Toray MBR

Instruction Manual

"NHPA Series"

06-G-MB2-NHPA-250820

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Innovation by Chemistry

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Contact Information

Toray Industries, Inc. — UF & MBR Membrane Products Department (Global Headquarters)

Nihonbashi Mitsui Tower, 1-1, Nihonbashi-Muromachi 2 chome, Chuo-ku, Tokyo, 103-8666 Japan

Tel: +81-3-3245-4542 Fax: +81-3-3245-4913

Toray Membrane USA, Inc. (TMUS)
13435 Danielson Street, Poway, California 92064 USA
Tel: +1-858-218-2360 Fax: +1-858-218-2380

Toray Membrane Europe AG (TMEU)
Kaspar Pfeiffer-Strasse 4, CH-4142 Münchenstein, Switzerland
Tel: +41-61-415-8710 Fax: +41-61-415-8720 E-mail: info.tmeu.mb@mail.toray

Toray Asia Pte. Ltd. (TAS)
67 Ubi Ave 1, Starhub Green, #04-12, Singapore 408942, Republic of Singapore
Tel: +65-6226-0525 Fax: +65-6226-0509

Toray BlueStar Membrane Co., Ltd. (TBMC)
Zone B, Tianzhu Airport Industrial Zone, Beijing 101318, China
Tel: +86-10-8048-5216 Fax: +86-10-8048-5217

Toray Membrane Middle East LLC (TMME)
3515, 3rd Industrial City, 8682, Dammam, 34857, Kingdom of Saudi Arabia
Tel: +966-13-568-0091 Fax: +966-13-568-0093

Toray Advanced Materials Korea Inc. (TAK)

Korea Toray R&D Center 7, Magokdonng-ro 10-gil, Gangseo-gu, Seoul 07790, Republic of Korea
Tel: +82-22-3279-7389 Fax: +82-2-3279-7088

website: **www.water.toray**

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Symbols used in this manual

	This symbol is used to indicate an imminent hazardous situation which, if not avoided, will result in serious injury or death.
	This symbol is used to indicate a potentially hazardous situation which, if not avoided, can result in serious injury or death.
	This symbol is used to indicate a potentially hazardous situation which, if not avoided, may result in injury or property damage.
 Prohibited	“Prohibited” This symbol indicates a prohibited action or procedure to avoid serious accidents or damages to the products.
 Instruction	“Instruction” This symbol indicates an important action or procedure which has to be taken without fail.

I. INTRODUCTION

Toray MBR is the submerged membrane module suitable for the Membrane Bio-reactor (MBR) that has been developed based on the polymer science and the membrane fabrication technologies accumulated for a long time in Toray Industries, Inc.

"NHPA Series" is a new model of MBR module that has improved membrane packing density, reduced power consumption, and ease of installation and maintenance, while reliable high filtration performance of TMR Series membrane has been kept unchanged. This module is configurable to suit the filtrate water volume and the MBR tank shape, and it is suitable for treating domestic wastewater and various types of industrial wastewater.

This manual explains MBR's features and describes the specifications of "NHPA Series" and its safe operations including installation, operation, maintenance procedures and peripheral equipment. Plant designers and operators should thoroughly read this manual to ensure stable operation.

1. Features of MBR

The process flow of the conventional activated sludge system (CAS) and MBR are shown in Figure I-1 and Figure I-2, respectively.

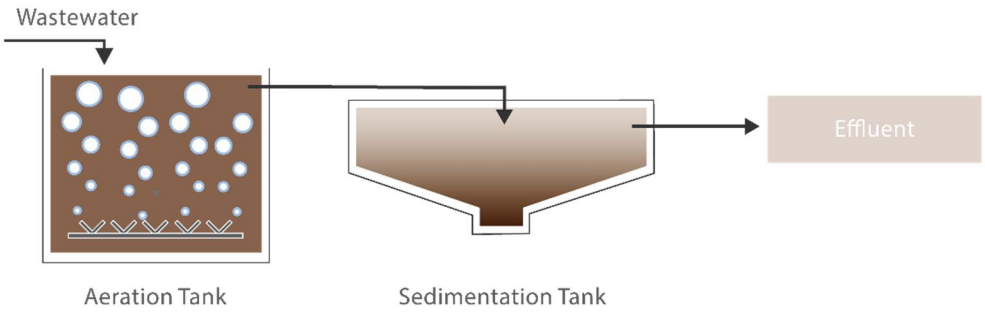


Figure I-1: CAS Flow

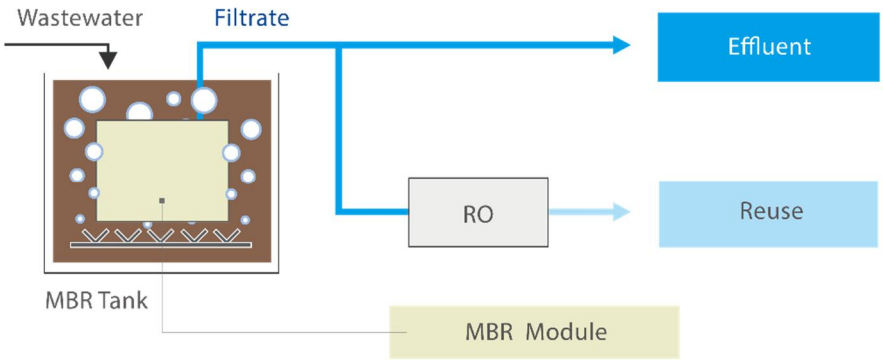


Figure I-2: MBR Flow

MBR provides the following advantages:

(1) Small Footprint

Unlike CAS, MBR separates sludge within an aeration tank using membranes, thus eliminating the space for the sedimentation tank. Also with membrane, MBR can hold higher concentration of activated sludge in the aeration tank, so its volume can be reduced. As a result, MBR requires a smaller footprint compared to CAS.

(2) High Quality of Treated Water

MBR removes suspended solids (SS) from the sludge liquid with membrane much more certainly than the conventional sedimentation process. MBR also rejects microorganisms such as Escherichia coli and Cryptosporidium efficiently.

2. Outline of "NHPA Series"

"NHPA Series" is the membrane module composed of element deck(s) and an aeration block. An element is a flexible structure of two flat membrane sheets, which are bonded together to create water channels between the membranes, are fixed at a constant clearance in a cassette. Each element is connected via plastic tube to the filtrate manifold. The unit that the cassettes loaded in a stainless-steel frame is called an element deck and set on an aeration block that supplies scouring air for membrane cleaning. A membrane module consisting of one or more element decks and an aeration block is placed in a MBR tank and used. (Figure I-3)

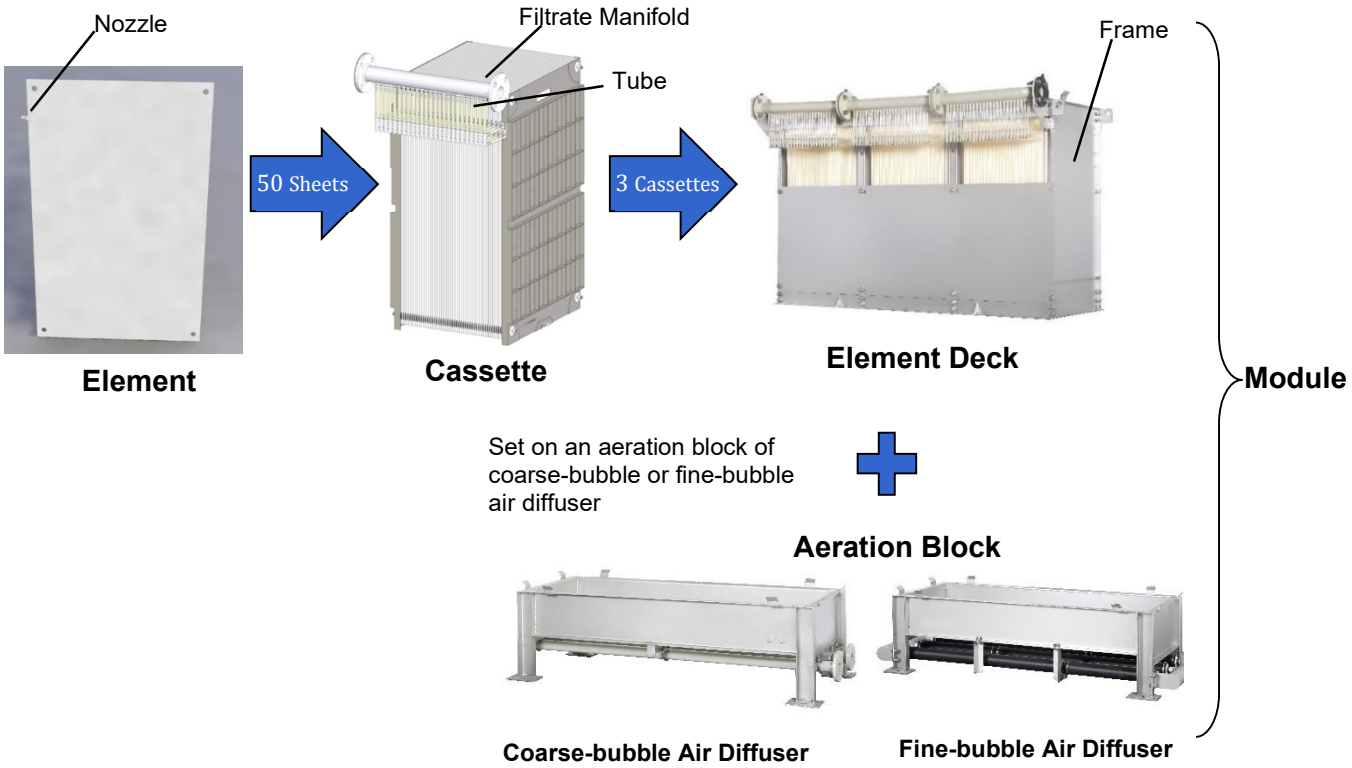


Figure I-3: Components and Appearance of Module
(NHPA150-1C/F：3 cassettes x 1 stack)

(1) Shape of Element

The element is a flat sheet type as shown in Figure I-4. The sludge accumulated on the membrane surface is cleaned up effectively with upward water stream generated with the scouring air supplied from the air diffusers installed at the bottom side (Figure I-5). This mechanism ensures that sludge cannot easily adhere to the membrane's surface and the stable filtration.

In addition, thin and flexible element makes it possible to have higher membrane packing density in the module similar to that of a hollow fiber membrane, and also the vibration of elements by scouring air improves membrane cleaning efficiency.

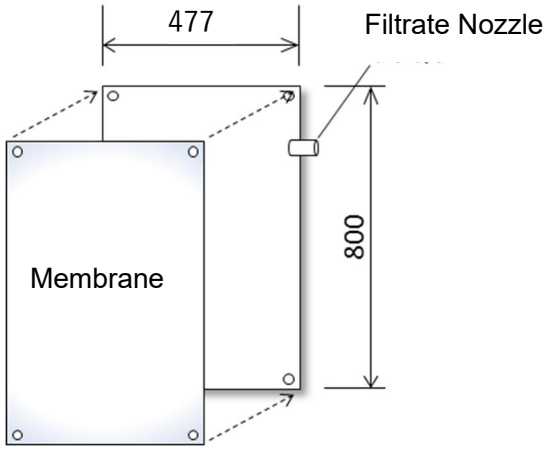


Figure I-4: Structure of Element

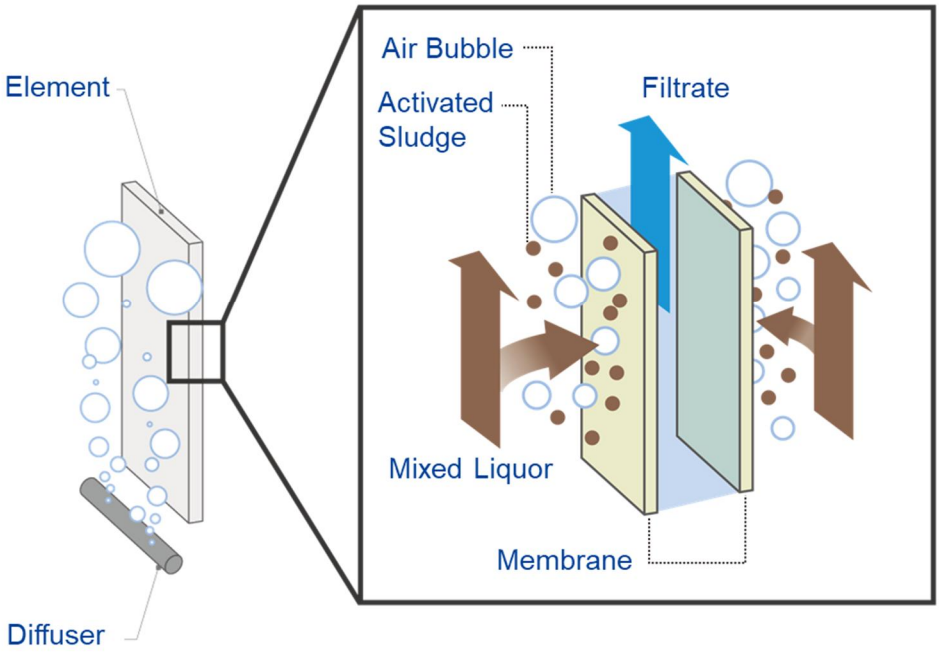


Figure I-5: Filtration Principle of Activated Sludge

(2) Membrane Structure

The flat sheet membrane consists of a PVDF (Polyvinylidene Fluoride) functional layer and a base layer of PET (polyester) non-woven fabric. This structure gives the membrane superior physical strength and high chemical resistance.

(3) Membrane Pore Size

Numerous small-size pores are distributed evenly over the membrane surface with a sharp pore-size distribution. This structure gives an outstanding high treated water quality and excellent water permeability, making the membrane highly resistant to clogging. (Figure I-6 and Figure I-7)

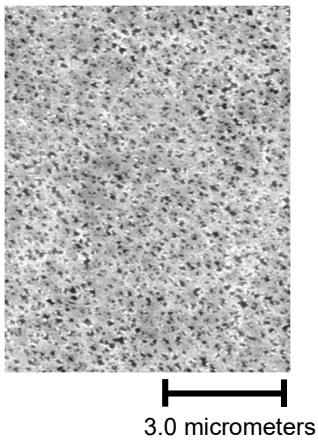


Figure I-6: Membrane Surface

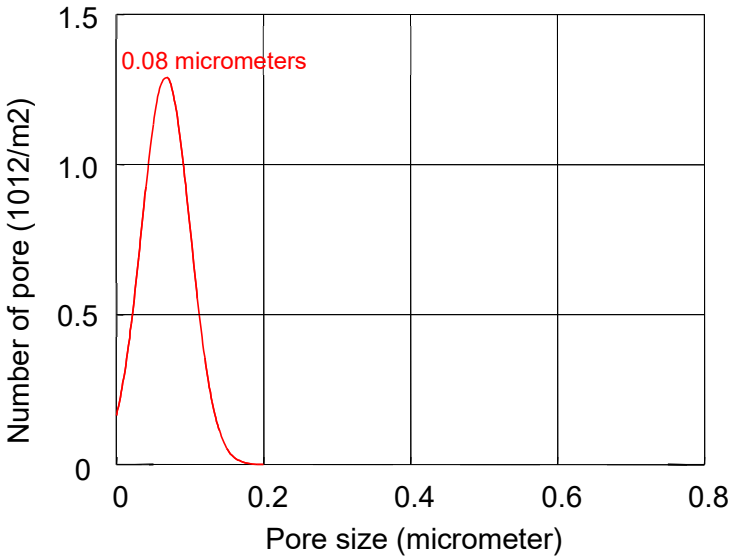


Figure I-7: Pore Size

(4) Cassette Replacement

Membranes can be taken out and exchanged by cassette unit. It is possible to replace only a cassette which contains a damaged membrane.

II. FOR SAFE OPERATION OF “NHPA SERIES”

Before using “NHPA Series”, please thoroughly read this Instruction Manual and follow the instructions described in this manual, especially the safety precautions shown below. The details of each precaution are described in the relevant chapter.

1. Safety Instruction for Unpacking, Storage, and Installation

DANGER


Prohibited

Attach chains or slings to the hanger when lifting an element deck, connected element deck, or aeration block of “NHPA Series”. Slowly raise the element deck /aeration block straight up to avoid shaking the element deck /aeration block. Never allow anyone to stand under the “NHPA Series” during lifting.


Prohibited

Never lift or operate the module with worn or damaged parts. Use chains or slings rated for the weight being lifted. Check the condition of each part before lifting.


Prohibited

Do not lift three or four stacked element decks at once.
When installing or removing element deck(s), always lift one element deck or one connected element deck consisting of two element decks that are bolted at all connection points.


Prohibited

When installing “NHPA Series” module, set up a scaffold or ladder. Never climb on the module. Use protective equipment to ensure the safety of operators.


Instruction

Make sure the place where modules will be unloaded is flat and free of obstacles. Otherwise, the module could tip over and get damaged.

CAUTION


Instruction

Wear appropriate personal protective equipment (such as safety gloves) to avoid cutting fingers or hands on the edge of the module frame.


Instruction

Ensure proper protection, including covering with protective sheets, during the transportation, storage, and installation of the NHPA Series. Do not put any heavy objects directly on the module, avoid collisions with other objects, and avoid contact with corrosive substances to prevent damage or deterioration to element, filtrate manifold, air diffuser, and frame.


Prohibited

Do not apply a strong force to air diffuser and filtrate manifold when moving the module. Otherwise, the air diffuser/filtrate manifold may get damaged.


Prohibited

Exposing the “NHPA Series” and elements to temperatures above 40 deg C or direct sunlight should be avoided. Exposure to direct sunlight/UV radiation will cause the polypropylene components to distortion.


Instruction

Cover with protective sheets during the construction process, from delivery to the start of operation, to prevent sparks emitted from welding equipment, fusion cutting, or grinding.


Prohibited

Protect modules from freezing at any time.


Prohibited

Do not apply excessive pressure of over 10 kPa from the filtrate side.


Instruction

Tighten a flange with tightening torque of 10 N·m when connecting plastic filtrate manifold to avoid deformation or breakage.
Also, choose the material for connecting pipe that will not weigh more than 20 kg on the connecting flange and put some supports to connecting piping as necessary.


Instruction

Tighten a flange with tightening torque of 20 N·m when connecting plastic coarse-bubble air diffuser to avoid deformation or breakage.
Also, choose the material for connecting pipe that will not weigh more than 20 kg on the connecting flange and put some supports to connecting piping as necessary.

2. Safety Instruction for Operation and Maintenance

WARNING


Prohibited

Filtrated water is not for potable uses. Do not directly drink the MBR filtrate.


Instruction

Before discharging the treated water to the environment or reusing it, make sure to analyze its quality and confirm that the water quality meets the intended purpose.


Instruction

As part of a cassette replacement process, when unscrewing the bolts, especially the last one, from the components, operators should hold the components to prevent them from falling, damaging, and injuring themselves. Also, be careful to handle the components with sludge on them because they may have become heavier.


Instruction

Cassettes are very heavy: 18 kg when unused and dry, and 25 kg when used and wet without sludge. Pull the cassette out slowly and straight along the rails with two operators to avoid distortion.


Prohibited

Hydrogen fluoride (HF) gas will be generated when membranes are incinerated. Request a qualified industrial waste disposal contractor for the disposal of the membrane.


Prohibited

Hydrogen chloride (HCL) or Dioxins will be generated when PVC is incinerated. Request a qualified industrial waste disposal contractor for the disposal of the PVC.

DANGER


Instruction

Choose the appropriate size, number, and arrangement of square timbers to ensure the stability of an element deck. An unstable condition may cause the element deck to be damaged or fall.

CAUTION


Instruction

Open the air discharge valve of the filtrate line to assure any accumulated air is released when filling the MBR tank with clean water or sludge. Close the air discharge valve before starting a clean water or filtration operation.


Prohibited

Do not use ground water for a clean water operation. Ground water may contain considerable concentrations of iron, manganese, calcium, or silica. Naturally occurring compounds of these elements can clog the membrane pores.


Instruction

Complete the clean water filtration process within two cycles of intermittent operation. Prolonged clean water filtration may lead to membrane pore clogging.


Prohibited

White foaming may occur in the MBR tank at the start of using membranes. The foaming is caused by the leaching of residual biodegradable hydrophilic components contained in the membrane at the beginning of a clean water operation. Foaming is normal and does not adversely affect the membrane filtration operation. If using an anti-foaming agent, do not use silicone-based anti-foaming agents as they may foul the membranes, but use alcohol-based ones instead.


Prohibited

Keep membranes wet once they get wet. If the membranes are allowed to dry out, the permeability of the membranes may be permanently significantly reduced.


Instruction

Prior to adding any seeding sludge into the MBR tank, pass all sludge through a 3.0 mm or less mesh screen to remove any contaminants.


Instruction

Set up a plant supplying the raw water to the MBR tank through a 3.0 mm or less screen, mesh type is recommended, to protect membranes and prevent clogging. Waste carryover or overflow must be always avoided, especially when wastewater like sewage contains fiber contaminants without a primary sedimentation tank. Choose a screen with enough capacity and removal performance.


Prohibited

Do not allow chemicals, toxic agents, oils, or any other substances into the raw water and MBR tanks that may adversely affect the condition of the activated sludge.


Instruction

Avoid abrupt changes to especially temperature, pH, salinity, and Transmembrane Pressure (TMP) even if these changes are within standard operating conditions Table VII-1.


Prohibited

If anti-foaming agents are to be added to the MBR tank, use only alcohol based anti-foaming products. Do not use silicone-based anti-foaming agent which may foul the membranes.


Prohibited

Avoid the module from freezing.


Instruction

The air scouring should be stopped when the filtration process is suspended. There are two exceptions:
1) Do not stop the air scouring during the normal relaxation period.
2) Do not stop the air scouring that is required for normal metabolic processes of the activated sludge or for prevention of sludge sedimentation. However, under these conditions the amount of scouring air flow directed to the diffuser should be reduced to just the amount required to maintain sludge viability or agitate sludge.


Instruction

Confirm that sludge and air are purged from the purge nozzle at the air diffuser cleaning. If there is no discharge or just air, the air diffuser or holes may have been clogged and not cleaned sufficiently.


Instruction

Replace module parts on a regular basis or whenever wear is observed during inspections.


Instruction

Use the Toray approved parts described in this manual for replacements.


Prohibited

Never use a pressure washer machine when cleaning a membrane module and element which can cause fatal delamination of element edge.


Instruction

When loading a cassette, make sure that all rods of the cassette are hooked on the rail. Insecure suspension of the rods can cause the cassette to fall from the element deck during operation.


Prohibited

Cassette cannot be replaced by an element unit. Never attempt to disassemble a cassette as restoring it won't be possible.

Follow the instructions in this manual and work with caution to avoid damaging the membranes when replacing a cassette/element deck or performing maintenance.

Make certain the tube is securely attached to the element nozzle and filtrate manifold when replacing the individual filtrate tubes to the filtrate manifold.

Do not apply excessive force to the nozzle and element when replacing filtrate tubes. Excessive force may result in element/ filtrate manifold damage.

Once a filtrate tube has been removed or disconnected from either the element nozzle or filtrate manifold, it should be replaced with a Toray approved replacement part. Old filtrate tubes lose their elasticity, and the integrity of the seal can be compromised.

When heating a tube for replacing, never use hot water above 70 deg C or heating tools like hair dryer. These will deform the tube and lose the watertightness between the tube and nozzle.

When replacing a fine-bubble air diffuser, be careful not to damage the rubber components during replacing.

If an aeration block of fine-bubble type is exposed to atmosphere, clean the air diffuser. Dry sludge on the surface of the air diffuser could cause damage to the rubber components.

3. Safety Instruction for Chemical Cleaning of Element

Store chemicals in a dark, cold place free from direct sunlight.

Chemical agents used for chemical cleaning can be harmful to one's health. Wear protective goggles, protective gloves, and other safety gear when handling chemicals. Make sure to check the details of its material safety data sheet (SDS) beforehand.

If chemicals accidentally get on your skin or clothes, wash them off immediately with a lot of tap water.

If chemicals splash into your eyes, immediately flush with large volumes of running water and consult a doctor.

Immediately stop the chemical cleaning operation if any of the associated cleaning equipment appears to be malfunctioning.

Inject chemicals to elements using the device or method that controls the supply pressure at less than 10 kPa. Injecting chemicals to elements without pressure control will damage the element.

Before starting injecting chemical to elements, confirm that the MBR tank liquid level is more than 500 mm above the top of the module.

Use tanks for chemical storage that are made of chemically compatible materials to prevent corrosion.

Never mix sodium hypochlorite with heavy metals or acids such as citric acid and oxalic acid. The chemical reaction will generate toxic chlorine gas.

Ensure that the pressure relief valve is opened and free of clogs before injecting chemicals. Excess internal element pressure will damage the membranes.

Chemicals may splash or leak from the pressure relief valve. Make any necessary adjustments to the chemical feed flow. Use the safety equipment such as goggles and gloves when inspecting discharge piping and making adjustments.

To avoid splashing of chemical solution, turn off the air scouring during a chemical cleaning.

III. SPECIFICATIONS AND PERFORMANCE OF “NHPA SERIES”

1. Specifications of Element

Table III-1 and Figure III-1 show the specifications and the physical dimensions for the NHPA Series element.

Table III-1: Specifications of Element (TSP-50080)

Model name		TSP-50080
Membrane configuration		Flat sheet
Application		Filtration of activated sludge
Filtration method		Suction filtration
Nominal pore diameter (μm)		0.08
Effective membrane area (m2)		0.7
Dimensions (mm) [Nominal value]	Total width	477
	Total height	800
	Thickness	2.0
Weight (kg)	Dry	0.25
	Wet (Reference)	0.5
Main material	Membrane	PVDF and PET non-woven fabric
	Nozzle	PE

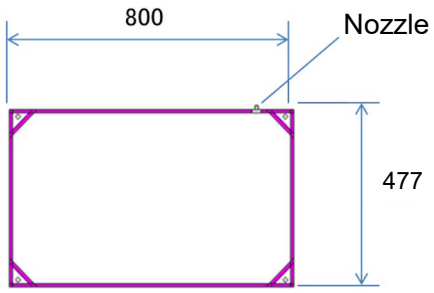


Figure III-1: Element Appearance (mm)

2. Specifications of Filtrate Tube Assembly

Table III-2 and Figure III-2 show the specifications and appearances of Filtrate Tube Assembly.

There are two types of tube sets with different appearances as shown in Figure III-2, 'with O-ring and without clip' and 'without O-ring and with clip', but the configuration of connecting two elements to one filtrate manifold nozzle via a connector is the same.

