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TORAY Submerged UF MEMBRANE ELEMENT Instruction Manual

Model:

HSU-1515

issued by Toray Industries, Inc.

Water Treatment & Environment Division

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Content

I. Introduction

Toray Submerged UF Hollow Fiber Membrane Rack is the submerged type hollow fiber UF (ultra filtration) membrane rack developed with the polymer science and the membrane fabrication technologies accumulated for a long time in Toray Industries, Inc.

The membrane material is Polyvinylidene fluoride (PVDF). The nominal molecular weight cut off of the membrane is 150,000 daltons. It has been confirmed that more than 90% of 150,000 daltons model polymers is consistently removed.

The element, with Polyethylene (PE) protective cylinder, is submerged type. The maximum operating trans-membrane pressure is 100 kPa (14.5 PSI). The flow direction is outside to inside which is suitable for high turbidity water treatment because the air-scrubbing can be adopted to remove suspended solid effectively.

1. Characteristics of Toray Submerged UF Membrane Rack

(1) High Filtration Flux

It provides high filtration flux and stable operation for the filtration of various raw water sources. The membrane is made with a special spinning method, which enables high permeability and high fouling resistance.

(2) Excellent Water Quality

It provides very good water quality for the filtrate, extremely low turbidity since the membrane has 150,000 dalton nominal molecular weight cut off. The rack is recommended to be applied in high turbidity water treatment, such as for tertiary treatment of sewage water and industrial waste water reuse.

(3) High Mechanical Strength

The membrane has very high mechanical strength because it is made of PVDF with the special spinning method developed by Toray. The rack provides high integrity and durability under recommended operating conditions.

(4) High Chemical Durability

The membrane material is PVDF, which allows you to clean the membrane with high concentrations of chlorine and with high concentrations of acid resulting in better cleaning and longer sustainable membrane flux rates.

2. Applications of Toray Submerged UF Membrane Rack

- Drinking Water Production
  Membrane Elements certified with NSF61
- Tertiary Treatment of Sewage Water
- Industrial Water Production
- Reuse of Industrial Waste Water

II. For Your Safety

- Please be sure to read and follow the instructions below before using. This manual should be retained for future reference.

- Follow the safety precautions as they are intended to protect operators and equipment from various risks such as physical harm and/or property damage. The following table shows a level of potential risk for each indicated symbol.

DANGER	This symbol indicates an imminent hazardous situation which will result in serious injury or death when the instruction is not observed.
WARNING	This symbol indicates a potentially hazardous situation which will result in serious injury or death when the instruction is not observed.
CAUTION	This symbol indicates a potentially hazardous situation which might result in injury or property damage when the instruction is not observed.

- The following table explains the information to be noted.

 Prohibited	“Prohibited” This symbol indicates a prohibited action or procedure.
 Instruction	“Instruction” This symbol indicates an important action or procedure which has to be taken without fail.

1. Safety Instruction for Unpacking and Installation

DANGER


Instruction

Be sure to wear safety gear such as rubber gloves and safety glasses for unpacking. The membrane is packaged in sodium hypochlorite solution (100mg/L). If the solution happens to touch on the skin, wash the affected part with running water. If the solution happens to get in the eyes or mouth, wash the affected part with sufficient amounts of clean running water for more than 15 minutes and see the doctor immediately.


Instruction

When lifting rack, please attach chains or slings to it and raise it straight upward calmly to prevent it from shaking. Please never allow any person under lifted article.


Instruction

When installing rack, please set up a foothold in advance. Please never do the work above the rack. Use protective equipment to ensure the safety of workers.

WARNING


Instruction

Be sure to wear safety gear such as a helmet and safety shoes to avoid injury.

CAUTION


Prohibited

The preservative solution should be washed out before using the element. After that, keep clean water on the element to prevent the membranes from drying out (for example, sprinkle on the element with water). Do not allow the element to dry even for a few hours.


Prohibited

The element should not be frozen.

Prohibited

Be careful not to damage or dent the element during handling.

Instruction

IDF/ISO Clamp Union Fittings 1.5 are applied for connecting the element of HSU-1515 to the piping. Do not overtighten the cramp as damage to the element may occur.

Prohibited

Keep the connection surface free of any dirt or oils.

Prohibited

Be sure not to install the element upside down. Confirm the element installed in the right direction.

Instruction

Be sure to install the element vertically for effective air scrubbing.

Instruction

Be sure to store the element transversely.

Instruction

At transportation, storage and installation rack, please take appropriate measures to protect rack from damage.
Do not put any heavy objects on the rack. Please take care to protect the rack from collision with other objects.

Instruction

Please take adequate measures to protect rack from sparks caused by welding, fusion cutting or grinding throughout the entire process from installation work to operation setup.

2. Safety Instruction for Filtration Operation

DANGER


Instruction

Flush all the piping out with clean water and make sure no debris is remaining in the piping prior to charging water to the element from the piping.


Instruction

Confirm that the preservative chemical in the element and the piping is completely washed out before starting the filtration operation. The preservative chemical is harmful to humans.


Instruction

Prior to use, make certain elements are washed. Filtrate water should be drained unless it meets the required quality.

WARNING


Instruction

Protect elements from direct sunlight and ultraviolet light. Ultraviolet light can degrade element housing and membranes.


Instruction

Constantly monitor filtrate water quality such as turbidity and/or the number of particles during filtration, and stop the operation if abnormal water quality is detected.


Prohibited

Do not exceed the maximum applicable trans-membrane pressure for filtrating 100 kPa or for backwashing 200 kPa. Higher pressures can damage the elements. Do not exceed the maximum temperature of 40 degree C . The higher temperature damages the elements.


Prohibited

Do not freeze the elements.


Instruction

The operating conditions, including the filtration flux and the periodical physical cleaning, must be properly set-up otherwise the trans-membrane pressure may rise too quickly. The operation range is described in the latter section of this manual.


Instruction

Do not overfeed air to the element. Excessive scrubbing air damages the membranes and/or shortens the membrane life.
The air flow rate should be within the range below for each element.

HSU-1515: 1.5 – 3.0 Nm^3/h


Instruction

At the Integrity tests, such as Pressure Decay Test (PDT) or Diffusive Air Flow (DAF) Test, keep the air pressure below 125 kPa. Keep the source air pressure lower than 200 kPa, to prevent the element damaged.

3. Safety Instruction for Chemical Cleaning

DANGER


Instruction

Take special precautions when handling chemicals during chemical cleaning. Wear the safety gear such as safety glasses and protective gloves. If chemicals come in direct contact with your skin or your clothes, treat the contacted part appropriately based on the MSDS.


Prohibited

Do not mix sodium hypochlorite with acid. Such mixture generates toxic chlorine gas.


Instruction

Stop operation whenever any anomaly occurs with the equipment or any signs of an anomaly are observed.

CAUTION


Instruction

In the chemical cleaning, strictly follow the procedure described in the latter section of this manual. Otherwise you may damage the elements or negatively affect the membrane performance.

4. Safety Instruction for Disposal

WARNING


Instruction

When dispose the element, please apply a service of a qualified waste disposing company. When the element is to be incinerated, please apply the appropriate facilities in which hydrogen fluoride (HF) gas can be neutralized. HF gas is generaterd with the incineration of membrane.

III. Outline

1. Outline of membrane

The hollow fiber membrane installed in this rack is made of PVDF (Polyvinylidene fluoride). Cross section of the structure is shown in Fig. 1. Flow direction to the hollow fiber membrane is outside to inside.

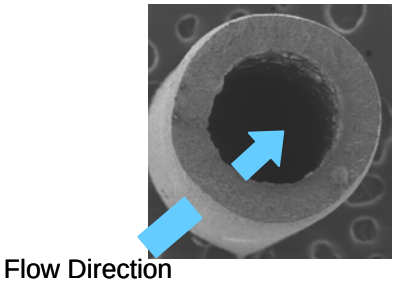


Fig. 1 Cross section picture of Toray PVDF hollow fiber

The diameter of the hollow fiber membrane is designed to be as follows:

For HSU-1515: Outside diameter is 1.4 mm. Inside diameter is 0.9 mm.

Molecular weight cut off (MWCO) of the HSU membrane is shown in Fig. 2. The MWCO is determined by dextran solution having molecular weight of 70,000, 200,000 and 500,000. The concentrations of the dextran are measured by the Refractive Index Detector.

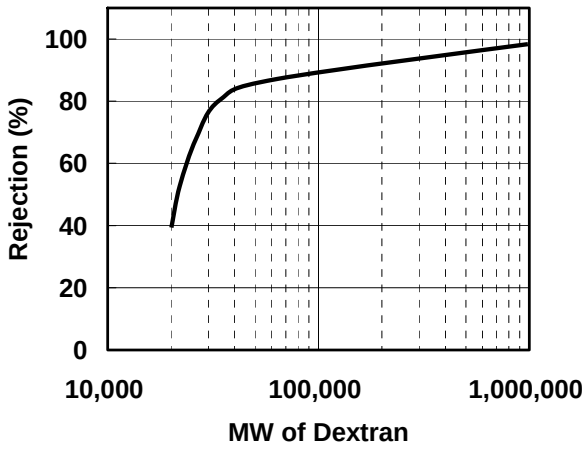


Fig. 2 Molecular weight cut off (MWCO) of the HSU membrane

The membrane is manufactured with special spinning method developed by TORAY and the nature of the membrane surface is modified for high fouling resistance. As a result, this membrane enables very high filtration flux compared to other PVDF membranes. In addition, the physical strength of the membrane fiber is so high that it hardly gets breakage during the normal operation for many years.

