Toray UF

Instruction Manual

“F-HFUG Series”

06-G-MB2-F-HFUG-260730

TORAY

Innovation by Chemistry

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1. INTRODUCTION

Toray PVDF Hollow Fiber Membrane Module "F-HFUG series" is a pressurized hollow fiber Ultra Filtration (UF) membrane module developed with polymer science and membrane fabrication technologies accumulated for a long time in Toray Industries, Inc.

The membrane material is Polyvinylidene Fluoride (PVDF). The nominal pore size of the membrane is 0.005 micrometers.

The module, which is permanently potted in its casing, is pressure-driven which provides filtrate quality equal to submerged modules, while offering greater Trans-Membrane Pressure (TMP) range for more flexible plant operation. Maximum TMP is 300 kPa (43.5 psi). The flow direction is outside-in, which is more suitable for treating high-turbidity water due to its effective air scrubbing capability. Additionally, outside-in flow configuration can remove suspended solids more effectively at higher recovery rates compared to inside-out flow configuration.

1.1. Characteristics of Toray "F-HFUG Series" Membrane Modules

High Filtration Flux

F-HFUG series 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.

Excellent Water Quality

F-HFUG series provides very good water quality for the filtrate, extremely low turbidity since the membrane has 0.005 micrometers nominal pore size. By halving the nominal pore size of HFUG series, F-HFUG series provides improved separation performance compared with HFUG series. F-HFUG series is recommended to be applied to the tertiary treatment of sewage and RO pretreatment in desalination. Additionally, F-HFUG series enhances operational stability and reduces costs in integrated UF-RO systems.

High Mechanical Strength

The membrane used in F-HFUG series exhibits exceptional mechanical strength, as it is made of PVDF and manufactured using a proprietary spinning method developed by Toray. F-HFUG series provides high integrity and durability under recommended operating conditions.

High Chemical Durability

F-HFUG series employs PVDF as the membrane material, allowing for cleaning with high

concentrations of chlorine and acid. This leads to enhanced cleaning performance and prolonged maintenance of membrane flux.

1.2. About “F-HFUG Series”

F-HFUG series has a lineup of various product specifications, from standard products, for high pressure operation use, products suitable for installation in existing plants, and compact types.

- F-HFUG-2020AN: Standard type module.
- F-HFUG-2020HN: High pressure resistant UF membrane module that can be connected to gravity-fed tank system (high positioned UF filtrate tank) and/or direct RO coupling systems, etc.
- F-HFUG-B2315AN: 6-inch, taller type UF membrane module.

1.3. Applications of Toray "F-HFUG Series" Membrane Module

- Drinking Water Production *1)
- Tertiary Treatment
- RO Pretreatment
- Industrial Water Production
- Reuse of Industrial Wastewater

*1): This application requires products certified for drinking water production. Please contact us for more information.

2. FOR YOUR SAFETY

Please be sure to read and follow the instructions below before using F-HFUG series. 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.

2.1. 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 stored within the module under immersion in a sodium hypochlorite solution (Max. 200 mg/L as Cl_2). If the solution happens to splash onto 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.

WARNING


Instruction

Be sure to wear safety gear such as a helmet to protect your head and safety shoes to avoid injury due to falling of related parts or equipment, such as module, etc.

CAUTION


Prohibited

The preservative solution should be drained out before using the modules. After that, fill tap water or equivalent quality water into the modules to prevent the hollow fiber membrane from drying out. Do not allow the modules to dry even for a few hours.


Prohibited

The membrane modules should not be frozen.


Prohibited

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


Instruction

Be sure to wear protective appropriate gloves to avoid injury of hands by packing box of the modules.


Instruction

Housing type joints and screw are applied to connect the modules to the piping. Follow the instruction of the connection provided by the supplier at the connection point. Wrong connections may damage the modules.


Instruction

When connecting and unconnecting the modules to the piping, be sure to secure a sufficient working space, and take care not to catch and hurt fingers.


Prohibited

Keep all connecting surfaces, O-rings, and gaskets should be free of dirt and oils.


Instruction

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

2.2. 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 connecting the modules.


Instruction

Confirm that the preservative chemical in the modules is completely drained out before starting the filtration operation. The preservative chemical is harmful to humans.


Instruction

Flush the modules at low pressure, filling from the bottom, and vent to remove any air from the modules. Air left in the modules may cause water hammer and may result in damage to the membrane.


Instruction

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


Prohibited

Do not use modules that has not comply with the regulations and standards for drinking water production applications in each country and region for drinking water production use.

WARNING


Instruction

Protect modules from direct sunlight and ultraviolet light. Ultraviolet light can degrade module.


Instruction

Constantly monitor the 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 feed pressure of 300 kPa (43.5 psi) for except F-HFUG-2020HN, and 600 kPa (87.2 psi) for F-HFUG-2020HN. Higher pressures can damage the modules. Do not exceed the maximum temperature of 40 °C (104 °F). The higher temperature damages the modules.


Prohibited

Do not allow modules to come into contact with substances such as oil, organic solvents, strong alkalis, or any chemicals that may damage plastic components (e.g., membranes, housings, EPDM O-rings, EPDM gaskets, and joints) under concentrations or conditions that could cause deterioration.


Prohibited

Do not freeze the membrane modules.


Instruction

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


Instruction

Make sure air tubes or connected pipes are properly fixed. Otherwise, the tubes or connected pipes may be blown away or start thrashing around during air scrubbing.


Instruction

Do not overfeed air to the modules. Excessive scrubbing air damages the membranes and/or shortens the membrane life.
The air flow rate should be within the range (Table 4-4, Specifications of Modules) for each module type.


Instruction

At the integrity tests, such as Pressure Decay Test (PDT) keep the air pressure below 130 kPa (18.9 psi). Also, keep the source air pressure lower than 200 kPa (29 psi), to prevent excess air inflow. All the air used for air scrubbing and integrity testing must be dry oil-free air.

2.3. 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 appropriate gloves. If chemicals come in direct contact with your skin or your clothes, treat the contacted part appropriately based on the SDS.


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 modules or negatively affect the membrane performance.

2.4. Safety Instruction for Disposal

WARNING


Instruction

Apply a service of a qualified industrial waste disposal contractor when disposing of the modules.
When incinerating modules, use an incinerator that does not produce dioxins and an appropriate facility that can neutralize hydrogen fluoride (HF) gas. If the incineration temperature is too low, dioxins will be generated, and HF gas will be produced when the membrane is incinerated.

3. WARRANTY CONDITIONS

For information on the warranty of Toray UF 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.

4. SPECIFICATIONS OF TORAY “F-HFUG SERIES” MEMBRANE MODULE

Table 4-1: Specifications of Membrane *1)

Membrane Material		PVDF (Polyvinylidene fluoride)
Nominal Pore Size *2)		0.005 micrometers
Trans-Membrane Pressure	Maximum *3)	300 kPa (43.5 psi)
	Normal Operation	Lower than 200 kPa (29.0 psi)
Storage and Operating Temperature Range		1–40 °C (34–104 °F)
Operating pH Range		1–10
Cleaning pH Range		0–12

*1): Note that the specifications are subject to change without notice.

*2): Estimation from removing model particles.

*3): Trans-Membrane Pressure (TMP) should be below 300 kPa (43.5 psi) at any time even during the filtration.

Table 4-2: Feed Water Limits *1), *2)

Turbidity	Intermittent Peak *3)	200 NTU
	Continuous Maximum	50 NTU
TSS	Intermittent Peak *3)	200 mg/L
	Continuous Maximum	50 mg/L
Ozone		Not detected
Pretreatment Filter Mesh Size		Smaller than 200 micrometers
Temperature Range		1–40 °C (34–104 °F)
pH Range		1–10
Max. Feed Pressure		Models except F-HFUG-2020HN: 300 kPa (43.5 psi) F-HFUG-2020HN: 600 kPa (87.0 psi)

*1): Note that the specifications are subject to change without notice.