Table III-2: Specifications of Filtrate Tube Assembly

Materials	Thermoplastic polyether-polyurethane (tube) Polypropylene (connector)
Tube inner x outer diameter (mm) Tube set dimension (mm)	8.2 x 10.2 Approx. 125 x 155

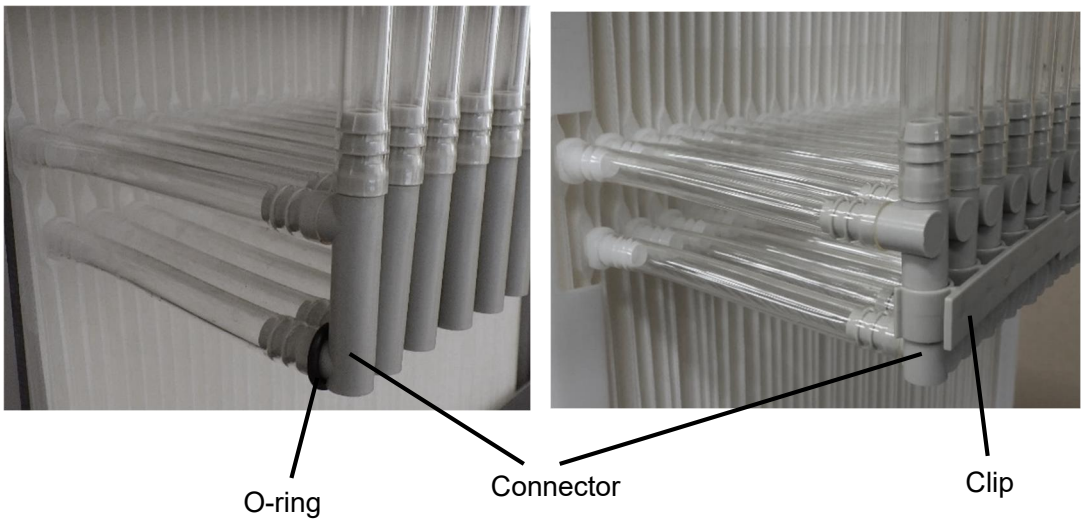


Figure III-2: Tube Set Appearance

3. Specifications and Performance of Module

"NHPA Series" module consists of element deck(s) (EBL050, 100, 150), with cassette(s) (ECS035) loaded into the frame, and an aeration block (ABL050-C/F, 100-C/F, 150-C/F). The cassette arrangements are shown in Figure III-3. The element deck is available with one, two, or three rows of cassettes. Furthermore, the three-row type can be stacked vertically in up to four decks, allowing flexible configurations tailored to the specific environment and usage conditions.

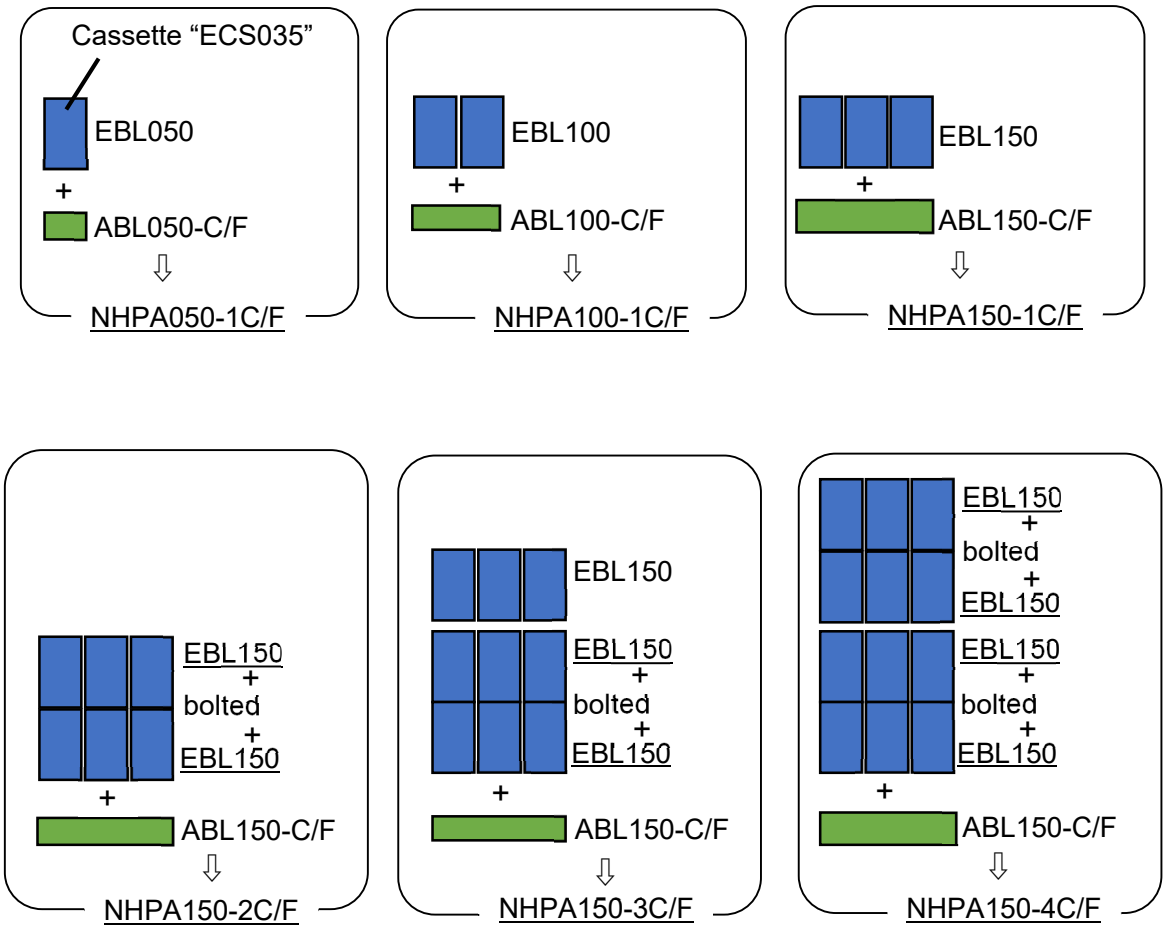


Figure III-3: Cassette Arrangement of NHPA Series

Table III-3a to d shows the specifications of "NHPA Series" cassette and module.

If you consider replacing the TMR or NHP210 Series with NHPA Series, please contact us, as there are certain aspects such as dimensional compatibility that need to be confirmed.

Table III-3a: Specifications of "NHPA Series" (ECS035, NHPA050-1C-4S, 100-1C-4S)

Model Name		ECS035 (Cassette)	NHPA050-1C-4S	NHPA100-1C-4S
Element deck type Appearance				
Element deck type		-	EBL050-4S	EBL100-4S
Cassette configuration in module		-	1 row x 1 stack	2 rows x 1 stack
Number of elements		50	50	100
Aeration block type		-	ABL050-4SC	ABL100-4SC
Air diffuser type		-	Coarse-bubble air diffuser	
Overall dimensions (mm)	Width	-	738	738
	Length	-	660	1,130
	Height	-	1,404	1,404
Dimensions (mm) *1	Width	485	565	565
	Length	440	497	982
	Height	818	1,320	1,320
Weight (kg)	Cassette/Element deck (dry)	18	50	80
	Cassette/Element deck (max.) (Max. weight with sludge) *2	146	175	340
	Aeration block	-	20	30
Material	Frame	-	304 SS (316 SS is available as option)	
	Filtrate manifold	PP		
	Air diffuser	-	304SS (316 SS is available as option)	
Connection	Filtrate manifold	ANSI 1 1/2-inch flange using M12 bolts/nuts One flange per stack		
	Air diffuser	-	ANSI 1 1/4-inch flange using M12 bolts/nuts Two flanges per aeration block	
Operating range *3	Temperature (℃)	5-40		
	pH *4	5-10		
	MLSS (mg/L)	Not higher than 18,000		
	Transmembrane pressure (kPa)	Chemical cleaning: Conduct it before 5 increases from the initial stable TMP at the same flow rate. Maximum allowable TMP: Not higher than 20		
	Cleaning chemicals feed pressure (kPa)	Not higher than 10		
	Scouring air flow rate (NL/min/module) *5	- *6	330 – 670 (standard 430)	670 – 1,340 (standard 870)

*1: Dimensions excluding filtrate manifolds (including tubes, nozzles, and brackets), air diffuser pipe, stack guides, and lifting points.

*2: Assuming the maximum weight in the case of sludge clogging between elements.

*3: For the standard operating condition, refer the Table VII-1.

*4: Except when the chemical cleaning with the designated chemical agents.

*5: 'NL' refers to the volume at 0°C and 101.325 kPa (1 atm).

*6: The MBR is not assumed to be operated solely by Cassette.

Table III-3b: Specifications of "NHPA Series" (NHPA050-1F-4S, 100-1F-4S)

Model Name		NHPA050-1F-4S	NHPA100-1F-4S
Appearance			
Element deck type		EBL050-4S	EBL100-4S
Cassette configuration in module		1 row x 1 stack	2 rows x 1 stack
Number of elements		50	100
Aeration block type		ABL050-4SF	ABL100-4SF
Air diffuser type		Fine-bubble air diffuser	
Overall dimensions (mm)	Width	738	738
	Length	615	1,115
	Height	1,404	1,404
Dimensions (mm) *1	Width	565	565
	Length	497	982
	Height	1,320	1,320
Weight (kg)	Cassette/Element deck (dry)	50	80
	Cassette/Element deck (max.) (Max. weight with sludge) *2	175	340
	Aeration block	20	30
Material	Frame	304SS (316 SS is available as option)	
	Filtrate manifold	PP	
	Air diffuser	EPDM/PVC/SUS	
Connection	Filtrate manifold	ANSI 1 1/2-inch flange using M12 bolts/nuts One flange per stack	
	Air diffuser	NPT 1 1/4-inch Screwed at one end of aeration block	
Operating range *3	Temperature (℃)	5-40	
	pH *4	5-10	
	MLSS (mg/L)	Not higher than 18,000	
	Transmembrane pressure (kPa)	Chemical cleaning: Conduct it before 5 increases from the initial stable TMP at the same flow rate. Maximum allowable TMP: Not higher than 20	
	Cleaning chemicals feed pressure (kPa)	Not higher than 10	
	Scouring air flow rate (NL/min/module) *5	330 – 430 (standard 430)	670 – 870 (standard 870)

*1: Dimensions excluding filtrate manifolds (including tubes, nozzles, and brackets), air diffuser pipe, stack guides, and lifting points.

*2: Assuming the maximum weight in the case of sludge clogging between elements.

*3: For the standard operating condition, refer the Table VII-1.

*4: Except when the chemical cleaning with the designated chemical agents.

*5: 'NL' refers to the volume at 0°C and 101.325 kPa (1 atm).

Table III-3c: Specifications of "NHPA Series" (NHPA150-1C-4S, 2C-4S, 3C-4S, 4C-4S)

Model Name		NHPA150-1C-4S	NHPA150-2C-4S	NHPA150-3C-4S	NHPA150-4C-4S
Appearance					
Element deck type		EBL150-4S			
Cassette configuration in module		3 rows x 1 stack	3 rows x 2 stacks	3 rows x 2 stacks + 3 rows x 1 stack	3 rows x 2 stacks + 3 rows x 2 stacks
Number of elements		150	300	450	600
Aeration block type		ABL150-4SC			
Air diffuser type		Coarse-bubble air diffuser			
Overall dimensions (mm)	Width	763	763	763	763
	Length	1,635	1,635	1,635	1,635
	Height	1,404	2,304	3,204	4,104
Dimensions (mm) *1	Width	565	565	565	565
	Length	1,467	1,467	1,467	1,467
	Height	1,320	2,220	3,120	4,020
Weight (kg)	Cassette/Element deck (dry)	115	230	345	460
	Cassette/Element deck (max.) (Max. weight with sludge) *2	500	1,000	1,500	2,000
	Aeration block	55			
Material	Frame	304SS (316 SS is available as option)			
	Filtrate manifold	PP			
	Air diffuser	PP			
Connection	Filtrate manifold	ANSI 1 1/2-inch flange using M12 bolts/nuts One flange per stack (1C: 1 piece, 2C: 2 pcs, 3C: 3 pcs, 4C: 4 pcs per module)			
	Air diffuser	ANSI 1 1/2-inch flange using M12 bolts/nuts Two flanges per aeration block.			
Operating range *3	Temperature (℃)	5-40			
	pH *4	5-10			
	MLSS (mg/L)	Not higher than 18,000			
	Transmembrane pressure (kPa)	Chemical cleaning: Conduct it before 5 increases from the initial stable TMP at the same flow rate. Maximum allowable TMP: Not higher than 20			
	Cleaning chemicals feed pressure (kPa)	Not higher than 10			
	Scouring air flow rate (NL/min/module) *5	1,000 - 2,000 (standard 1,300)			

*1: Dimensions excluding filtrate manifolds (including tubes, nozzles, and brackets), air diffuser pipe, stack guides, and lifting points.

*2: Assuming the maximum weight in the case of sludge clogging between elements.

*3: For the standard operating condition, refer the Table VII-1.

*4: Except when the chemical cleaning with the designated chemical agents.

*5: 'NL' refers to the volume at 0°C and 101.325 kPa (1 atm).

Table III-3d: Specifications of "NHPA Series" (NHPA150-1F-4S, 2F-4S, 3F-4S, 4F-4S)

Model Name		NHPA150-1F-4S	NHPA150-2F-4S	NHPA150-3F-4S	NHPA150-4F-4S
Appearance					
Element deck type		EBL150-4S			
Cassette configuration in module		3 rows x 1 stack	3 rows x 2 stacks	3 rows x 2 stacks + 3 rows x 1 stack	3 rows x 2 stacks + 3 rows x 2 stacks
Number of elements		150	300	450	600
Aeration block type		ABL150-4SF			
Air diffuser type		Fine-bubble air diffuser			
Overall dimensions (mm)	Width	763	763	763	763
	Length	1,702	1,702	1,702	1,702
	Height	1,404	2,304	3,204	4,104
Dimensions (mm) *1	Width	565	565	565	565
	Length	1,467	1,467	1,467	1,467
	Height	1,320	2,220	3,120	4,020
Weight (kg)	Cassette/Element deck (dry)	115	230	345	460
	Cassette/Element deck (max.) (Max. weight with sludge) *2	500	1,000	1,500	2,000
	Aeration block	55			
Material	Frame	304SS (316 SS is available as option)			
	Filtrate manifold	PP			
	Air diffuser	EPDM/PVC/SUS			
Connection	Filtrate manifold	ANSI 1 1/2-inch flange using M12 bolts/nuts One flange per stack (1F: 1 piece, 2F: 2 pcs, 3F: 3 pcs, 4F: 4 pcs per module)			
	Air diffuser	NPT 1 1/2-inch Screwed at both ends of aeration block			
Operating range *3	Temperature (℃)	5-40			
	pH *4	5-10			
	MLSS (mg/L)	Not higher than 18,000			
	Transmembrane pressure (kPa)	Chemical cleaning: Conduct it before 5 increases from the initial stable TMP at the same flow rate. Maximum allowable TMP: Not higher than 20			
	Cleaning chemicals feed pressure (kPa)	Not higher than 10			
	Scouring air flow rate (NL/min/module) *5	1,000 - 1,300 (standard 1,300)			

*1: Dimensions excluding filtrate manifolds (including tubes, nozzles, and brackets), air diffuser pipe, stack guides, and lifting points.

*2: Assuming the maximum weight in the case of sludge clogging between elements.

*3: For the standard operating condition, refer the Table VII-1.

*4: Except when the chemical cleaning with the designated chemical agents.

*5: 'NL' refers to the volume at 0°C and 101.325 kPa (1 atm).

Table III-4 and III-5 shows the performance of “NHPA Series” modules.

Table III-4: Filtrate Water Quality (Reference Value)

Model Name		All Models
Filtrate water quality *1	TSS (mg/L) *2	Not higher than 3.0
	Turbidity (NTU) *3	Not higher than 1.0

*1: This value can be attained when operated under the standard operating conditions as specified in this Instruction Manual and Operation and Maintenance guideline during a period specified separately by Toray.

*2: Measuring method of TSS is complied with ISO 11923:1997 Water quality - Determination of suspended solids by filtration through glass-fiber filters.

*3: Measuring method of NTU is complied with EPA Method 180.1: Determination of Turbidity by Nephelometry.

Table III-5: Flow Capacity (Reference Value)

Model Name		NHPA050-1C/F	NHPA100-1C/F	NHPA150-1C/F
Filtration flow (m3/d) *4	Sewage	3 - 25	7 - 50	10 - 75
	Industrial wastewater	3 - 17	7 - 33	10 - 50

Model Name		NHPA150-2C/F	NHPA150-3C/F	NHPA150-4C/F
Filtration flow (m3/d) *4	Sewage	20 - 150	30 - 225	40 - 300
	Industrial wastewater	20 - 100	30 - 150	40 - 200

*4: This value is just a reference value and not a guaranteed value of Toray. Sustainable operating filtration flow capacity varies among the plant depending on the type of wastewater, total process design, and operating condition. In case of industrial wastewater application, it is strongly recommended to conduct a pilot test before MBR designing.

IV. MEMBRANE FILTRATION PROCESS DESIGN FOR “NHPA SERIES”

This section will address the following for the Toray “NHPA Series”: Standard sequence of operation/time chart, illustrated piping, flow schematic, and module(s) layout in the MBR tank.

1. Standard Time Chart

Usually intermittent filtration (filtration with relaxation) is recommended. **The most common mode of filtration operation is nine (9) minutes of filtration followed by one (1) minute of suspended membrane filtration (membrane relaxation) with continued air scouring**, as shown in Figure IV-1. This period of relaxation, with no filtration, allows the continued air scouring to be more effective at removing solids that may have accumulated on the surface of the membrane. Intermittent filtration followed by a relaxation period is recommended for stable and efficient membrane filtration.

The air scouring should be suspended when the filtration process is stopped except for the following conditions:

1) During normal membrane relaxation periods.
2) During suspended filtration operation unless aeration is required for mixing or biological demand requirements. For the latter the air flow should be reduced to minimum flow rates to prevent sludge damage by over-aeration. (5-minute intermittent aeration per hour)

※ During low wastewater supply period, basically all modules should be in operation at lower flux rate, considering maintaining viable activated sludge. In case operation of some or all modules will be shut down, the air scouring for those modules should be suspended or applied intermittently following the above description. For long-term shutdown, please refer to the Chapter X, Section 1. Storing Products after Use.

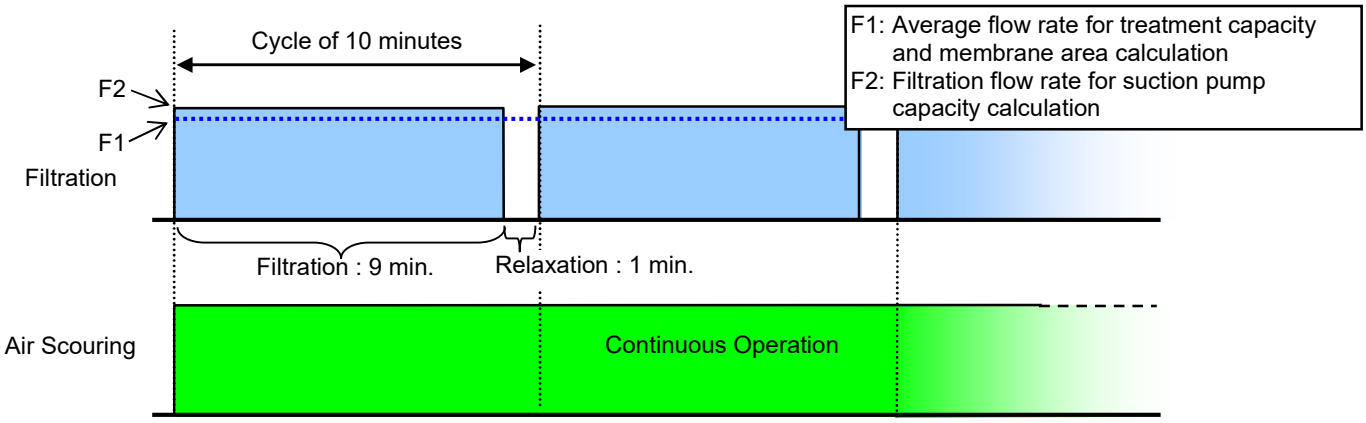


Figure IV-1: Recommended Time Chart for Intermittent Filtration

2. Flow Diagram of Membrane Filtration

Two (2) flow diagrams of the membrane filtration process are shown below. One is for gravity filtration (when site conditions permit) and the other using a suction pump. Also depicted are major ancillary devices required for the membrane filtration process.

To reduce the risk of membrane clogging, all activated sludge should pass through a fine screen having openings of 3.0 mm or less prior to being added into the MBR tank.

Failure to incorporate the screen device may result in large solids clogging or causing physical damage to the membrane surfaces. Details are described in the following section (3).

In order to equalize BOD load and filtration flow capacity, it is recommended that a buffer/equalization tank be installed to help stabilize operation of the biological treatment and membrane filtration process.

(1) Gravity Filtration Configuration

The filtration process can be accomplished by using elevation differences between the liquid level of the MBR tank and the level of the filtrate outlet (see Figure IV-2).

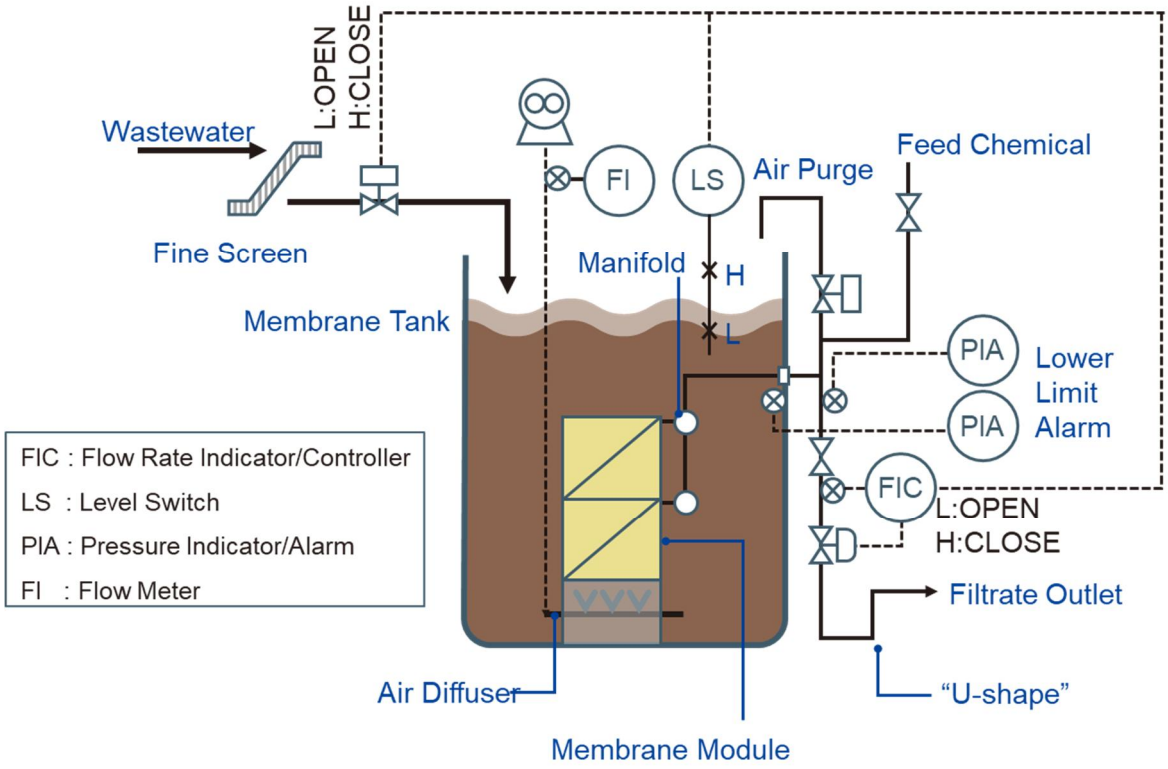


Figure IV-2: Schematic Flow Diagram for Gravity Filtration

In order to obtain enough suction pressure for the filtration process, consider pressure loss of all pipes and valves. In addition, the filtrate outlet should be located at least 3 m below the surface of the MBR tank liquid level.

It is recommended that the piping from the filtrate manifold to the filtrate outlet should directly penetrate the MBR tank wall, as shown in Figure IV-2. In addition, if the filtrate outlet is an open end of air discharge, it is recommended that a U-shaped "trap" be constructed to seal the filtrate piping with water.

The filtrate flow rate is controlled with the automatic control valve (filtrate control valve). When the liquid level of the MBR tank gets to the designed lower limit, the filtrate control valve fully closes to effectively stop the filtration process. When the liquid level of the MBR tank reaches the designed upper limit, the automatic shut-off valve on the wastewater influent line closes to stop the wastewater flow to the MBR tank.

In the gravity filtration mode, air may accumulate in the filtrate lines. **To prevent reduction or loss of suction, the air in the filtrate line should be periodically purged to atmosphere at least once per day. The air purge nozzle should be installed at the highest position of the filtrate line.** The line should also be fitted with an automatic shut-off valve (the air purge valve) just upstream of the air purge nozzle (As shown in Figure IV-2). Air can be easily released by opening the air purge valve when filtration process is stopped (when the filtrate control valve is fully closed).

(2) Pump Suction Configuration

Figure IV-3 illustrates the general configuration for pump suction filtration.

