**! WARNING:** Never use corrosive chemicals that can affect stainless steel.

**! NOTE:** In chemical cleaning inject solution by gravity for in-situ chemical cleaning of membranes.

**! NOTE:** The amount of chemical cleaning solution used should be 3l per cartridge when conducting chemical cleaning method.

**! NOTE:** When the TMP reaches -250 mbar chemical cleaning must be carried immediately or permeate pump is stopped.

## 4. Clean water Test and Actual Operation

Before commissioning, please conduct the Clean Water Test to confirm proper operation of the items/actions listed below.

- Permeate pump, MBR tank blower and other membrane related equipment
- Aeration and Filtration operation
- Leak test for the Permeate piping and Diffuser piping
- Flow rate, TMP, and water temperature

Please adjust or repair the plant if any abnormalities are found during the Clean Water Test.

### 4.1 Precautions in Wet Test

It is important to note the following points to use the Evac Membrane module affectively.

- Design the system such that filtration stops when aeration is being suspended or diffuser cleaning is being conducted.
- Intermittent filtration (Also called as relaxation) (Example; 1min aeration without filtration, 9min filtration), is required to avoid membrane fouling. Intermittent filtration should always start from aeration without filtration.
- The Membrane module must be fully submerged in clean water as it is operated. Put clean water such as tap water or technical water into the MBR Tank up to the level specified for a normal operation (The required water depth for operation should be more than 500 mm above the top of Membrane module).

**! NOTE:**      **Design the system so that filtration stops anytime when aeration to the Membrane module is stopped or Diffuser Cleaning is carried out. If filtration is done when aeration to the Membrane module is stopped or Diffuser Cleaning is carried out, membrane fouling may occur.**

## 4.2 Wet Test Preparation

Perform the following inspections and preparation before starting the “clean water” test.

- Re-check the air supply piping connection and the permeate piping connection.
- Re-check to see if all the Membrane module(s) is/are leveled within recommended value.
- Make sure that a pressure gauge, flow control valve and a flow meter are properly installed in permeate line.
- Please make sure each Diffuser Branch Pipe is fixed properly to Diffuser Header.
- Make sure to clean the inside of MBR Tank completely before it is filled with clean water. If the test is done in the MBR Tank where sands and debris are not completely removed, membrane can be damaged and fouled.
- Small metal parts from pipe connections and from MBR tank are really harmful. Please clean the MBR units tanks and pipes before taking the unit in use.
- Before filling the MBR Tank, open the chemical injection valves to allow the air trapped in Membrane sheets to escape.
- Put clean water such as tap water or technical water into the MBR Tank up to the level specified for normal operation. When using secondary clarifier effluent from the existing sewage treatment plant instead of clean water.

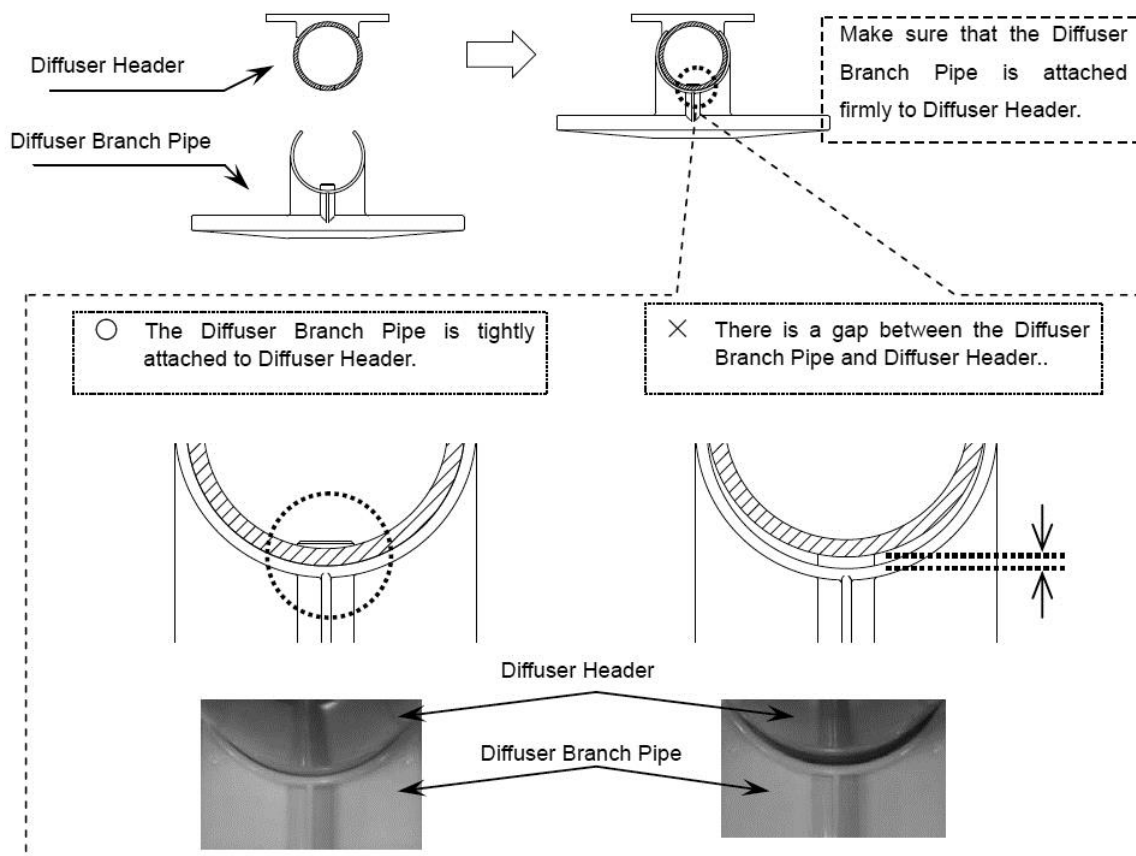


Figure 2 Diffuser Pipe (Diffuser Header and Diffuser Branch)

**! NOTE:** Diffuser Branch Pipes are detachable. Please make sure all the Diffuser Branch Pipe is fixed properly to Diffuser Header. If it is not fixed properly, uneven aeration or drop of Diffuser Branch Pipe may happen.

**! NOTE:** Make sure to clean the inside of the MBR Tank completely before filling it with clean water. If sand, grit and debris are not completely removed, damage to membranes or fouling may occur.

**! NOTE:** When filling the MBR Tank with clean water, open the chemical injection valves in order to allow the air trapped in the Membrane Cartridges(sheets) to escape. If there is no vent, the increase in pressure in Membrane Cartridges(sheets) may cause membrane tear.

**! NOTE:** Close the chemical injection valves immediately after the air is released from the Membrane Cartridge. If they are left open, extraneous material can penetrate the system to cause clogging in Tubes and pipes and Permeate Pump trouble.

### 4.3 Wet Test Operation

After the MBR Tank is filled with clean water, perform clean water test operation according to the following procedure.

- Start the aeration blower, and make sure its smooth operation and uniform aeration \* Foaming caused by the hydrophilic agent coating the Membrane Cartridges is a normal phenomenon.
- When using one blower for multiple Membrane modules, check to see that air supply to each Membrane modules is balanced. If it is significantly unbalanced, re-check the air supply rate to each Membrane modules, piping configuration (specifically, re-check whether a proper header piping is chosen and whether the pipe diameter is not too small), and level of each Diffuser Case.
- After starting filtration, measure and record permeate flow rate, TMP, and water temperature in the MBR Tank.
- Stop filtration after clean water test operation is completed
- Stop aeration immediately after filtration is stopped.