2. Outline of element

TORAY PVDF Hollow Fiber Membrane Element “HSU-1515” is submerged type which is shown Fig. 3.

Effective membrane area of an element is as follows:

HSU-1515: 20 m^2

HSU-1515: suitable for high turbidity water, large-scale water treatment plants.

Fig. 3 Picture of element (HSU-1515)

3. Outline of rack

“Rack” contains a number of membrane elements stacked at equal clearance and two air diffusers. Each element is connected to the permeated water manifold.
The air diffuser consists of a number of holes to supply scouring air to each membrane element.
This rack is used submerged in water to be treated.
Rack image is shown Fig. 4.

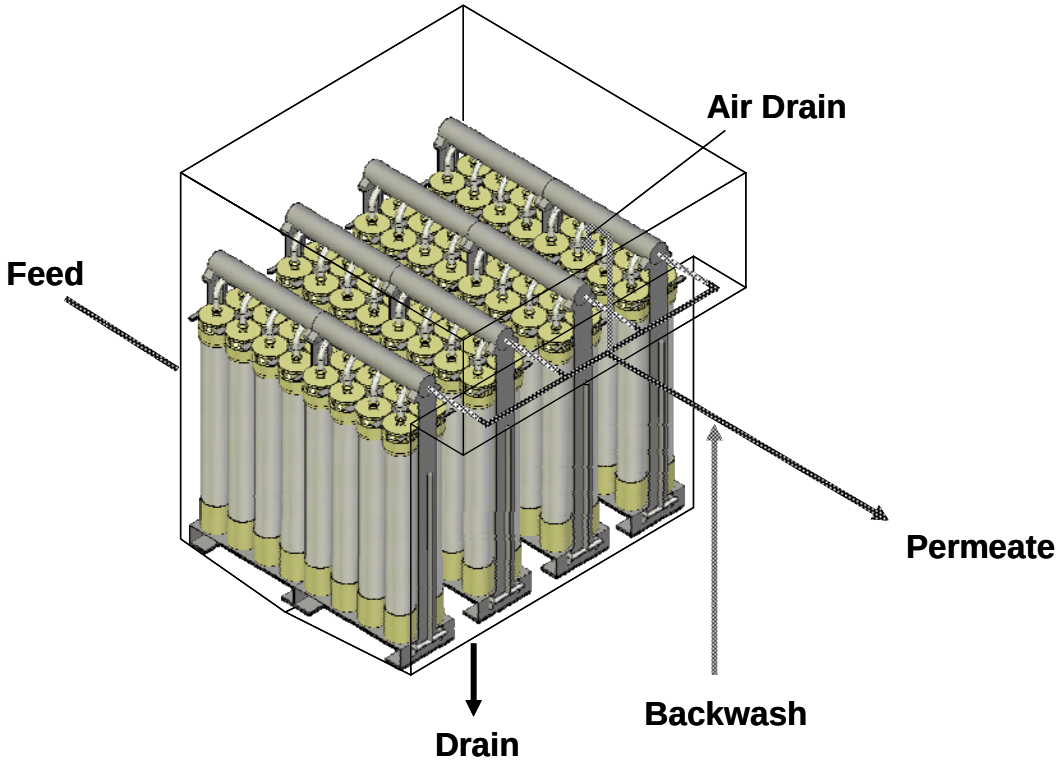


Fig. 4 Image of “Rack” (4 units of R16 Model are submerged in tank)

IV. Specifications and Configuration

1. Specifications of Membrane

Table 1. Specifications of membrane *1)

Membrane Type		HSU
Nominal Molecular Weight Cut Off		150,000 *2)
Membrane material		PVDF
Filtrating Trans-Membrane Pressure	Maximum *3)	100 kPa
	Normal Operation	Not higher than 100 kPa
Backwashing Trans-Membrane Pressure	Maximum *4)	200 kPa
	Normal Operation	Not higher than 150 kPa
Storage and Operating Temperature Range		0 - 40 degree C
Operating pH Range		1 – 10

*1): Please note that the specifications are subject to changes from time to time.

*2): The nominal molecular weight cut off is determined with the model test of dextran.

*3): TMP (Trans-Membrane Pressure) should be below 100 kPa at any time even during the filtration.

*4): TMP (Trans-Membrane Pressure) should be below 200 kPa at any time even during the backwash.

2. Specifications and Configuration of Element

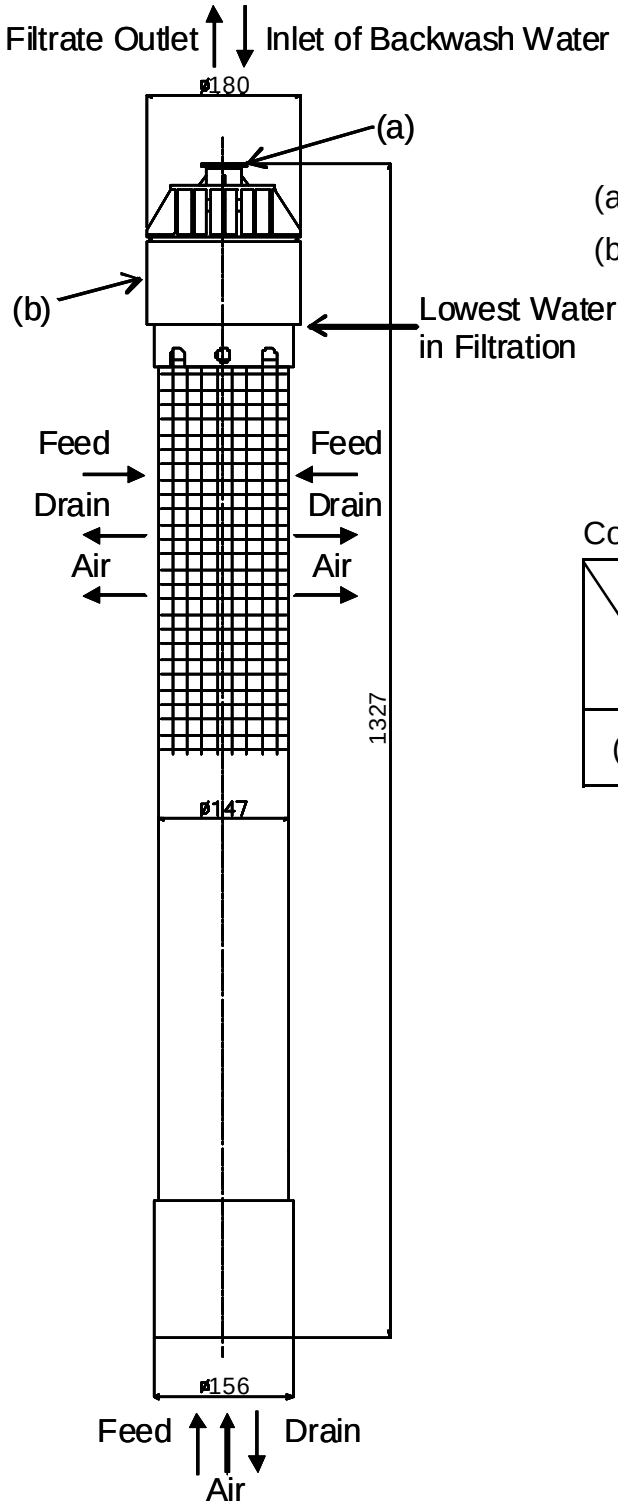
(1) Specifications of element

Table 2. Specifications of element *1)

Element Type		HSU-1515
Membrane Type		HSU
Membrane Surface Area (Outer Surface)		20 m^2
Dimensions	Diameter	147 mm
	Length	1,327 mm
Weight	Wet Condition	18 kg
Materials	Cap	ABS
	Protective Cylinder	PE
	Potting Material	Epoxy or equivalent
Connections	Top Center	IDF/ISO Clamp Union Fitting 1.5s
Operating Conditions	Max. Feed Water Flow	2.0 m^3/h
	Max. Backwash Flow	3.0 m^3/h
	Max. Air Flow	4.5 Nm^3/h
	Normal Air Flow	1.5 – 3.0 Nm^3/h
	Filtration Method	Submerged, Outside to inside
	Maximum Temperature	40 degree C

*1): Please note that the specifications are subject to changes from time to time.

(2) Configuration of element



(a): Nozzle

(b): Nut

Connections

	Pipe fitting outer diameter mm	Connectors
(a)	50	IDF/ISO Clamp Union Fitting 1.5s

Fig. 5 Configuration of element

3. Specifications and Configuration of Rack

(1) Specifications of Rack

Table 3. Specifications of Rack Module “R16“ *1)

No. of Elements / Rack		16 elements
Element Type		HSU-1515
Total Membrane Area (Outer Surface)		320 m^2
Dimensions	Height	1,800 mm
	Length	1,587 mm
	Width	365 mm
Weight	Wet Condition	Max. 500 kg
Materials	Element	PVDF, ABS, PE, Epoxy or equivalent
	Rack	304SS *2)
	Pipe	304SS *2), PP, HIVP
Operating Conditions	Max. Feed Water Flow	32 m^3/h
	Max. Backwash Flow	48 m^3/h
	Max. Air Flow	72 Nm^3/h
	Normal Air Flow	24 – 48 Nm^3/h
	Filtration Method	Submerged Outside to inside
	Maximum Temperature	40 degree C

*1): Please note that the specifications are subject to changes from time to time.