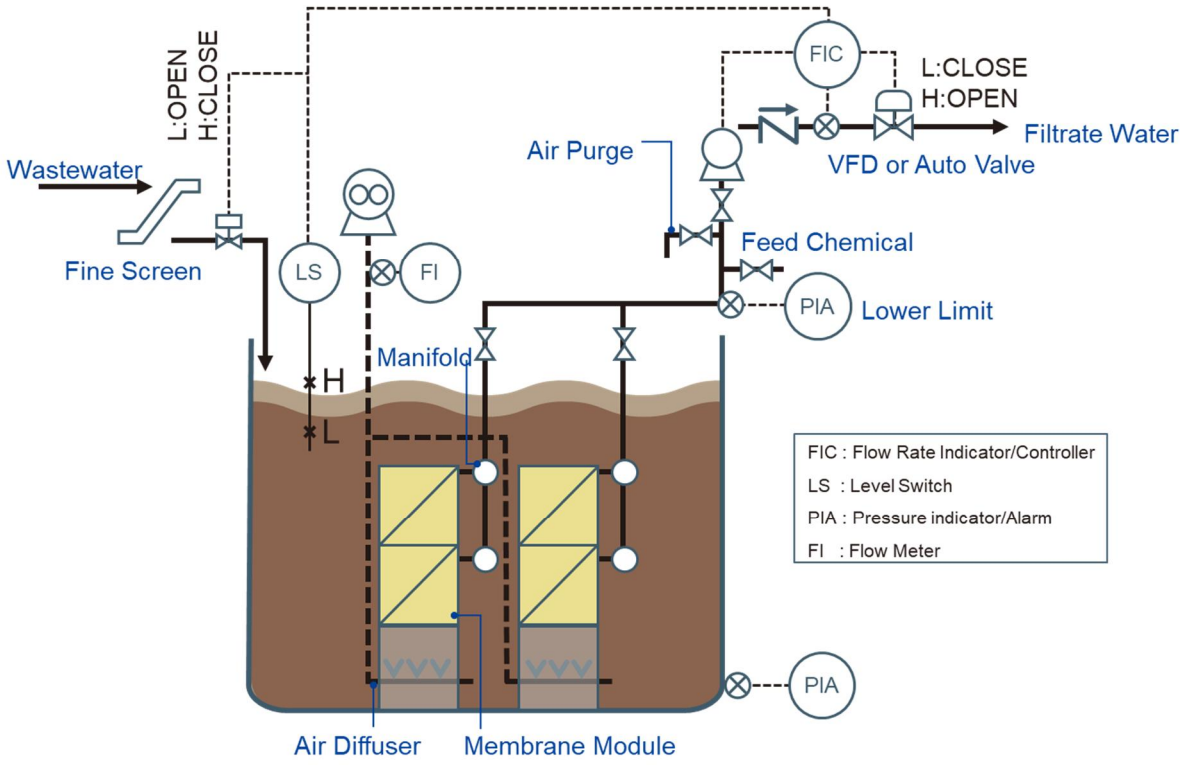


Figure IV-3: Schematic Flow Diagram for Pump Suction Operation

When incorporating a suction pump to facilitate water flow through the membrane, the filtrate flow rate should be controlled using a flow meter fitted with control output signals and a suction pump fitted with a VFD device or an automatic control valve. In the event the MBR tank liquid level reaches the designed lower limit, the filtration mode should be stopped. As with the gravity filtration mode previously discussed, should the MBR tank liquid level reach the designed upper limit, the upper limit controller will close the wastewater inlet control valve.

Since the liquid in the tank contains a significant amount of dissolved air, some of that dissolved air will accumulate in the filtrate pump suction line. **It would be necessary to periodically purge the filtrate line of any accumulated air and in this context, it is quite beneficial to locate the pump at the top of filtrate piping.** A range of methods can be used to remove air from the filtrate line: vacuum pump, ejector, or manual water injection. Contact Toray for details.

(3) Required Ancillary Devices for Membrane Filtration Process

Required ancillary devices for membrane filtration process are listed below. In some instances, additional components may be required.

A. Fine screen

Incoming raw water to the MBR tank should pass through a screen having 3.0 mm or less openings. Mesh type screens are recommended. Failure to incorporate a screening device will result in clogging or permeant damage to the membrane.

Selecting the suitable fine screen device to remove foreign substances especially from raw water consisting of fibers is very important. Moreover, overflow or waste carryover into the MBR tank must be always avoided.

B. Flow control device

A flow rate controller, a flow meter combined with an automatic control valve, or a flow meter combined with VFD controlled suction pump should be installed on the filtrate line to control the flow rate of filtrate water. It is recommended that each train be fitted with its own discreet filtrate flow rate controller when operating more than one “NHPA Series” module simultaneously.

C. Trans-membrane pressure (TMP) measurement & calculation

For trans-membrane pressure (TMP) determination, the differential pressure (in the filtrate line and liquid level) needs to be measured and calculated. When operating several “NHPA Series” modules simultaneously in one train, it is advised installing one differential pressure gauge for each train.

The following examples are the TMP measurement methods for the case where the liquid level in the MBR tank is stable and for the case where it fluctuates. Prepare the pressure gauge with an accuracy of 0.1 kPa as the MBR operates with small pressure.

[Liquid level: Stable]

When the liquid level is stable, the pressure on the outside of the membrane (= the filtrate side) at the liquid surface is zero and that is the TMP if the position of the pressure sensor is the same as the liquid level. If the position of the pressure sensor differs from the liquid level, a pressure correction is required.

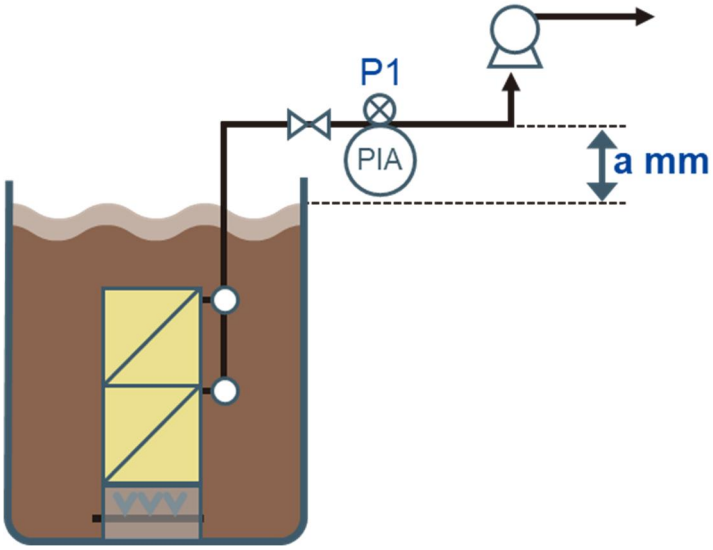


Figure IV-4: TMP Measurement & Calculation (Stable Liquid Level)

- a = 1,000 mm (= 10 kPa, 100 mbar)
- PIA reading

	Filtration (pump ON)	Relaxation (pump OFF)
P1 (kPa)	-15	-10

TMP is calculated as follows.
$TMP= -(P1_{Filtration} - (-a)) = - [(-15) - (-10)] = 5$ kPa

Or the corrected pressure is the same as the pressure at relaxation (pump OFF),
$TMP= -(P1_{Filtration} - P1_{Relaxation}) = - [(-15) - (-10)] = 5$ kPa

[Liquid level: Fluctuating]
When the liquid level is fluctuating, install pressure gauges to the filtrate line and the outside of the MBR tank. The difference between these two pressure gauges is the TMP. When the positions of two pressure sensors are different, then a pressure correction is required.

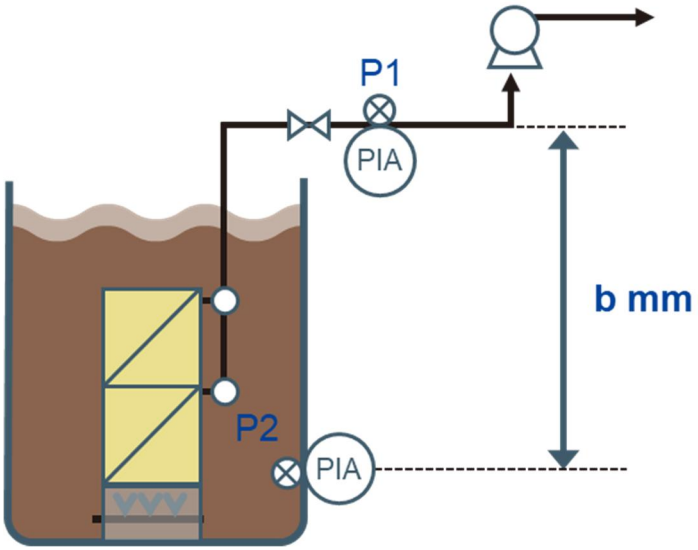


Figure IV-5: TMP Measurement & Calculation (Fluctuating Liquid Level)

- b = 4,000 mm (= 40 kPa, 400 mbar)
- PIA readings

	Filtration (pump ON)
P1 (kPa)	-15
P2 (kPa)	30

In this case, TMP is calculated as follow.

$TMP = P2_{Filtration} - P1_{Filtration} - b = (30) - (-15) - 40 = 5$ kPa

D. Air supply unit (such as a blower)

This unit supplies air to the air diffusers of “NHPA Series” module. The air flow rate supplied to the module should be always within the range of “Scouring Air Flow Rate” indicated in Table VII-1, not the maximum scouring air flow rate of the specification. Choose a blower with a discharge pressure that includes an additional pressure loss of around 1 kPa for coarse-bubble air diffuser and around 10 kPa for fine-bubble air diffuser, in addition to the pressure by the liquid depth. Rotary, turbo, or centrifugal blowers can be used, but they must be oil-free. For fine-bubble air diffuser, attach an air intake filter that can remove more than 99.5% of 2-micrometer dust, depending on the installation environment, to prevent clogging due to foreign substances.

E. Air flow meter

An air flow meter must be installed to check the flow rate of the air supplied to the air diffuser. In case of operating several “NHPA Series” modules simultaneously in a train, it is advised installing, at a minimum, one air flow meter for each train.

F. Suction pump

A suction pump is required in the case of pump suction configuration. To achieve an accurate designed filtrate flow rate, the suction pump should be fitted with a VFD controller. The use of a volute pump (centrifugal pump) or volumetric pump (screw pump) with self-priming functions is recommended.

G. Level sensor

Level sensors are required to be installed in the MBR tank to monitor and control the liquid level of the MBR tank and to facilitate calculating TMP via the PLC.

H. Siphon breaking device on filtrate piping

When using a suction pump, it may be necessary to have a means to break the filtrate siphon if the filtrate discharge point is lower than liquid level of the MBR tank. This siphon flow has to be avoided, and the filtrate flow has to be stopped whenever the pump stops.

Set up a plant supplying the raw water to the MBR tank through a 3.0 mm or less screen, mesh type is recommended, to protect membranes and prevent clogging. Waste carryover or overflow must be always avoided, especially when wastewater like sewage contains fiber contaminants without a primary sedimentation tank. Choose a screen with enough capacity and removal performance.

3. Layout of Modules in MBR Tank

(1) Layout of Modules in MBR Tank

Figure IV-6a shows how the liquid circulates in the MBR tank. An upward flow of liquid is generated as the air is supplied from the air diffuser located at the bottom of the membrane modules. This flow circulates downward along both sides of the element deck.

This circulation flow serves to scour the element surfaces and at the same time to mix the activated sludge. **It is very important to arrange the membrane modules with appropriate distances between each module to obtain an effective activated sludge circulation, as well as not having excessive space around the modules which allows sludge sedimentation (installing sludge agitation if necessary).**

Figure IV-6a and Figure IV-6b illustrate a side view and a top view of the MBR tank containing three membrane modules. It is required to adhere to the dimensions of W1, W2, W3, and L1 listed below.

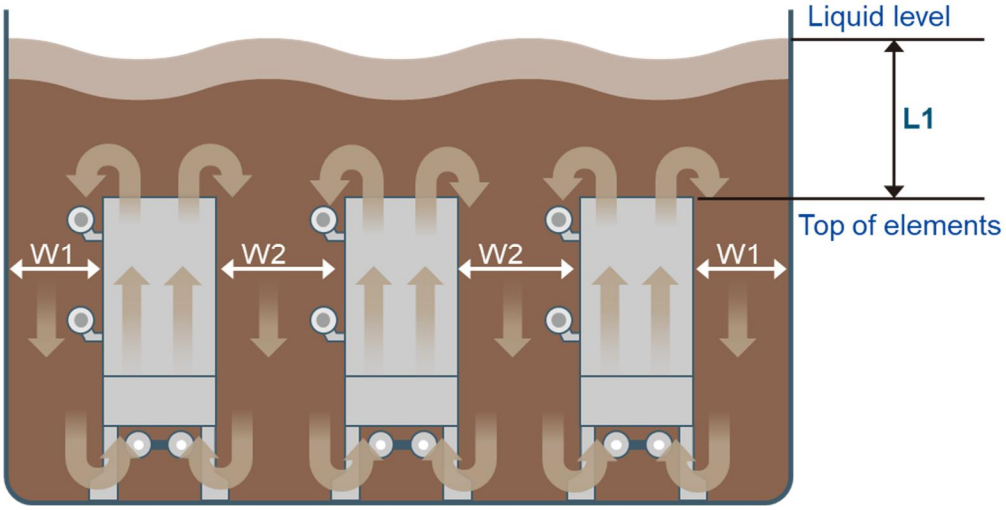


Figure IV-6a: Membrane Module Layout in MBR Tank (side view)

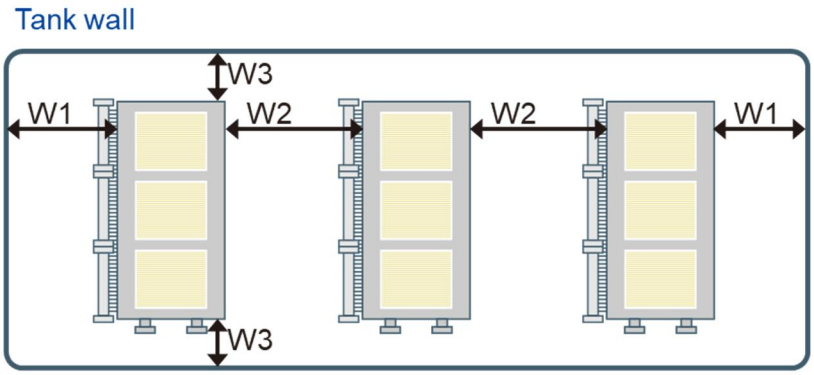


Figure IV-6b: Membrane Module Layout in MBR Tank (top view)

(i) W1 : 380 to 680 mm
(ii) W2 : 430 to 730 mm
(iii) W3 : Normally around 400 mm
W3 should be as short as possible (normally about 400 mm) within the range allowing piping and maintenance work.
(iv) L1 : 500 mm or over
L1, the distance between the top of the element and the liquid level of the MBR tank, should be 500 mm or over at any time of the operation.

*** Refer to the "Dimensions" on the Table III-3 for layout design, not "Overall dimensions".**

* Contact Toray if there are any issues with the layout of modules, such as installing modules in the existing tank. If the existing tank floor is not level, it is recommended that stands be installed as shown in Figure IV-7.

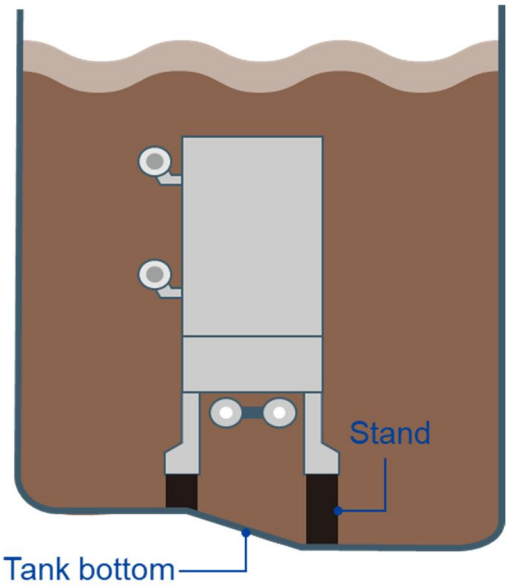


Figure IV-7: Installation with Stands (side view)

(2) Layout of Modules Installed with Other Aeration Equipment

In the case that the membrane modules are to be installed in a MBR tank with other oxygen-supplying aeration equipment or in an existing tank where there is already other oxygen-supplying aeration equipment, take the following precautions in addition to what is mentioned in the above section.

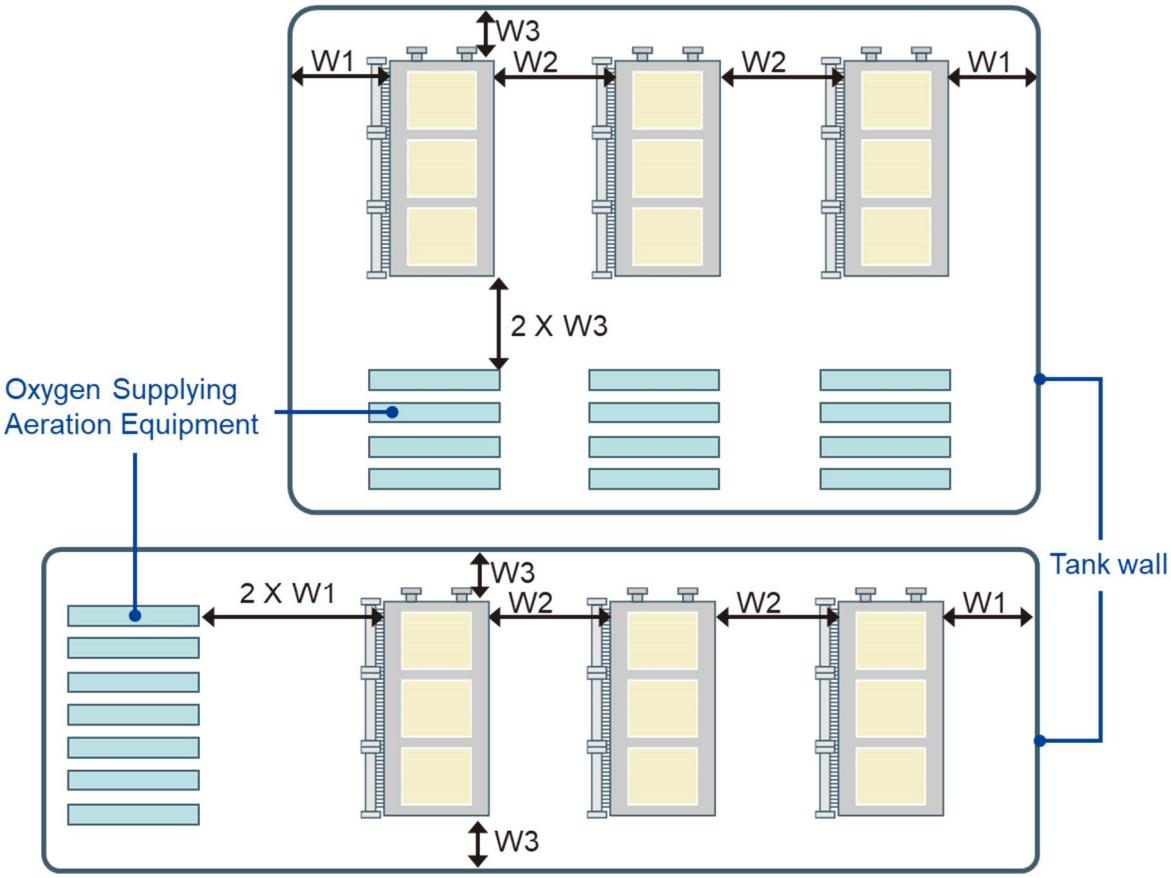


Figure IV-8: Membrane Module Layout in MBR Tank with Other Aeration Equipment (Top View)

4. Piping

The procedures of the pipe arrangement for the air diffusers and the filtrate manifold are described in this section. For connection specifications of the air diffuser and the filtrate manifold, please refer to the reference document.

(1) Pipe Arrangement for Air Diffusers

There are two types of air diffuser for NHPA Series, coarse-bubble and fine-bubble, and their configurations differ. Therefore, replacing coarse and fine types is extremely difficult. Be aware of this when selecting the diffuser type.

A. Coarse-bubble air diffuser

The coarse-bubble air diffuser requires periodic cleaning due to clogging that occurs during operation, which necessitates a flushing piping configuration. Cleaning can be implemented either on a per module or per air diffuser header pipe basis. Descriptions for each cleaning method are provided below, followed by the notes and recommendations for both methods.

[Configuration for cleaning per module]
Connect two flanges (A) located on the coarse-bubble air diffuser at one side of an aeration block and the header pipe from the air supply device (blower) by using the riser pipes. Also, install a branch pipe and air discharge valve for cleaning to the riser pipe. It is also necessary to install an air flow meter and control valve and recommended installing a pressure gauge in the air supply to check the conditions of the blower and air diffuser. Refer to Figure IV-9 and see Figure VIII-2 for the procedure for cleaning the air diffusers.

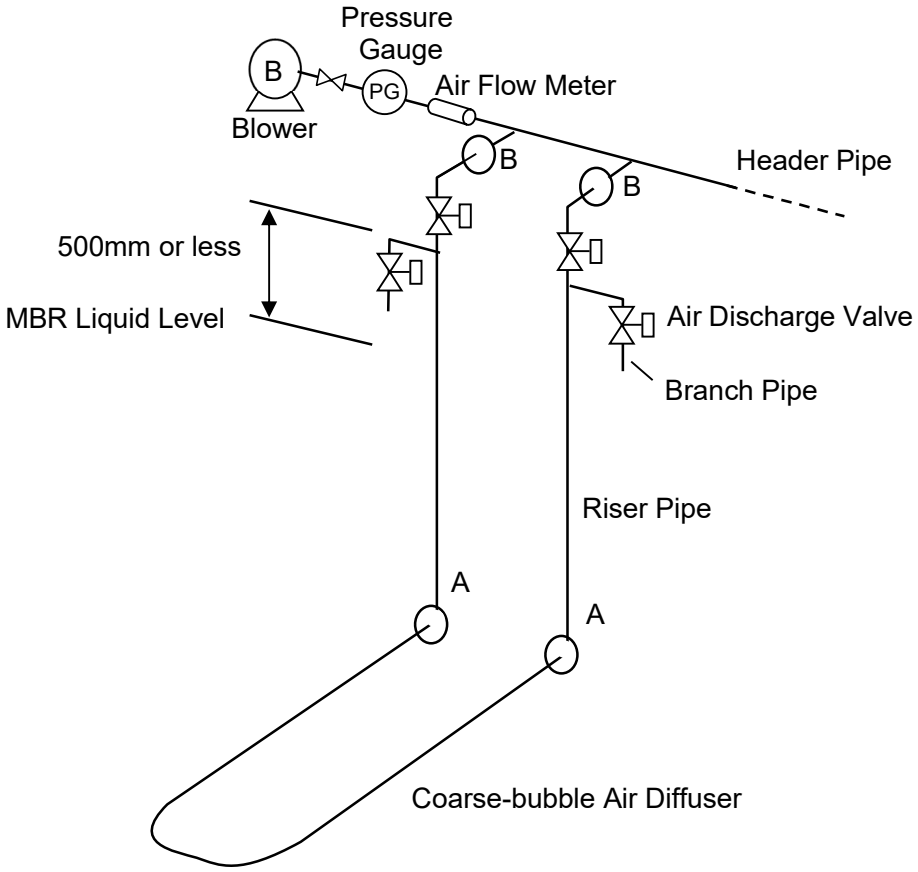


Figure IV-9: Corse-bubble Air Diffuser Configuration Example (Per Module)

[Configuration for cleaning per air diffuser header pipe]
After connecting two header pipes to the air supply device (blower), connect one of the two flanges of the coarse-bubble air diffuser of an aeration block to one of the header pipes and the other flange to the other header pipe by using the riser pipes. Attach four automatic valves to two header pipes at the air supply and drain sides. It is also necessary to install an air flow meter and control valve and recommended installing a pressure gauge in the air supply to check the state of the blower and air diffuser. Refer to Figure IV-10 and see Figure VIII-2 for the procedure for cleaning the air diffusers.

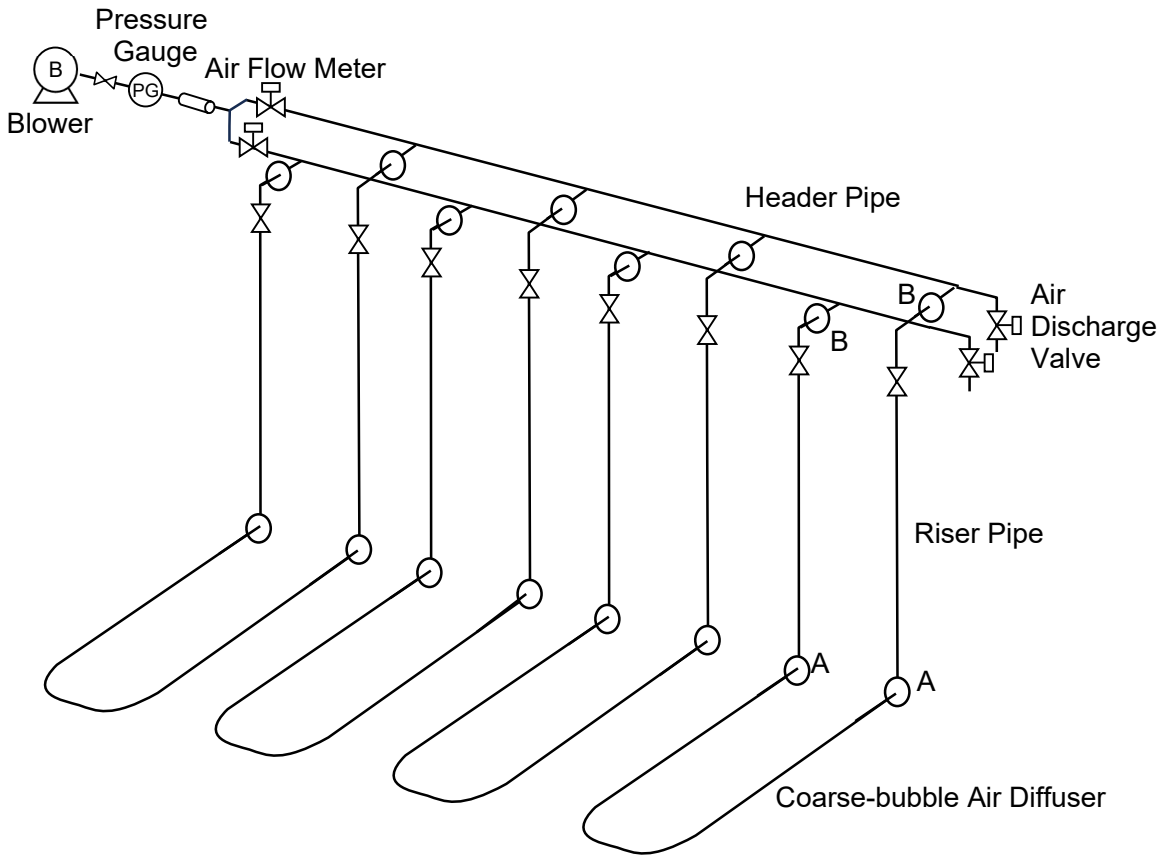


Figure IV-10: Corse-bubble Air Diffuser Configuration Example (Per Header Pipe)

[Notes and recommendations for both configurations]

- Coarse-bubble air diffusers are made of polypropylene or stainless steel, depending on the module type. For polypropylene air diffusers, put some supports to connecting pipes such as riser pipes and use lightweight heat-resistant plastic pipes and flexible pipes/joints to **regulate the load to the flange connection points at less than 20 kg per flange**.
- **Configure the air scouring for membrane**, which operates at a constant air flow rate during filtration, **at the different system from the aeration for biological treatment**, which changes according to DO control or inflow load.
- **Air diffuser cleaning should be automatically conducted** by components/valves that are equipped with automatic valves and PLC systems to ensure efficient cleaning, as air diffuser cleaning is very important for MBR operation.
- In case the aeration block needs to be pulled up from the MBR tank during maintenance, installing the flange (B) above the liquid level of the MBR tank is recommended.

B. Fine-bubble air diffuser

Connect the piping from the air supply device for air scouring, such as a blower, to one or both sides of the aeration block using a screw connection (A) (Figure IV-11 shows the configuration of connections at both sides). In the middle of this piping, install a flange connection (B) above the liquid level to disconnect the piping when removing the aeration block.