*2): For any concerns about design, please contact us.

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

WARNING

- Do not allow modules to come into contact with substances such as oil, organic solvents, strong alkalis, or any chemicals that may damage plastic components (e.g., membranes, housings, EPDM O-rings, EPDM gaskets, and joints) under concentrations or conditions that could cause deterioration.

CAUTION

- To prevent damage, do not exceed a maximum feed pressure of 300 kPa (43.5 psi) for the modules except F-HFUG-2020HN, and 600 kPa (87.0 psi) for F-HFUG-2020HN. Additionally, the maximum allowable TMP is 300 kPa for all modules. When the feed pressure of F-HFUG-2020HN exceeds 300 kPa, a corresponding level of back pressure is required. If the filtrate water is supplied to the high-pressure pump of an RO system, the supply pressure to the high-pressure pump becomes the back pressure.

Table 4-3: Cleaning Limits *1)

		Maximum Concentration for Cleaning	Max. Oxidant CT Value (Concentration x Time) or Max. Acid/Alkari Contact Time	Cleaning Temperature Range *2)
Oxidant *3)	Sodium Hypochlorite	3,000 mg/L as Cl2 (10 ≤ pH ≤ 12)	1,000,000 mg/L hours as Cl2	20–40 °C 68–104 °F
	Peracetic Acid	0.25 wt%	900,000 mg/L hours	
	Hydrogen Peroxide	1.00 wt%	3,600,000 mg/L hours	
Acid	Citric Acid	3.00 wt%	1,000 hours (0 ≤ pH)	
	Oxalic Acid	1.00 wt%		
	Hydrochloric Acid	1.0 mol/L		
	Sulfuric Acid	0.05 mol/L		
	Nitric Acid	0.1 mol/L		
Alkari	Sodium Hydroxide	0.01 mol/L	360 hours (pH ≤ 12)	

*1): Note that the specifications are subject to change without notice.

*2): The minimum water temperature for chemical cleaning is 20 °C / 68 °F. Cleaning operations can be performed at temperatures above 1 °C / 34 °F; however, the cleaning efficiency will be significantly reduced at temperatures below 10 °C / 50 °F.

*3): Conditions in which substances that can act as catalysts, such as Fe, which accelerates oxidation, coexist are not taken into consideration.

Table 4-4: Specifications of Modules *1)

Module Type		F-HFUG -2020AN	F-HFUG -2020HN	F-HFUG -B2315AN
Membrane Surface Area (Outer Surface)		90 m^2 (969 ft^2)		75m^2 (807 ft^2)
Dimensions	Diameter	216 mm (8.50 inches)		178 mm (7.01 inches)
	Length	2,160 mm (7.087 ft.)		2,332 mm (7.651 ft)
Weight	Full of Water	92 kg (203 lbs)	103kg (227 lbs)	65 kg (143 lbs)
	Drained	49 kg (108 lbs)	65 kg (143 lbs)	35 kg (77 lbs)
Materials	Housing	PVC-U and/or equivalent		
	Potting	Epoxy resin		
	O-ring	EPDM		
Connections	Top	Housing type joint 80A		Housing type joint 2 inches (U.S.)
	Bottom	Housing type joint 80A		Housing type joint 2 inches (U.S.)
	Side	Housing type joint 65A		Union joint2.3 inches (original)
Operating Conditions	Max. Feed Water Flow	15 m^3/h (66 gpm)		12.5 m^3/h (55 gpm)
	Max. Backwash Flow	16.8 m^3/h (74 gpm)		13.8 m^3/h (61 gpm)
	Max. Air Flow	9.0 Nm^3/h (5.3 scfm)		6.7 Nm^3/h (3.9 scfm)
	Filtration Method	Outside to inside, Dead end		
	Max. Feed Pressure	300 kPa (43.5 psi)	600 kPa (87.0 psi)	300 kPa (43.5 psi)
	Temperature Range	1-40 °C (34-104 °F)		

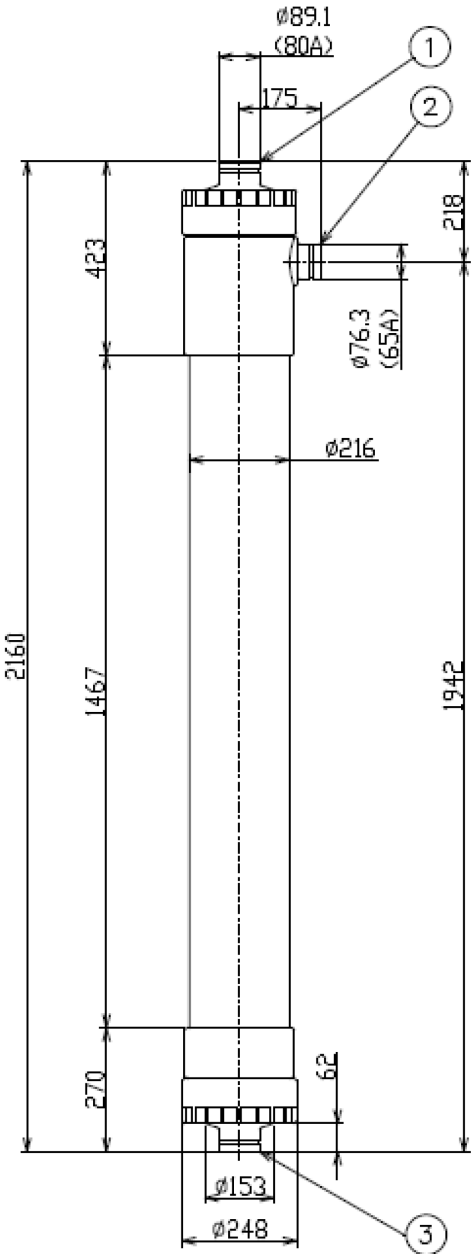
*1): Note that the specifications are subject to change without notice.

CAUTION

- Handle and operate the modules within the ranges and the limits indicated in Tables 4-1 through 4-4. Operation out of these ranges or limits may damage the modules and affect filtration performance.

5. CONFIGURATION OF TORAY “F-HFUG SERIES” MEMBRANE MODULE

5.1. F-HFUG-2020AN



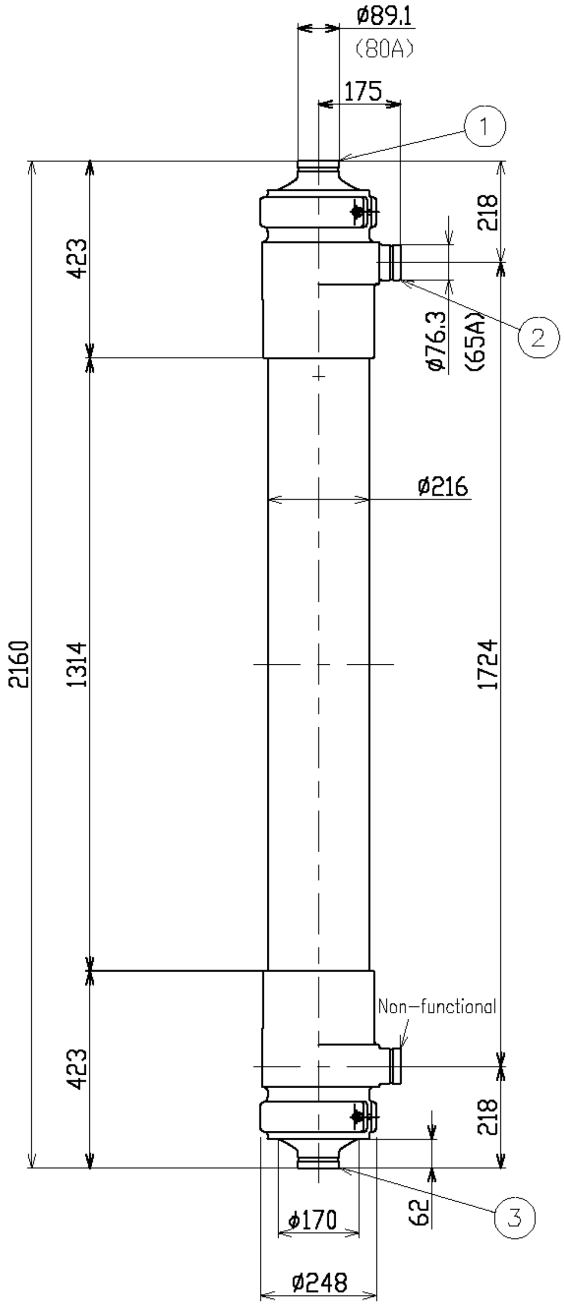
①: Filtrate Outlet / Backwash Water Inlet
②: Air Outlet / Backwash Water Outlet
③: Feed Water Inlet / Air Inlet / Drain Outlet