*2): 316SS is available as option.

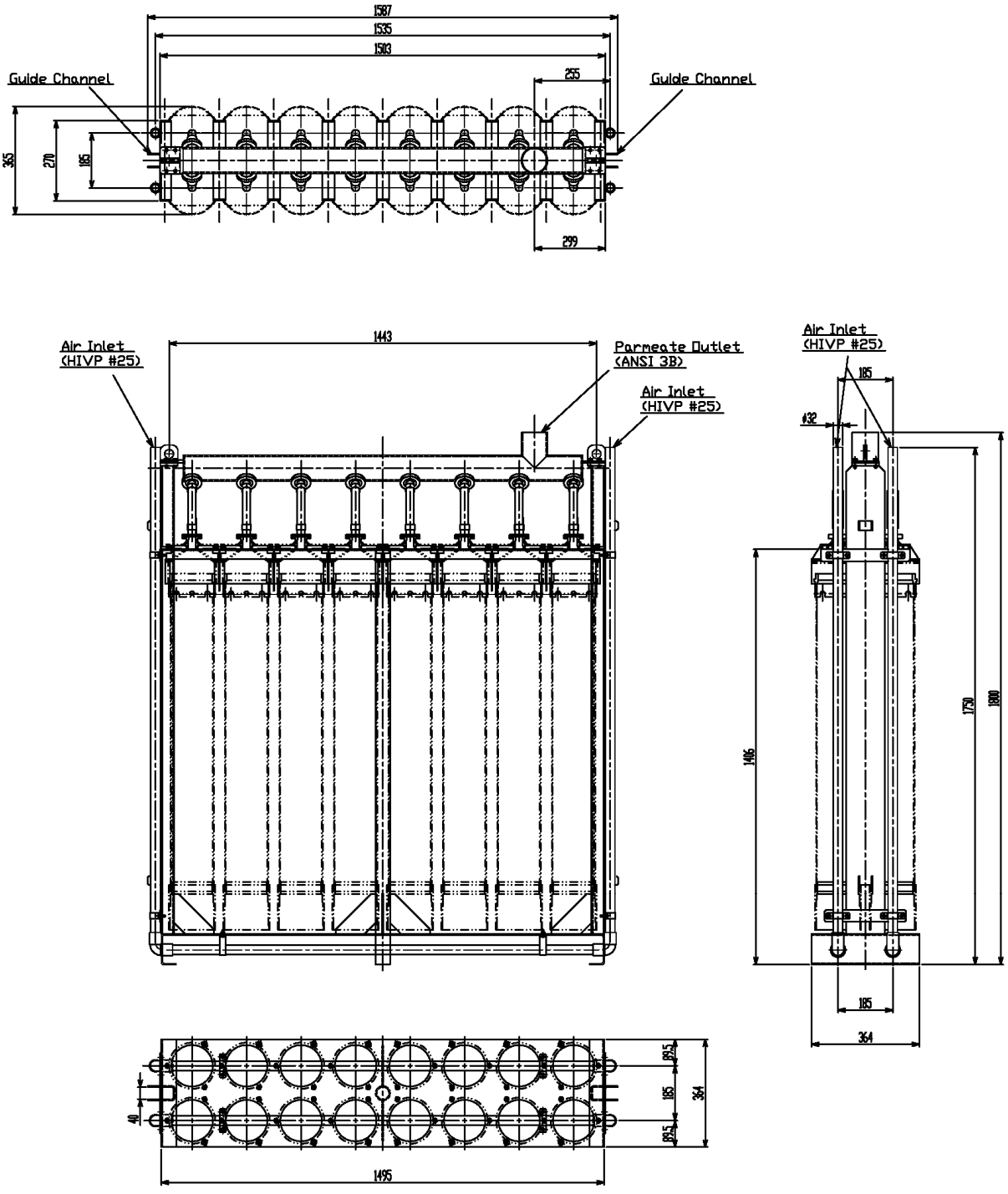
Table 4. Specifications of Rack Model “R08“ *1)

No. of Elements / Rack		8 elements
Element Type		HSU-1515
Total Membrane Area (Outer Surface)		160 m^2
Dimensions	Height	1,800 mm
	Length	851 mm
	Width	365 mm
Weight	Wet Condition	Max. 250 kg
Materials	Element	PVDF, ABS, PE, Epoxy or equivalent
	Rack	304SS *2)
	Pipe	304 SS*2), PP, HIVP
Operating Conditions	Max. Feed Water Flow	16 m^3/h
	Max. Backwash Flow	24 m^3/h
	Max. Air Flow	36 Nm^3/h
	Normal Air Flow	12 – 24 Nm^3/h
	Filtration Method	Submerged Outside to inside
	Maximum Temperature	40 degree C

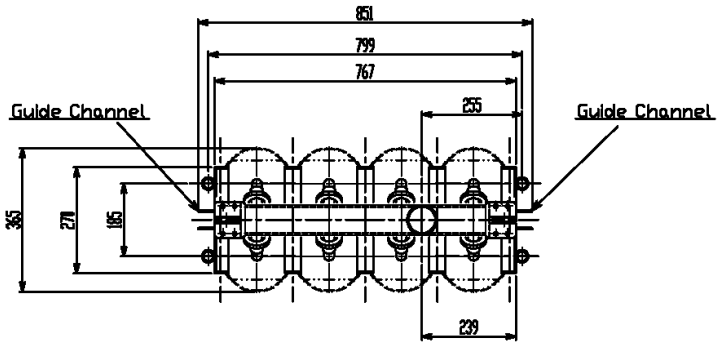
*1): Please note that the specifications are subject to changes from time to time.

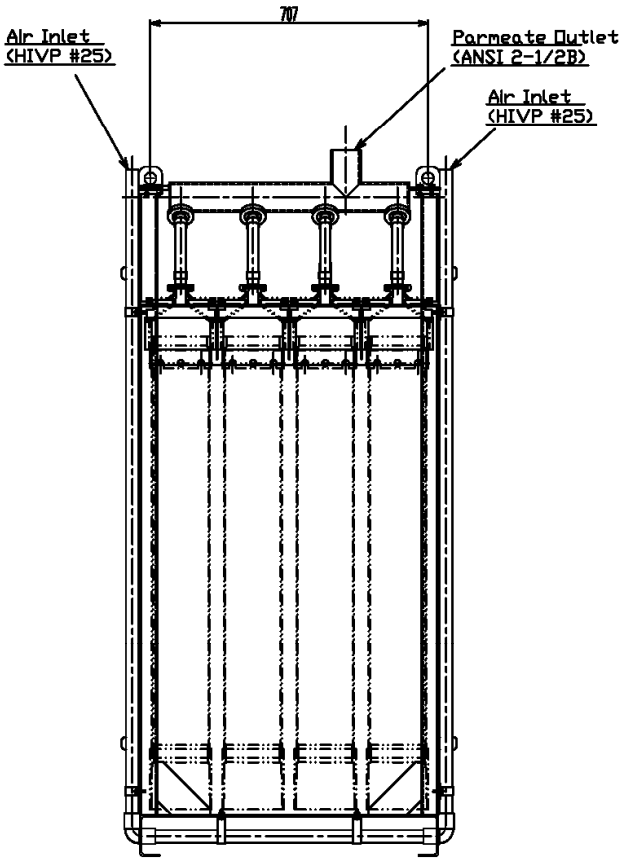
*2): 316SS is available as option.

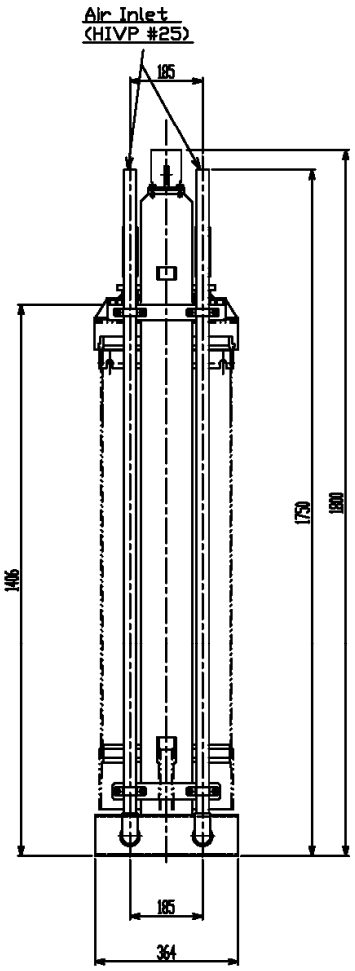
(2) Configuration

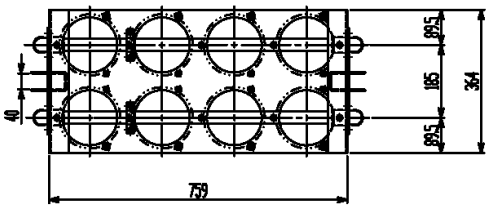


Rack Model “R16”









Rack Model “R08”

4. Feed water and Cleaning Limits

Table 5. Feed water limits *[1)]

Element Type		HSU-1515
Turbidity	Intermittent Peak *[5)]	1,000 NTU
	Continuous Maximum	200 NTU
TSS	Intermittent Peak *[5)]	1,000 mg/L
	Continuous Maximum	200 mg/L
Pretreatment Filter Mesh Size		Smaller than or equal to 0.5 mm
Temperature Range		0 - 40 degree C
pH Range		1 – 10

*1): Please note that the specifications are subject to changes from time to time.