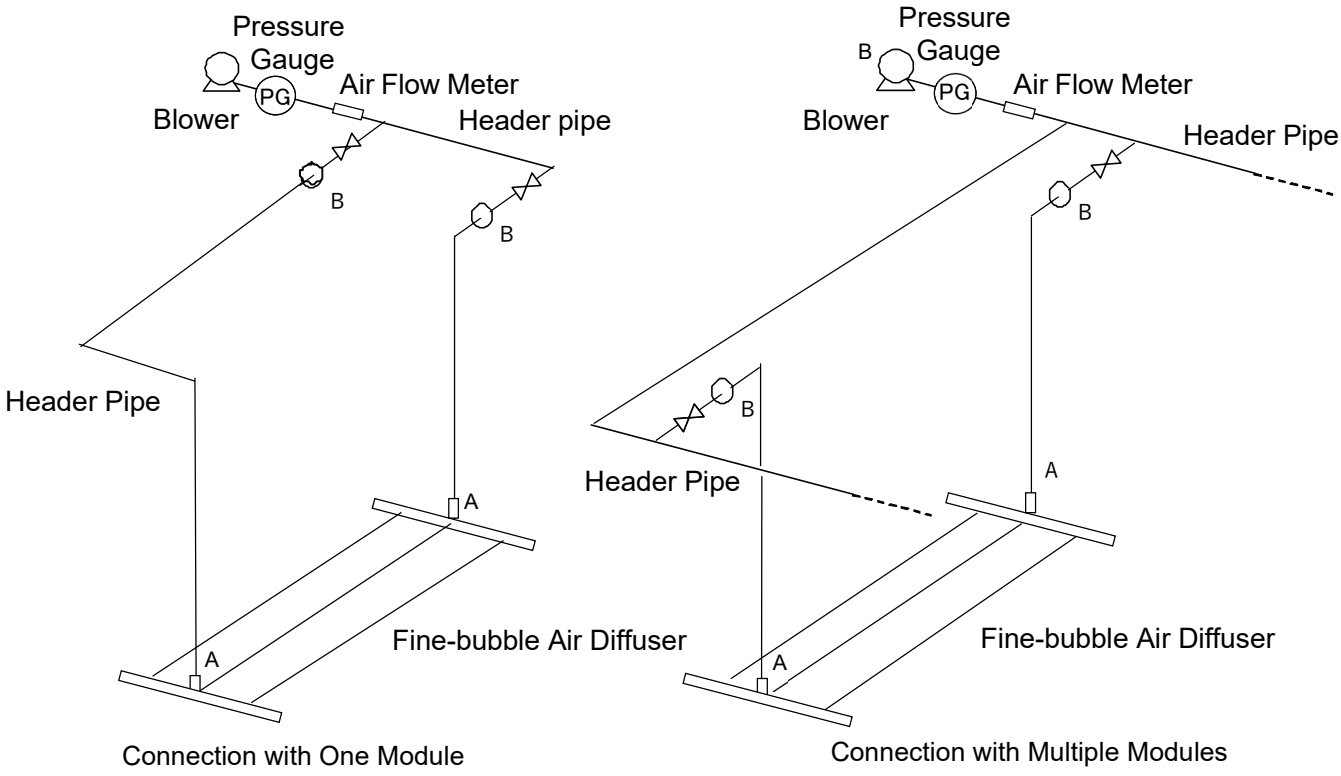


Figure IV-11: Fine-bubble Air Diffuser Configuration Example

Configure the air scouring for membrane, which operates at a constant air flow rate during filtration, at the different system from the aeration for biological treatment, which changes according to DO control or inflow load.

It is also necessary to install an air flow meter and control valve and recommended installing a pressure gauge in the air supply to check the state of the blower and air diffuser.

(2) Piping to the Filtrate Manifold

Figure IV-12 and Figure IV-13 illustrate two approaches of the filtrated water piping from the MBR tank. Figure IV-12 shows downward piping and Figure IV-13 shows upward piping.

The downward piping is incorporated when sufficient suction can be developed by gravity (the filtrate discharge is below the MBR tank). The upward piping is for operation when a suction pump is required (the pump is above the MBR tank).

In both upward and downward piping, the chemical injection valve and the air discharge valve should be installed on a pipe tee between the pipe from the filtrate manifold to the filtrate control valve.
It is also advised confirming that the diameter of filtrate piping is suitable for the assumable maximum flow rate at each point, especially after aggregating filtrate flow from several modules such as header pipes.
The devices required for chemical cleaning are detailed in the section VIII-3.

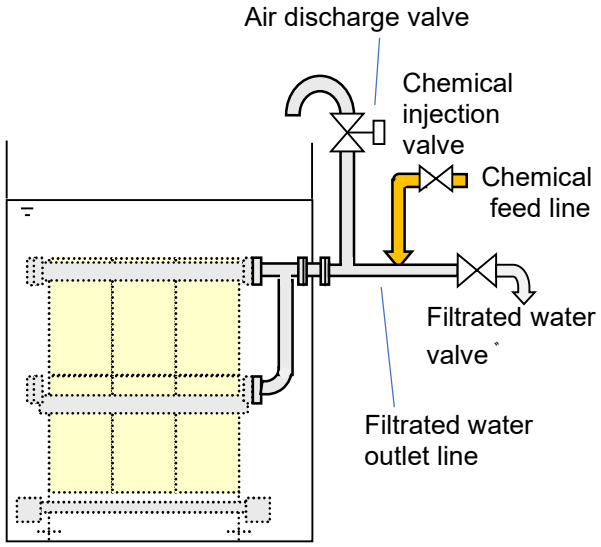


Figure IV-12: Downward Piping from MBR Tank

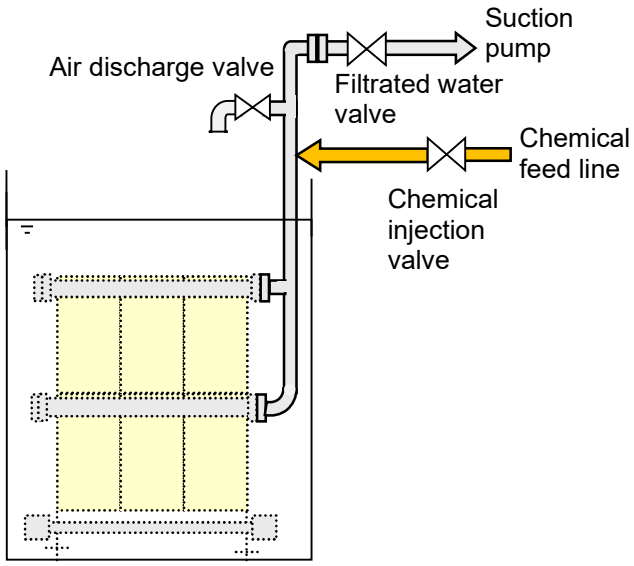
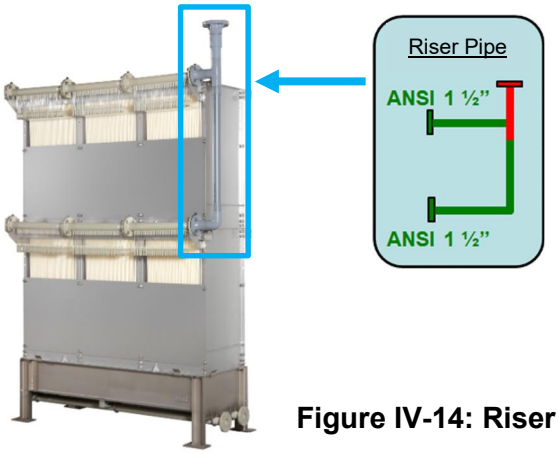


Figure IV-13: Upward Piping from MBR Tank

It is advised to prepare and attach a "riser pipe" (out of Toray's scope of supply) **to connect the upper and lower filtrate manifolds of two element decks that are stacked and bolted**. **Figure IV-14 shows examples of the riser pipe installation. In this figure, the upper and lower filtrate manifolds are attached at the same side and connected with a riser pipe.**
Regarding the NHPA150-3C/F and 4C/F, prepare and install a separate riser pipe for the third and fourth element decks, and do not connect the all filtrate manifolds to a single riser pipe.

Please select the pipe diameter for the filtrate piping including a riser pipe so that an appropriate internal flow velocity is maintained even at the maximum flow rate. Verify that the flow velocity remains appropriate especially after the point where the pipes merge.



[Recommended size]
Filtrate piping of "Red color" should be 2 inch or bigger.

Figure IV-14: Riser Pipe Installation Example

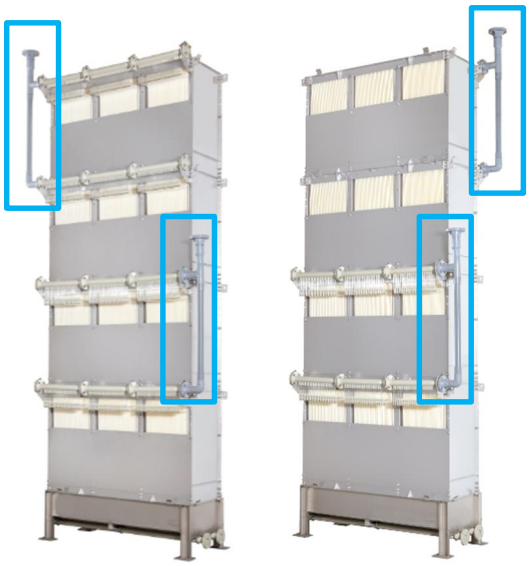


Figure IV-15: Riser Pipe Installation Examples for Four Stacked Decks

CAUTION	When using plastic air diffuser/filtrate manifold, consider piping material and regulate the load to the flange connection points less than 20 kg per flange, in order to avoid deformation, leakage, or breakage of the plastic air diffuser/filtrate manifold. Put some supports to the connecting pipe as necessary.
CAUTION	Be sure to confirm that the diameter of filtrate piping is suitable for the assumable maximum flow velocity at each point, especially after aggregating filtrate flow from several manifolds such as header pipes.

(3) Maximum number of modules in a single header

A maximum number of 30 modules per filtrate header with subgroups of max 10 modules for air scouring (diffuser cleaning) and chemical cleaning is possible to design.

V. INSTALLATION OF “NHPA SERIES”

1. Preparatory Procedure

(1) Take precautions to plan the route for the “NHPA Series” to the MBR tank.
The route should include the unloading area for the “NHPA Series” to the final installation site.

(2) Arrange the necessary equipment to unload the “NHPA Series” from a truck such as a forklift or pallet jack etc.

(3) **Prior to the installation, confirm that all necessary piping components are in place within the MBR tank. Make certain that all construction waste materials have been removed from the tank.** All loose materials remaining in the tank should be removed from the tank prior to the installation of the “NHPA Series”. **In addition, it is important to test all water and air lines to confirm that all field assembled joints are free of leaks.**

2. Unloading/Lifting Products

Unload "NHPA Series” with suitable equipment such as forklift, crane, or truck mounted hydraulic lift gate.
Inspect the "NHPA Series" module for any damage inflicted during transport.

(1) The packaging unit and number of boxes for NHPA modules vary depending on the model and quantity of modules being delivered. Ensure that all required components and materials are included when unpacking.

(2) Do not lift the packages from overhead when unloading the package which contains multiple element decks or aeration blocks. Always lift these packages from underneath using a forklift or pallet jack.

(3) To avoid damage, do not stand or sit on the packages.

(4) A cassette can be handled by manpower only before starting operation. If several cassettes are installed in an element deck frame, do not move it by hand and use appropriate equipment such as a forklift.

(5) When lifting the element deck, hook a chain or sling to the lifting hole (see separate document) and lift it straight up while keeping it horizontal with the lifting equipment.

(6) Be careful not to damage element nozzles, air diffusers, filtrate manifolds, or other components when lifting.

(7) Employ good safety practices when unloading and moving the “NHPA Series” components.

Attach chains or slings to the lifting lugs when lifting “NHPA Series”. Slowly raise the module straight up. Avoid sudden changes in movement to minimize shaking the module. Never allow anyone to stand under the “NHPA Series” during lifting

	Never lift or operate the module with worn or damaged lifting equipment. Use chains or slings that can handle the weight to be lifted. Check the condition of each equipment before lifting.
	Prior to lifting, make ready a flat area to set the module down. This will minimize the potential for damage. Damage will occur if the module is allowed to tip over.
	Do not apply a strong force to air diffuser/filtrate manifold when moving the module. Otherwise, the air diffuser/filtrate manifold may get damaged.

3. Checking Products

Upon arrival of the “NHPA Series”, immediately check the following:

(1) Make certain all items are delivered as stated on the shipping documents.
(2) Check to make sure no damage was inflicted during transport.
(3) Check to confirm that the protective covers remain in their correct position.
(4) Check to confirm that all the filtrate tubes are surely connecting elements and filtrate manifold.

4. Storing Products

"NHPA Series" has to be stored indoors at temperatures below 40 deg C. If the “NHPA Series” cannot be stored indoors due to prevailing construction site conditions, try to minimize the time being out of doors. Always comply with all recommended storage conditions.

At all times during transportation and installation of the “NHPA Series”, protect the module elements and other components from damage. Take special measures to protect the elements from sparks caused by welding, fusion cutting, or grinding. If any of these activities are in progress, be sure to protect the elements by using fireproof sheets or other protective materials.

(1) Keep the module upright at all times and do not place any heavy objects on the module.
(2) Maintain the temperature below 40 deg C.
(3) Prevent from freezing.
(4) Prevent from getting wet. Avoid conditions where condensation may occur on the module or elements.
(5) Do not submerge in water until such time as the “NHPA Series” is ready for final installation.
(6) Avoid module exposure to direct sunlight.
(7) Protect from falling objects. Again, avoid exposure to sparks from grinding or welding.

	Exposing the “NHPA Series” and elements to temperatures above 40 deg C or direct sunlight should be avoided. Exposure to direct sunlight/UV radiation will cause the polypropylene air diffuser and filtrate manifold to deteriorate.
	Protect “NHPA Series” from freezing.
	Take adequate measures to protect “NHPA Series” from sparks caused during welding, fusion cutting, or grinding.
	Do not place heavy objects on the module. Protect the module, including element, filtrate manifolds, air diffuser, frames, from damages or deterioration by potential collisions with other moving objects, or contact with corrosive substances.
	Be careful not to damage the rubber parts of fine-bubble air diffusers.

5. Installing Products

Check the followings before module installation:

- ✓ Make sure all necessary work in the MBR tank has been completed.
- ✓ Make sure the tank and all pipes have been thoroughly cleaned and free of debris.
- ✓ Confirm that there are no leaks in any of the tank and water or air lines.
- ✓ Using clean water in the tank, check the operation of major equipment components such as: pumps, blowers, sensors, and control systems.

Refer to the separate diagram and confirm that the installation and connection positions are correct.

(1) Select a Way of Element Deck Installation

The installation of the module involves placing the aeration block in the MBR tank and then placing the element deck on it. For the NHPA050-1C/F, 100-1C, 150-1C/F, and 150-2C/F, choose to either bolt the element deck to the aeration block or use guide rails to install it without bolting. When using guide rails, the element deck can be lifted down along the guide rails to the designated position, ensuring proper positioning and preventing tipping. This eliminates the need for bolting the element deck to the aeration block and allows for the insertion and removal of the element deck without draining the sludge from the MBR tank.

* For the downward piping from MBR tank (Figure IV-12), it is required to drain the sludge until the liquid level reaches a point where the filtrate piping can be separated.

On the other hand, for the NHPA150-3C/F and 150-4C/F, a module consisting of three or four stacked element decks, requiring anti-tipping measures to improve installation stability. Therefore, always use guide rails for installation.

Please refer to the separate document for the guide rail specifications and design and manufacture them considering the conditions of the plant where they will be installed.

(2) Install an Aeration Block

The aeration block should be anchored to the designated position at the bottom of the MBR tank using anchor bolts, regardless of whether guide rails are used. (Other installation methods are possible, but please consult us for details). **The air diffusers should be installed in a horizontal position to achieve uniform air diffusion. The maximum allowable deviation from dead level for the air diffusers is 3/1,000 on the top surface of the aeration block in both lateral and vertical directions.**

When using guide rails, attach the guide rail components. Each element deck has a lot number engraved on it. After installing the element deck, record the number and its loaded position in the tank.

(3) Plumb in Air Diffusers

Before plumbing in the air diffusers, flush all pipes out and remove any dirt or foreign objects.

Regarding to the polypropylene coarse-bubble air diffuser, connect the riser pipe of the air supply device and the air diffuser with flanges at two points on one end. Air diffuser is shipped from the factory with two rubber gaskets. Tightening rubber gaskets with the tightening torque of 20 N·m. As coarse-bubble air diffuser is made of polypropylene, please consider piping material and regulate the load to the flange connection points less than 20 kg per flange, in order to avoid distortion, leakage or breakage of the plastic air diffuser. If the load is higher than the limit above shown, put some supports on the piping to reduce the load.

The connection of the fine-bubble air diffuser has an internal thread. There are connection points at one or both ends of the air diffuser. Prepare and use the suitable threaded pipe fittings or similar fittings.

After plumbing in the air diffusers, fill the MBR tank with clean water until the aeration blocks are completely submerged in the clean water. Next turn on the air supply, check to make certain that the air is being evenly distributed throughout the aeration block.

(4) Install Element Decks

Depending on the module type and the quantity shipped, the two stacked element decks are either fully connected with bolts or connected only at the four corners. Check the connection type and follow the appropriate steps below.

A. (Preparation work) Connecting the element decks

For the modules with two or more element decks (NHPA150-2C/F, 3C/F, and 4C/F), connect two element decks with bolts/nuts to form a connected element deck.

Prepare one connected element deck for NHPA150-2C/F, one connected element deck and one element deck for NHPA150-3C/F, and two connected element decks for NHPA150-4C/F.

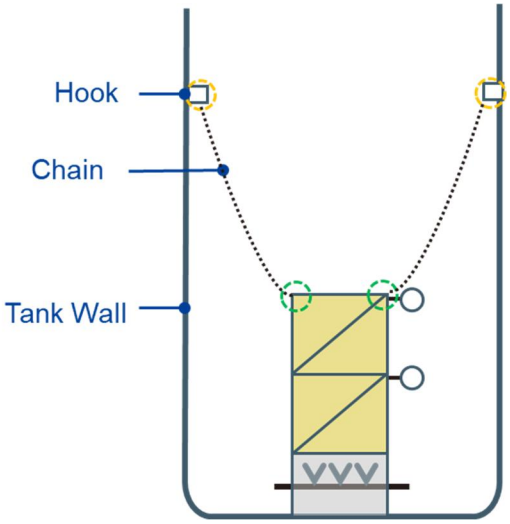
B. Installation WITHOUT using guide rail system (available for one and two-stacked type)
Place the element deck or connected element deck onto the aeration block. Secure them together using the bolts provided.

C. Installation WITH using guide rail system (available for all types)
One or two-stacked type:
Place the element deck or connected element deck onto the aeration block. Securing them with bolts is not required.

Three-stacked type:
Place the connected element deck onto the aeration block and then place another element deck on top of it. Securing them with bolts is not required.

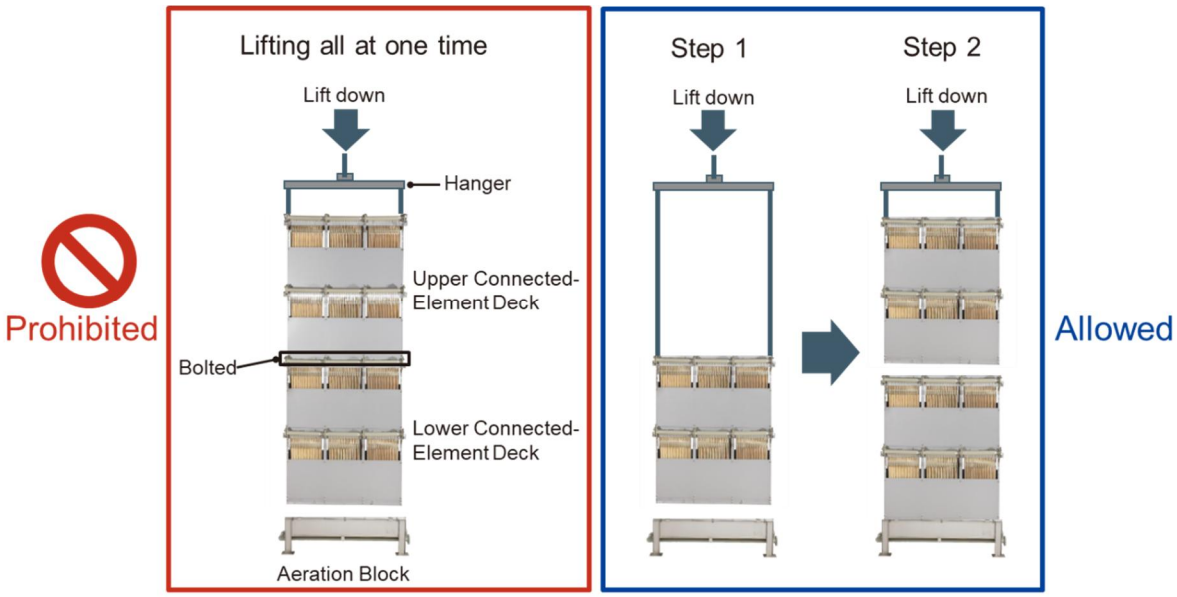
Four-stacked type:
Place the connected element deck onto the aeration block and then place another connected element deck on top of it. Securing them with bolts is not required.

After securely placing the (connected) element deck(s) into the MBR tank, attach one end of the chain or wire to the lifting bracket on the (connected) element deck, as indicated by the green circles in the figure. Then, hang the other end onto the hook located above the sludge in the MBR tank, as indicated by the yellow circles.



After completing the installation, make sure to record the lot numbers of all element decks, as well as the position in the MBR tank. **Take protective measures for the elements, such as covering them with fire-resistant sheets.**

Do not lift the upper (connected) element deck and lower connected element deck as a single unit while they are bolted together. Upper/lower (connected) element deck must be installed one by one to avoid distortion or damage to the element deck which may cause severe accident.



(5) Plumb in Filtrate Manifold

Before plumbing in the filtrate manifold, flush all pipes out and remove any dirt or foreign objects, and perform a leak check.

The filtrate manifolds are shipped with a blank flange temporarily attached at one end, but a separate flange is required to connect to the filtrate line. Prepare a suitable flange, connect one end to the filtrate line, and either tighten the temporarily attached blank flange at the other end or reposition and secure it. Tighten a flange with tightening torque of 10 N·m when connecting plastic filtrate manifold to avoid deformation or breakage. Also, choose the material for connecting pipe that will not weigh more than 20 kg on the connecting flange and put some supports to connecting pipes as necessary.

Before connecting the filtrate manifold, perform flushing and leak checks of the filtrate line. Applying excessive pressure (over 10 kPa) from the filtrate side may cause damage to the elements.

 DANGER	Attach chains or slings to the lifting lugs when lifting “NHPA Series”. Slowly raise the module straight up. Avoid sudden changes in movement to minimize shaking the module. Never allow anyone to stand under the “NHPA Series” during lifting
 DANGER	Use chains or slings with sufficient load rating to lift the weight of the "NHPA Series" or any of its components. Before lifting the element deck or aeration block, check the condition of each part and if any damage that could be a safety hazard is found, stop the work.
 DANGER	When installing “NHPA Series” module, make provisions, in advance, to access the upper portions of the membrane module via a scaffold or ladder. Do not climb on the module structure. Never step on the air diffuser and filtrate manifold. Use protective equipment to ensure the safety of operators.
 DANGER	Never lift the three or four stacked element decks at once. When installing or removing element decks, lift one element deck or one connected element deck that consists of two individual element decks stacked and bolted together.
 CAUTION	Wear the appropriate personal protective equipment (e.g. work gloves) in order not to cut hand on the edge of the module frame.
 CAUTION	Tighten a flange with tightening torque of 20 N·m when connecting plastic coarse-bubble air diffuser to avoid deformation or breakage. Also, choose the material for connecting pipe that will not weigh more than 20 kg on the connecting flange and put some supports to connecting pipes as necessary.
 CAUTION	Tighten a flange with tightening torque of 10 N·m when connecting plastic filtrate manifold to avoid deformation or breakage. Also, choose the material for connecting pipe that will not weigh more than 20 kg on the connecting flange and put some supports to connecting pipes as necessary.
 CAUTION	Avoid pressurizing the filtrate side of the module over 10 kPa.

VI. START OF OPERATION

1. Clean Water Operation

(1) Check the following items prior to module(s) operation

A. Check that the air diffuser pipe and the filtrate pipes are properly connected to the module(s).

B. Check that the element deck is securely installed on the aeration block.

C. Remove any protective materials covering the MBR tank. Check that the MBR tank is completely free of dust and debris. The presence of soil and dust may cause damage to the module.

D. **Open the air discharge valve on the filtrate line to release any air from the filtrate side of the elements before filling the MBR tank with clean water.**

E. Fill the MBR tank with clean water (tap water or filtered water) to reach the recommended operating liquid level.

F. Close the air discharge valve before starting a clean water operation.

CAUTION	Open the air discharge valve to release air from the elements before feeding clean water to the MBR tank. Close the air discharge valve before starting a clean water operation.
CAUTION	Do not use natural ground water for clean water operation, as it may contain much amount of iron, manganese, calcium, and silica which may cause the clogging of the membrane pore.

(2) Clean water operation

After feeding clean water to the MBR tank, follow the recommended procedures below to start the clean water operation.

A. Start the blower to supply air to the air diffusers. Check that the required amount of air is supplied to the air diffusers and the diffused air is being distributed evenly within each module.

* White foaming may occur in the MBR tank during clean water operation. The foaming is caused by the leaching of residual biodegradable hydrophilic components contained in the membrane. Foaming is normal and does not adversely affect the membrane filtration process **but if you want to remove this, do not use silicone-based anti-foaming agent which may cause clogging of membrane pores but use alcohol-based ones instead.**

B. Check that the recommended amount of air is evenly supplied to each module when using one blower to supply air for multiple modules. If the supply is uneven, adjust the control valves installed on the branch pipes leading from the header pipe to each module. Alternatively, consider reconfiguring the piping, such as the diameter of the header pipe.

C. Check the system controls and associated control components with clean water for proper operation and proper sequence of operation excluding filtration operation.

D. Start the clean water filtration process. Measure and record the trans-membrane pressure (TMP) and water temperature at designed filtration rates (at normal, maximum, and minimum flow rates).
Complete the clean water filtration process within two cycles of intermittent operation. Prolonged clean water filtration may lead to membrane pore clogging. At the initial operation of suction pump, priming (filling the suction piping with water) may be needed for proper pump suction and in that case avoid pressurizing the filtrate side of "NHPA Series" over 10kPa.