**! CAUTION:** Avoid prolonged clean water test operation because it may cause Membrane fouling due to dust and debris in the MBR Tank.

**! CAUTION:** After completing wet test operation, do not dry out the Membrane Cartridges. Dried membranes would become hydrophobic and fall in permeability.

## 4.4 Actual Operation

The air amount required for each Membrane module differs among unit models. Keep the supplied air amount per unit within the range described in Table 1 at page 9.

When the permeate flow rate becomes stable, measure the permeate flow rate during the actual operation. In addition, measure water head or TMP for the gravity filtration system or suction pressure (TMP) for the suction filtration system.

If using a defoamer due to foaming in the MBR Tank, use petroleum-based one. Use of silicone-based defoamer will cause a membrane fouling. (Evac recommended product: Struktol SB2032)

The followings are the operating conditions for Evac MBR Process. Operate within the following range:

- MLSS: 12,000 - 16,000 [mg/L]
- Viscosity: 100 [mPa·sec] or less
  - Evac's recommended measuring instrument: VT-03 made by Rion Co.,Ltd.
- Filterability Using a Filter Paper:  
10 [mL/ 5min] or more
  - Refer to "Paper Filtration Test Method" in the next section.
- Dissolved Oxygen Concentration (DO value):  
1 [mg/L] or more

When sludge dewatering liquors are returned into the MBR Tank, take care of the amount of polymer in it. Flocculants or polymer may accelerate membrane fouling and corrosion of Stainless steel.

**! CAUTION:** Never use chemicals that will have an adverse effect on activated sludge, such as toxic substances and large amount of oils, into the tank. They may decrease filterability of activated sludge resulting in membrane fouling.

**! CAUTION:** Never use corrosive chemicals that may affect steel parts.

**! CAUTION:** Aeration without filtration for a long time results in damage on Membrane Cartridges. Limit aeration to a minimum when filtration is suspended.

## 5. Handling Precaution for Membrane modules

### 5.1 Important precautions in Membrane module unload

Plan carefully a carry-in route to the tank where the Membrane module is to be installed. Prepare the equipment that will be used to unload the Membrane module shipment. Secure a temporary storage place for the Membrane modules. Make sure that MBR tank construction has been completed and carefully cleaned. During construction work, cover the Membrane modules with fireproof sheet (customer provision) to protect it from welder or grinder sparks.

Do not remove the plastic wrapping film from upper Membrane module until operation starts. Do not remove the plastic wrapping sheet of lower membrane modules until upper Membrane modules are installed. It prevents Membrane cartridges getting wet and dusty. Do not wet the Membrane cartridges before use. When wet Membrane cartridge dry, it loses capacity significantly. Take care not to damage the membrane surface, or it may result in suspended solids contamination in the permeate water. Damaged membranes cannot be repaired and used.

**! WARNING:** Keep Membrane cartridges away from heat, flame and sparks. They may cause damage on parts of Membrane module.

**! WARNING:** Never leave out Membrane module for a long time where there will be an exposure to direct sunlight or high summer temperature. This condition changes the shape or quality of the Membrane parts so that proper operation cannot be conducted.



Figure 3 Membrane module wrapped to plastic sheets



## 5.2 Membrane module unload

When unloading the Membrane module, use a prepared crane, hoist, or forklift.

The recommended methods to pack, transport, and lift the Membrane module or the Diffuser Case is described below:

Membrane module:

- When Membrane module is shipped, each Membrane module must be packed with plastic wrapping film and fixed to wooden pallet.
- When using a forklift, insert its forks into wooden pallet.
- Please take care not to damage manifolds and nozzles of Membrane cartridges during the Membrane module installation works.

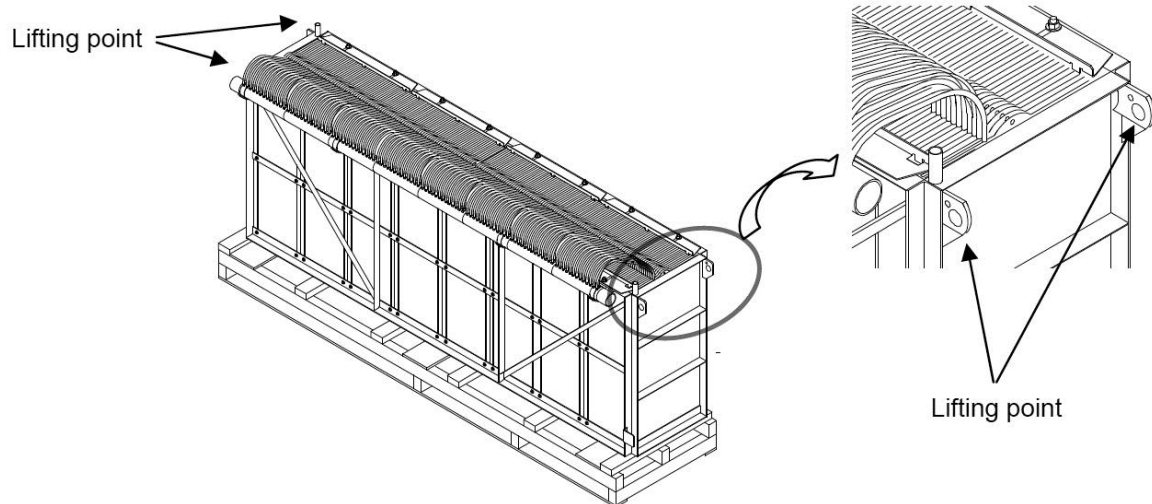


Figure 4 Membrane module lifting point

**! DANGER:** Never go around or below the lifted Membrane module or Diffuser Case. If they fall, severe accident may occur.

### 5.2.1 Check list for Membrane module

When a package of the Membrane module arrives, it is recommended to check the following:

- Confirm that the package contains all the components and parts indicated in the packing list.
- Make sure all the components and parts are not damaged during the shipment.

### 5.3 Membrane module Storage

Check list for storing the Membrane modules:

- Membrane module must be stored on a level surface.
- Always cover the Membrane Modules with the plastic wrapping film during the storage
- Please avoid an exposure to direct sunlight, and store Membrane modules indoors with the room temperature between 5 and 40°C.
- Please avoid high humidity or dusts during storage.
- Spare Membrane Cartridges for replacement should also be stored indoors

**! WARNING: Keep Membrane cartridges away from heat, flame and sparks. They may cause damage on parts of Membrane module.**

**! WARNING: Never leave out Membrane module for a long time where there will be an exposure to direct sunlight or high summer temperature. This condition changes the shape or quality of the Membrane parts so that proper operation cannot be conducted.**

**! NOTE: Do not remove the plastic wrapping film from upper Membrane modules until operation starts. Do not remove the plastic wrapping sheet of lower membrane modules until upper Membrane modules are installed. It prevents Membrane cartridges getting wet and dusty.**

**! NOTE: Do not wet the Membrane cartridges before use. When wet Membrane cartridge dry, it loses filterability significantly.**

### 5.4 Membrane module Installation

Check the arrangement of Membrane Modules with an equipment layout drawing for the facility, and install it / them within the deviations descriptions described in the following sections.

Install the Membrane modules in the following steps:

- Diffuser Case Installation
- Guide Pipe installation
- Membrane module Installation
- Stabilizer Installation
- Lifting Chain Installation

#### 5.4.1 Diffuser Case Installation

Remove the wooden pallet from the Diffuser Case.