*5): The duration time should be less than 48 hours and the occurrence frequency should not exceed more than once a month.

Table 6. Cleaning limits for all types of elements*[1)]

Cleaning pH Range	0 – 12
Cleaning Temperature Range	0 - 40 degree C
Maximum Concentration of NaClO as Cl_2	3,000 mg/L ($10 \leq pH \leq 12$)
Maximum NaClO Exposure (lifetime contact time) as Cl_2	1,000,000 mg/L hours
Maximum Acid Contact Time	1,000 hours ($pH \geq 0$)

*1): Please note that the specifications are subject to changes from time to time.

CAUTION

Handle and operate the elements within the ranges and the limits indicated in Table 1 to 6. Operation out of these ranges or limits may damage the elements, and affect filtration performance.

V. Installation

1. Element into Rack

(1)Unpack the wooden box. Take the element out of plastic bag.

DANGER	- Wear rubber gloves and safety glasses when you unpack the element.

(2) Confirm the nozzle and the nut are not loose.

WARNING	- Do not drop the element.
CAUTION	- Be careful not to install the element upside down. Confirm the element is installed in the right direction. - Do not allow the element to dry even for a few hours, especially in summer. - Do not freeze the element.

(3) Set the element vertically into a rack (see Fig. 6). Make sure that the element is installed vertically. Please contact us if you need the detail information of the rack.

(4) Connect a filtrate piping to a connection point of the element with a ferrule joint (see Fig. 6).

CAUTION	- Keep the connection surface free of any dirt or oils. - Do not over-tighten the clamp when using ferrule joints (IDF/ISO Clamp Union Fittings 1.5s), or you may damage the element.

(5) Immerse gradually the element rack in a submerged tank which filled raw water.

WARNING

- Do not drop the element rack.
- Use the equipments such as chain blocks, a crane or a forklift truck when you handle the element rack.

(6) Make sure that the element rack is installed vertically.

CAUTION

- If the element is not installed vertically, the effect of the air scrubbing would be reduced and an effective filtration will be impaired.

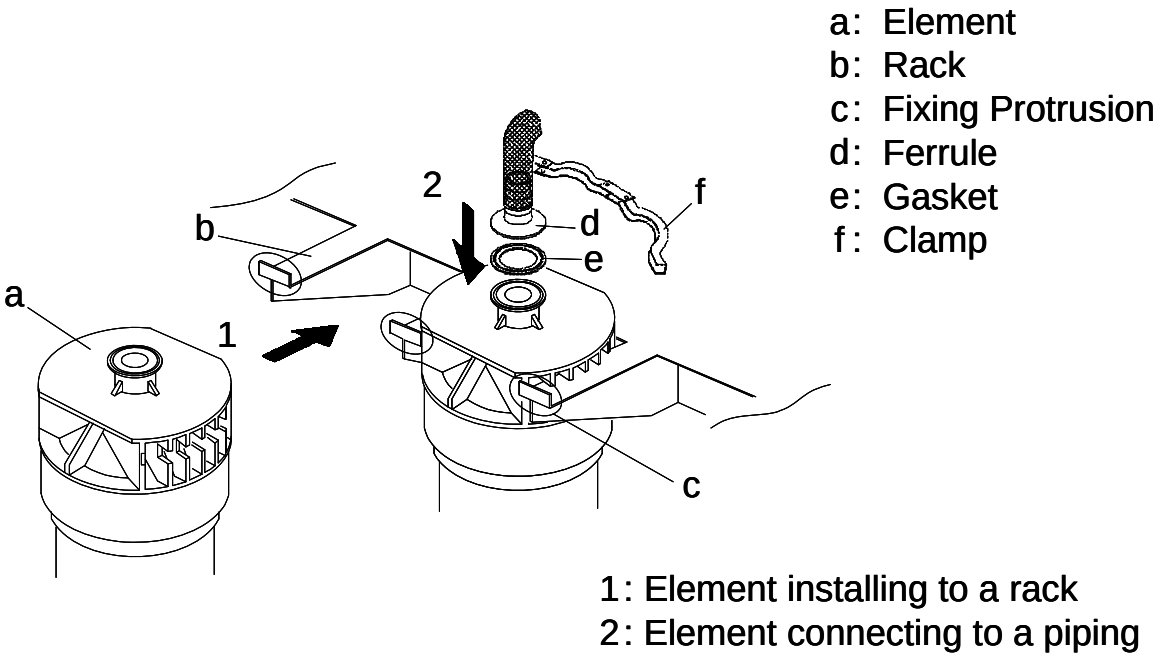


Fig. 6 Installation of Element in Membrane Rack

2. Layout of Rack in Membrane Submerged Tank

Fig.7 and Fig.8 present a top view and a side view of the tank containing three membrane racks. It is required to keep the dimensions of W1, W2, W3 and L1 as mentioned below.

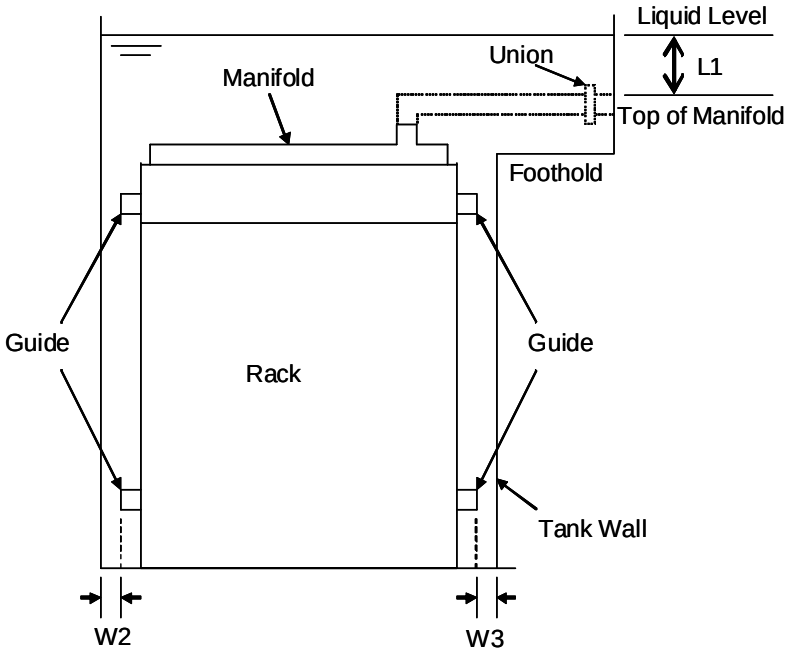


Fig. 7 Rack Layout in Membrane Submerged Tank (side view)

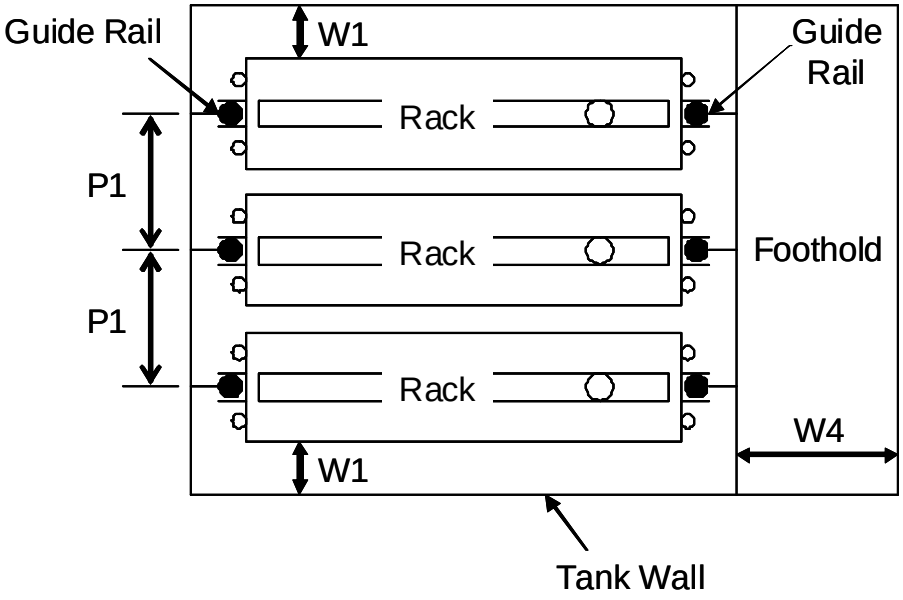


Fig. 8 Rack Layout in Membrane Submerged Tank (top view)

(i) P1: more than 424 mm

(ii) L1: L1, the distance between the top of the rack and the liquid level of the tank, should be more than 100 mm at anytime of the normal operation. (the maximum is when after finishing backwash, the value is changing depend on operation condition. Please contact us for the details)

(iii) W1: more than 30 mm

(iv) W2: more than 30 mm

(v) W3: more than 30 mm

(vi) W4: more than 800 mm

VI. Operation

1. Advance preparation

(1) Check that all piping is connected appropriately and flushed out prior to the operation. Fig. 9 shows a typical example of piping.