E. Stop the clean water filtration process and discontinue the air supply as soon as the above tests have been satisfactorily completed.

	White foaming may occur in the MBR tank when supplying air. The foaming is caused by the leaching of residual biodegradable hydrophilic components contained in the membrane at the beginning of a clean water operation. Foaming is normal and does not adversely affect the membrane filtration operation. If using an anti-foaming agent, do not use silicone-based anti-foaming agents as they may cause foul the membranes, but use alcohol-based ones instead.
	Complete the clean water filtration process within two cycles of intermittent operation. Prolonged clean water filtration may lead to membrane pore clogging.
	Keep the membranes wet once they get wet. If the membranes are allowed to dry out, the permeability of the membranes may be permanently reduced.
	Avoid pressurizing the filtrate side of the module over 10 kPa.

2. Seeding Sludge Injection

Do not attempt to produce filtrate from any raw water that has not first been seeded with activated sludge. Failure to do so will result in severe clogging of the membrane pores.
Follow these steps when seeding sludge in the MBR tank with activated sludge

(1) Locate a nearby wastewater treatment facility that treats wastewater similar in composition to the wastewater to be treated with the “NHPA Series”. Make arrangements to transport some of that healthy, activated sludge from the nearby wastewater facility to the facility needing the seeding sludge. Activated sludge with higher MLSS concentration and higher MLVSS/MLSS ratio is preferable. **Initial MLSS concentration of the MBR tank should be at least 3,000 mg/L or higher. Higher than 7,000 mg/L is preferred.**

(2) Drain the clean water if the MBR tank has been filled with it, then **add the seeding sludge through a 3.0 mm or less mesh screen to the MBR tank to remove any contaminants.**

(3) Begin feeding the raw water as soon as possible after the activated sludge has been introduced into the MBR tank.
(4) Do not use seeding agents.
(5) Do not use silicone-based anti-foaming agent which may cause clogging of membrane pores.

	Prior to the introduction of any seeding sludge into the MBR tank, pass all sludge through a 3 mm or less mesh screen to remove any contaminants.
	Open the air discharge valve to release air from the elements before feeding clean water to the MBR tank. Close the air discharge valve before starting a clean water operation.

3. Actual Filtration Operation

After successfully seeding the sludge within the MBR tank, start the air supply to the diffusers, start sludge circulation, and activate the filtration process and the raw water feed. Pay particular attention to the following operational parameters.

(1) The condition of the seeded activated sludge may not be optimal for membrane filtration until such time as the food to microorganism ratio (F/M) has been optimized. To avoid fouling the elements while the activated sludge is evolving, operate the MBR well below the designed flux rate. **This is especially important until the activated sludge MLSS concentration approaches 7,000 mg/L. Gradually increase the flux rate as the condition of the activated sludge improves.**
(2) At the initial operation of suction pump, priming (filling the suction piping with water) may be needed for proper pump suction and in that case avoid pressurizing the filtrate side of "NHPA Series" over 10kPa.
(3) Sludge parameters such as MLSS and sludge filterability (see VII. 4. (11)) should be checked frequently to assess the actual sludge condition.
(4) Check the air diffuser cleaning procedure and associated automated valves for proper operation. Details for the procedure are given in the chapter VIII.
(5) Once the filtrate flow has stabilized, measure and record the trans-membrane pressure (TMP) and the liquid temperature. Details for operation control are given in the next chapter.

 CAUTION	The air scouring should be stopped when the filtration process is suspended. There are two exceptions: 1) Do not stop the air scouring during the normal relaxation period. 2) Do not stop the air scouring that is required for normal metabolic processes of the activated sludge or for prevention of sludge sedimentation. However, under these conditions the amount of scouring air flow directed to the diffuser should be reduced to just the amount required to maintain sludge viability or agitate sludge.
 CAUTION	Avoid pressurizing the filtrate side of the module over 10 kPa.

VII. OPERATION CONTROL

1. Standard Operating Conditions

Table VII-1 shows standard operating conditions for “NHPA Series".

To ensure stable operation, operating parameters such as MLSS, sludge viscosity, DO (dissolved oxygen concentration), and pH should be kept in the range of recommended standard operation conditions listed in the Table VII-1 below. All wastewaters should pass through a 3mm (or less) mesh screen before introducing into the MBR tank. Large solids may damage the membrane surfaces.

If anti-foaming agents are to be added to the MBR tank, use only alcohol based anti-foaming products. Do not use silicone-based anti-foaming agent which may cause clogging of membrane pores.

* Recommended alcohol based anti-foaming products:
- Kurita Water Industries “Kuriless 653”
- Schill & Seilacher Struktol SB 2032

Table VII-1: NHPA Series Standard Operating Conditions

Parameter		Unit	Operating Condition
MLSS		mg/L	7,000 - 18,000
Sludge viscosity *		mPa・s	Viscometer 1: Not higher than 100 Viscometer 2: Not higher than 250
DO		mg/L	1.0 or more
pH		-	6 - 8
Liquid Temperature		℃	15 - 40
Scouring air flow rate	NHPA050-1C/F	NL/min/Module	430
	NHPA100-1C/F		870
	NHPA150-1C/F ~ 4C/F		1,300

＊The sludge viscosity is measured using a single-cylinder rotational viscometer. Sludge with high MLSS generally exhibits non-Newtonian fluid characteristics, and the viscosity measured by the rotational viscometer varies depending on the rotor speed and rotor diameter. The values in Table VII-1 are measured using the following equipment and conditions:

Viscometer 1: Toki Sangyo Co., Ltd. Model BL Ⅱ (Rotor speed: 60 rpm)

Viscometer 2: Toki Sangyo Co., Ltd. Model TVC-10 (Rotor speed: 20 rpm)

WARNING	Filtrate water is not suitable for drinking. Do not drink filtrate water directly.
WARNING	Analyze the quality of the filtrate water to ensure that the water quality meets the intended purpose before actual use.

 CAUTION	Do not allow contamination of chemicals, toxic agents, oils, or other substances into the biological tank or wastewater that can adversely affect the condition of activated sludge.
 CAUTION	Avoid abrupt changes in temperature, salinity, pH, trans-membrane pressure (TMP), or any other conditions even if they are within the standard operating conditions (Table VII-1).
 CAUTION	Perform regular inspections of the module. Replace worn parts, as needed, in a timely fashion.
 CAUTION	If anti-foaming agents are to be added to the MBR tank, use only alcohol based anti-foaming products. Do not use silicone-based anti-foaming agent which may cause clogging of membrane pores.
 CAUTION	Protect the modules from freezing.

2. Operating Parameters

The performance of the “NHPA Series” varies depending on raw water quality and site-specific operating conditions. In order to achieve stable “NHPA Series” operation, it is crucial to regularly monitor and record the following operating parameter values for more stable operation, problem prevention before it occurs, and proper troubleshooting.

(1) **Scouring air flow rate (blower air flow)**
(2) Scouring air pressure (blower discharge pressure)
(3) **Filtrate flow rate**
(4) **Trans-membrane pressure (TMP) (including filtrate pressure, relaxation pressure, MBR tank liquid level for calculation)**
(5) Liquid temperature in the MBR tank
(6) DO (dissolved oxygen) concentration in the MBR tank
(7) pH in the MBR tank
(8) **MLSS in the MBR tank**
(9) Raw water quality (BOD, COD, turbidity, T-N, T-P, etc.)
(10) Filtrate water quality (BOD, COD, turbidity, T-N, T-P, TSS etc.)
(11) Excess-sludge discharge rate
(12) Sludge viscosity
(13) **Sludge filterability**

Preferable recording frequencies are;

- Every minute for on-line instruments
- Every day for off-line instruments and sludge properties

・ Every week for water quality analysis

3. Basic Control Philosophy

Presented below is the point of the generic MBR control philosophy. The actual MBR system control philosophy will be based on the specific site operating conditions.

(1) Suction Pump

The filtrate suction pump should be controlled to operate for intervals of nine (9) minutes on and one (1) minute off. The filtrate suction pump motor should be fitted with a VFD drive. A filtrate flow transmitter should be installed to provide a control signal to the suction pump VFD. The suction pump should be stopped if the liquid level in the MBR tank drops to a predetermined low liquid level. If, at any time, the air supply to the MBR module or RAS (return activated sludge) is interrupted, the suction pump should be stopped. Do not operate the filtrate suction pump on low MBR tank level or high TMP. Once the air supply has been restored the MBR tank and good RAS circulation is observed, delay the activation of the suction pump for one minute to make certain sufficient sludge mixing has taken place prior to restarting the filtration process. The suction pump should always be off when performing air diffuser cleaning.

(2) Membrane Scouring Blower

The blower supplying air for membrane scouring should be on continuously. Air flow (and suction pump) should be stopped if the liquid level in the MBR tank falls below the preset low level for a long period or the flow to the MBR tank stops. In such cases the air supply should be applied for five (5) minutes each hour the system is not producing filtrate. This is required to keep the sludge well mixed and in good condition for restarting the filtration process while avoiding too much stress to the elements.

(3) MBR Tank Liquid Level

If the liquid level in the MBR tank reaches the low level, the suction pump and membrane scouring air should be stopped. If the MBR tank reaches high level the raw water feed supply should be stopped.

(4) Trans-membrane Pressure (TMP)

Three TMP alarms should be incorporated into the MBR control logic.

- TMP (H) should be activated when the TMP increases 3 kPa from the initial TMP. Perform or prepare for a chemical cleaning.
- TMP (HH) should be activated before the TMP increases 5 kPa from the initial TMP. Perform a chemical cleaning immediately.
- TMP (HHH) should be activated when the TMP reaches 20 kPa and means that the operation has exceeded the safe operating range. Immediately stop the filtration.

(5) Equalization Tank

Equalizing/balancing wastewater load in terms of both quality and quantity is quite important for stable operation of MBR. In this regard having an equalization tank with mixing equipment is recommended.

4. Daily Inspection

Daily inspections and early resolution of issues or abnormalities can prevent major problems and membrane product damage, while also ensuring more stable operation. The daily inspection items and their management are listed below. Analyze the conditions and recorded operating parameters in Section 2 of this chapter, and take steps to confirm, adjust, and improve the current state of the MBR system.

(1) Pretreatment System

Check the pretreatment systems (particularly the screening device) frequently. At regular intervals, remove any accumulated trash that may accumulate on the screening device.

(2) Scouring Air Conditions

Check the air flow rate and blower discharge pressure of the air supply line to the MBR air diffuser to ensure that scouring air is being evenly distributed within a module and between modules. Too low of an air flow rate can result in membrane clogging. Too high of an air flow rate can result in element damage. If uneven air distribution is observed conduct an air diffuser cleaning as described in Section 2, Chapter VIII. If the air flow rate cannot be achieved even after cleaning, stop filtration and check the air supply piping for leaks, incorrect valve positions, blower inefficiency, or possible air line restrictions.

If the scouring air flow rate drops or becomes extremely irregular or if air supply is stopped, then immediately stop filtration to prevent membrane clogging.

(3) Trans-Membrane Pressure (TMP)

Check the trend of the trans-membrane pressure (TMP). When the TMP increases by 3 kPa from the initial setting at a constant filtrate flow rate, prepare for chemical cleaning and make sure to conduct cleaning before it increases by 5 kPa. A sudden increase in the TMP suggests that the membrane surfaces are clogging. Clogging can be caused by abnormal scouring air distribution, too high flux rate, too high MLSS concentration, or deteriorating sludge properties. If TMP values are increasing, check the MBR operating conditions and the biological condition of the sludge. Take necessary actions to correct operating conditions and then perform a chemical cleaning.

It is advised measuring the TMPs at different flow rates, e.g. 100% flow, 50% flow, and 33% flow, when starting MBR operation after commissioning. This is for checking correct

functioning of pressure measurement and head loss at filtrate piping for different flow velocities.

(4) Activated Sludge Characteristics

The activated sludge of the membrane bioreactor should be self-cohesive and free from odor. The color of healthy activated sludge is typically brown, however this color can differ among plants, depending on wastewater composition, organic load, etc. If an unexpected change is observed in sludge characteristics, check current operating conditions such as BOD load, MLSS concentration, DO, pH, temperature, and/or wastewater composition, and take appropriate corrective actions.

(5) Liquid Temperature

The desirable liquid temperature is 15 deg C to 40 deg C. If the temperature is out of this range and the activated sludge properties are not optimum, it is recommendable to install a temperature control device to cool or heat the liquid.

(6) DO

The aeration tank and the MBR tank should be kept in an aerobic condition. If DO is less than 1.0 mg/L, take necessary actions such as increasing the air flow rate of the biological aeration unit, or lowering the sludge concentration by increasing the excess sludge discharge rate. In the case where the air supply for biological aeration requirements and the air piping for membrane scouring comes from the same blower, do not exceed the recommended range of membrane scouring air flow rate to the diffuser. To increase DO concentration of the liquid within the MBR tank, adjust the separate biological aeration system.

(7) pH

The recommended pH range is 6 to 8. If pH is out of this range and the activated sludge properties are not optimum for filtration, adjust the pH by gradually adding acid or alkali.

(8) MLSS

MLSS concentration in the MBR tank is recommended between 7,000 to 18,000 mg/L. If the MLSS is too low, increase the MLSS concentration in the MBR tank by reducing the sludge discharge rate. If the MLSS concentration is too high, check the RAS (return activated sludge) flow rate. If it is determined that the RAS flow rate is too low, increase the RAS flow rate to the proper value. If RAS flow rate is correct, increase excess sludge discharge rate.

(9) Liquid Levels

Check to confirm that the liquid levels of the MBR tank are being maintained within the recommended values. If it is determined that the levels are not as per the design, check the followings: level control devices, level control circuits, filtrate pump VFD controls, activated sludge feed control valve, and membrane flux rate. Take corrective action as necessary.

(10) Sludge Viscosity

It is recommended that the sludge be no higher than 100 mPa.s (measured by B-type viscometer) or 250 mPa.s (measured by C-type viscometer). If the sludge viscosity is too high, check MBR operating conditions and biological conditions such as F/M ratio, and take necessary corrective actions.

(11) Sludge Filterability

Paper filtration method is a simple and reliable method to determine the filtration properties of the sludge. See the method described in the attached document. Toray recommends conducting paper filtration test and measurement of TOC and/or turbidity of filtered water routinely. In the case an abrupt decrease in filterability is recorded and/or increase in TOC/turbidity, check the operating and biological conditions, and take appropriate actions.

VIII. MAINTENANCE OF “NHPA SERIES”

1. Maintenance Items and Maintenance Frequency

It is recommended that the following maintenance tasks be performed on a regular basis to maintain optimal performance of the “NHPA Series” module.

(1) Clean the fine screens to remove screenings and large solids from the screens and keep the pretreatment process in good condition.

(2) Coarse-bubble air diffuser: Before an uneven air diffusion is detected, or at least once every 24 hours even if there is no uneven air diffusion observed.
Fine-bubble air diffuser: When an uneven air diffusion is detected.

(3) Perform a chemical cleaning if the current recorded TMP increases by 3 to 5 kPa (30 to 50 mbar) from the initial recorded TMP (assuming the filtrate flow rate is the same value) or every six (6) months, whichever comes first.

(4) Replace filtrate connection tubes connected to the filtrate manifold when they show some deterioration.

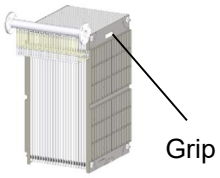
(5) Replace cassettes or element decks if, after chemical cleaning, filtrate flow or quality cannot be restored.

(6) Replace fine-bubble air diffusers when extraordinary uneven air diffusion is detected even after cleaning.

＊The general replacement cycle for the fine bubble diffuser is 3-5 years, however this is just a guideline and cannot be generalized as its lifespan is greatly affected by the components in the wastewater and the usage environment. Consider replacing the diffuser when deterioration of the aeration rubber occurs, scale or microbial adhesion is acknowledged on the rubber surface which causes operation problem such as uneven aeration or increase of the supply air pressure.

(7) Keep a record of the changes in condition before and after the maintenance work, such as before and after cleaning the air diffuser.

	Be sure to use Toray approved replacement parts.
	Contact Toray sales department to obtain information on how to order Toray approved replacement parts.
	When replacing the filtrate tube, make sure to insert it all the way into the base of the filtrate manifold and element nozzles.
	Do not apply excessive force to the nozzles of filtrate manifold or element when replacing filtrate tubes. Excessive force may result in element/filtrate manifold damage.
	Once a filtrate tube has been removed or disconnected from either the element nozzle or filtrate manifold it should be replaced with a Toray approved replacement part. Old filtrate tubes lose their elasticity, and the integrity of the seal can be compromised.

CAUTION	The cassette is not designed to be replaced on a per-element basis. Do not attempt to disassemble it, as this will prevent it from returning to a normal state.
CAUTION	 When handling a cassette, hold the grip and do not hold the other parts of the cassette, such as filtrate manifold.

2. Air Diffuser Cleaning

In the operation of MBR, it is very crucial to maintain good cleaning of membrane surface through even scouring air. The cleaning methods and frequencies differ between coarse-bubble diffusers and fine-bubble diffusers, so each will be explained. Additionally, if you use this product with sludge that has a high inorganic content, please consult us in advance.

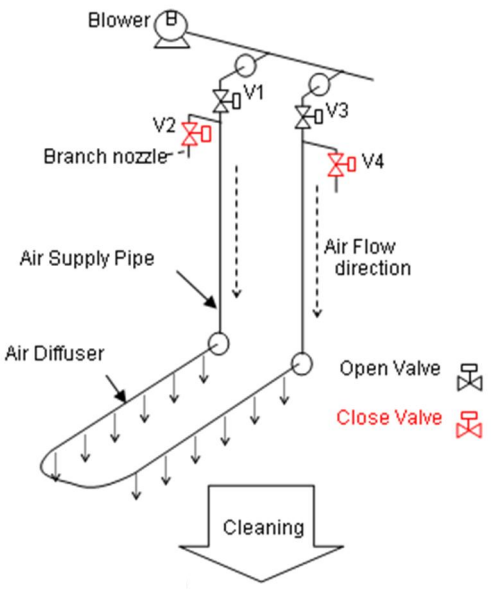
(1) Coarse-bubble Air Diffuser Cleaning

A clogged air diffuser cannot evenly distribute air to the elements resulting in, which causes that solids build up on the element surface, or, in extreme cases, the element gets damage. **It is recommended that the MBR module(s) be equipped with air diffuser cleaning components/valves that can be automatically controlled from the MBR system PLC. Cleaning of the air diffusers should be performed at least once per 24 hours or as needed to maintain even air distribution.**

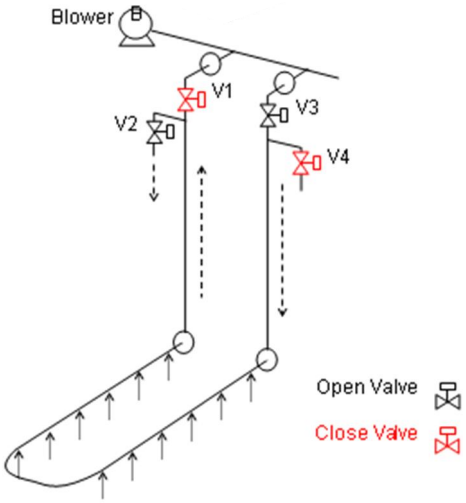
A. Air diffuser cleaning procedure for single module

To clean the air diffuser holes, it is necessary to flush the activated sludge through the diffuser holes into the diffuser piping and finally out from the air/sludge discharge nozzles. This is accomplished by supplying air to the diffuser piping in the reverse direction (see below).

[Filtration Operation]



[Chemical Cleaning]



(i) <u>The filtration must be stopped at first.</u>
(ii) Open the V2 discharge nozzle valve. As the air from the blower is discharged from the V2 valve, the pressure inside the air diffuser becomes lower than the pressure with liquid depth, and sludge flows into the diffuser piping from the diffuser holes (for 30 seconds).
(iii) Close the V1 valve. The sludge is discharged with the air from the V3 side through the V2 valve. Discharges of air and sludge with air are repeated alternately.
Keep the V2 valve open and clean for 1 to 5 minutes.
(iv) Open the V1 valve, and then close the V2 valve.
(v) Clean the other line in the same manner as follows.
(vi) Open the V4 discharge nozzle valve. Sludge comes into the diffuser piping (for 30 seconds).
(vii) Close the V3 valve. Discharges of air and sludge with air through the V4 valve are repeated alternately.
Keep the V4 valve open and clean for 1 to 5 minutes.
(viii) Open V3 valve, close V4 valve, and return the valve positions of the air diffuser to their positions at the filtration.
(ix) A minute later, confirm the air supply recovered and restart the filtration process.

The flow of air through the diffuser and out the discharge nozzle will create a suction drawing off the sludge into the diffuser piping. This reverse flow of sludge that will remove any accumulated solids clogged in the diffuser holes. The efficiency of the air diffuser cleaning will improve by the reverse procedure of the air flow direction.

Observe the flow coming out of the discharge nozzles (V2 and V4) when performing an air diffuser cleaning. If there is no discharge or only air is released, it indicates that the diffuser/holes are clogged and not being cleaned adequately. In some cases, lengthening the duration of the diffuser cleaning cycle can improve the efficiency of the diffuser cleaning.

Confirm that air/sludge are discharged from the discharge nozzle during cleaning the air diffuser. If there is no discharge or only air is released, it indicates that the diffuser/holes are clogged and not being cleaned adequately.

B. Air diffuser cleaning procedure for multiple modules that connect to the same header pipe

For multiple module operation, the flushing procedure described in the previous section can be applied for each module, or a more convenient and simple approach is shown in Figure VIII-1. Two flanges of the air diffuser should be connected to each of the two air headers, and each header equipped with two valves (automatic valves are strongly recommended) at the inlet point and end point (both higher than liquid level of the MBR tank).

The procedure and standard duration time of each action are as follows:

✓ Flushing: to clean air diffusers, 1 to 5 minutes for each flushing event.

✓ Purge: to blow out inside header pipes, around 30 seconds for each purge event.

Filtration must be stopped prior to starting the air diffuser cleaning procedure and restarted one minute after air scouring is started. Please take care not to allow sludge to flow toward the blower.

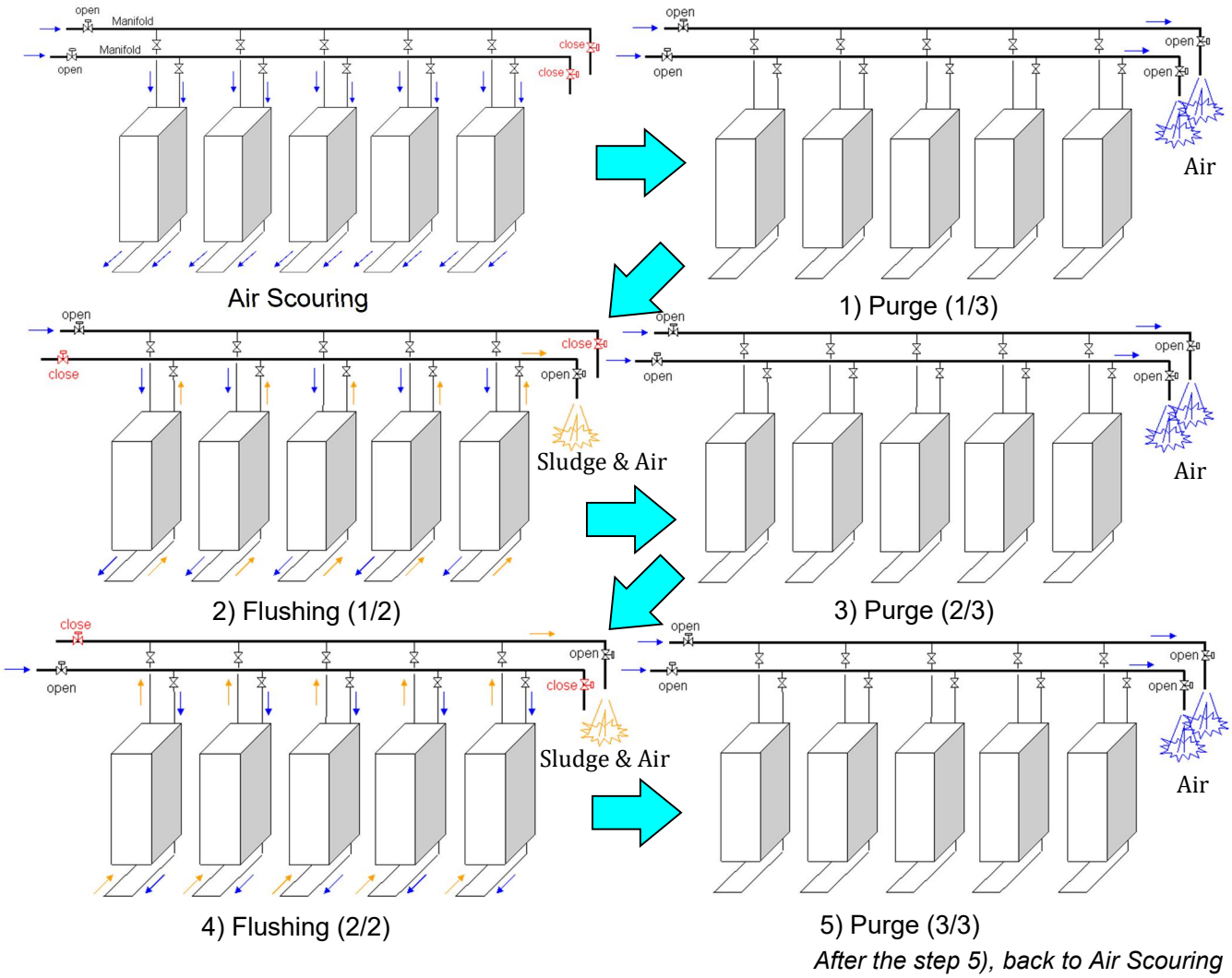


Figure VIII-1: Air Diffuser Cleaning Procedure for Multiple Modules

(2) Fine-bubble Air Diffuser Cleaning

Usually in domestic wastewater treating cases, air diffuser cleaning is not required as sludge does not come into the fine-bubble air diffuser. However, in the unlikely event that the diffuser is covered with clogs, uneven air diffusion may cause membrane clogging and elements damage in the worst case.

To prevent possible diffuser troubles, check the value of air flow meter and pressure gauge of the membrane air supply line regularly and ensure that the fixed amount of air within the standard range is supplied. Also, check that the air is diffused evenly within one module and evenly among modules.

If an extraordinary air flow rate or uneven diffusion is inspected, clean the air diffusers according to the following procedure:

A. Fine-bubble air diffuser cleaning procedure

(i) Repeat the operation of turning on and off the blower several times or increasing and decreasing the blower air flow several times. This operation expands and contracts the rubber part of air diffusers and thus removes the sludge on their surface. From a preventive maintenance point of view, an installation of automatic diffuser cleaning system is one of the ways.