Connections

	Pipe fitting outer diameter mm (in)	Connectors
①	89.1 (3 1/2”)	Housing type joint 80A
②	76.3 (3”)	Housing type joint 65A
③	89.1 (3 1/2”)	Housing type joint 80A

Figure 5.1-1: F-HFUG-2020AN

5.2. F-HFUG-2020HN



①: Filtrate Outlet / Backwash Water Inlet
②: Air Outlet / Backwash Water Outlet
③: Feed Water Inlet / Air Inlet / Drain Outlet

Connections

	Pipe fitting outer diameter mm (in)	Connectors
①	89.1 (3 1/2”)	Housing type joint 80A
②	76.3 (3”)	Housing type joint 65A
③	89.1 (3 1/2”)	Housing type joint 80A

Figure 5.2-1: F-HFUG-2020HN

5.3. Housing Type Joint 80A and 65A

Housing Type Joint 80A and 65A are intended for module type F-HFUG-2020AN, F-HFUG-2020HN.

Figure 5.3-1: Housing Type Joint 80A

Figure 5.3-2: Housing Type Joint 65A

Table 5.3-1: Specifications of Housing Type Joints *1)

Size	80A (For top and bottom nozzles)		65A (For side nozzles)	
Materials	(Housing) Polyamide + Glass Fiber (Gasket) EPDM Rubber (Bolt/Nut) Stainless Steel			
Type	A	B	A	B
Height (mm)	126	128	109.5	108
Width (mm)	45	47	50	46
Length (mm)	177	160	156	148
Weight (kg)	0.6	0.5	0.3	0.3
Bolt/Nut Size (mm)	19	14	13	14

*1): Note that the specifications are subject to change without notice.

5.4. F-HFUG-B2315AN

F-HFUG-B2315AN module provides several connection options. Top/Bottom cap can be changed optional parts depending on actual connection. Please contact Toray for more information.

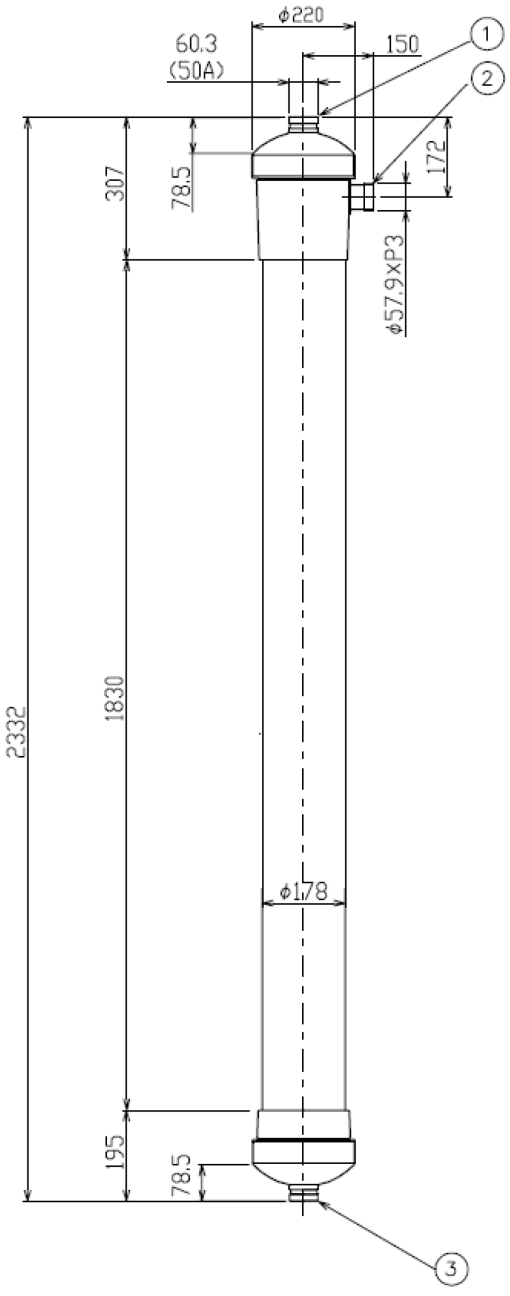


Figure 5.4-1: F-HFUG-B2315AN

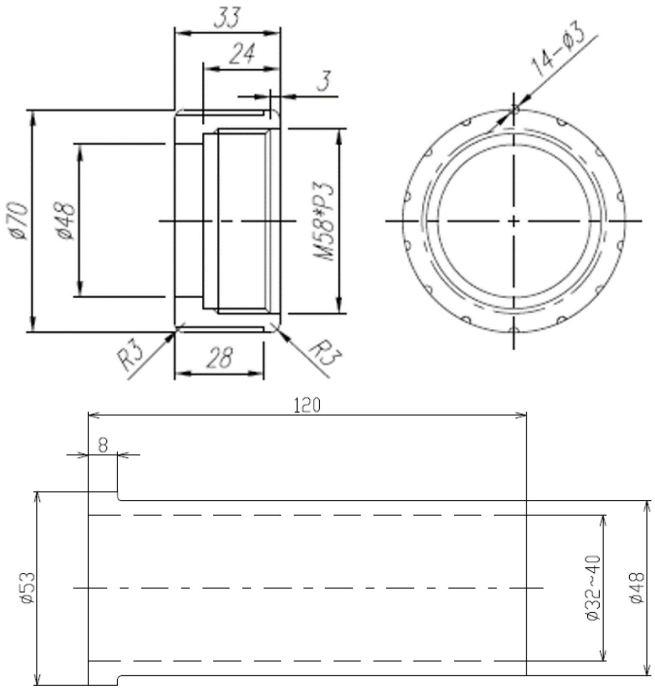
①: Filtrate Outlet / Backwash Water Inlet
②: Air Outlet / Backwash Water Outlet
③: Feed Water Inlet / Air Inlet / Drain Outlet

Connections

	Pipe fitting outer diameter mm (in)	Connectors
①	60.3 (2”)	Housing type joint 2 inches (U.S.)
②	57.9 (2.3”)	Original *1) + AS568-325 (Gasket)
③	60.3 (2”)	Housing type joint 2 inches (U.S.)

The Housing Type Joint for F-HFUG-B2315AN corresponds to 50A, but it is not supplied by Toray.

*1) Referential Drawings of ② Air Outlet / Backwash Water Outlet connection



6. UF PLANT CONFIGURATION

Figure 6-1 illustrates a representative configuration of pumps, tanks, valves, and piping of a UF plant. Figure 6-1 also presents an example of process flow for performing an automated Pressure Decay Test (PDT). It should be noted that the optimal plant configuration may vary depending on plant scale and specific operational requirements. Accordingly, please use Figure 6-1 as a reference when planning the design for a plant incorporating UF modules. Should you require clarification or have inquiries regarding membrane-related design considerations, please contact us.