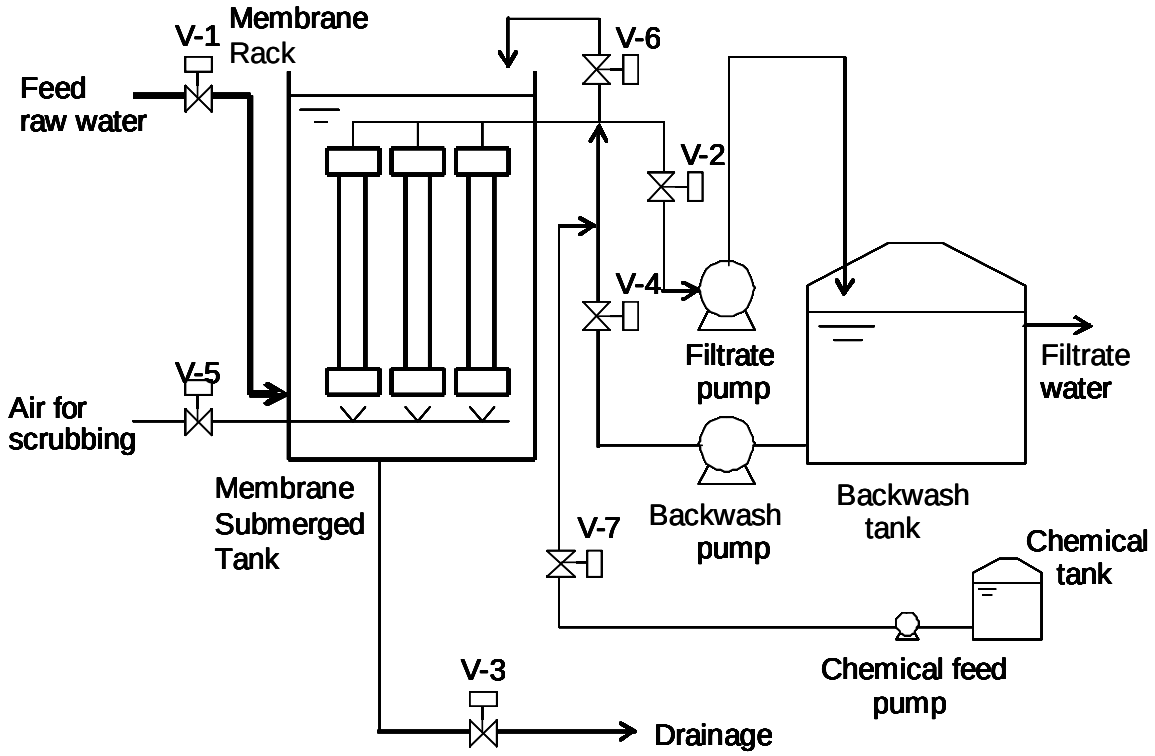


Fig. 9 Typical example of piping

(2) Open the feed water valve (V-1) to provide the submerged tank with the feed raw water. Make sure the water level of the submerged tank is higher than the top of the filtrate piping.

(3) Open the filtrate water valve (V-2) and the air drain valve (V-6). Make sure the filtrate piping between the filtrate pump and the membrane element is filled by filtrated water.

(4) Close the air drain valve (V-6) and then run the filtrate pump. Make sure the water in the backwash tank is enough for the next step, stop the filtrate pump and close the feed water valve (V-1) and the filtrate water valve (V-2).

(5) Open the air drain valve (V-6) and the backwash valve (V-4) and run the backwash pump until the filtrate piping is filled by filtrated water.

(6) Make sure all pumps are “stopped” and all valves are “closed”.

CAUTION

- The element is packaged in sodium hypochlorite solution (100mg/L) as the preservative at the time of shipment. The preservative should be washed out before using the element. After that, keep clean water on the element to prevent the membranes from drying out. Do not allow the element to dry even for a few hours.

2. Filtration

Fig. 10 shows a typical example of the flow diagram for filtration.

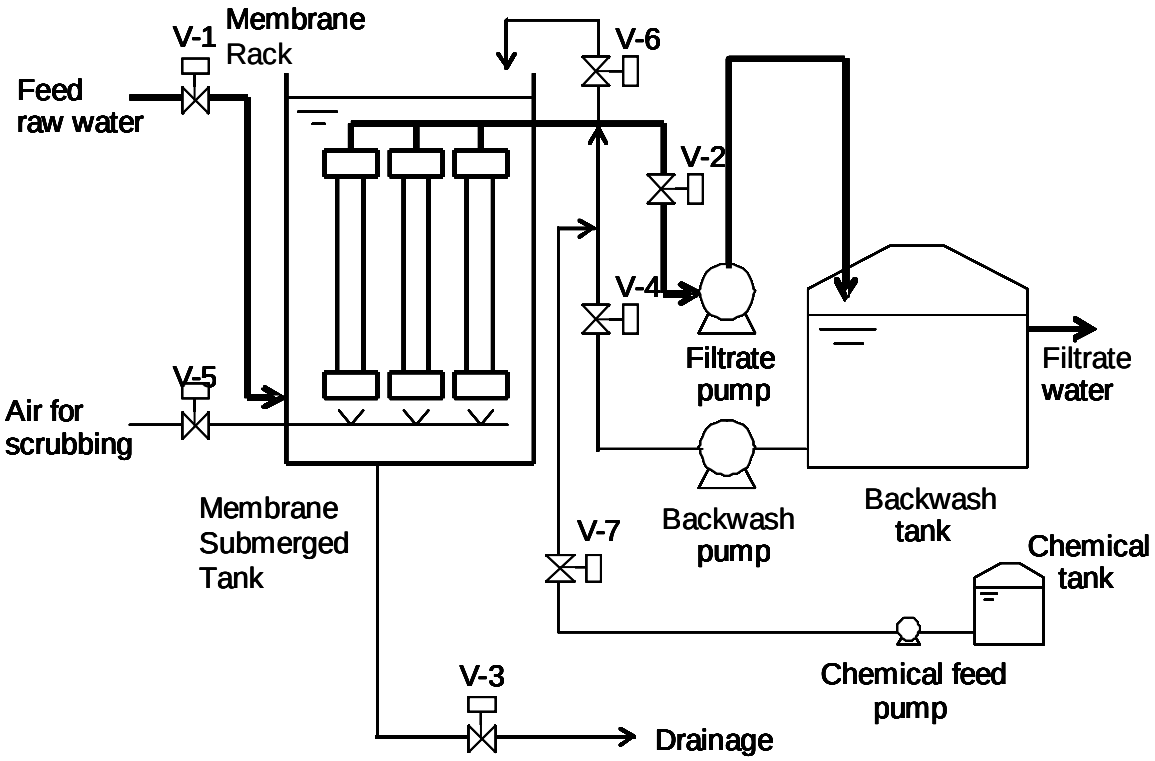


Fig. 10 Flow diagram for filtration

(1) Open the feed water valve (V-1) to provide the submerged tank with the feed raw water.

(2) Open the filtrate water valve (V-2) and run the filtrate pump. The flow rate of the filtrate water is controlled either by a control valve (not shown in the figure) set up after the filtrate pump on the filtrate line or by controlling the rotation speed of the filtrate pump.

(3) Make sure the filtrate water quantity is controlled.

(4) Make sure the water level of the submerged tank is higher than the Lowest Water Level shown in Fig. 5 at any time in control of feed flow.

CAUTION

- Do not impose the higher pressure to the element than the maximum applicable trans-membrane pressure, for filtrating 100 kPa.
- Do not operate the element at higher temperature than the maximum applicable temperature, 40 degree C. The higher temperature damages the element.
- Do not keep the element without water even for a few hours.
- Operating conditions including the filtration flux and the physical cleaning should be properly set up, observing the rise of trans-membrane pressure (Details are described in the next session.). Please contact us if you need technical support.

(5) When you stop the filtration, stop the filtrate pump and close the filtrate water valve (V-2), and then close the feed water valve (V-1) after make sure water level of the submerged tank is higher than the Lowest Water Level shown in Fig. 5.

CAUTION

- Always monitor filtrate water quality during filtration, and stop the operation if abnormal water quality is detected. If abnormal water quality is detected, check the integrity of the element with PDT (Pressure Decay Test) or DAF (Diffusive Air Flow) Test. The test procedure is provided as the technical information by Toray.

3. Backwash and Air-scrubbing

The physical cleaning with backwash and air-scrubbing should be carried out periodically and automatically for the continuous filtration. The frequency of the physical cleaning mainly depends on the raw water quality (Typical frequency is once every 30 minutes normally. Please contact us if you need technical support.). Fig. 11 shows a typical example of the flow diagram for backwash and air-scrubbing.