(ii) If the air flow rate or uneven diffusion is not resolved with this operation, try the next action described below.

Lift the module and take it out of the tank to the safety and steady place. Gently scrub the diffusers with a brush or use pressured water to remove the contamination from their surface. Generally, the diffusers can be cleaned with a tap water hose. If lime or other substance is tightly stuck to the diffusers, use a high-pressure cleaner to remove them. The cleaning time is five to ten seconds per air diffuser, though it depends on the contamination situation or the water pressure.

(iii) If the problem with the diffuser is not resolved with the above procedures, replace the air diffuser by following IX. PARTS REPLACEMENT, the section 4.

Be careful not to damage the rubber parts of air diffusers.

3. Chemical Cleaning of Element

(1) Timing of Chemical Cleaning

Continuous filtration of the sludge will eventually result in plugging of the element pores with trapped solids. Clogging of the membrane pores is indicated by a gradual increase in trans-membrane pressure (TMP). A chemical cleaning is recommended when any of the following conditions are observed.

A. When TMP rises by 3 kPa from its initial operating level (assuming the filtrate flow rate is the same), start cleaning preparation. Conduct a cleaning until the TMP rises by 5

kPa or every 6 months of operation, whichever comes first. For example, if an MBR was operated at 7 kPa TMP in its initial period, then 10 kPa is the trigger for preparation and chemical cleaning should be done before it reaches to 12 kPa.

B. When a sudden and significant increase of TMP is observed. Chemical cleanings are most effective in restoring membrane permeability if the membranes are not severely fouled. However, if you let the MBR operation continue until TMP reaches its upper limit, 20 kPa, then membrane fouling may get serious and chemical cleaning effectiveness can be less than expected. Follow the cleaning trigger described in above

.

C. The trend of TMP increase varies depending on the conditions of each plant (wastewater composition, operating conditions, biological treatment conditions, etc.). Monitor the TMP trends and consider an appropriate chemical cleaning cycle for the respective plant. Daily maintenance is also effective in extending the membrane's lifespan.

D. If the membrane permeability is not recovered by a single chemical cleaning, multiple chemical cleaning may be necessary to restore membrane performance. Repeat hypo cleaning or hypo/acid alternating cleaning, considering the foulant nature and TMP recovery.

(2) Chemical Agents Available for Chemical Cleaning

Select a cleaner that is most appropriate for the suspected foulant when considering chemical cleaning agents. Selecting an inappropriate cleaner can result in further loss in membrane performance or possible membrane damage. Table VIII-1 lists suitable cleaning chemicals and standard cleaning conditions.

Table VIII-1: Cleaning Chemicals and Standard Cleaning Conditions by Contaminant**

Contaminant	Chemical	Solution concentration	Amount used	Hold time
Organic matter	Sodium hypochlorite	2,000 - 6,000 mg/L (Effective chlorine concentration) (10<pH<12)	0.9 L/ element	1 to 3 hours
Inorganic matter (either of the two chemicals)	Oxalic acid*	0.5 - 1.0 wt%	0.9 L/ element	1 to 3 hours
	Citric acid	1.0 - 3.0 wt%	0.9 L/ element	1 to 3 hours

* Oxalic acid should not be applied when wastewater contains calcium, since calcium oxalate may form on the membrane surface which can choke membrane pores.

** It is not permitted to use chemical agents that are not described in this Toray MBR instruction manual and/or to apply excessive concentration of chemical agents, due to concerns of MBR performance decline. If those actions are taken without prior consultation, Toray does not take any responsibilities for Toray MBR

performance. In some cases, we may be able to propose appropriate measures or alternative solutions based on our achievements. Please contact us in advance if you are having any problems.

For the dilution water used in chemical preparation, RO water, tap water, or membrane filtrate water without suspended solids (SS) can be used. However, if soluble inorganic or organic substances are present, the active ingredients of the chemicals may be consumed, or precipitates may form. Check for chemical mixture in advance and ensure there are no issues during chemical preparation.

(3) Handling of Chemical Agents

Follow normal safety precautions when handling potentially harmful chemicals. Avoid direct contact with skin. Wear safety goggles, protective gloves, and other suitable safety gear to avoid injuries. Read the chemical Safety Data Sheet (SDS) information in advance to familiarize yourself with dangers and remedies should a chemical spill or contact accident occur.

Sodium Hypochlorite Solution / NaClO

A. Handling Precautions

(a) Ventilate well. Avoid heat sources and sparks. Also avoid contact with acids.
(b) Handle the chemical container with great care. Avoid toppling, bumping, or dragging it.
(c) Take care not to spill liquid chemicals and avoid breathing in vapors. In the case of dry chemical powders, handle in a manner that minimizes the formation of chemical dust.
(d) Securely seal all chemical containers after each use.
(e) Thoroughly wash your hands and face and rinse out your mouth after using chemicals.
(f) Do not eat or drink anything in the working place except in a designated place.
(g) Do not bring gloves or other contaminated protectors into the rest area.
(h) Forbid unauthorized entry to the place where chemicals are handled.
(i) Wear appropriate protectors to avoid inhalation, eye or skin contact, and direct contact with your clothes.
(j) Provide local ventilation in the case of handling chemicals indoors.

B. Storage Precautions

(a) Store the container in a dark, cold place. Avoid direct sunlight. Firmly seal to prevent direct contact with air.
(b) Use corrosion-resistant containers for storage.

Oxalic Acid / $(COOH)_2$

A. Handling Precautions

(a) Keep away from strong oxidants and bases.
(b) Handle the chemical container with great care. Avoid toppling, bumping, or dragging it.
(c) Take care not to spill liquid chemicals and avoid breathing in vapors. In the case of dry chemical powders, handle in a manner that minimizes the formation of chemical dust.
(d) Securely seal all chemical containers after each use.

(e) Thoroughly wash your hands and face and rinse out your mouth after using chemicals.
(f) Do not eat or drink anything in the working place except in a designated place.
(g) Do not bring gloves or other contaminated protectors into the rest area.
(h) Forbid unauthorized entry to the place where chemicals are handled.
(i) Wear appropriate protectors to avoid inhalation, eye or skin contact, and direct contact with your clothes.
(j) Provide local ventilation in the case of handling chemicals indoors.

B. Storage Precautions
(a) Store the container in a dark, cold place. Avoid direct sunlight. Firmly seal to prevent direct contact with air.
(b) Use corrosion-resistant containers for storage.

Citric Acid / $HOOCCH_2C(OH)(COOH)CH_2COOH$

A. Handling Precautions
(a) Keep away from strong oxidants and bases.
(b) Handle the chemical container with great care. Avoid toppling, bumping, or dragging it.
(c) Take care not to spill liquid chemicals and avoid breathing in vapors. In the case of dry chemical powders, handle in a manner that minimizes the formation of chemical dust.
(d) Securely seal all chemical containers after each use.
(e) Thoroughly wash your hands and face and rinse out your mouth after using chemicals.
(f) Do not eat or drink anything in the working place except in a designated place.
(g) Do not bring gloves or other contaminated protectors into the rest area.
(h) Forbid unauthorized entry to the place where chemicals are handled.
(i) Wear appropriate protectors to avoid inhalation, eye or skin contact, and direct contact with your clothes.
(j) Provide local ventilation in the case of handling chemicals indoors.

B. Storage Precautions
(a) Store the container in a dark, cold place. Avoid direct sunlight. Firmly seal to prevent direct contact with air.
(b) Use corrosion-resistant containers for storage.

WARNING	Chemical agents used for chemical cleaning can be harmful to one's health. Wear protective goggles, protective gloves, and other safety gear when handling chemicals. Make sure to check the details of its material Safety Data Sheet (SDS) beforehand.
WARNING	If chemicals come in contact with your skin or clothes, immediately wash the contacted area with a large volume of running water.

 WARNING	If chemicals splash into your eyes, immediately flush with large volumes of running water and contact a doctor.
 WARNING	Store chemicals in a dark, cold place free from direct sunlight.
 WARNING	Use chemical storage tanks constructed of chemically compatible materials to prevent corrosion.
 WARNING	Never mix sodium hypochlorite with heavy metals or acids. The resulting chemical reaction will generate toxic chlorine gas.

(4) Element Chemical Cleaning Procedure

Chemical cleaning involves injecting the chemical solution through the filtrate nozzle to fill the element, allowing the solution to permeate from the inside to the outside of the membrane for cleaning.

When injecting a chemical solution, do not exceed the injection pressure of 10 kPa and inject the specified amount within 5 minutes. To achieve proper injections, incorporate a pressure relief pipe, select a pump with the appropriate specifications, and configure the piping with consideration of pressure loss.

The upper limit of injection pressure refers to the actual pressure applied to the membrane, not the pressure from the supply source such as a pump. Therefore, the pressure relief pipe should be positioned as close to the membrane as possible, after accounting for pressure drops due to piping resistance. During trial operations with clean water, adjust and confirm the equipment settings and valve openings to ensure the required liquid amount can be supplied below the upper pressure limit.

While the basic equipment is common, the flow of chemical cleaning varies depending on the position of the filtrate piping and the method of chemical injection. Figure VIII-2 presents the flow diagram for the filtrate downward discharge piping using head injection or pump feed, and Figure VIII-3 presents the flow diagram for the filtrate upward discharge piping using head injection or pump feed. Operating procedures are common for both diagrams, but for head injection, the description related to pump operation (underlined and italicized parts) is not necessary.

Chemical Cleaning Procedure

(i) Confirm that the chemical injection valve is closed *and that the chemical feed pump is in the off position*.

(ii) Using the chemical tank, mix the desired amount and concentration of chemical solution.

(iii) Stop the filtration process, stop air scouring, and finally close the filtrate valve.

(iv) Open the pressure relief valve.

(v) Open the chemical injection valve to the adjusted valve opening position *and start the chemical feed pump at pump operating conditions*.
(vi) Monitor to ensure that the chemical solution is being injected without leaking from the pressure relief pipe.
(vii) After injecting the specified amount of chemicals to the elements, which should be done within 5 minutes, *stop the chemical feed pump*, and close the chemical injection valve.
(viii) Allow the elements to soak for 1 to 3 hours.
(ix) Start the module aeration and stir/mix the sludge for 5 minutes.
(x) Check the sludge for abnormalities, close the pressure relief valve, open the filtrate valve, and resume the filtration process.

* When starting up the MBR after a chemical cleaning, some residual cleaning chemical may be present in the filtrated water for 2 or more filtration cycles. It is recommended that the filtrate flow be directed back into the raw water tank until no residual cleaning chemical is detected. Before directing the filtrate from the raw water tank back to the normal filtrate discharge line, test the filtrate pH and chlorine concentration.
* If air remains in the chemical injection path (chemical piping, filtrate piping, etc.), it can cause an airlock, preventing smooth chemical injection. To prevent this, switch open/close of valves while ensuring each pipe is fully filled, and provide a line to release any remaining air. Create procedures and equipment to prevent air from mixing with the chemical injection, which will prevent airlocks.

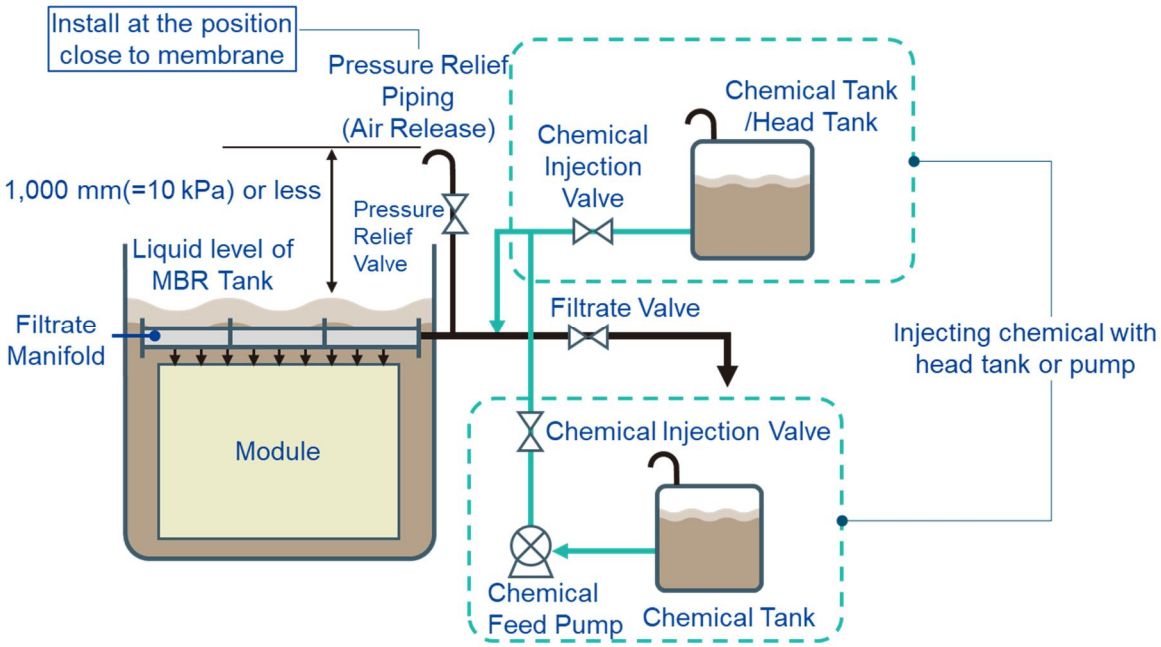


Figure VIII-2: Chemical Cleaning Flow Diagram (Filtrate Downward Discharge Piping)

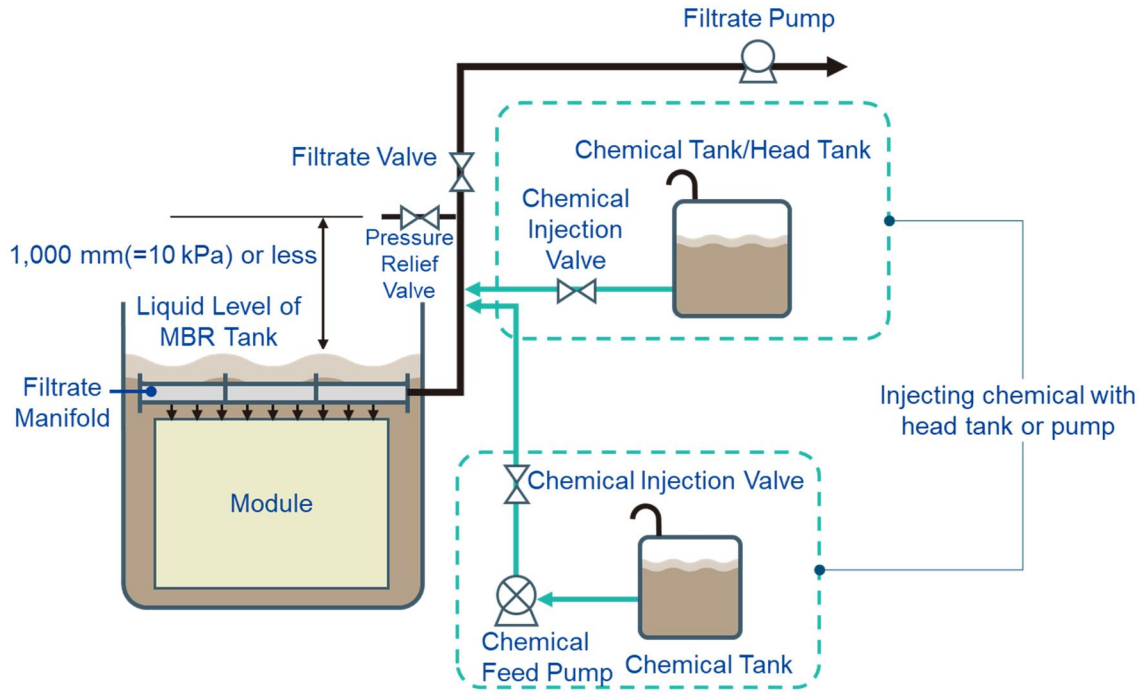


Figure VIII-3: Chemical Cleaning Flow Diagram (Filtrate Upward Discharge Piping)

WARNING	Ensure that the pressure relief valve is opened and free of clogs before injecting chemicals. Excess internal element pressure will damage the membranes.
WARNING	Chemicals may splash or leak from the pressure relief valve. Make any necessary adjustments to the chemical feed flow. Use the safety equipment such as goggles and gloves when inspecting discharge piping and making adjustments.

Precautions for Element Chemical Cleaning

A. **Keep the injecting pressure below 10 kPa.** Direct chemical injection from the chemical pump without a pressure relief part will raise the pressure above 10 kPa, which can result in damage to the element or module. Chemical injection rate is affected by such as the fouling condition of the membrane, the amount of chemical already injected, or the remaining air. Remove the air from the chemical pathway, ensure that no air is entrained in the injected chemical, and complete the injection within five minutes.

B. Make certain the module is completely submerged in the tank prior to injecting any chemicals. The liquid level above the module should be maintained at 500 mm or higher.

C. Elevated chemical cleaning solution temperatures increase the membrane cleaning effectiveness. However, make certain not to allow the chemical solution temperatures to

exceed 40 deg C. Conversely, lower chemical solution temperatures reduce the effectiveness of the chemical cleaning process. Try to maintain the chemical solution temperature as high as possible under 40 deg C.

D. When starting up the MBR after a chemical cleaning, some residual chemical solution may be present in the filtrate water for 2 or more filtration cycles. It is recommended that the filtrate flow be directed back into the raw water tank until no residual chemical solution is detected. Before directing the filtrate from the raw water tank back to the normal filtrate discharge line, test the filtrate pH and chlorine concentration.

E. **If a sodium hypochlorite cleaning is immediately followed by acid cleaning or in reverse order, make certain that these chemicals never contact with one another in the chemical tank or piping.** Mixing of the two chemicals will generate toxic chlorine gas.

F. For the dilution water used for chemical solution, you can use waters that are free of suspended solids (SS), such as RO water, tap water, or filtrate water. However, if the water contains soluble inorganic or organic substances, the active ingredients of the chemicals may be consumed, or precipitates may form. Confirm the mixture in advance and check during chemical preparation.

G. As a result of contacting with hypo solution, some activated sludge nearby membrane surface can be destroyed, which leads to a foaming issue. This sludge damage will be recovered in the course of time after operation restart and thus not a big trouble.

! WARNING	Immediately stop the chemical cleaning operation if any of the associated cleaning equipment appears to be malfunctioning.
! WARNING	Never mix sodium hypochlorite with heavy metals or acids. The resulting chemical reaction will generate toxic chlorine gas.
! WARNING	Do not inject any chemical into the membrane directly from the chemical pump discharge. Excessive element internal pressure will damage the element. Be sure to inject chemicals at a pressure less than 10 kPa.
! WARNING	Before starting injecting chemical to elements, confirm that the MBR tank liquid level is more than 500 mm above the top of the module.
! CAUTION	To avoid splashing of chemical solution, turn off the air scouring during a chemical cleaning.

IX. PARTS REPLACEMENT

1. Lifting Element Deck /Aeration Block

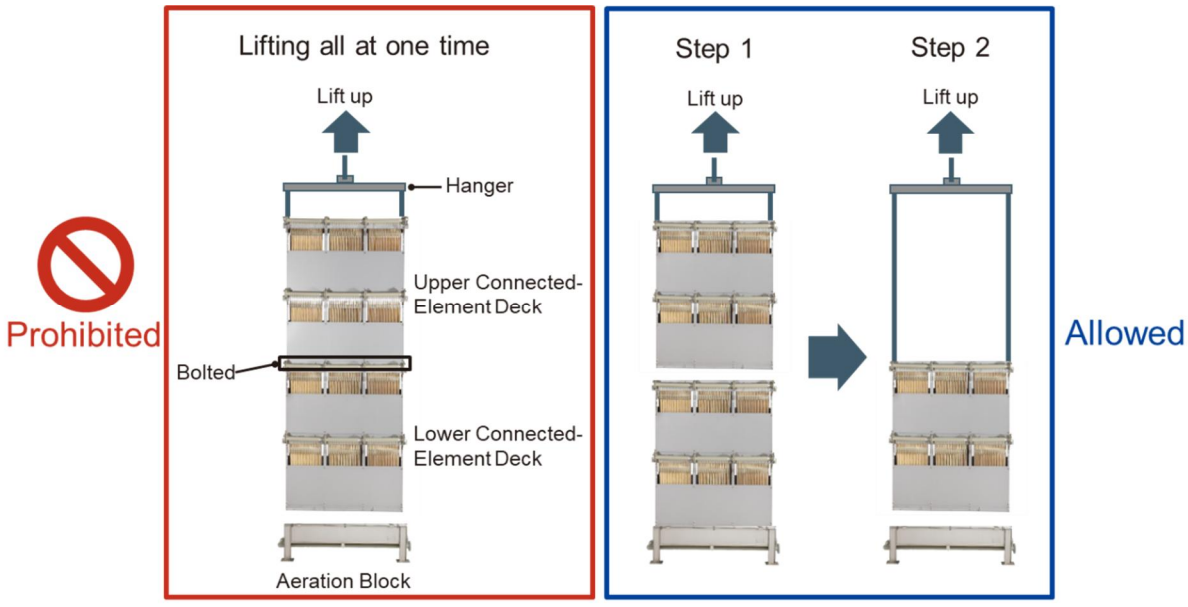
To replace the module components, it is necessary to take out an element deck and aeration block from the MBR tank. When lifting up or down the element deck or aeration block, follow the steps below. Additionally, regularly removing the element deck to check its condition and perform necessary maintenance is effective for the operation and maintenance of the MBR.

(1) If the element deck is fixed to the aeration block with bolts and nuts, discharge all the activated sludge from the MBR tank, and then remove the bolts and nuts connecting the element deck and the aeration block. If the installation uses guide rails, skip this step as the element deck is not fixed to the aeration block.

(2) Disconnect the filtrate manifold from the filtrate line. When guide rails are used for installation, remove the sludge up to the height of the disconnecting piping before disconnecting if the position of the piping is below the operating liquid level.

(3) Hook the chain/sling attached with an element deck to a hanger.
Connect the hanger which has four proper loading points at its corners and the element deck with chains or slings. For safe lifting of the element deck, very slowly raise the element deck straight up and avoid sudden changes in movement to minimize shaking the element deck.

(4) When lifting NHPA150-3C/F or 4C/F that consists of element deck and/or connected element decks, do not lift the upper and lower element decks/connected element decks all together. The upper/lower element deck/connected element deck has to be lifted one by one to avoid distortion or damage to the element decks which may cause severe accident. See the instruction below.



(5) The aeration block can be taken out after the element deck is taken out. When removing the aeration block for inspection or parts replacement, remove the anchor bolts fixed at the bottom of the tank and lift it out.

DANGER	Attach chains or slings to the lifting lugs when lifting “NHPA Series”. Slowly raise the module straight up. Avoid sudden changes in movement to minimize shaking the module. Never allow operators to stand under the “NHPA Series” during lifting.
DANGER	Use chains or slings with sufficient load rating to lift the weight of the "NHPA Series" or any of its components. Before lifting the element deck or aeration block, check the condition of each part and if any damage that could be a safety hazard is found, stop the work.
DANGER	Never lift the three or four stacked element decks (NHPA150-3C/F or 4C/F) at once. When installing or removing element decks, lift one element deck or one connected element deck that consists of two individual element decks stacked and bolted together.
CAUTION	Wear the appropriate personal protective equipment (e.g. work gloves) in order not to cut hand on the edge of the module frame.
CAUTION	If an aeration block of fine-bubble type is exposed to atmosphere, clean the air diffuser. Dry sludge on the surface of the air diffuser could cause damage to the rubber components.
CAUTION	Keep the membranes wet once they get wet. If the membranes are allowed to dry out, the permeability of the membranes may be permanently reduced.

2. Replacing Cassette

Regarding the replacement method for the NHPA series cassette ECS035, this section specifies the replacement procedure: taking out/inserting a cassette from/into a frame.

(1) See the chapter V, sections 1 to 4, for the procedures of receiving, checking, and storing a cassette.

(2) Preparation for Replacing

A. Recommended Tools

Refer to Table IX-1 for the recommended tools for replacement work and prepare them accordingly.

Table IX-1: Recommended Tools for Replacement

Tools		Specification	Quantity	Remarks
Cleaning	- Washing place	5×10 m	A	To remove sludge with water
	- Pressure washer machine		2	To remove dirt from components other than a membrane module
	- Hose	With on/off switchable spray nozzle	2 × A	To wash a membrane surface
	- Square timber	20 cm squares x 60 ~ 80 cm length	2 × B 3 × B 4 × B 8 × B	To replace a cassette of EBL050 To replace a cassette of EBL100 To replace a cassette of EBL150 To replace a lower cassette of a connected EBL150
	- Scaffold	Portable	2 × A	
Hand Tools	- Socket wrenches	13 mm,17 mm, and 19 mm	C	To assembly/disassembly a membrane module
	- Box end wrenches	13 mm,17 mm, and 19 mm	C	Same as the above
	- Wrench extender	For socket wrenches	C	Use when having difficulty with a standard wrench
	- Flex Socket Wrench	19 mm	C	Use when having difficulty with a standard wrench
	- Offset Box Wrench	19 mm	C	Use when having difficulty with a standard wrench
	- Torque wrench	Adapt to each size of socket	A	To manage a torque
	- Pallet		2 × A	A place for module components
	- Bucket		2 × A	Temporary storage of removed bolts and nuts
Other Tools	- Cassette		Required quantity	Unused and new
	- Tarpaulin		Proper quantity	To cover the module being worked on

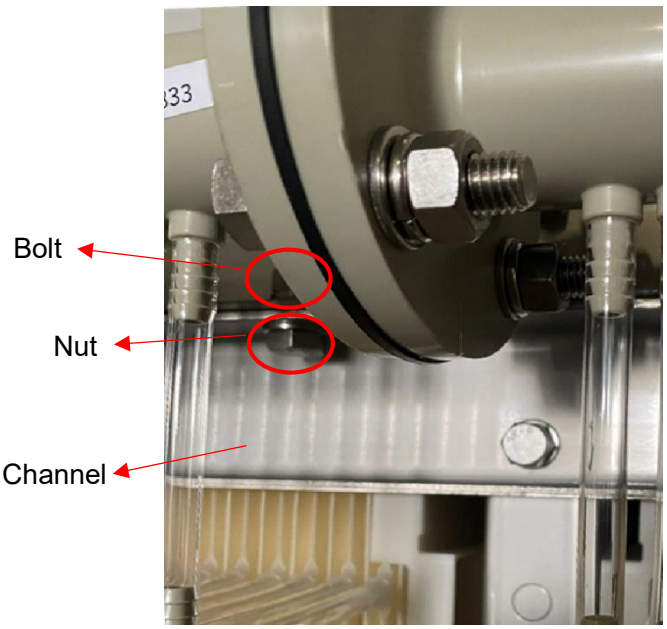
A: The number of cleaning teams

B: The number of element decks (EBLs) that are set aside temporarily

C: The number of operators in a cleaning team

B. Overall

- As shown in Figure IX-1, this manual describes the procedure for replacing the cassette on the right side of the NHPA150 element deck (single-stack type), as viewed from the filtrate manifold. For the NHPA050 and NHPA100 models, the lengths of the components that hold the cassettes vary depending on the number of cassettes installed. However, if the element deck is a single-stack type, the basic replacement procedure remains the same.
- A cassette should be taken out or inserted from the side where the filtrate manifold is located.
- The NHPA150 includes connected element deck(s). Each connected element deck consists of two individual element decks stacked and bolted together. The upper cassette of a connected element deck can be replaced while the decks are bolted, and the procedure is the same as that for the single-stack type. On the other hand, when replacing the lower cassette, the two bolted decks must be separated, and the replacement must be carried out on a single-stack element deck.
- During the procedures in steps (8) and (11), the bolts of the upper channel are positioned on the back of the filtrate manifold, which may make the work difficult using standard tools. Use proper tools like a socket wrench with wrench extender.
- The procedures in the step (4), when separating the upper and lower element decks, the bolt/nut at the filtrate manifold are positioned on the back of the manifold, which may make the work difficult using standard tools. Use proper tools such as a 19 mm flex socket wrench to reach the bolt at the top side of the channel, and a 19 mm offset box wrench to reach the corresponding nut at the opposite side of the channel.