Installation a single Diffuser Case so that the upper surface is levelled within 5 mm deviation. When installing multiple Diffuser Cases, install them that upper surfaces of any and all the Cases levelled within 10 mm deviation. This is to keep the air from the diffuser to be equally disturbed to each Membrane Cartridges.

Make sure to fix the Diffuser Case on the bottom of MBR Tank using Evac guides. Please consult Evac if needed.

Be sure to fix the base plate of the Diffuser Case with nuts tightly and grout mortar in interspaces between the base plate and MBR tank bottom plate. After all the Diffuser Cases are levelled.

**! NOTE:** For one Membrane module level deviation should be within 5 mm.

**! NOTE:** Diffuser cases must be leveled within 10 mm.

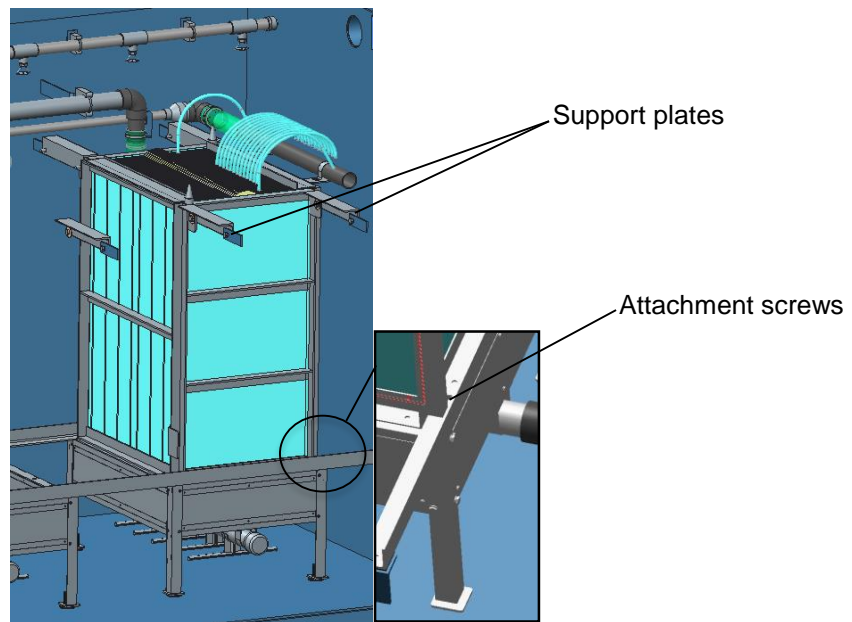


Figure 5 Installation Deviation for Membrane module and Guide pipe

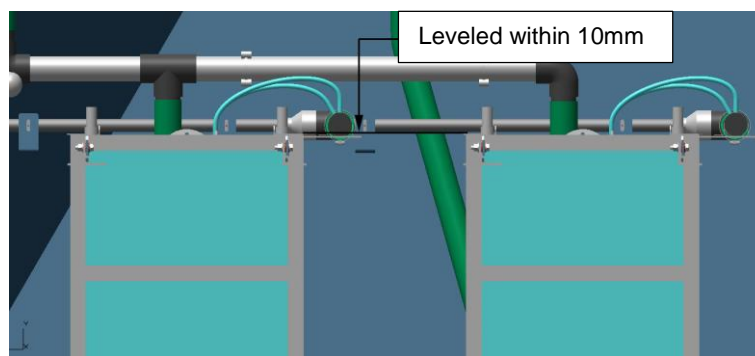


Figure 6 Membrane modules must be leveled within 10 mm deviation

### 5.4.2 Membrane module Installation

- Remove the wooden pallet from the Lower Membrane module.
- Do not remove the plastic wrapping film until the time just prior to installation of the Membrane module.
- Extreme care must be taken not to expose Membrane Cartridges to welder or grinder sparks.
- Remove the fixing bolts on the Diffuser Case.
- Mount the Membrane module onto the Diffuser Case. Then, securely fix the Membrane module with four fixing bolts.

**! WARNING:** Secure the safety of workers by using scaffolding and safety equipment in order to avoid a fall accident. Never climb the Membrane module or stand on Membrane Cartridges.

### 5.5 Permeate piping connection

To Connect permeate piping, use the following general procedure:

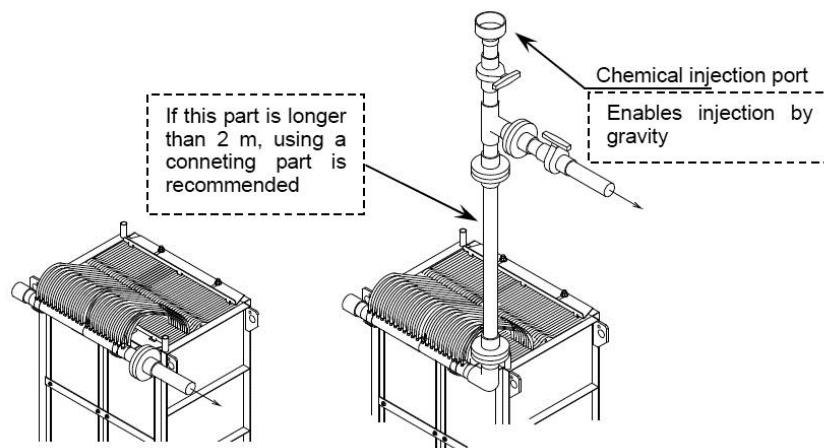


Figure 7 Example of Permeate Piping Connection

- When designing multiple Membrane module system, main permeate header piping should be installed to combine the multiple permeate piping. Make sure that header piping is level.
- Select one side of Manifold and connect it to the permeate piping, and the other side should be sealed with fitting caps.
- Install the branch pipe using connections such as a flange so that the Membrane module can be easily lifted up during maintenance.
- Install chemical injection ports on each Membrane module branch or on the permeate header pipe. The height of the injection ports should be set to keep chemical injection pressure to each Membrane module at 15 kPa or less (1.5 m or less).
- When hard pipe is connected to the Manifold from the Permeate Header Pipe, install an connecting part, such as a union in the straight pipe from the Permeate Header Pipe in order to decouple the pipe at no longer than 2 m. This is for preventing excess loading onto the Manifolds when lifting up Membrane module. If a flange is used to decouple, prevent it from an interference with the Guide Pipe when lifting up the Membrane module.

**! CAUTION:** Never insert the using a hammer. This may cause damage on manifolds and diffusers.

**! NOTE:** Before bonding, clean up all the stains and chips at the connection points completely. They may cause blockage in tubes and damage on membranes.

**! NOTE:** Design the piping configuration such that the Manifold is not under load during lifting of Membrane module, otherwise the Manifold may break.

**! NOTE:** Before connecting each piping, remove all dust and chips within connection points completely. They may cause clogging in Tubes or damage the Membranes

## 5.6 Air Supply System Connection

Each Diffuser has one connection point, the air supply connection. Connect piping using specified glue for vinyl chloride pipes. Because the air supply piping tend to vibrate intensively, provide enough support to the MBR Tank so as not to damage or wear the pipes.