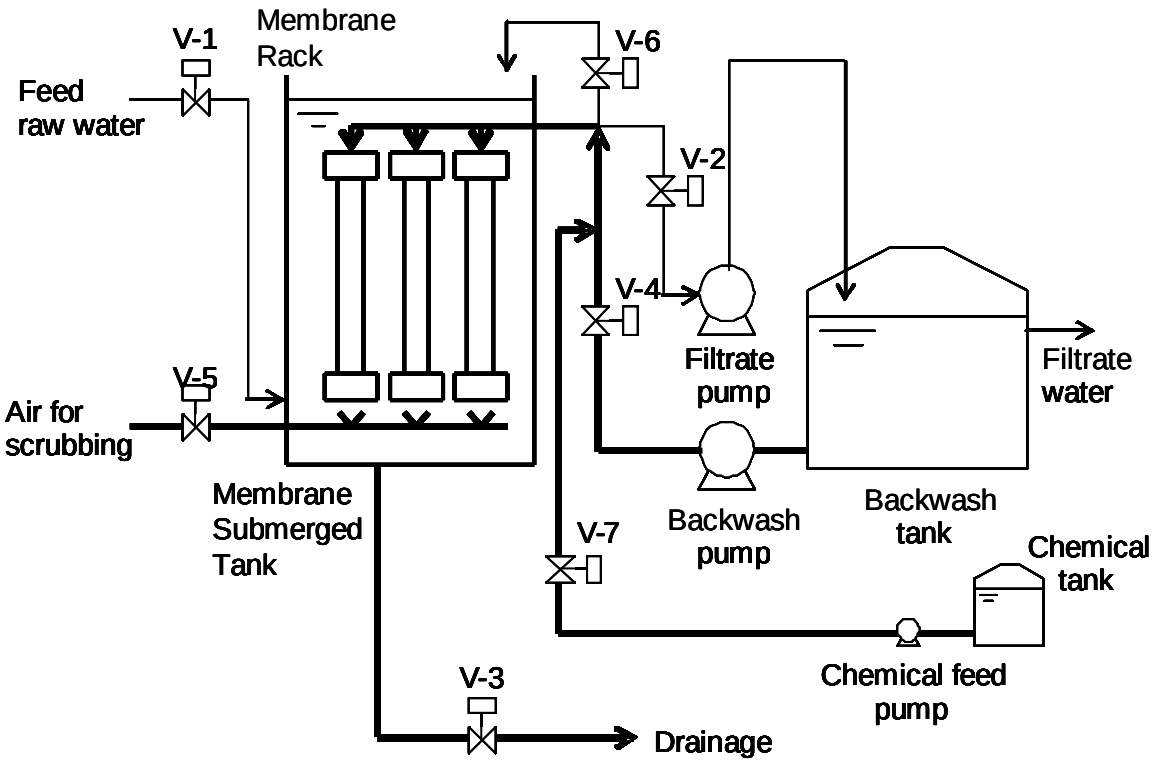


Fig. 11 Flow diagram for backwash and air-scrubbing

(1) Close the feed water valve (V-1).

(2) Stop the filtrate pump and close the filtrate water valve (V-2) when the water level of the submerged tank reaches the Lowest Water Level shown in Fig. 1.

(3) Open the air drain valve (V-6) and the backwash valve (V-4) and run the backwash pump. After purging any air out (normally a few seconds) from the backwash line, close the air drain valve (V-6) to feed back the filtrate water from the backwash tank to the element.

The flow rate of backwash water is set up in advance normally for 1.1 to 1.5 times filtrate water flow rate.

It is acceptable to open the chemical feed valve (V-7) and run the chemical

feed pump at the same time as running of the backwash pump.

CAUTION

- Do not impose the higher pressure to the element than, the maximum applicable trans-membrane pressure for backwashing, 200 kPa.
- Do not operate the element at higher temperature than the maximum applicable temperature, 40 degree C. The higher temperature damages the element.

(4) At the same time, open the air-scrubbing valve (V-5) for air-scrubbing.

CAUTION

- The air flow rate for air-scrubbing should be within the range below. Excessive air flow rate may damage the membranes.

  HSU-1515: 1.5 – 3.0 Nm^3/h

(5) After backwashing with air-scrubbing for a fixed time (normally 60 seconds), close the air scrubbing valve (V-5), stop the chemical feed pump (if used) and the backwash pump and close the chemical feed valve (V-7) and the backwash valve (V-4).

(6) Open the drainage valve (V-3).

(7) Close the drainage valve (V-3) after backwashed water is drained out from the submerged tank.

(8) Open the feed water valve (V-1).

(9) After making sure the water level of the submerged tank is higher than the top of the filtrate piping, close the feed water valve (V-1).

4. Toray Maintenance Cleaning

Instead of chemical dosing for every backwash, soaking the membranes in chemical solution several tens of minutes a day is also effective for membrane performance retention. This process is called Toray Maintenance Cleaning (TMC). TMC is usually held following the backwash and air-scrubbing which does not contain the chemical dosing. The frequency and the soaking time of TMC mainly depend on the raw water quality (Normally once a day and each soaking time is 20 minutes. Please contact us if you need technical support.).

5. Air Diffuser Cleaning

The clogging of diffuser holes causes uneven air diffusion and membrane clogging, and the racks are broken in the worst case. Please clean the air diffusers once a day to prevent such trouble.(it is recommended to install the automatic air diffuser cleaning system with automatic valves).

The air diffusers are cleaned up with the reverse flow of the sludge from the diffuser holes into the diffuser pipes, which is generated by the air jet flow from the compressor through the air diffuser pipes to the branch discharge nozzle.

Air diffuser cleaning procedure

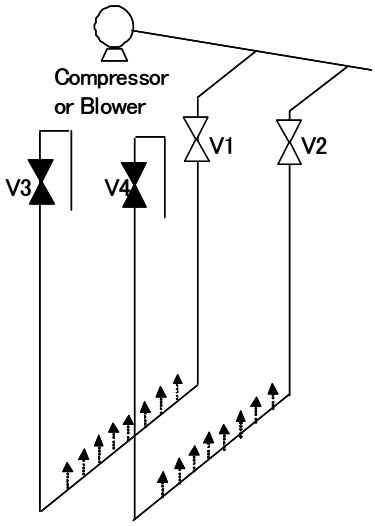


Fig.12 Condition when air scrubbing

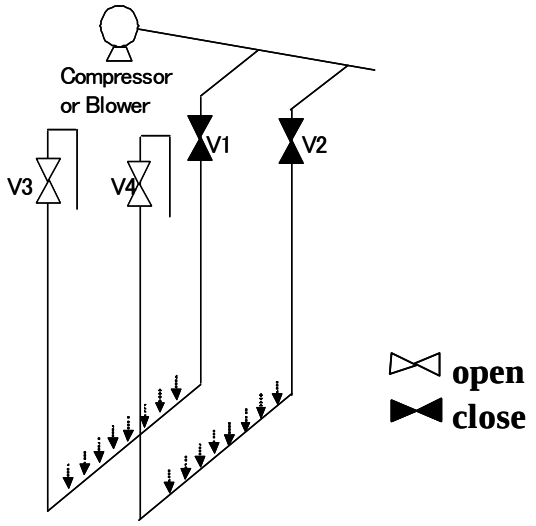


Fig.13 Condition when stop operation

(1) After do the air scrubbing (Fig.12), close V1 and V2, open V3 and V4 valve (Fig.13). At this step, the water from the tank comes through the diffuser holes into diffuser piping, and is discharged with the water (Stop operation).

(2) Keep this stop operation condition for about 5 seconds. After that, open V1 and V2 valve. At this step, the material deposit inside the diffuser holes and diffuser tank will come out through V3 and V4 together with the water (Cleaning operation, see Fig. 14).

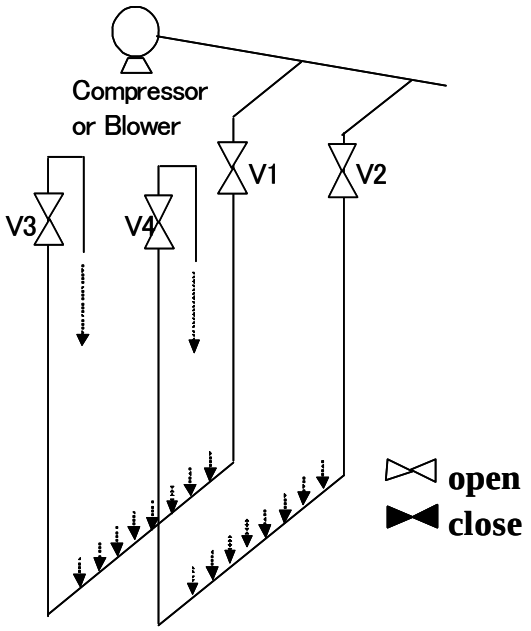


Fig. 14 Condition when cleaning process

(3) After keeping the cleaning process for about 5 seconds, stop the operation again. Repeat the stop and cleaning process for about 5 times, then close V1, V2 and V3 valves. Drain out the water inside the tank, restart the feed and filtration process.

(4) If the clogging occurs only on the one of the air diffuser line, do the cleaning only for that line by repeating (1) – (3).

6. Temperature Correction Factor

The permeability of the membranes is influenced by temperature mainly because the water viscosity changes with temperature. When you evaluate the permeability correctly, you need to eliminate the temperature effect with the temperature correction factor (TCF) shown in Fig 15.

A Trans-Membrane Pressure (TMP) measured at some real temperature can be converted to 25 degree C corrected TMP with multiplying by TCF at real temperature shown in Fig. 15.

A filtrate flow rate measured at some real temperature can be converted to 25 degree C corrected filtrate flow rate with divided by TCF at real temperature shown in Fig. 15.