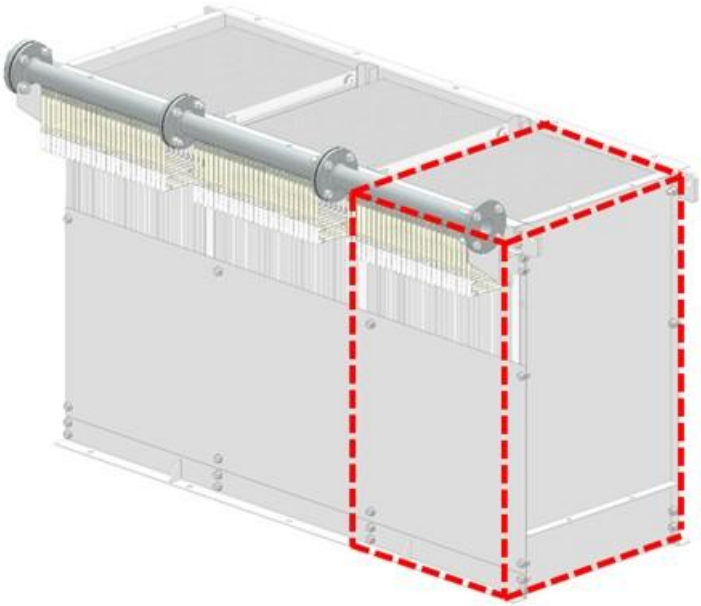


Figure IX-1

(3) Taking out an Element Deck and Placing at a Working Area

Prepare square timbers as follows, in each size of 20 cm x 20 cm x 60 ~ 80cm.
EBL050: 2 square timbers
EBL100: 3 square timbers
EBL150: 4 square timbers for single stack deck,
8 square timbers when replacing the lower cassette of two stacked decks

Place the square timbers at the proper positions on a flat floor shown in Figure IX-2 so that the center of each square timber will be under the bolt of the frame.

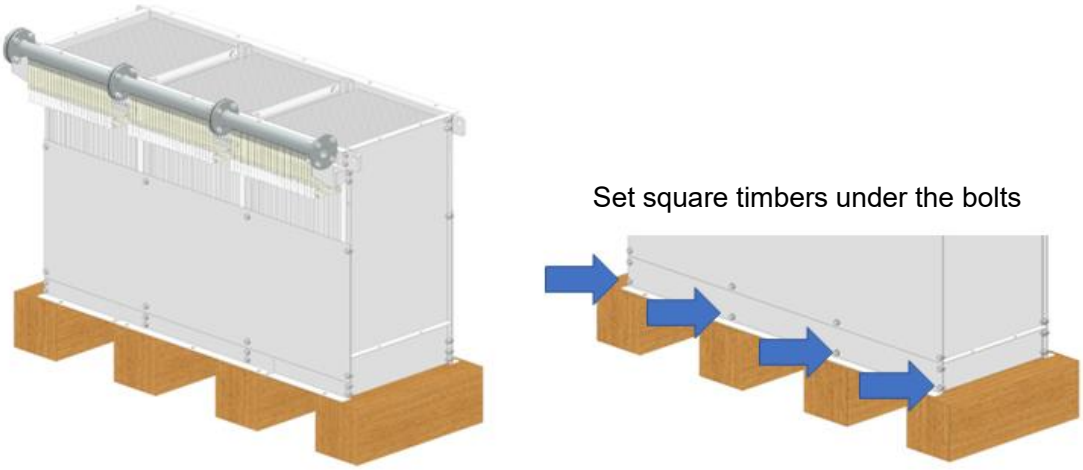


Figure IX-2

DANGER

Choose the appropriate size, number, and arrangement of square timbers to ensure the stability of an element deck. An unstable condition may cause the element deck to be damaged or fall.

Lift the element deck from the tank using a crane, wash off sludge on the outer surface of the element deck with hose water while hanging it over the tank, and place it on the prepared square timbers.
Check and record the lot number of the element deck.

CAUTION

Always use hose water to remove the sludge surrounding an element deck.
Never use a pressure washer machine because the high-pressure water can cause fatal delamination of membrane.

(4) Separating Two Stacked Element Decks (a connected element deck)

NHPA150-2, -3, and -4C/F include one or two connected element decks. Each connected element deck consists of two individual element decks stacked and bolted together.
If replacing a cassette on the upper deck, proceed directly to step (5), as no additional work is required. If replacing a cassette on the lower deck, the connected element deck must be separated, since the weight of the upper deck is applied to the lower deck.
Refer to Figure IX-3 for instructions on removing the bolts and nuts that connect the two element decks.
The bolts at the filtrate manifold side are positioned on the back of the filtrate manifold. Use proper tools to reach the bolts, such as a 19 mm flex socket wrench for the top-side bolt of the channel, and a 19 mm offset box wrench for the bottom-side bolt.
After separating the upper and lower decks, place each deck on the square timbers as prepared in step (3).

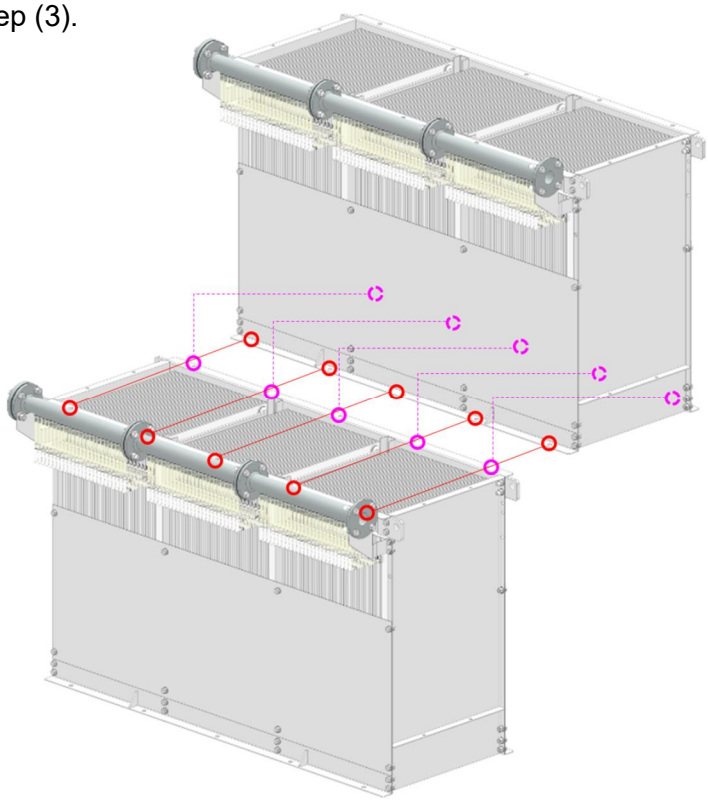


Figure IX-3

(5) Detaching the Flanges of the Filtrate Manifold on the Cassette to Be Replaced

Detach the bolts set that connects the flange of the filtrate manifold to take out the cassette to be replaced. The flange of the filtrate manifold shown in Figure IX-4 is connected on one end to the next cassette's filtrate manifold and on the other end to the filtrate riser pipe or blank flange.

4 positions on one end (a total of 8 positions on both ends) are attached with M12 bolts of length 50 mm, washers, spring washers, and nuts (hereinafter called "bolts set"). Use a size 19 wrench to unscrew the bolts set.

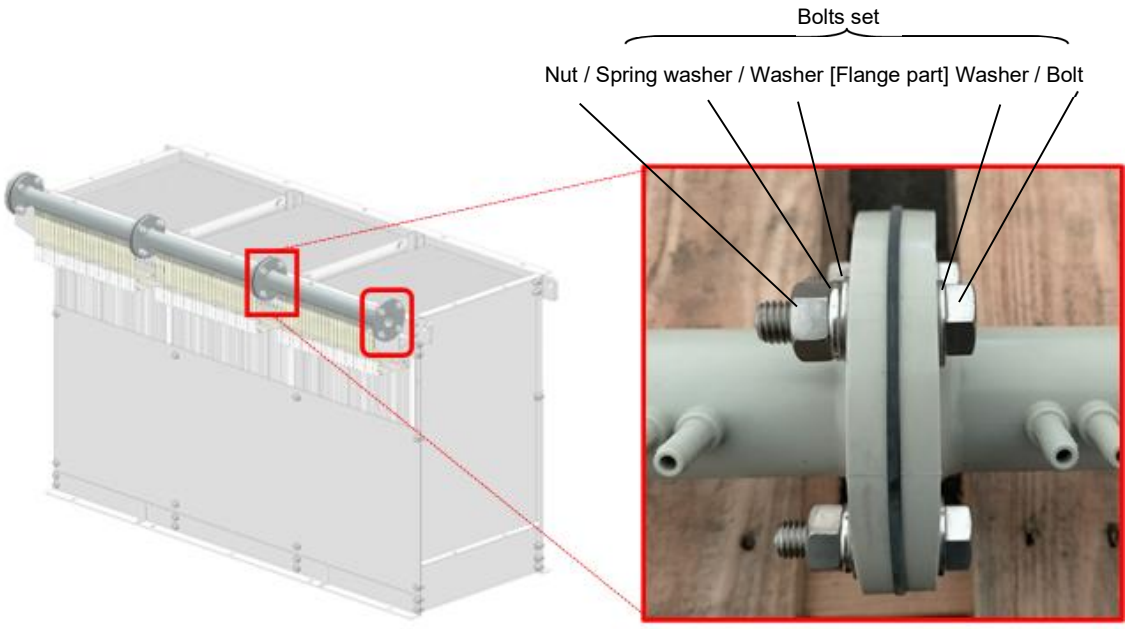


Figure IX-4

(6) Detaching the Side Plate

The side plate is fixed at 8 positions with M10 bolts set of length 20 mm. The bolts set used at the center supports, where nuts are welded on the backside of the frame, and at both ends supports are different.

Supports at the center: M10 bolt of length 20 mm, spring washer, washer.

Supports at both ends: M10 bolt of length 20 mm, washer, [connecting part], washer, spring washer, and nut.

Use a size 17 wrench to unscrew the bolts and detach the side plate.

* All bolt combinations are as described above with/without nut welding.

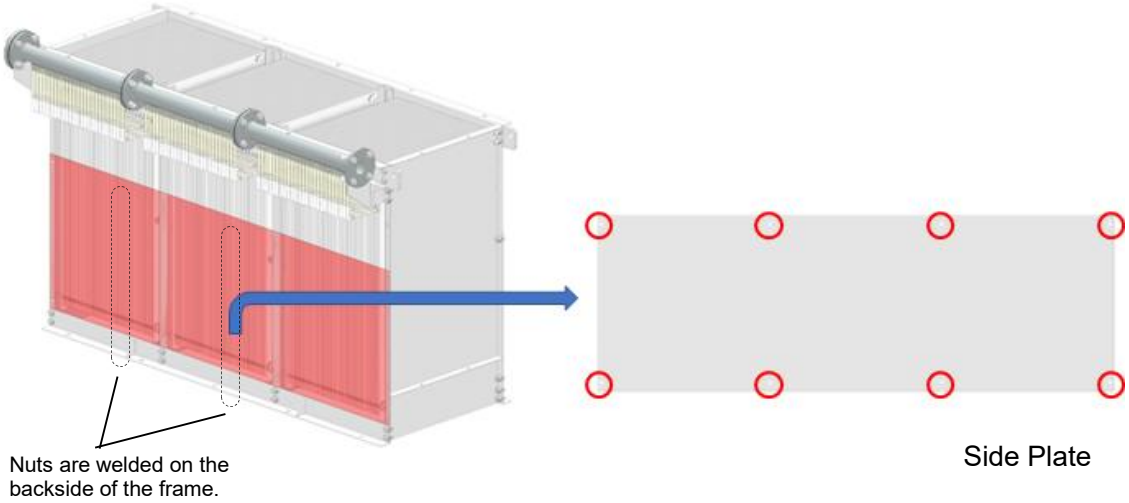


Figure IX-5

WARNING

When unscrewing the bolts, especially the last one, from the components, operators should hold the components to prevent falling, damaging, and injuring. Also, be careful to handle the components with sludge on them because they may have become heavier.

(7) Detaching the Filtrate Manifold Brackets

Manifold brackets are attached to both the right and left ends of the element deck.
If replacing the right cassette, as shown in the example in this manual, detach the right bracket. If replacing the center cassette, detaching the bracket is not necessary, as it does not interfere with the cassette.
A bracket is fixed at 2 positions with M8 bolts set of length 20 mm. Use a size 13 wrench to unscrew the bolts.

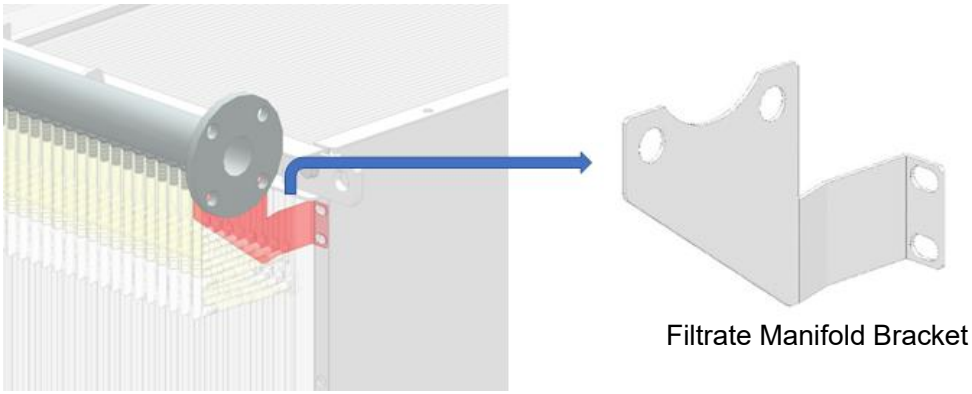


Figure IX-6

(8) Detaching the Top Channel

The top channel is fixed with M10 bolts set of length 20 mm at 2 center positions and of length 40 mm at 4 positions on both ends. Nuts are welded on the backside of the frame at the 2 center supports.

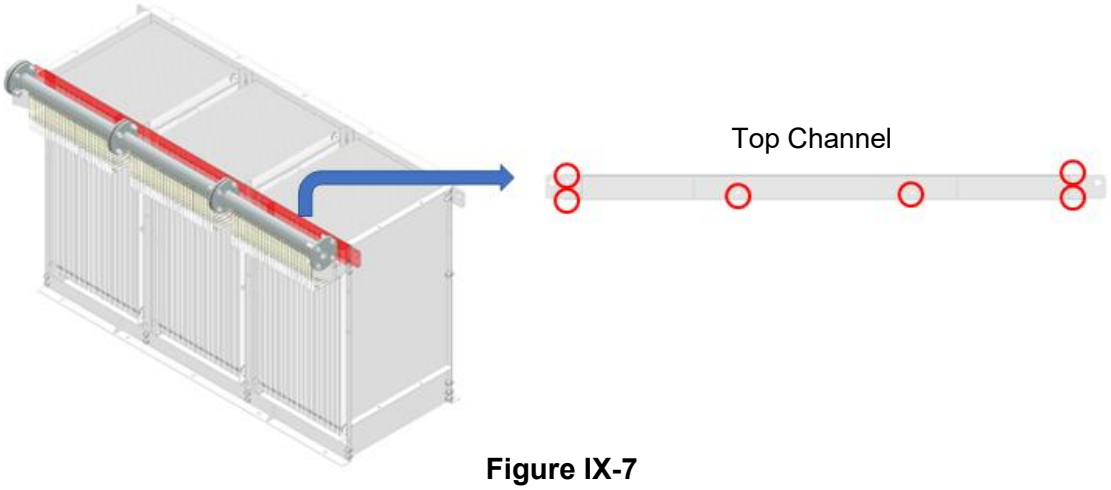


Figure IX-7

(9) Taking out a Cassette

Taking out the cassette to be replaced.
Check the condition of sludge adhesion between the membranes. Sludge makes a cassette heavier. Therefore, carefully remove sludges between the membranes of the cassette to be taken out with hose water to avoid damaging the membranes.
A cassette is hooked with 4 rods at its four corners both right and left sides, which is that total of 8 rods are hooked on the rail. Move the cassette along the rail and take it out.

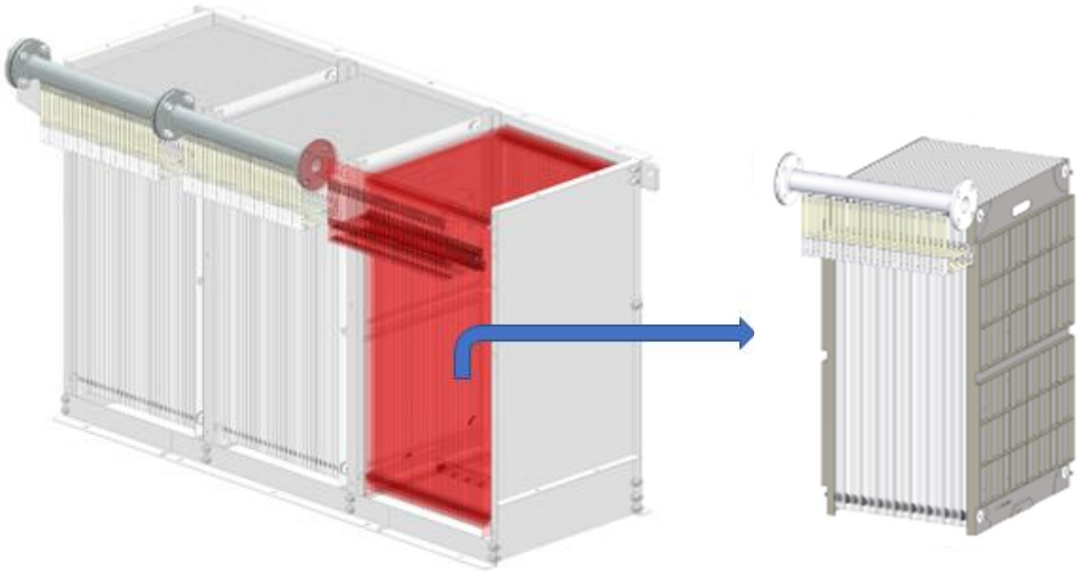


Figure IX-8

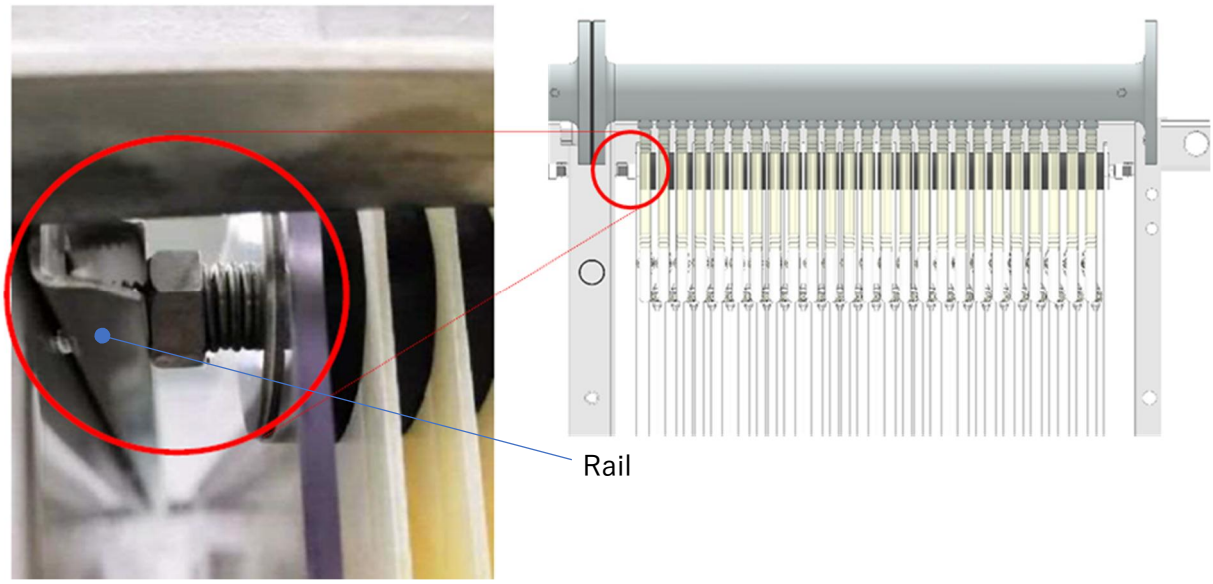


Figure IX-9

Pull out the cassette slowly while holding the membrane side panels to avoid damaging the membranes. There is the grip on the top center of the side panel. After pulling the cassette out to the position where you can hold the grips, hold the grips and slide out the cassette along the rail.

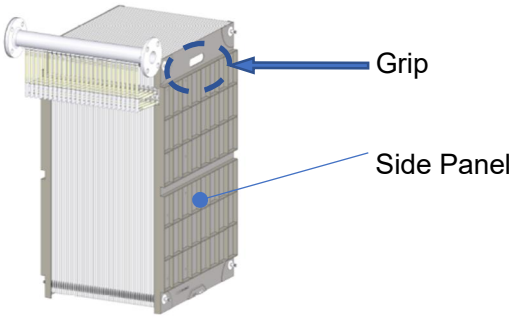


Figure IX-10

WARNING	Wear the appropriate personal protective equipment (e.g., safety gloves) in order not to cut hands by the membrane side plate or the edge of the module frame.
WARNING	Cassettes are very heavy: 18 kg when unused and dry, 25 kg when used and wet without sludge. Pull the cassette out slowly and straight along the rails with two operators to avoid distortion.
CAUTION	Hold the grips on both side plates to avoid damaging the membranes when handling the cassette.

(10) Inserting a new cassette

Take out a new cassette from a box, check the outer surface of the cassette for damage, and confirm that all the filtrate tubes are surely inserted all the way to the end of the nozzles. If no problems are found, insert the new cassette into the frame. Hook the 4 rods which will be on the opposite side of the filtrate manifold onto the rail. Insert the cassette slowly along the rail and hook the 4 rods on the filtrate manifold side onto the rail. Push the cassette until it reaches the back of the frame.
Record the lot numbers of both the removed and new cassettes, as well as the replacement position in the element deck.

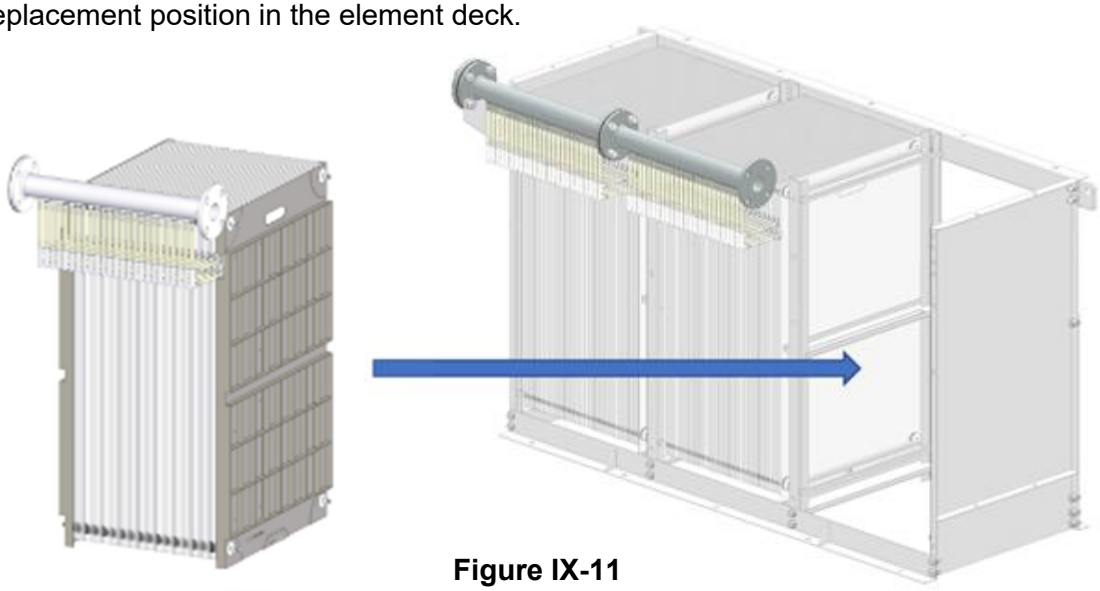


Figure IX-11

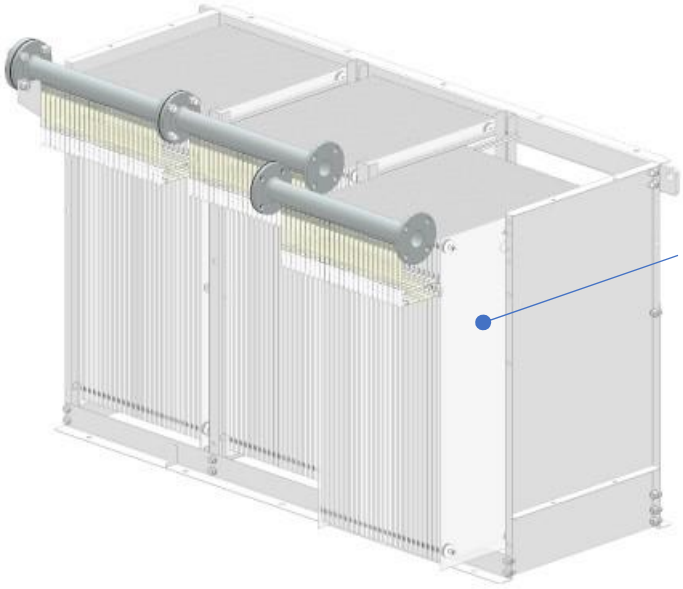


Figure IX-12

WARNING

Cassettes are very heavy: 18 kg when unused and dry, 25 kg when used and wet without sludge. Pull the cassette out slowly and straight along the rails with two operators to avoid distortion.