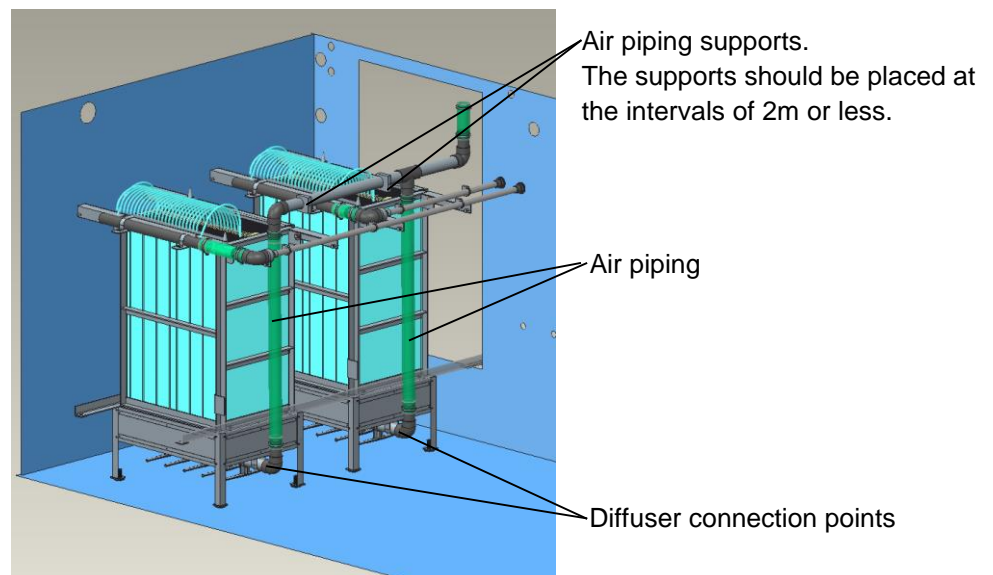


Figure 8 Evac air piping configuration

**! NOTE:** Before connection each piping, remove all dust and chips within connection points completely. They may cause clogging in Tubes or damage the Membranes.

Table 5 Recommended Permeate and Air Supply Piping Size

Membrane Module Model	Permeate piping	Air Piping	
	Connection Point	Inlet side	Diffuser connecting Points
MS50	Ø60	Ø60	Ø50
MS75	Ø60	Ø60	Ø50
MS100	Ø60	Ø60	Ø50
MS150	Ø60	Ø65	Ø75
MS200	Ø65	Ø65	Ø75

## 6. Maintenance

### 6.1 In-situ Chemical Cleaning

When TMP increases -200 mbar perform the in-situ chemical cleaning of the Membrane Cartridges immediately. Even if there is no TMP increase, it is important to perform a periodic in-situ chemical cleaning of the Membrane Cartridges at least once a half-year in order to keep stable operation.

If in-situ chemical cleaning cannot reduce TMP or sludge firmly attaches (piles) between Membrane Cartridges, take out the Membrane Cartridge from the Membrane module and remove the sludge on the membrane surface using soft tools such as sponge or rubber scraper. Never use a hard tool which may damage the Membrane Sheet.

**! WARNING:** Never mix sodium hypochlorite and oxalic acid (or other acid). Doing so will produce toxic chlorine gas, which may cause severe accident.

**! CAUTION:** Before using chemicals, read the Material Safety Data Sheet (MSDS) carefully, and wear protective equipment such as masks, goggles, gloves, etc. Misuse of them may cause physical accidents.

**! CAUTION:** It is recommended to inject solution by gravity for in-situ chemical cleaning of Membranes (Injection pressure: 15 kPa or less). If pressurized by pump, it may cause a sudden pressure increase inside Membrane Cartridges, which may lead to damage of Membrane Cartridges and/or Membrane modules.

**! CAUTION:** The amount of chemical cleaning solution should be 3 L per cartridge. Larger amounts of chemical solution may cause breakages of Membrane Cartridges and/or Membrane modules.

**! CAUTION:** Even if the specified volume of chemicals 3 L per cartridge cannot be injected, never force it in. Excessive positive pressure leads to damage of Membrane Cartridges.

#### 6.1.1 Cleaning Procedure

Organic fouling of the membrane micro-pores can be cleaned by using a dilute solution of bleach (sodium hypochlorite/ $\text{NaClO}$ ). Stock chemical solution should be diluted to 0.5%, and make 3 L of the dilute cleaning solution per cartridge. However, if the sludge concentration is lower than 10,000 mg/L, dilute the chemical to 0.25%.

Inorganic fouling (Iron, Aluminum, and/or others) of the membrane micro-pores can be cleaned by Oxalic Acid or Citric Acid will be necessary to recover membrane performance. Prepare about 3 L of 0.5 to 1.0% Oxalic Acid solution per cartridge. (If the Membrane Cartridges are polluted with Ca, NEVER use Oxalic Acid. Hydrochloric Acid or Citric Acid should be utilized.)

**! CAUTION:** Stop filtration and aeration of Membranes during chemical cleaning.

Make sure that the liquid level in MBR Tank is 300 mm or more above the top of Membrane module, or the permeate tubes are completely submerged. Inject the prepared chemical solution into every

Membrane Cartridge via injection port. (Injection time takes approximately 10 to 20 minutes.) Pressurized chemical injection by pump should be avoided and injection by gravity (10 kPa or less and instantaneously 20 kPa or less) is recommended. In order to prevent a pressure increase within Membrane Cartridges, the chemical should be injected by, for instance, adjusting the rate with valve. Moreover, the chemical should be injected intermittently in order to release the trapped air from Membrane Cartridges. Especially, when cleaning a calcium carbonate fouling (caused by treating Ca included wastewater) by acid, a careful attention should be taken since the chemical reaction would generate carbonic acid gas and this may blow out from the injection port. Finally, if the entire 3 L/cartridge chemical cannot be injected, never forcibly inject it all.

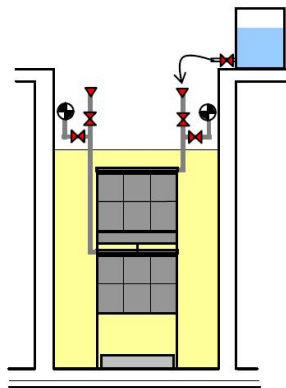


Figure 9 In-Situ Chemical Cleaning Method

After injection of the chemical solution, leave the Membrane Cartridges for 1 to 2 hours. As a guide, it takes approximately 2 hours for cleaning organic substances, and 1 hour for cleaning inorganic substances.

Because the chemical solution flows back slowly from the permeate side to activated sludge side by low pressure, it is more effective to clean the membrane before it is fully fouled, or during the period when increase in filtration pressure is still small since the operation has just started.

**! WARNING:** Never lift the Membranes without conducting filtration for at least 30 minutes after the chemical cleaning. If Membranes are removed as soon as chemical cleaning has finished, accidents due to trickle of the chemical and/or damage in Membrane Cartridges may occur.

## 6.2 Chemical Handling Instructions

This chapter provides a short introduction of chemicals used in Evac MBR process. More detailed descriptions please read the Material Safety Data Sheet (MSDS) supplied by chemical supplier.

**! CAUTION: Always read the Material Safety Data Sheets carefully before handling chemicals.**

### 6.2.1 Sodium Hypochlorite, NaClO

#### Storage Precautions

- Store in a cool, dark place (refrigerate it). Avoid an exposure to direct sunlight.
- Never mix the solution with heavy metals because chemical decomposition can be accelerated.
- The storage tank should be plasticized or maybe an iron container coated with corrosion resistant material.