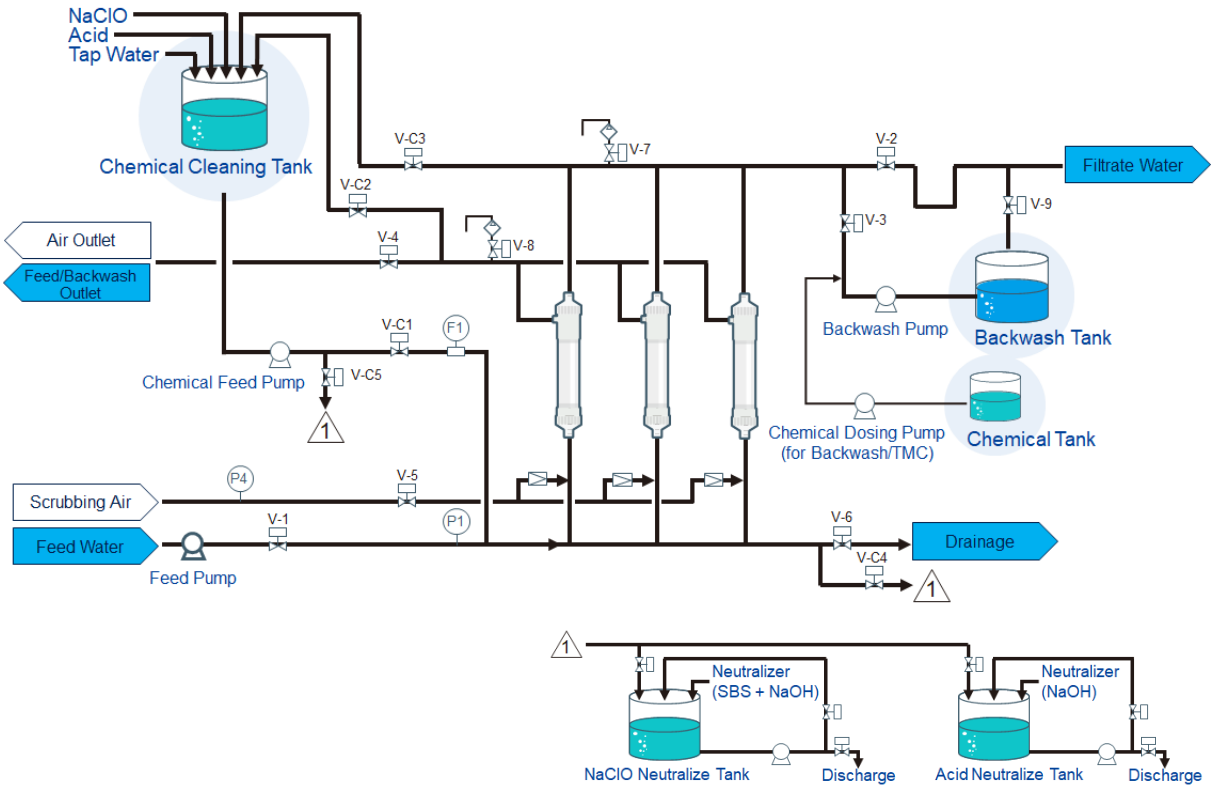


Figure 6-1: UF Plant Configuration

7. INSTALLATION

The standard procedure to install membrane modules is described below.

1. Unpack membrane module from its wooden or corrugated box.

CAUTION	● Be sure to wear appropriate protective gloves to avoid injury of hands when unpacking the box of the modules.

2. Remove a plugging plate from each nozzle of the module.
3. Drain out the preservative solution from the module.

DANGER	● Wear rubber gloves and safety glasses when draining the preservative chemical. Note that the preserving chemical is sodium hypochlorite solution (Max. 200 mg/L as Cl_2). If this solution splashes onto your skin, wash the affected part with running water. If the solution gets in your eyes or mouth, wash the affected part with enough running water for over 15 minutes and see the doctor immediately.

4. Prepare a pedestal that matches the shape of the bottom cap of each type of module. And put the module vertically on the pedestal in the module rack. Fix the module upright with the connections and/or a support belt (see Figure 7-1).

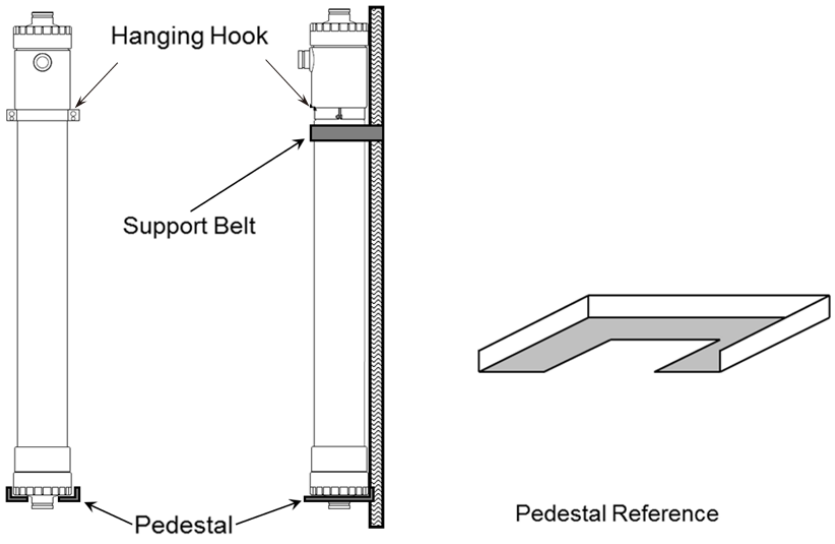


Figure 7-1: Example of Membrane Module Installation

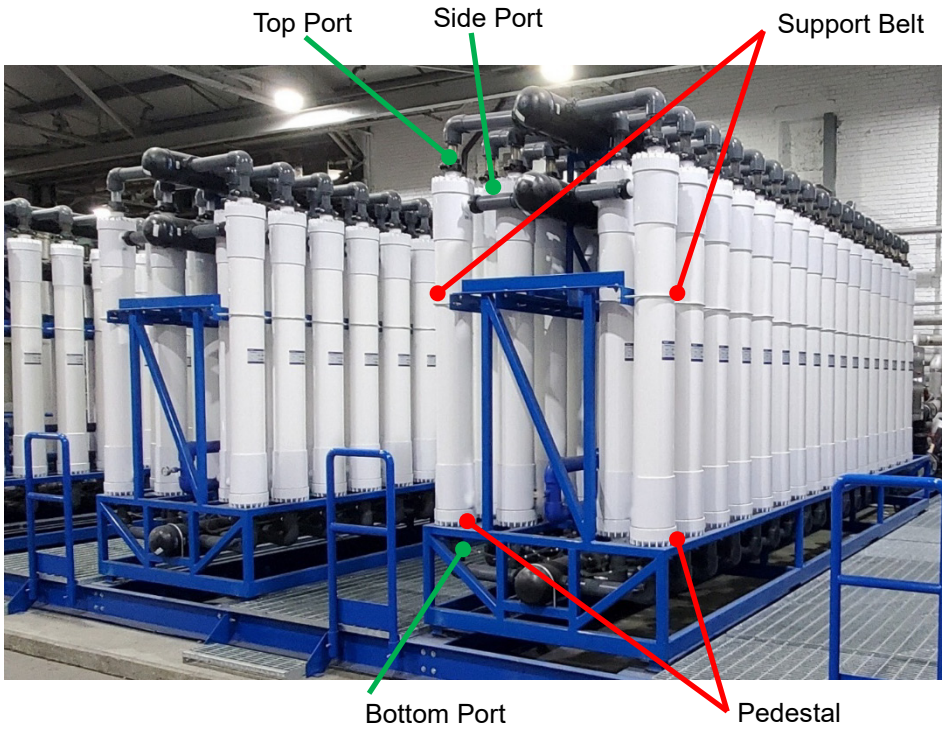


Figure 7-2: Example of Rack Structure

WARNING	• Be careful not to drop the module during handling. • Use equipment such as chain blocks, a crane, or a forklift truck when you handle the module. The F-HFUG- series module is too heavy to handle by hand.
CAUTION	• Take care not to catch and hurt fingers. • Be careful not to install the module upside down. Confirm the module is installed in the right direction. • Do not overtighten the module with the hanging hook and/or the supporting belt, or you may damage the module. • Do not allow the hollow fiber membranes to dry even for a few hours, especially in summer. • Do not freeze the module.