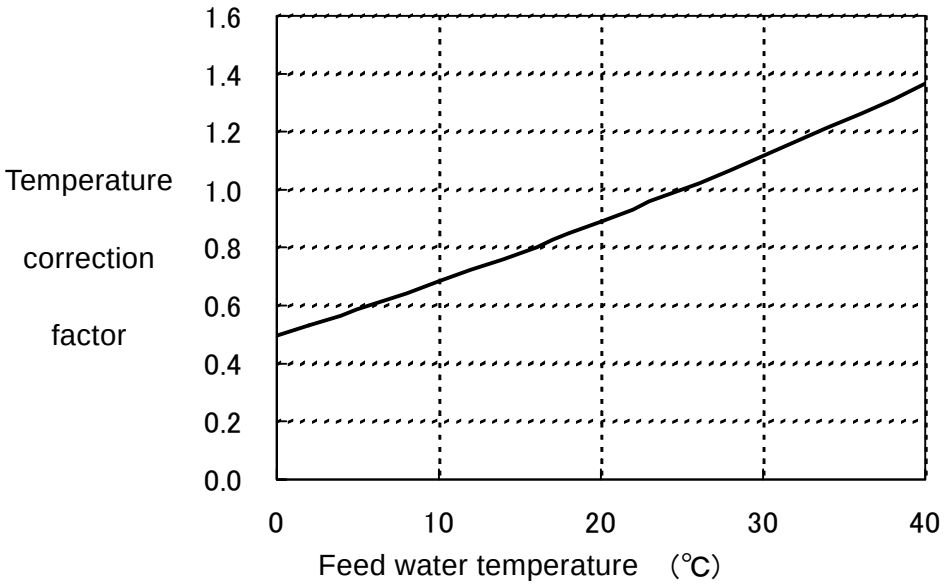


Fig. 15　Temperature correction factor (TCF)

The equation for calculating TCF at a temperature (T degree C) is as follows.

TCF
= 0.0008902 / (0.01257187 x EXP((1－0.005806436 x (273.15 + T)) / (0.001130911 x (273.15 + T) - 0.000005723952 x (273.15 + T) x (273.15 + T))) / 1000)

Please contact us if you need to know how to measure the TMP.

VII. Integrity Test and Maintenance

1. Pressure Decay Test (PDT)

Pressure Decay Test (PDT) is recommended for testing the integrity of TORAY Submerged PVDF Hollow Fiber Membrane Element. The PDT is conducted by applying pressurized air to the element and monitoring the rate of pressure decay over a specific duration of time.

PDT Flow Diagram

Below figure indicates a flow diagram for the PDT.

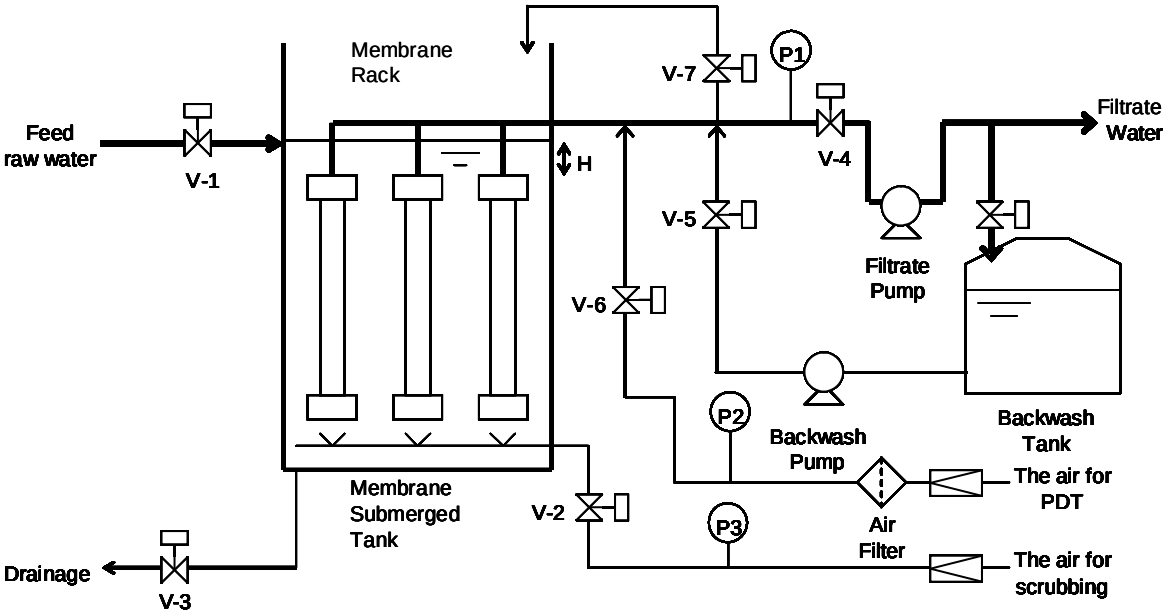


Fig. 16 Flow diagram for the PDT

PDT Method

(1) Stop filtration to be tested. Ensure all of the elements are completely submerged. Set the distance (H) of top of the element to water level of the submerged tank to approximately 0.1 m. Close all valves.

(2) Set the PDT air pressure to a fixed value (P2=100 kPa) by using a regulator.

(3) Introduce oil free air to the permeate side by opening the PDT valve (V-6).

(4) Set the air pressure of the filtrate manifold to a fixed value (P1=100 kPa) by fine adjustment of the regulator. Close the PDT valve (V-6) when the air

pressure of filtrate header pipe is stabilized.

(5) Monitor the pressure decay (Δp) of the feed air pressure for 5 to 10 minutes, dependent on the number of elements. See Fig. 17 for examples of pressure decay due to one broken membrane fiber. If pressure decay is excessive, a visual inspection of the element will be required (see step 7). The pressure decay rate depends on the H. The Fig. 10 shows in case of H = 0.1 m. Please correct the Fig. 17 by using the actual H.

(6) Diffusion of air through the water filled pores of the membrane fiber leads to a pressure decay of approximately 1 kPa in 5 minutes (dependent on the volume of the pipe work manifolds, etc.). A single broken membrane fiber in 128 HSU-1515 elements gives a pressure decay of approximately 5 kPa in 5 minutes, so a decay of 5 kPa in 5 minutes is normally used to indicate the presence of a single broken membrane fiber for this size of unit.

(7) In case of the pressure decay is excessiveness, identify the elements with broken membrane fibers by visual check of water surface (bubbling) in the submerged tank. The pressure time should be kept within 15 minutes to keep from drying out of the membrane.

(8) Mark any leaking elements for subsequent replacement.

(9) After the 3 to 10 minutes pressure hold test period (or after identifying the elements with broken membrane fibers), relieve pressure in the permeate side of the membrane element by opening the air vent valve (V-7). If there are elements with broken membrane fibers, dismount it after the pressure release.

(10) Open the backwash valve (V-5), run the backwash pump and vent air from the filtrate manifold through the V-7.

(11) After venting air from the filtrate line, close the V-5 and the V-7, then stop the backwash pump.

(12) The unit is now ready for processing.

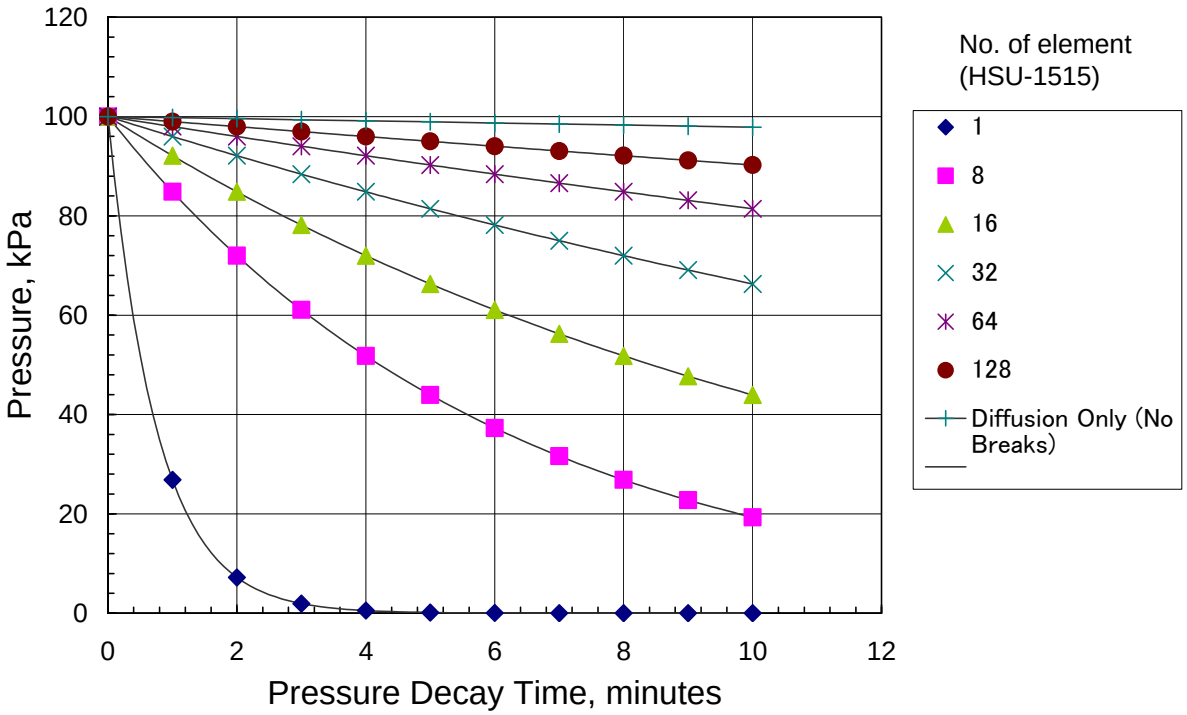


Fig. 17 HSU-1515 pressure decay rates with one broken membrane fiber (calculated)

NOTE: Above figure and indicates the estimate values. The actual values may depend on the volume of the pipe work, temperature, etc.