#### Handling Precautions

- Carefully read the detailed handling precautions (such as MSDS) attached to the chemical, and handle it properly.
- Never mix the chemical with heavy metals or acids. Especially, never mix the chemical with acid, or it will generate toxic chlorine gas. If the chemical is accidentally mixed with acid, quickly neutralize it with a basic solution such as sodium hydroxide.
- Always wear a mask, safety goggles, and rubber gloves when handling.
- If accidental contact with human body or clothes occurs, immediately rinse with tap water.
- If accidental contact with eye by occurs, immediately rinse the eye with a large amount of tap water and seek medical attention.

### 6.2.2 Oxalic Acid (Powder), C<sub>2</sub>H<sub>2</sub>O<sub>4</sub>

#### Storage Precautions

- Carefully read the detailed handling precautions (such as MSDS) attached to the chemical, and handle it properly.
- Store this chemical at a cool, dark place (refrigerate it). Avoid an exposure to direct sunlight.
- The storage tank containing dissolved oxalic acid must be a container, which is plasticized or is made of iron coated with corrosion resistant material.

#### Handling Precautions

- Never mix oxalic acid with sodium hypochlorite, or it will generate toxic chlorine gas. When the chemical is mixed with it by mistake, neutralize it with alkali solution such as sodium hydroxide.
- Always wear a mask, safety goggles, and rubber gloves when handling.
- If accidental contact with human body or clothes occurs, immediately rinse with tap water.
- If accidental contact with eye occurs, immediately rinse the eye with large amounts of tap water and seek medical attention.



### 6.2.3 Hydrochloric Acid, HCl

#### Storage Precautions

- Carefully read the detailed handling precautions (such as MSDS) attached to the chemical, and handle it properly.
- Store this chemical at a cool, dark place (refrigerate it). Avoid an exposure to direct sunlight.
- Do not store combustible materials in the vicinity of this chemical.
- Never put this chemical close to fire or source of heat.

#### Handling Precautions

- Never inhale dispersed gas.
- Always wear a mask, safety goggles, and rubber gloves when handling.
- When handling this chemical outside, have the wind at your back.
- Before opening the container lid, remove internal pressure.
- Avoid a contact of skin, mucosa, clothes, and eyes from this chemical.

### 6.2.4 Citric Acid (Powder), C<sub>6</sub>H<sub>8</sub>O<sub>7</sub>

#### Storage Precautions

- Carefully read the detailed handling precautions (such as MSDS) attached to the chemical, and handle it properly.
- Store the chemical at a well-ventilated place. Avoid an exposure to direct sunlight.
- Since the chemical is efflorescent, store the chemical with an enclosed package.
- Do not leave the chemical in the vicinity of ignition source.

#### Handling Precautions

- Handle the chemical at a well-ventilated place.
- Do not swallow a dispersed dust of the chemical.
- Always wear a mask, safety goggles, and rubber gloves when handling.
- After handling the chemical, wash hands and face, and gargle.
- Do not use high-temperature matter, sparks, fire, etc. around the chemical.
- Do not leave the chemical in the vicinity of ignition source.
- If accidental contact with skins occurs, immediately rinse with tap water and soap.
- If accidental contact with eye occurs, immediately rinse the eye with large amounts of tap water for at least 15 min. and seek medical attention.

## 6.3 Periodic Inspection

A Supplier's regular inspection in every two years is recommended.

Please conduct Customer's inspection in addition to the Supplier's regular inspection. Please make sure that there is no crack, distortion, bend, corrosion or other abnormalities on any part of Membrane modules (especially, Lifting Points), Diffuser Cases, Lifting Tool (Optional Parts) (especially, shackles), Lifting Chain (Optional Parts), Guide Pipe (Optional Parts), and Hanging Frame (Customer's provision). If using any of these parts in corrosive environment, increase the frequency of the inspection. If corrosion is found in any parts, replace the parts immediately.

For the following items, please conduct periodic Customer's inspections aside in addition to the regular maintenance mentioned above.

- SS in the effluent
- TMP fluctuations
- Unbalanced air supply to each Membrane module

Please refer to section "Troubleshooting" whenever abnormalities are found during the operation or maintenance of the Membrane Cartridges. If significant SS contamination is found in the permeate water, it is likely that the Membrane Cartridges have surface damage (holes, scratches, etc.) or that some permeate Tubes have become disconnected. The discharged water quality may then exceed the effluent quality standard. In such cases, please immediately stop operation and consult with Evac.

## 6.4 Replacement parts

### 6.4.1 Frequency of Replacement

- Supporting Rubber - To be replaced every three years
- Tube - To be replaced every five years
- Membrane Cartridge - To be replaced every three to seven (5-10) years

Although Membrane modules and Diffuser Cases are not regarded as periodic replacement parts, these parts may require replacement depending on plant operational conditions.

**! NOTE:        Frequency to need of replacements depend on plant operational conditions**

### 6.4.2 Storage Instruction for Replacement Parts

For storage of replacement parts, follow the guidance below. If the parts become deformed and/or change in quality, normal operation cannot be performed.

Prevent the parts from direct sunlight or wetting, and store them indoors with temperature between 5 and 40°C.

Replacement Membrane Cartridge is shipped in a cardboard package containing five cartridges. When storing the cardboard package, prevent from piling up at the flat side and stand them with the longer side on the floor (or on pallet). In order to avoid exposure to water, use pallet, wrapping film, etc. for the storage.

A large number of Replacement Membrane Cartridges are delivered either as a special package containing 50 cartridges fixed on a wooden pallet (two packages can be fixed on one wooden pallet) or as 20 cardboard packages bundled and fixed on a wooden pallet. When multiple set of 20 cardboard packages are delivered, two pallets can be piled up at maximum. In this case, follow the procedure below.

- Do not pile up more than 2 pallets.
- Put off the pallet for upper packages.
- Pile up the upper pallet forming a 90° angle with the lower pallet.

- Fix the packages and pallets firmly with some support or band in order to keep the packages from slouching.

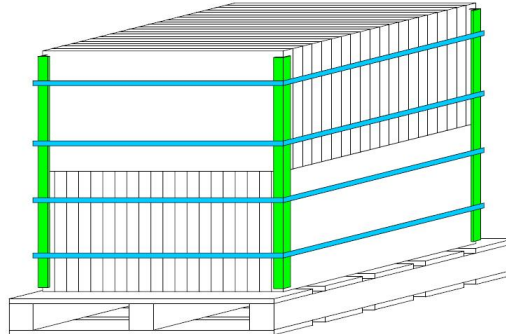


Figure 10 Storage of multiple cardboard packages (Example)

- ! CAUTION:** Never leave out Replacement Parts for a long time where there will be an exposure to direct sunlight, especially during summer when it is intensively hot. This condition makes Membrane modules parts out of shape and it changes in quality so that proper operation cannot be conducted.
- ! CAUTION:** Do not wet the Membrane Cartridges before use. When wet Membrane Cartridges dry again, their filtration performance decreases remarkably.
- ! NOTE:** Every replacement parts must be replaced after its recommended period. Failure to do so leads to damage Membrane Cartridges, Membrane modules, etc.