5. As shown in Figure 7-2, connect the rack piping to the module at its three ports. The maximum fastening power of the housing type joints should not exceed 40 Nm. For the connections, use housing type joints and tighten by hand. Before tightening or loosening housing type joints, make sure there is enough space to work safely, and be cautious to avoid injury to your fingers or other parts of the body.

CAUTION

- All connecting surfaces, O-rings, and gaskets should be free of dirt and oils.
- Follow the instructions below when storing the modules. Improper handling may result in damage to the module.

6. To completely inject air into the module at Air Scrubbing process during filtration operation, install the air inlet on the vertical pipe located directly below the module, and at a position higher than the header pipe to minimize the risk of air entering the header. Please refer to Figure 7-3. Also, a check valve is necessary to the air piping to avoid water reverse flow.

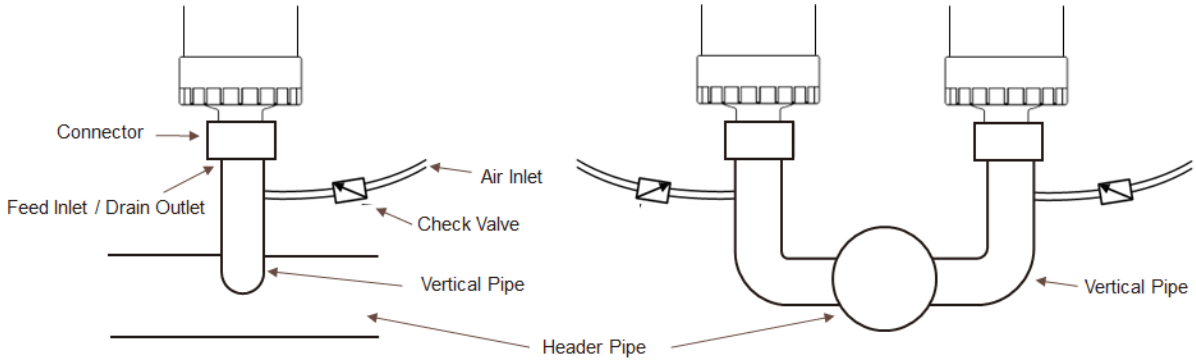


Figure 7-3: Examples of Air Pipe Installation

WARNING

- Make sure air tubes or connected pipes are properly fixed. Otherwise, the tubes or connected pipes may be blown away or start thrashing around during air scrubbing.

7. Make sure that the module is installed vertically.

CAUTION

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

8. OPERATION

8.1. Fundamental of UF Filtration

The water and air inflow and outflow to the membrane module are shown in the figure below.

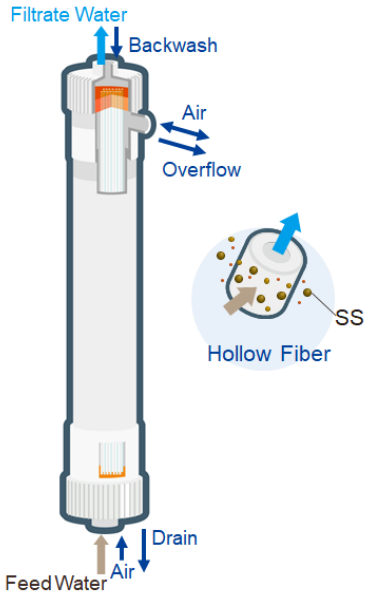


Figure 8.1-1: Water and Air Flow Directions in UF Membrane Module

The filtration method of the UF membrane is dead-end filtration.
When feed water containing suspended solids is filtered, the suspended solids become concentrated inside the housing and foul the membrane surface, resulting in an increase in TMP. Therefore, after a certain period of filtration, the foulants on the membrane and inside the membrane module are discharged by backwashing or air scrubbing. This condition is illustrated in Figure 8.1-2.
Furthermore, if TMP increases due to organic matter or scale that cannot be removed by backwashing or air scrubbing, perform chemical cleaning.

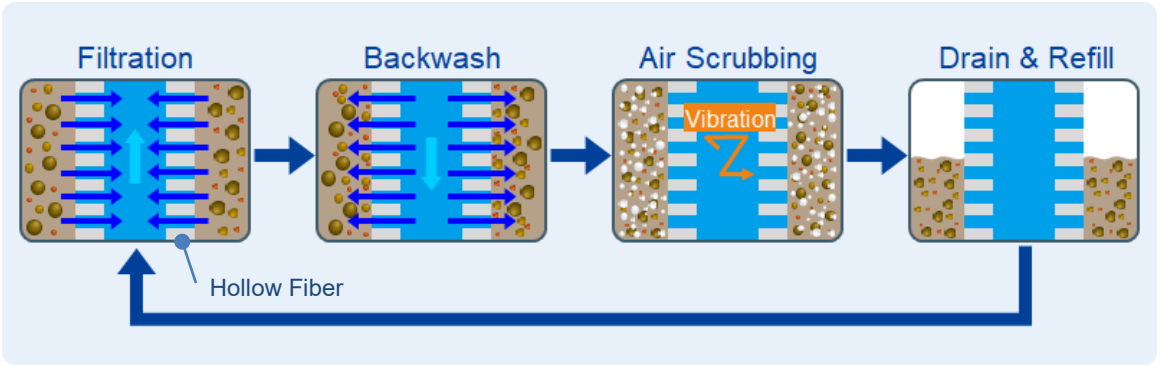
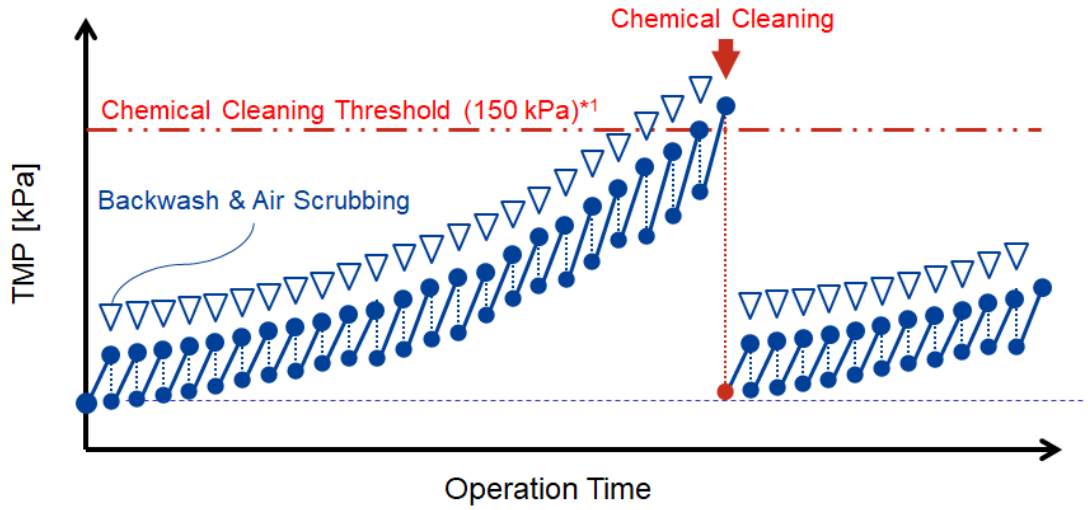


Figure 8.1-2: Standard Filtration Cycle

The following graph schematically shows these changes plotted against operating time and TMP.