WARNING	Wear the appropriate personal protective equipment (e.g., safety gloves) in order not to cut hands by the membrane side plate or the edge of the module frame.
CAUTION	Hold the grips on both side plates to avoid damaging the membranes when handling the cassette.
CAUTION	Insert the cassette into the frame slowly and straight along the rails to avoid distortion.
CAUTION	Make sure that all rods of the cassette are hooked on the rail. Insecure suspension of the rods can cause the cassette to fall from the element deck during operation.

(11) Attaching the Top Channel

Attach the top channel with M10 bolts set of length 20 mm at 2 center positions and of length 40 mm at both ends. Nuts are welded on the backside of the frame at the 2 center supports.
Use a size 17 wrench and tighten torque of 24.5 N·m.

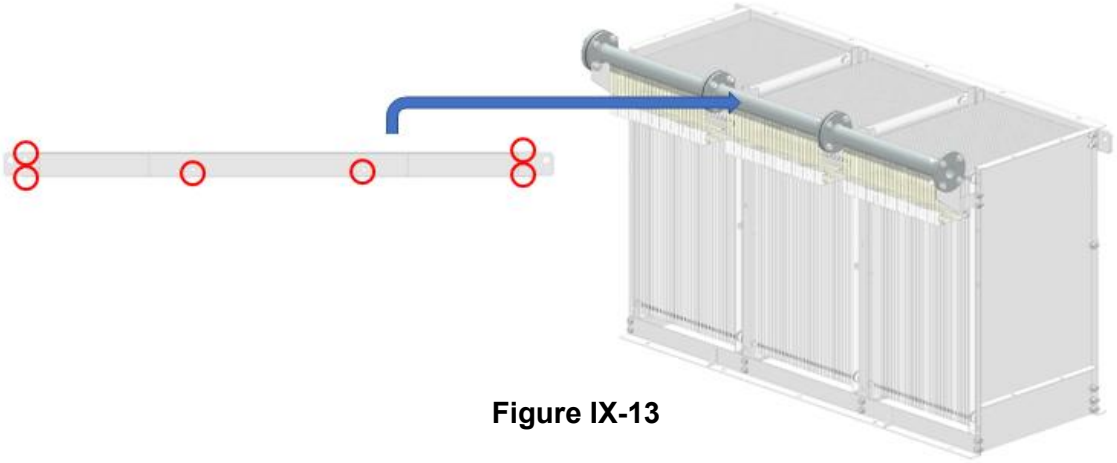


Figure IX-13

(12) Attaching the Side Plate

Tighten the side plate to a torque of 10 N·m.

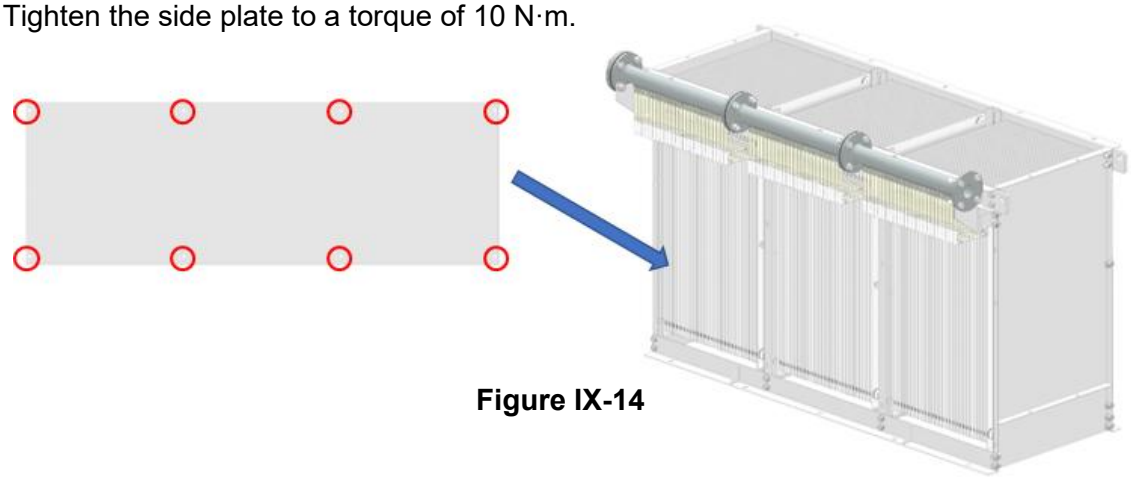


Figure IX-14

(13) Returning the Filtrate Manifold Brackets

Use a size 13 wrench and tighten the filtrate manifold brackets that has been removed to a standard torque of 12.5 N·m.

(14) Fixing the Filtrate Manifold Flanges

Attach the bolts of the filtrate manifold flanges on the replaced cassette and the cassette under it. Tighten them using a size 19 wrench to a torque of 10 N·m.

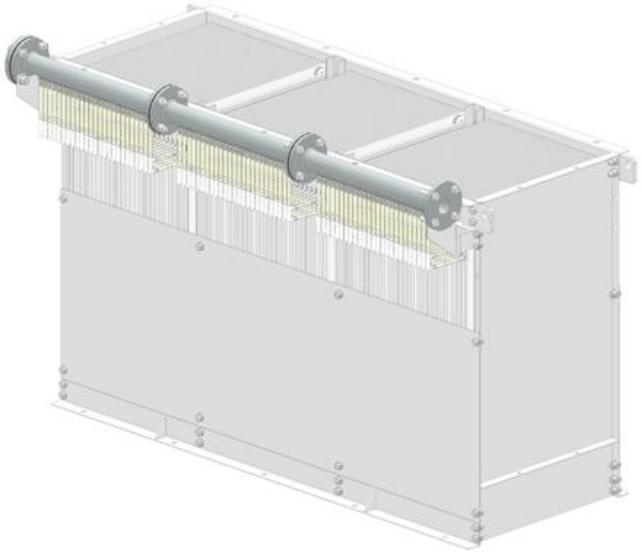


Figure IX-15

CAUTION

Check spring washers securely fixed after screwing the bolts and nuts of manifold flange with a torque. If the spring washer is sufficiently bent, that's sufficient. Over-tightening can deform the flange.

(15) Bolting Two Element Decks (the case of the connected element deck)

If the connected element deck has been separated for cassette replacement, lift the upper element deck using a crane and place it onto the lower deck. Reconnect the two decks using bolts and nuts.

The bolts at the filtrate manifold side are positioned on the back of the filtrate manifold. Use proper tools to access the bolts, as used during disassembly. Tighten them with a 19 mm wrench to a torque of 42 N·m.

(16) Returning the Element Deck

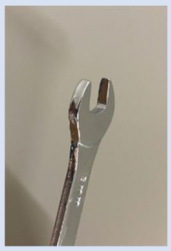
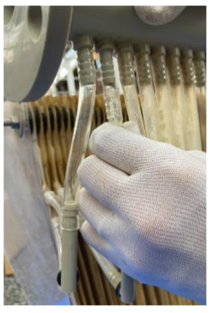
Check that the components are all set, and bolts and nuts are all tightened securely. Return the element deck into the MBR tank.

3. Replacing Filtrate Tube Assembly

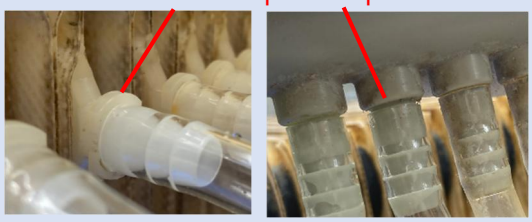
This section explains how to safely replace individual Filtrate Tube Assembly (hereinafter called FTA) connecting element to filtrate manifold of NHPA MBR membrane module. Operators should thoroughly read this section and acknowledge that the replacement work has potential risk of damaging cassette and module components, and/or loss of filtration integrity (sludge leakage).

	Be sure to use Toray approved replacement parts.
	Contact Toray sales department to obtain information on how to order Toray approved replacement parts.
	Make certain the tube is securely attached to the element nozzle and manifold when replacing the individual filtrate tubes to the filtrate manifold.
	Do not apply excessive force to the nozzle and element when replacing filtrate tubes. Excessive force may result in element/filtrate manifold damage.
	Once a filtrate tube has been removed or disconnected from either the element nozzle or filtrate manifold it should be replaced with a Toray approved replacement part. Old filtrate tubes lose their elasticity, and the integrity of the seal can be compromised.

NHP Filtrate Tube Assembly (FTA) Replacement Procedure

	Steps	Remarks
1	Prepare the following tools. ✓ NHP cassette ✓ New FTA(s): Purchase from Toray ✓ Open-end wrench: size 8mm (5/16”), thickness 3mm (thin type) ✓ Hot water: 55-65 deg C, max. 70 deg C ✓ Gloves   	➢ Replacement should be done without taking cassette out from NHP module SS frame. (It can also be done after taking cassette out from the frame.) ➢ To maintain sealing performance, do not replace any parts of the FTAs individually. Instead, replace the FTAs by cassette units (25 tube sets per cassette). ➢ Remove sludge and debris attached around the FTAs to be replaced. ➢ Never use tools other than the open-end wrench specified in the left column, such as thick wrench or pliers, for protecting element nozzle and membrane surface from unintended damage. ➢ Never use hot water above 70 deg C, alternative heating tools like hair dryer, or lubricant. These will deform the tube and lose its integrity.
2	Remove used all FTAs to be replaced from the cassette.   	➢ If the clip is attached, remove it. ➢ Remove the tube towards the nozzle direction. ➢ Make sure not to break the nozzles on the elements and the filtrate manifold. Never pose an impact to the element nozzle when applying the wrench. This may lead to the MBR operation difficulty as those nozzles cannot be replaced. ➢ Never twist or bend the nozzles. Never use non-specified tools such as driver, cutter, or scissors. ➢ The removed FTAs and clip cannot be reused.
3	Repeat the steps No.4 to 6 below until replacing all necessary FTAs.	➢ Complete connection of one new FTA first, then move to the next FTA. One by one. ➢ We assume one person per one cassette for the replacement work.

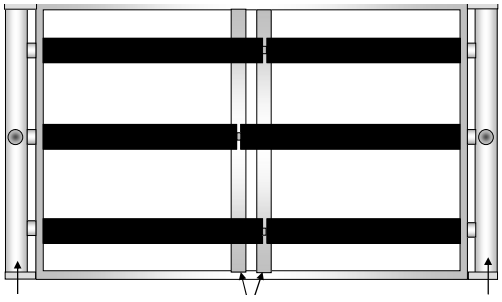
4	Dip both ends of one new FTA into hot water. 	➢ Dip approximately 10 mm from the tip of the tubes into hot water for 3 seconds. Do not dip more than 10 mm for maintaining the rigidity of the FTA other than tips. **CAUTION** Hot temperature ➢ Never use hot water above 70 deg C or alternative heating tools like hair dryer which will deform the tube and lose its integrity.
5	Connect the horizontal tubes of the new FTA with two elements.   Holding the nozzle by wrench (close-up) 	➢ Hold the base of the element nozzle with the open-end wrench firmly so the nozzle won't sway. ➢ Hold the tube at 15 to 20 mm from the tip and connect it straight and completely to the base of the element nozzle. Refer to the step No.7. ➢ An FTA has two connection tubes with the element nozzles, one for upper nozzle and the other for lower nozzle. ➢ Make sure not to break the nozzles on the elements. Never pose an impact to the element nozzle when applying the wrench. This may lead to the MBR operation difficulty as those nozzles cannot be replaced. ➢ Never twist or bend the nozzles. Never use non-specified tools other than open-end wrench. Never apply lubricant to the nozzles or tubes.
6	Connect the vertical tube of the new FTA with the manifold. 	➢ Hold the manifold firmly so the filtrate manifold nozzle won't sway. ➢ Connect the tube completely to the base of the filtrate manifold nozzle. Refer to the step No.7. ➢ Make sure not to break the nozzles on the filtrate manifold. This may lead to the MBR operation difficulty as those nozzles cannot be replaced. ➢ Never twist or bend the nozzles. Never use non-specified tools. Never apply

		lubricant to the nozzles or tubes.
7	Confirm the complete connection of all tubes inserted to the base of the nozzles. Insert tubes up to this point 	➢ Insert completely to each nozzle if finding incomplete connection. Refer to left photos.
8	Attach the clip.  FTA replacement completed. 	➢ If the tube sets are the type with a clip, attach a new clip. ➢ Ensure that the tubes are properly inserted, all parts are attached, and there are no twists in the tubes and parts.

4. Replacing Fine-bubble Air Diffuser

When replacing a fine-bubble air diffuser, discharge the sludge from the MBR tank to enable the replacement of the aeration block in the MBR tank. If the enough work space is not available in the MBR tank, lift the aeration block from the MBR tank by following the instruction described in the chapter IX, section 1.

Aeration block ABL150-F (top view)



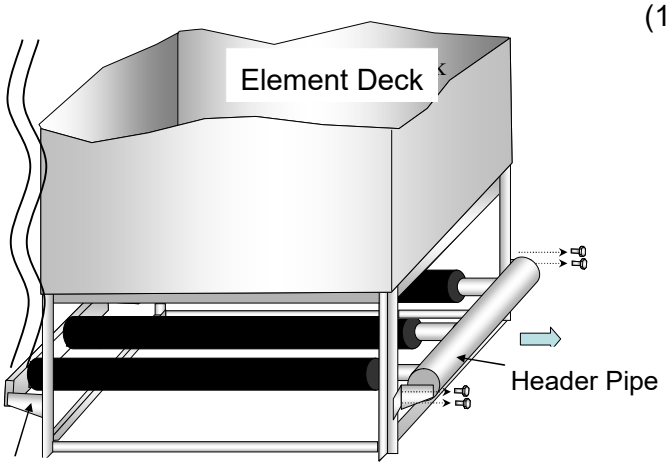
Header Pipe Pipe Support Header Pipe

As shown in the left figure, the aeration block ABL150-F consists of header pipes on the outer sides, pipe supports on the inner sides, and six fine-bubble diffusers. The fine-bubble diffusers are of two different lengths and are arranged alternately, with three diffusers per type.

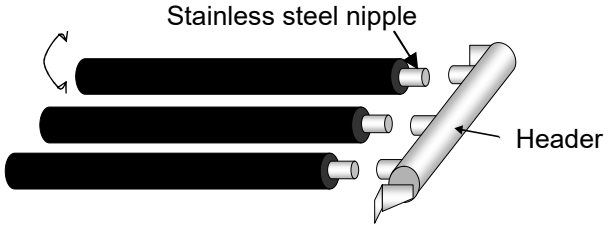
(The ABL050-F and ABL100-F models are designed with a single-sided header pipe and

include three fine-bubble diffusers of same length.)

The replacement procedure is as follows. Use the tool in size M12.

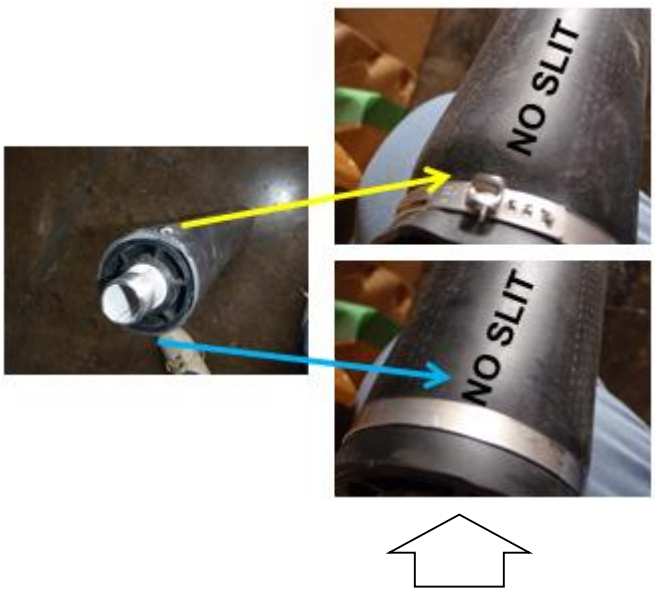


(1) Disjoint the header pipe from the aeration block.
In the left figure, only one side is shown, and the cover plate is omitted for your easy understanding.



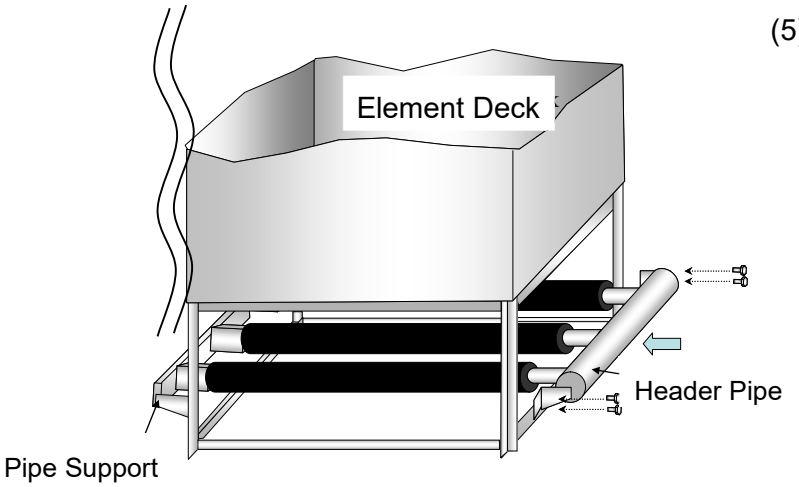
(2) Unscrew the air diffuser pipes from the header pipe.

(3) Seal the nipples of new air diffusers with Teflon seal tape. Wrap the tape clockwise around the first one or two threads of the screw.



(4) Joint the new air diffusers of the same length as the removed ones to the header pipe. Use a pipe wrench for the joint (Don't tighten by gripping the rubber part of the diffuser). Make sure that the surface of the rubber part having no holes (slits) must face upward or downward (The surface on which stainless clamps are fixed must face upward or downward).

No Slit Area shall be located at top and bottom when connecting to the header pipe.



(5) The two sets of header pipes with diffuser pipes will have one set with a long diffuser pipe in the center and the other set with long diffuser pipes at both sides. Confirm the position of the pipe support and arrange the corresponding header pipe/diffuser pipe sets accordingly.

(6) Fit the header pipes to the aeration block while fixing air diffusers on the pipe supports.

WARNING	Wear the appropriate personal protective equipment (e.g., safety gloves) in order not to cut hands by the edge of the module frame.
CAUTION	Be careful not to damage the rubber parts of air diffusers.

5. Replacement Parts List

Please contact Toray for the details of the specifications.

Replacement Parts

Name	Item Type	Frequency
Filtrate Tube Assembly	NHP-TUBE-SET (25 sets)	When deterioration detected.
Cassette or Element Deck	ECS035	When deterioration detected, or when filtrate flow or quality cannot be restored even after chemical cleaning.
	EBL050-4S EBL100-4S EBL150-4S	
Fine-bubble Air Diffuser	DIFFUSER-NHP-050-F: 3 short pipes DIFFUSER-NHP-100-F: 3 long pipes DIFFUSER-NHP-150-F: 3 long and 3 short pipes	When deterioration of the diffuser rubber or uneven diffusion is observed.

The required number of parts by module type when replacing a whole module.

Module Type	Filtrate Tube Assembly Type x Quantity	Cassette Type x Quantity	Element Deck Type x Quantity
NHPA050-1C/F-4S	NHP-TUBE-SET x 1	ECS035 x 1	EBL050-4S x 1
NHPA100-1C/F-4S	NHP-TUBE-SET x 2	ECS035 x 2	EBL100-4S x 1
NHPA150-1C/F-4S	NHP-TUBE-SET x 3	ECS035 x 3	EBL150-4S x 1
NHPA150-2C/F-4S	NHP-TUBE-SET x 6	ECS035 x 6	EBL150-4S x 2
NHPA150-3C/F-4S	NHP-TUBE-SET x 9	ECS035 x 9	EBL150-4S x 3
NHPA150-4C/F-4S	NHP-TUBE-SET x 12	ECS035 x 12	EBL150-4S x 4

Module Type	Fine-bubble Air Diffuser Type x Quantity
NHPA050-1F-4S	DIFFUSER-NHP-050-F x 1
NHPA100-1F-4S	DIFFUSER-NHP-100-F x 1
NHPA150-1F～4F-4S	DIFFUSER-NHP-150-F x 1

＊Be sure to use Toray approved replacement parts.

X. STORING AND DISPOSING

1. Storing Products after Use

Take the following steps to preserve and store used “NHPA Series” modules.

(1) Short-term storage up to 24 hours:

Leave the module submerged in the tank.

No special procedure is required only for this short-term storage, other than stopping filtration, however similar operation as Mid-term storage is also applicable such as intermittent aeration (typically five (5) minutes every hour) and opening air discharge valve on filtrate piping.

(2) Mid-term storage up to seven (7) days:

In case of module storage with sludge inside (without sludge drainage), stop filtration and aeration should be stopped or intermittent e.g. five (5) minutes every hour to agitate and supply minimal DO to the sludge.

Continuous aeration should not be applied from the viewpoint of membrane protection. Also, open air discharge valve on filtrate piping during aeration to avoid the possible air accumulation inside module and subsequent module damage.

(3) Long-term storage longer than seven (7) days:

Take following steps for membrane preservation.

- Drain the sludge in the MBR tank.
- Using a water hose, wash off the sludge from the modules with clean water. In addition, wash off any remaining sludge on the tank walls. Never use a pressure washer machine on the membrane module and element.
- Fill the MBR tank with clean water until the module is completely covered. Periodically check the liquid level and add more water if needed to keep the module covered with water. Open air discharge valve before pouring water and keep it open during storage.
- A periodic dosing of the MBR tank storage water to a < 50 mg/L concentration of sodium hypochlorite will help inhibit the growth of algae/microorganism during the storage period. Maintaining a hypochlorite concentration higher than 50 mg/L for a long-term interval could cause damage to stainless steel components.
- If air diffusion is required during long-term storage, the aeration cycle should be controlled to aerate only five (5) minutes every hour.

(4) Before re-commissioning of the modules:

Before re-commissioning of the modules, sludge in the tank needs to be fully mixed before starting filtration by sludge circulation/return and air scouring, taking sufficient time to achieve homogenized sludge. **And for Mid- and Long-term storage, it is strongly recommended conducting a chemical cleaning of the modules to remove any**

biofilm growth that may have developed on the membrane surface and piping during the storage period.

If used module (after washing off sludge) must be kept out of water, its duration should be limited within 24 hours and periodic sprinkling of water on the modules (especially membrane surfaces) is needed. In that case, it is required to cover the module (especially top and sides) with a tarp or some other plastic sheet that will protect the module from dust, wind, and direct sunlight.

 CAUTION	Never use a pressure washer machine on the membrane module and element. The edges of the elements may come off.
 CAUTION	Keep the membranes wet once they get wet. If the membranes are allowed to dry out, the permeability of the membranes may be permanently reduced.

2. Disposing Procedure

Follow these general guidelines when disposing of the membrane after use.

(1) Clean the membrane module with clean water. After the module has been rinsed off, allow the surfaces to dry. Dry surfaces make handling and transport easier.
(2) This module will become mixed waste consisting of plastic and metal scraps. It can be disassembled and separated for disposal.
(3) Dispose of the module and its components in accordance with local disposal methods (landfill, incineration, etc.) and regulations. If separation is required by regulations (such as separating combustible and noncombustible materials), follow those guidelines.
(4) Hydrogen fluoride (HF) gas will be generated when membranes are incinerated. Request a qualified industrial waste disposal contractor for the disposal of the membrane.
(5) Hydrogen chloride (HCL) or Dioxins will be generated when PVC is incinerated. Request a qualified industrial waste disposal contractor for the disposal of the PVC.

 WARNING	Hydrogen fluoride (HF) gas will be generated when membranes are incinerated. Request a qualified industrial waste disposal contractor for the disposal of the membrane.
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XI. TROUBLESHOOTING

Most of the problems in the operation of “NHPA Series” are related to poor membrane air scouring, chemical cleaning delay, and inappropriate pretreatment. The following table lists some performance losses, their causes, and possible countermeasures.

Table XI-1: Troubleshooting

	Problem	Cause	Action
1	The scouring air flow is below the required level.	The blower is broken.	Stop the filtration and inspect the blower.
		The air diffusers are clogged.	Clean the air diffusers.
2	The air diffusion is uneven in the module or between modules.	The air diffusers are clogged.	Clean the air diffusers.
		The valve openings of each air supply line are uneven.	Adjust the valve openings.
		The bottom of the element deck is stuck with debris.	Check the pretreatment system. Inspect the module. Correct operation and maintenance work of the pretreatment system.
3	The filtrate flow rate has decreased, or the transmembrane pressure (TMP) has increased.	Membrane clogging has got severe.	Conduct chemical cleaning.
		Sludge is accumulated on the membrane surface due to uneven air scouring.	Inspect the blower and clean the air diffusers to improve air scouring.
			Conduct chemical cleaning. Remove sludge cake by external cleaning.
		Abnormal properties of sludge have worsened its filterability.	Improve sludge properties. ・Adjust the excess sludge discharge rate. ・Prevent entry of abnormal components, such as oils. ・Adjust the BOD load and oxygen supply. ・Adjust the raw water quality (add nitrogen, phosphorous, etc.)
		Air is accumulated inside filtrate piping.	Prime the filtrate piping with water. Install air removal equipment such as vacuum pump. Relocate the filtrate piping.
4	The concentration of suspended solids in the filtrate water has increased.	Element and/or tube has been broken.	Seal the element and manifold nozzle*1 Replace the cassette.
		The filtrate piping is leaking.	Inspect the faulty parts*2 and repair the affected parts.

		Germs are generated on the membrane or the filtrate line.	To clean the filtrate piping, inject a sodium hypochlorite solution with an effective chlorine concentration of 100 to 200 mg/L.

*1: Even if a cause is found in the tube, there is still the possibility of contamination inside the element. Thus, seal the element and manifold nozzle.

*2: When conducting leak inspections of pipe joints and welded areas under pressurized conditions, ensure that no pressure is applied to the module.

XII. WARRANTY CONDITIONS

For information on the warranty of Toray MBR products, please refer to our water treatment membrane website (https://www.water.toray/) or the warranty certificate issued separately. Please contact us if you have any questions.

XIII. REFERENCE

Following information is provided upon your request:

(1) Assembly of Modules
(2) Assembly of Guide Rail System
(3) Assembly of Hangers.
(4) Procedure of Paper filter test.

Toray specializes in the development and manufacture of innovative membrane technologies. We offer an integrated approach using our RO, NF, UF, MBR, and antiscalant products to solve water and process treatment challenges. Contact us today to find out how Toray can help maximize water recovery, achieve high water quality for water reuse, lower energy requirements, and minimize life cycle costs. **TORAY, experts in RO, NF, UF and MBR.**

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