## 6.5 Removing Membrane module

It is recommended that the membrane maintenance is arranged simultaneously with the Evac MBR plant overhaul. Before maintenance work on the membrane module(s), the Evac MBR operation should be intercepted:

- Turn all the switches to '0' position from the control panel.
- Close all inlet lines to Evac MBR plant.
- Close the permeate lines by Shut off the permeate line valves.
- Switch the equalizing tank's mixing blower to 'MAN'. The contents of the MBR tank should be moved to the equalizing tank as instructed in the previous section "Checking the membrane module(s)".
- Observe the level situation inside the MBR tank through the top hatch and also the alarm for high level in equalizing tank. Now the water level in the MBR tank should be about 100 mm from the bottom and lower than the MBR tank's main hatch opening on the side of the tank.
- After draining the MBR tank loosen the MBR tank main hatch bolts and remove the hatch by using for example a crane or a hoist. Openings in the main hatch horizontal stiffeners can be utilized for lifting the main hatch with lifting slings or chains.

Before entering the MBR tank check that there are no loose items at the bottom of the tank. If found, remove them.

After the loose items are removed:

- Gently rinse the membrane module(s) with technical or tap water and simultaneously remove possible big particles of sludge or sewage lumps.
- Take Photos of all abnormal situations in the tank. Photos helps Evac warranty to service handle situations better.

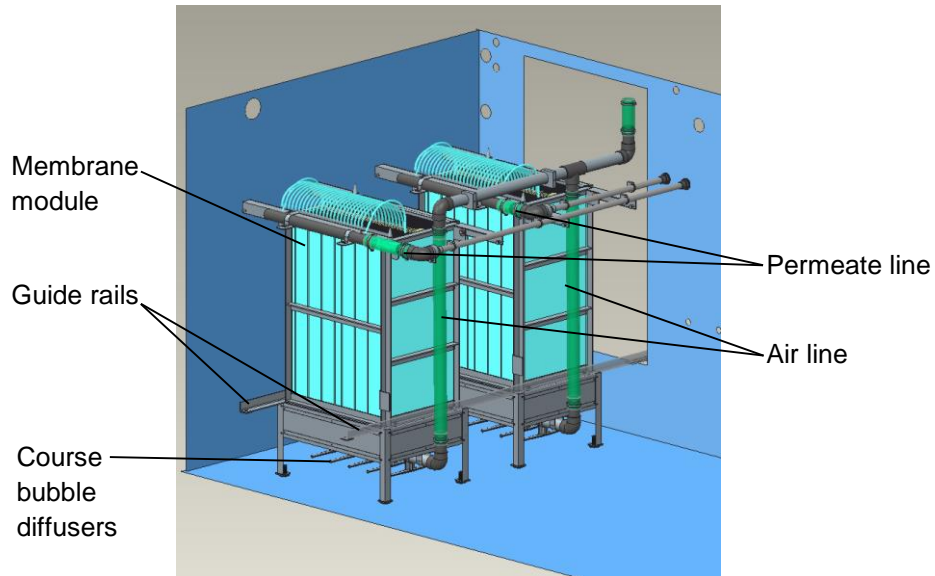


Figure 11 Membrane modules

- Detach the membrane module permeate line by removing the hose with hose clamps (see the picture below).

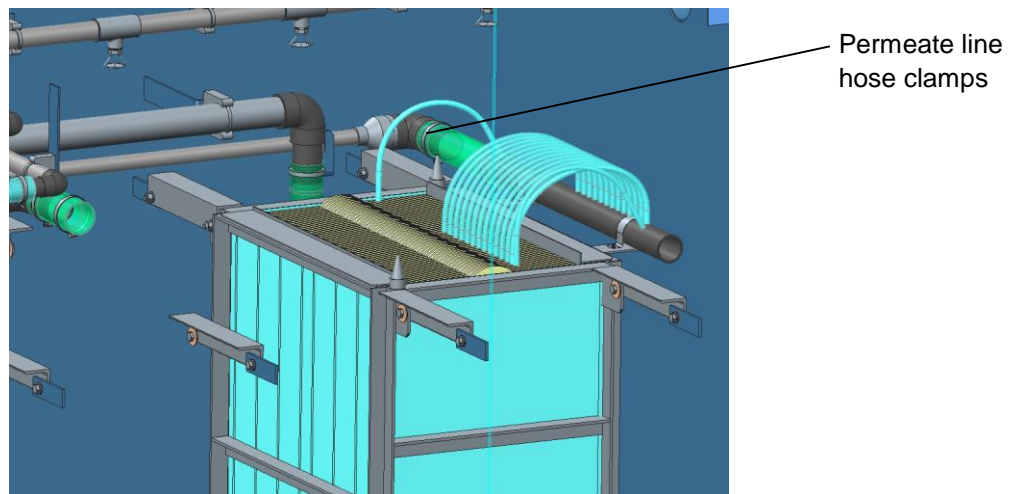


figure 12 Removing permeate line

- Detach the membrane module vertical fasteners (4 pcs) from the membrane module lifting eyes and move the fasteners aside (see the picture below). In Evac Custom MBR unit this attachment may be different. Always consult Evac when operating custom unit.

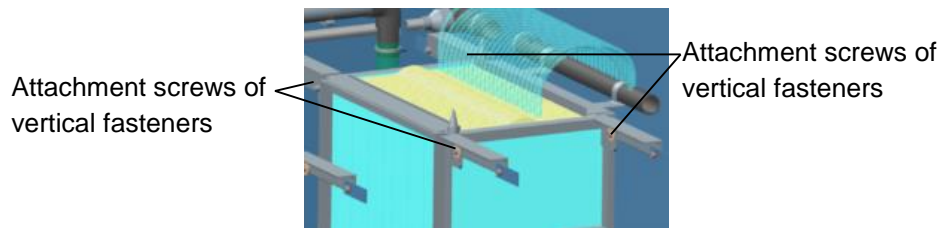


Figure 13 Vertical fasteners

- Unscrew the membrane module fastening bolts (4 pcs) of the guide rails of the membrane module (see the picture below)

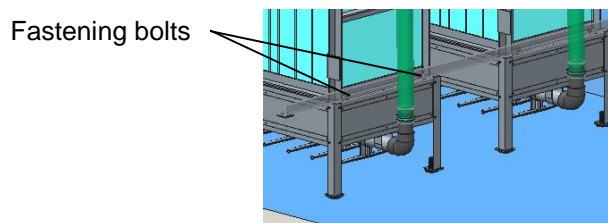


Figure 14 Guide rail fastening bolts

- Before pulling out the membrane module from the MBR tank arrange suitable auxiliary level in front of the main hatch to receive the membrane module. Other option is to attach lifting slings to the membrane module lifting eyes so that before pulling out the membrane module it can be supported with the attached lifting slings.
- Take a firm grip of the membrane module or attach a hauling sling around the membrane module and pull the membrane module out of the MBR tank along the guide rails (see the picture below). Membrane module has plastic sliding plates installed at the bottom for reducing the friction.