*1: Chemical cleaning is recommended when the TMP reaches 150–200 kPa.

Figure 8.1-3: Variation in TMP during Standard Backwash Operation

As shown in the graph, TMP increases during filtration and is partially reduced by backwashing or air scrubbing, but it gradually rises over time. Therefore, when the TMP reaches the chemical cleaning threshold, perform chemical cleaning to recover performance.

This section described the basic operating cycle; however, depending on feed water quality, enhanced cleaning processes such as Drain Backwash or Toray Maintenance Cleaning (TMC) may be applied (see 8.2.2 Filtration Cycle with Drain Backwash (Patented) and 8.2.3 TMC (Toray Maintenance Cleaning) for details).

If you need to perform an operating method or cycle that is not described in this manual, please contact us.

8.2. Filtration Cycles and Cleaning Methods

8.2.1. Filtration Cycle with Standard Backwash

This section explains the operating cycle when treating relatively good-quality feed water. As shown in Figure 8.2.1-1, during filtration, suspended solids in the feed water accumulate on the membrane surface and inside the housing. These are removed from the membrane surface by backwashing and air scrubbing and drained from the housing. After the housing has been refilled with feed water, the filtration process is resumed.

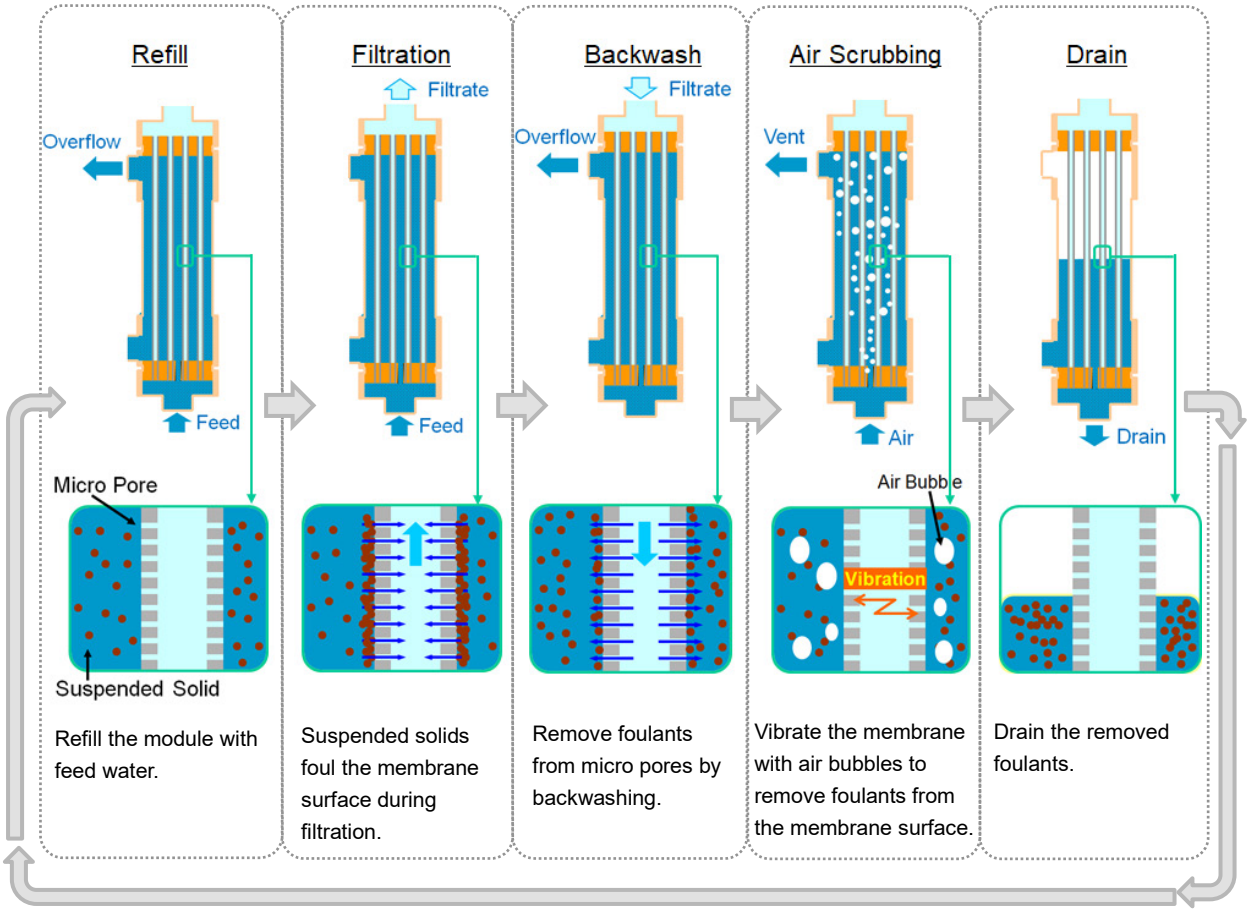


Figure 8.2.1-1: Standard Backwash Filtration Cycle

8.2.2. Filtration Cycle with Drain Backwash (Patented)

High turbidity in the feed water can result in substantial accumulation of suspended solids within the housing and membrane bundle during dead-end filtration, which may not be completely removed by standard backwashing, air scrubbing, and draining. In such cases, an operating method called Drain Backwash is applied, in which draining is performed while supplying backwash water to effectively drain foulants from the membrane surface and inside the membrane bundle.

For the selection criteria between Drain Backwash and Standard Backwash, please refer to section 8.2.4 Criteria for Determining Operation Process.

Figure 8.2.2-1 illustrates the TMP trend under high-turbidity feed water conditions, comparing standard backwash with drain backwash, and demonstrates that drain backwash enables more stable operation.

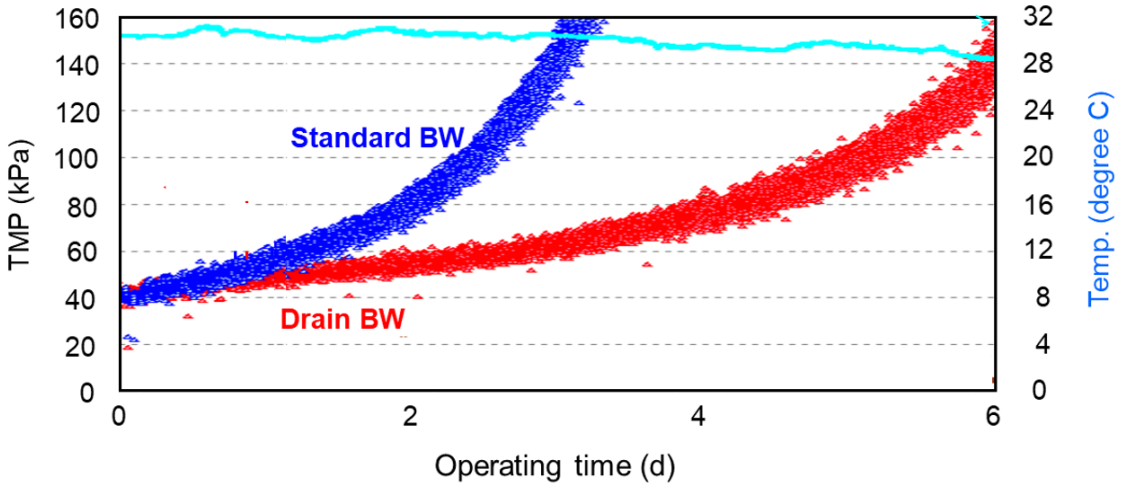


Figure 8.2.2-1: Variation in TMP during Drain Backwash Operation

The following Figure shows Drain Backwash processes.

Drain Backwash involves more steps compared to Standard Backwash. However, since the equipment configuration is the same, the operating mode can be switched based on the feed water quality.