VIII. Maintenance

1. Chemical cleaning

The chemical cleaning should be carried out to remove foulants accumulated in the membrane pores or sticking to the membrane surface.

CAUTION

- Carry out the chemical cleaning before the trans-membrane pressure rises up to 70 kPa or at least every 6 months, otherwise the element filtration performance could be reduced significantly.
- Follow the instruction described in this manual when you carry out the chemical cleaning. If you use the unacceptable chemicals or perform the cleaning altered from the recommended procedure, the membranes could be seriously damaged.

DANGER

- Pay full attention when handling chemicals and be sure to wear the safety gear such as glasses and gloves. The chemicals used for the chemical cleaning are harmful to people. If chemicals directly contact your skin, your eyes or other body parts, take the appropriate treatment as stated in its MSDS.
- Do not mix sodium hypochlorite with acid. Such mixture generates toxic chlorine gas.
- Stop operations when any instrumental anomalies occur or any sign of anomalies are observed.

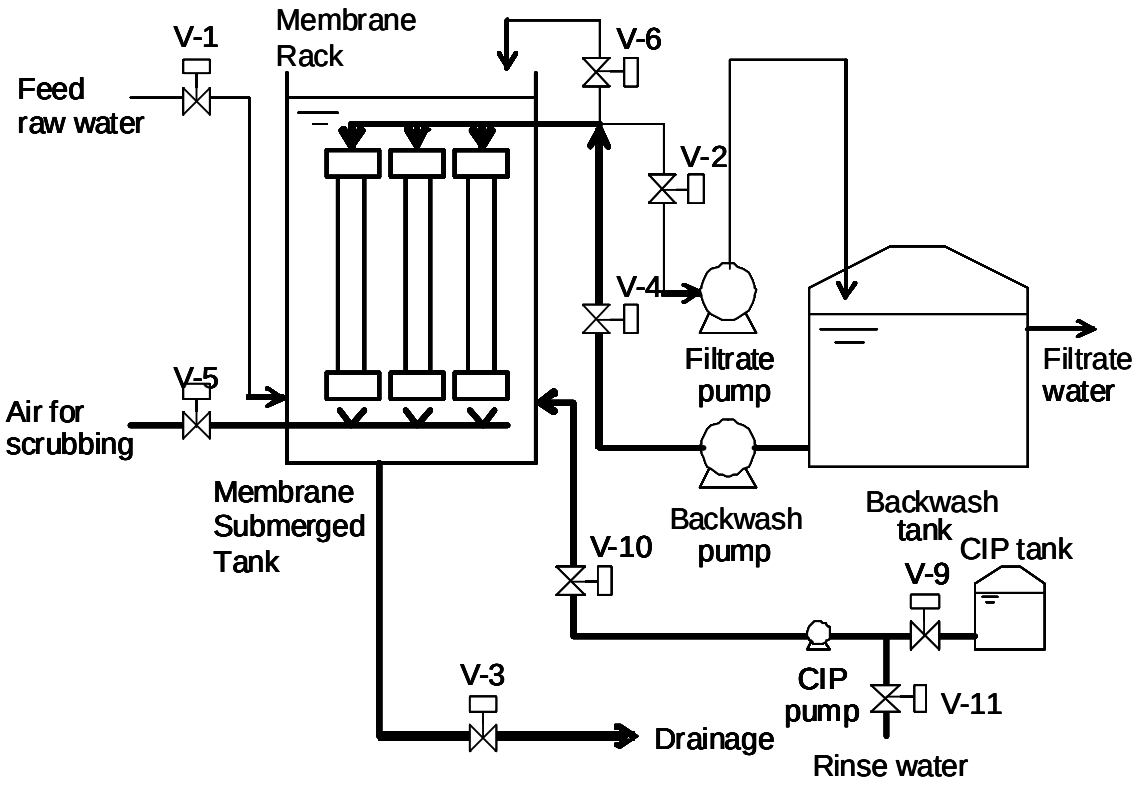


Fig. 18 Flow diagram for chemical cleaning

(1) The flow diagram for cleaning simultaneously both outer surface and inside of hollow fiber membranes is shown in Fig. 18. The flow diagram can be changed case by case. Please contact us if you need the information in detail.

(2) After making sure the Backwash and Air-scrubbing process is just finished, open the drainage valve (V-3) and the air drain valve (V-6) to drain water of the submerged tank and the element.

(3) After making sure all water of the submerged tank is drained, close the drainage valve (V-3).

(4) Open the Chemical valve (V-9) and the Cleaning In Place (CIP) valve (V-10) and run the CIP pump to feed the chemical to the submerged tank.

(5) After making sure the chemical level of the submerged tank is higher than the top of the membrane element, stop the CIP pump, close the Chemical valve (V-9) and the CIP valve (V-10) and hold the chemical for a fixed time (normally 2 hours). During the soak, open the air-scrubbing valve (V-5) a few times (normally every 30 minutes and each scrubbing time is 1 minute). In case of the chemical cleaning efficiency is not high, a chemical circulation process from feed side to filtrate side (not shown in the figure) instead of the soak is available.

CAUTION

- The air flow rate for air-scrubbing should be within the range below for each element. Excessive air flow rate may damage the membranes.

  HSU-1515: 1.5 – 3.0 Nm^3/h

(6) Open the drainage valve (V-3) to drain the chemical out from the submerged tank completely and from the element almost completely.

(7) Close the drainage valve (V-3).

(8) Open the rinse valve (V-11) and the CIP valve (V-10), and run the CIP pump to feed rinse water to the submerged tank for rinse.

(9) After making sure the water level of the submerged tank is higher than the top of the filtrate piping, stop the CIP pump and close the rinse valve (V-11) and the CIP valve (V-10). Then open the air-scrubbing valve (V-5). After 30 seconds, close the air-scrubbing valve (V-5).

(10) After 5 minutes, close the air drain valve (V-6) and then open the drainage valve (V-3) to drain rinsed water out from the submerged tank completely.

(11) Close the drainage valve (V-3).

(12) Open the air drain valve (V-6) and the backwash valve (V-4), and run the backwash pump. After purging any air out (normally a few seconds) from the backwash line, close the air drain valve (V-6) to feed back the filtrate water from the backwash tank to the element.

The flow rate of backwash water is set up in advance normally for 1.1 to 1.5 times filtrate water flow rate.

(13) Stop the backwash pump and close the backwash valve (V-4) when the water level of the submerged tank reaches the top of the filtrate piping. Then open the air-scrubbing valve (V-5). After 30 seconds, close the air-scrubbing valve (V-5).

(14) Open the drainage valve (V-3) to drain rinsed water out from the submerged tank completely.

(15) Repeat the process of (11) to (14) until make sure the submerged tank water meets the required water quality.

(16) Close the drainage valve (V-3).

(17) Open the feed water valve (V-1).

(18) After making sure the water level of the submerged tank is higher than the top

of the filtrate piping, close the feed water valve (V-1).

CAUTION	- Take appropriate measures to prevent the mis-operation or accidents that could cause the chemicals to get into the product water. Check the piping and correctly position of each valve before starting the chemical cleaning.

(19) The standard conditions for chemical cleaning are shown in Table 5.

- The concentration, the chemical quantity and the hold time shown in Table 5 should be observed. Otherwise the element may get damaged and/or the life of membranes may be shortened.
- The cleaning temperature should be 20 to 40 degree C.

Table 5. Standard conditions for chemical cleaning

Pollutants	Chemicals	Maximum Concentration	Hold Time
Inorganic Substances	Citric acid *1	3.0 wt%	1 - 3 hr
Organic Substances	Sodium hypochlorite	3,000 mg/L as chlorine ($10 \leq pH \leq 12$)	1 - 3 hr

*1: Besides citric acid, hydrochloric acid (with the maximum concentration of 1.0 mol/L), oxalic acid (with the maximum concentration of 1.0 wt%), sulfuric acid (with the maximum concentration of 0.05 mol/L) and nitric acid (with the maximum concentration of 0.1 mol/L) are acceptable.

CAUTION	- In the case of cleaning with acid and with sodium hypochlorite alternately, rinse the cleaning line and the element with rinse water thoroughly after each cleaning.
DANGER	- Do not use any other chemicals than those indicated above. - Do not mix sodium hypochlorite with acid. Such mixture generates toxic chlorine gas.

IX. Storage of New Element and Rack after use

Follow the instruction below when you store the element.

CAUTION

- Be careful not to freeze the element.

1. Storage of New Membrane Element

Keep the element in the original packing in a dark and cool place (0 – 40 degree C).
Avoid direct sunlight and moisture.

2. Storage of Rack after use

In the case of the suspension of operation for less than three days, stop the feed water, hold the water in the submerged tank and keep the water level of the submerged tank is higher than the top of the membrane rack. Keep the element at 0 – 40 degree C.
If the suspension lasts more than three days, fill the submerged tank with the chemical described in Table 6. Use filtrate quality water. Replace the chemical every maximum storage period described in Table 6. Keep the element at 0 – 40 degree C.

Table 6. Conditions for storing membrane rack for more than three days

Maximum storage period	Chemical	Concentration of the Chemical	Storage temperature
3 days	sodium hypochlorite	20 mg/L as chlorine	0 – 40 degree C

This Instruction Manual does not intend to guarantee the results of application of the information provided herein or the safety and the compatibility of this product.
Before using this product, the user is asked to check for its safety and compatibility with the intended purpose.
The content of this Instruction Manual is subject to revision from time to time.