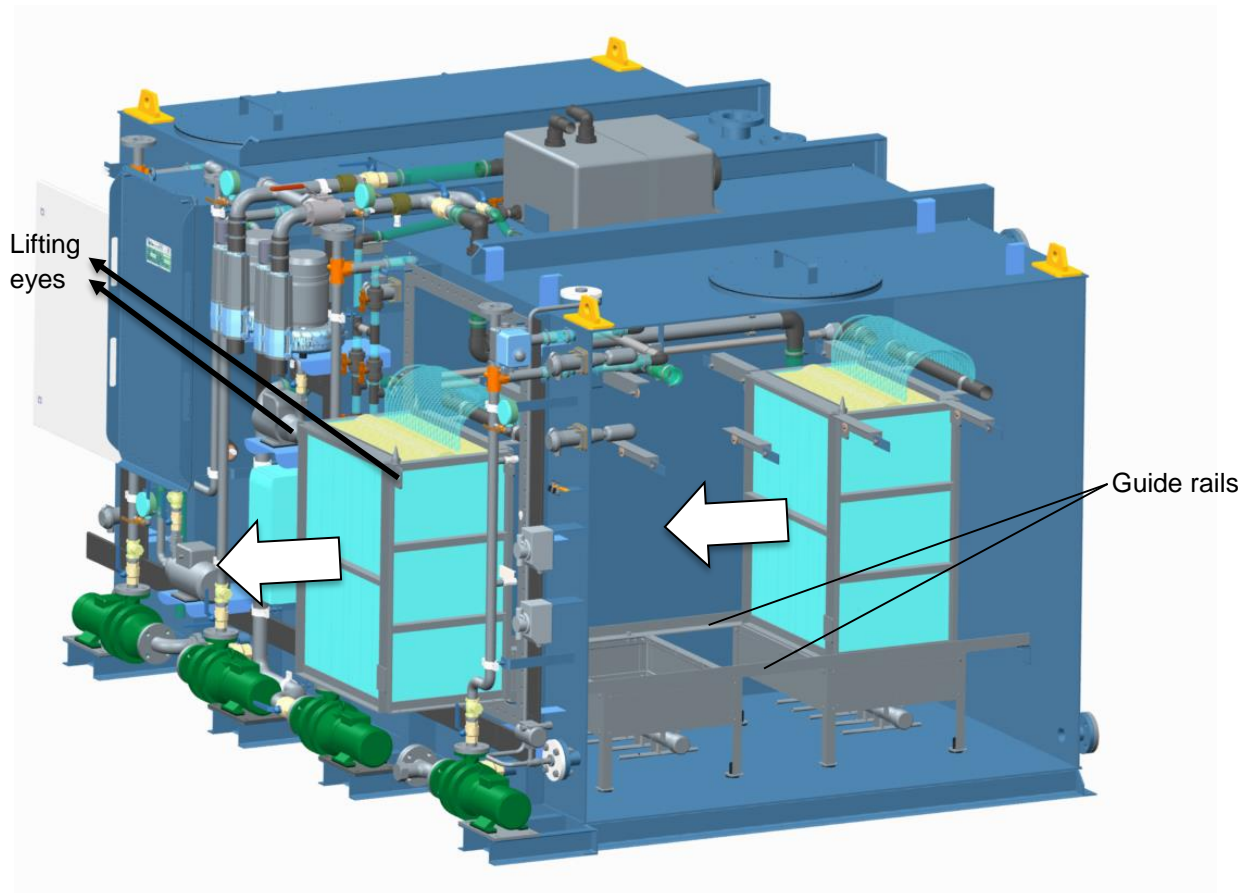


Figure 15 Removing Membrane module from MBR tank

- If there are several membrane modules utilize the level in front of the main hatch or the lifting slings with the second membrane module. Take a firm grip of the membrane module or attach a hauling sling around the membrane module and pull the membrane module out of the MBR tank along the guide rails.

**! DANGER:** Before going down into the tank, keep working environment safe by observing local rules/regulation. As a reference, Japanese rules require that oxygen be higher than 18% and hydrogen sulfide be lower than 10 ppm.

**! DANGER:** If any defect of parts or Membrane module abnormality such as cracks or corrosion is found upon inspection, replace the parts or Membrane module immediately. Continuous usage of those may cause an accident.

**! WARNING:** Never lift a Membrane module containing chemical solution in the Membrane Cartridges. Spillage of the contained solution may cause physical injury or damage to surrounding equipment.

**! NOTE:** In Evac Custom MBR unit this attachment may be different. Always consult Evac when operating custom unit.

## 6.6 Replacement of Membrane Cartridges

Before replacing Membrane Cartridges, remove the Stabilizer Pipe and disconnect the permeate piping from permeate header. Then, Membrane module can be taken out from MBR Tank and replacement work can be done without lowering the water level. However, if the Guide Pipe is not installed (when the Membrane module is fixed to Diffuser Case), lower the water level to the level where the Membrane module is accessible.

Remove the Membrane Cartridge(s) to be replaced from the Membrane module according to the following procedure.

- For the Membrane Cartridge to be replaced, disconnect Tube from Cartridge Nozzle. However, do not disconnect Tubes (keep connected) from Manifold. Pull the Tube straight upward at removing it. Never pull the Tube obliquely or pull multiple Tubes at one time.
- Loosen the nuts on the Retaining Plate. It is not necessary to remove the nuts completely. Slide the Retaining Plate off the Retaining Rubber see figure 16.
- Anti-seize agent containing molybdenum disulfide is applied to the bolts which fix the Retaining Plate. Please refer to the MSDS.
- Remove the Retaining Rubber.
- Set the Hand Hook into the lifting hole of the Membrane Cartridge and lift the Cartridge straight up.

**! NOTE:** Please contact Evac when you replace the Membrane Cartridges.

**! NOTE:** When inserting the Membrane Cartridges into the Membrane module, never drop them, or it may damage Membrane Cartridge and/or Membrane module.