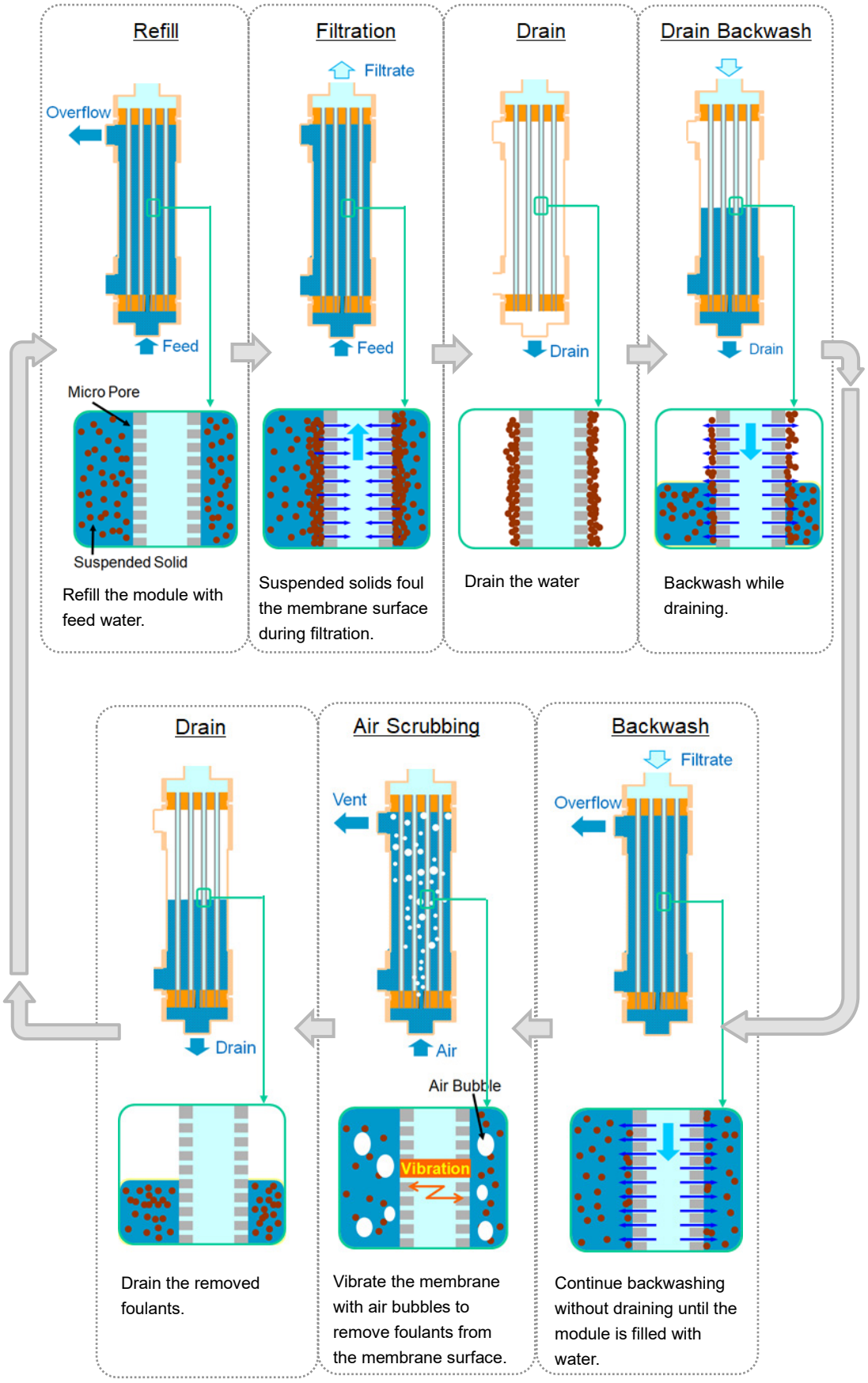


Figure 8.2.2-2: Drain Backwash Filtration Cycle

8.2.3. TMC (Toray Maintenance Cleaning)

When the feed water has a high concentration of organic matter, TMP may rise prematurely. In such situations, sodium hypochlorite TMC is applied. When the feed water contains high levels of manganese or iron, or when coagulants are directly added, using citric acid TMC in combination may help further suppress the increase in TMP.

TMC is a cleaning method that uses lower chemical concentrations and a shorter soaking time compared to the chemical cleaning performed when the TMP approaches its operational threshold. The effect of applying TMC is illustrated in the graphs below: Figure 8.2.3-1 shows operation without TMC, while Figure 8.2.3-2 shows operation with TMC. By applying TMC, pressure rise can be mitigated, enabling extended continuous operation.

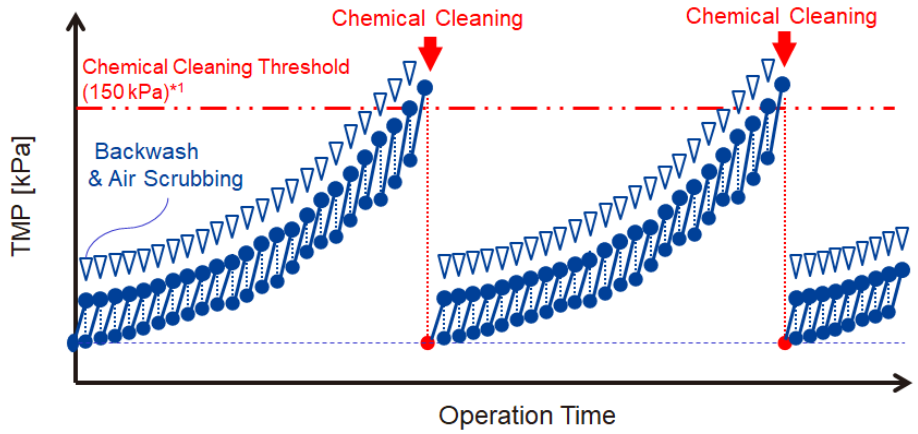


Figure 8.2.3-1: Variation in TMP **without** TMC Application

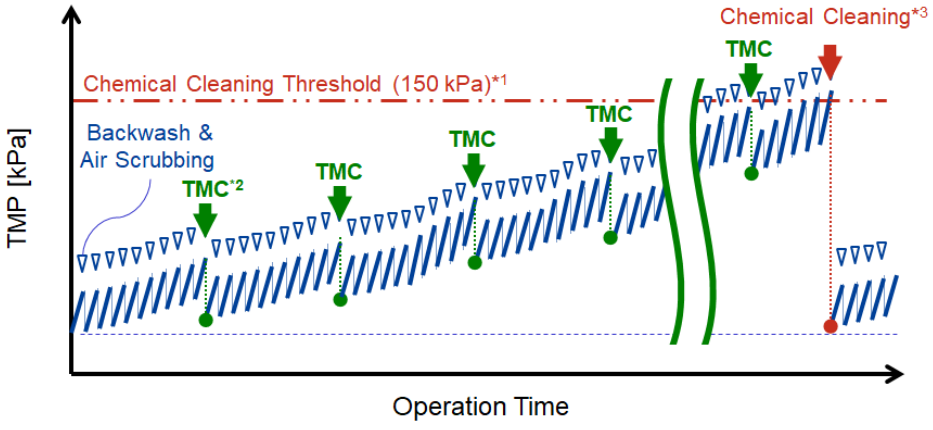
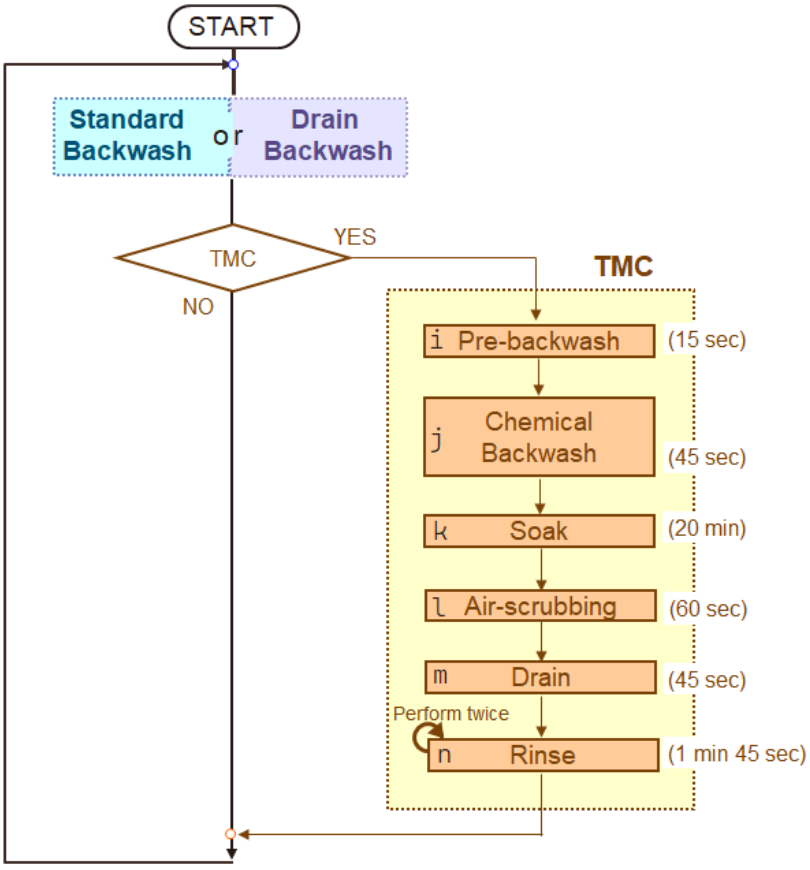