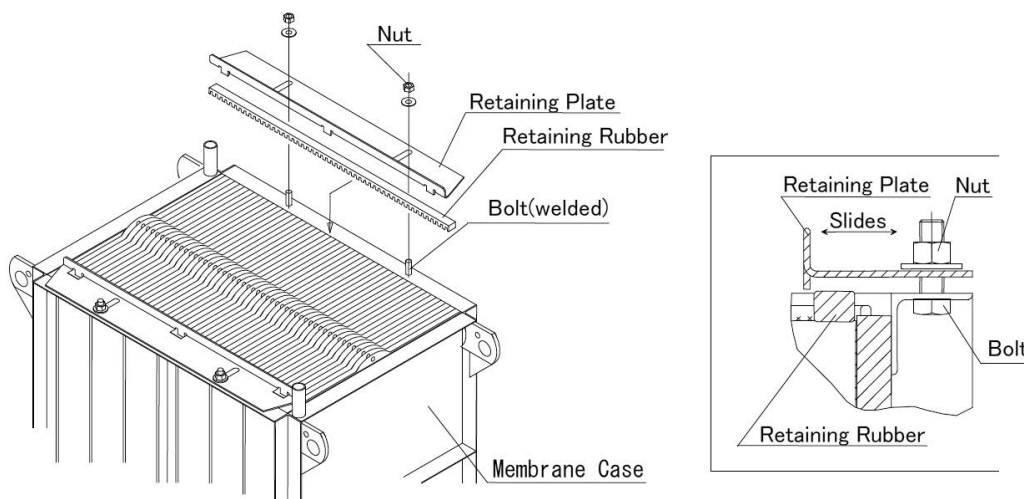


Figure 16 Structure of Retaining Plate and Retaining Rubber

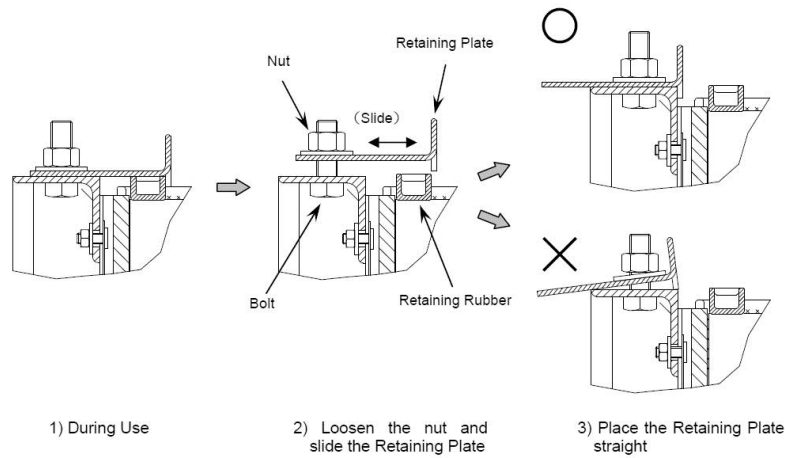


Figure 17 Structure of Retaining Plate

- Slowly insert the new Membrane Cartridge one by one into the Membrane module. Never drop the Cartridge into the Case, and never force them into the Case.
- Set the Retaining Plate and the Retaining Rubber according to the following procedure.
  - Make sure that all the Membrane Cartridges are set securely in the Membrane module.
  - Set the Retaining Rubber over the Membrane Cartridges see figure 16.
  - Slide the Retaining Plate back in place.
  - Remove any foreign object from the bolts and nuts which fix the Retaining Plate. Apply lubricant to the bolts and tighten the nuts securely.
- Re-attach the Tube to the Nozzle of the new Cartridge. Be sure to attach the Tube straight and take care not to damage the Nozzle.

Before restarting operation, set all the Membrane Cartridges in the Membrane module. If all the Membrane Cartridges are not set, air scouring efficiency would reduce and may cause Membrane fouling and/or damage of Membrane module.

Handle the Membrane Cartridge carefully one by one. Take care not to damage the Membrane surface with a sharp edge, hard matters, or with rough handling. In case the Membrane Sheet is damaged, the Membrane Cartridge cannot be used and must be replaced with a new one.

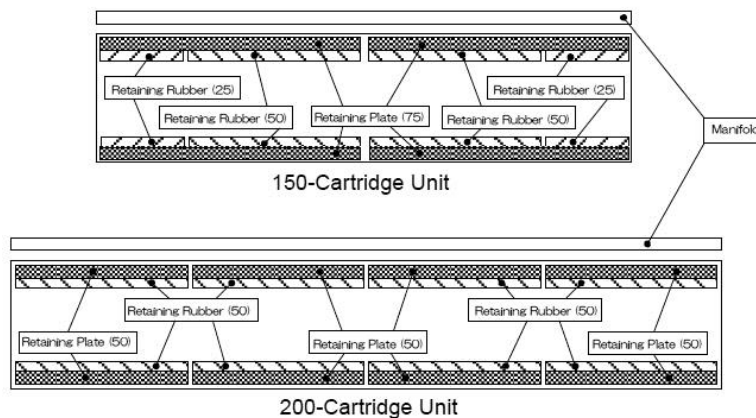


Figure 18 Structure of Retaining Plate and Retaining Rubber



## 6.7 Membrane module Accessories

### 6.7.1 Special tools

Hand hook should be used to lift up each Membrane Cartridge from the Membrane module.

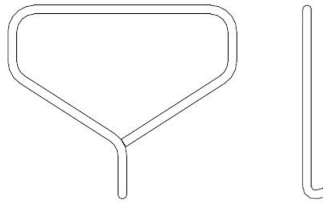


Figure 19 Hand hook

## 7. Troubleshooting

This troubleshooting chapter is for Evac supplied Membrane modules. More detailed troubleshooting chapter can be found in Evac supplied Operation and maintenance manual.

	Problem	Possible Cause	Remedies
1	Airflow rate fails to reach the specific value	Blower Failure	Repair or replace the blower(s)
		Choking Diffuser(s)	Clean the Diffuser(s).
2	Non-uniform aeration of a Membrane module	Diffuser clogging	Clean the Diffuser(s).
		Sludge fouling on Membrane surface	Clean the Membranes
		Diffuser Cases are not level.	Level the Diffuser Cases
3	High filtration pressure or the designed flux cannot be achieved.	Operational flux is higher than the design flux.	Adjust operational flux to match the design flux.
		Membrane surface is fouled.	When there is no sludge cake deposition on the Membrane surface, conduct chemical cleaning.  When there is sludge cake deposition on the Membrane surface, conduct chemical cleaning after manual cleaning.
		Characteristics of the activated sludge are bad. (e.g. filterability is low or viscosity is high)	Improve the sludge condition.
4	Permeate is turbid and has not been properly treated.	Tube is separated or damaged.	Replace the Tube.
		The Membrane Cartridges are damaged.	Replace the Membrane Cartridges.
		Manifold is damaged.	Replace the Manifold.
		Permeate piping connection is loose.	Repair the permeate piping connection.

**! NOTE:** If troubles are found despite following the maintenance procedures in this manual, please consult Evac.

## 8. Spare parts

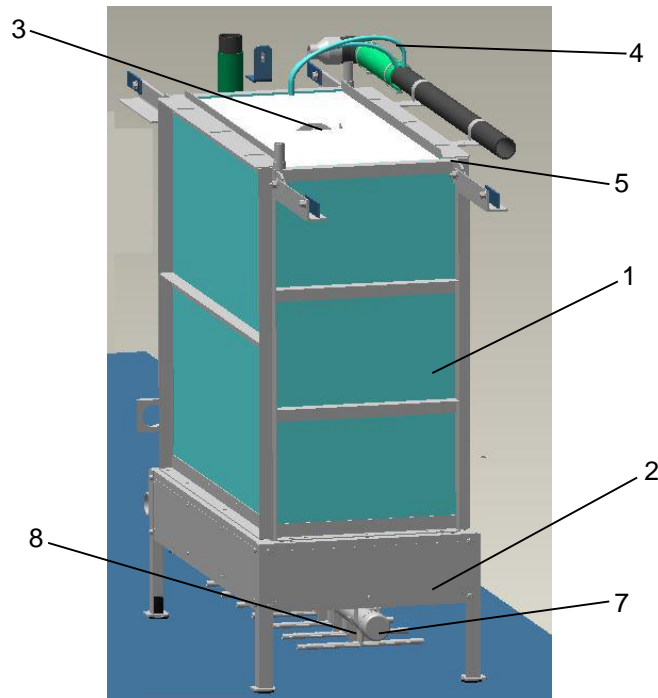


Figure 20 Membrane module spare parts

	Part	Model	Material	Evac PN	Remarks
1	Membrane module	MS25	-	6560002	
		MS50		6559939	
		MS75		6559940	
		MS150		-	
2	Diffuser case	-	-	-	
3	Membrane cartridge	-	ABS	6546866	P.R.P
4	Tube	-	PUR	6573241	P.R.P
5	Retaining rubber (50)	-	EPDM		P.R.P
	Retaining rubber (25)	-	EPDM		P.R.P
7	Diffuser	S25R	PVC/ABS	6560003	
		S50R		6559941	
		S75R		6559942	
8	Diffuser Saddle		SUS	6557161	

P.R.P: Periodic Replacement Part

## 9. Appendix

### 9.1 Evac Manuals

Following list presents the Manuals that Evac supplies together with MBR unit.

- Evac MBR User Manual (Operator and Maintenance manual)
- Evac HMI Manual (for special custom project)
- Evac Membrane Module User Manual
- Evac MBR installation guide
- Evac Sensor manual

**! NOTE: Individual component manuals delivered if needed**



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