Figure 8.2.3-2: Variation in TMP **with** TMC Application

TMC can be incorporated into either the Standard Backwash cycle or the Drain Backwash cycle. Configure the system to initiate the TMC process at the designated timing, as illustrated below. When implementing TMC, the standard operating condition is to exclude sodium hypochlorite dosing from the backwash solution for both Standard and Drain Backwash operations.



The durations listed for each process represent standard times. Actual times may vary depending on the plant scale, the feed water quality, and other operating conditions.

Figure 8.2.3-3: TMC Flow Chart

8.2.4. Criteria for Determining Operation Process

The criteria for determining the backwash cycle and TMC implementation depends on feed water quality, the presence of RO process as post-treatment, and other factors. The basic concept is outlined in the table below; however, additional considerations, including plant requirements, must be reviewed individually. For detailed information, please contact us as needed.

Table 8.2.4-1: Criteria for Determining Backwash Cycle and TMC Implementation

Condition	Backwash
Low SS *1)	Standard Backwash
High SS	Drain Backwash

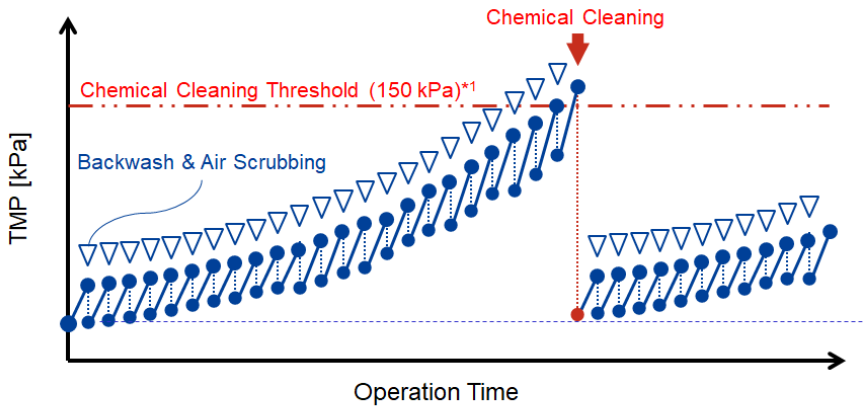
*1) SS (Suspended Solids): Low < 30 mg/L < High

Condition	TMC
Low Organic Matter *2)	Without TMC
High Organic Matter or Pretreatment for RO	With TMC

*2) Organic Matter (TOC): Low < 3 mg/L < High

8.2.5. Chemical Cleaning

As filtration operation continues, the transmembrane pressure (TMP) gradually increases. When the TMP reaches 150 kPa, perform chemical cleaning to recover membrane performance. The operation time and the trend of TMP are shown in Figure 8.2.5-1.



*1: Chemical cleaning is recommended when the TMP reaches 150–200 kPa.

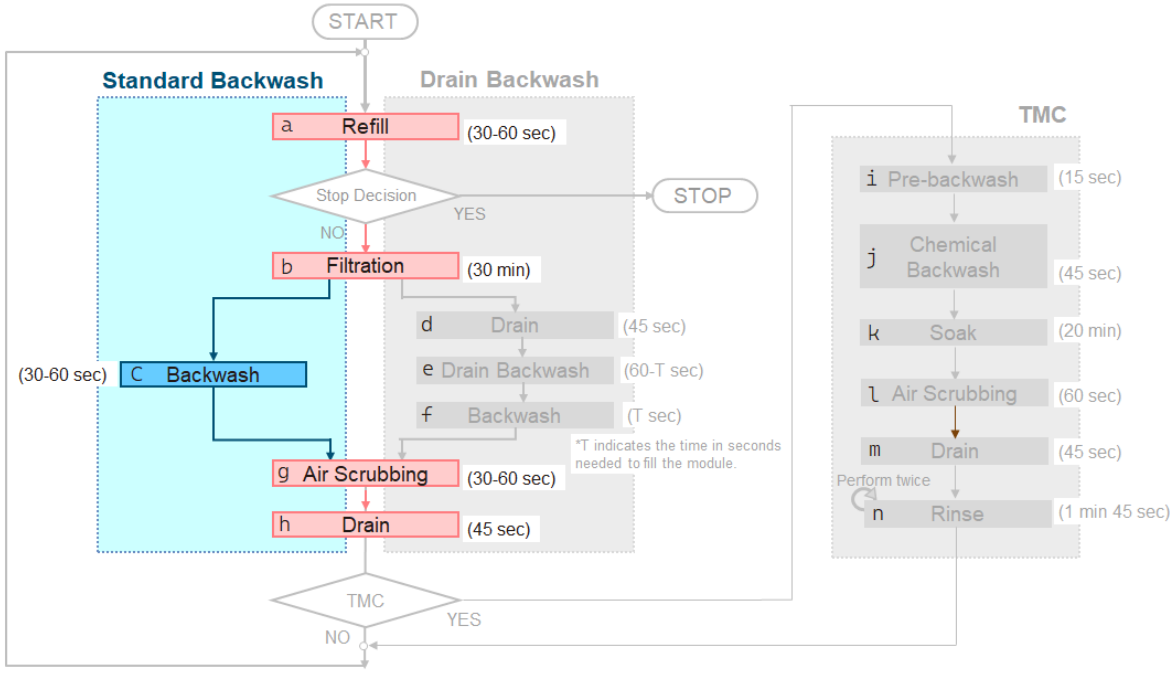
Figure 8.2.5-1: Variation in TMP during Chemical Cleaning

8.3. Processes and Timing Chart

In the previous section, we explained the basic UF operating cycle and the selection of operating process combinations. In this section, we provide a reference example of equipment configuration, describe the operating procedures and precautions, and present the operating sequence of each component in timing chart.

8.3.1. Standard Backwash Processes

The operating flow during a Standard Backwash cycle is as shown in the following flow chart: a. Refill → b. Filtration → c. Backwash → g. Air Scrubbing → h. Drain.



The durations listed for each process represent standard times. Actual times may vary depending on the plant scale, the feed water quality, and other operating conditions.

Figure 8.3.1-1: Standard Backwash Flow Chart

The equipment flow diagram, operating procedures, and precautions for each process are as follows.

8.3.1.a. Refill

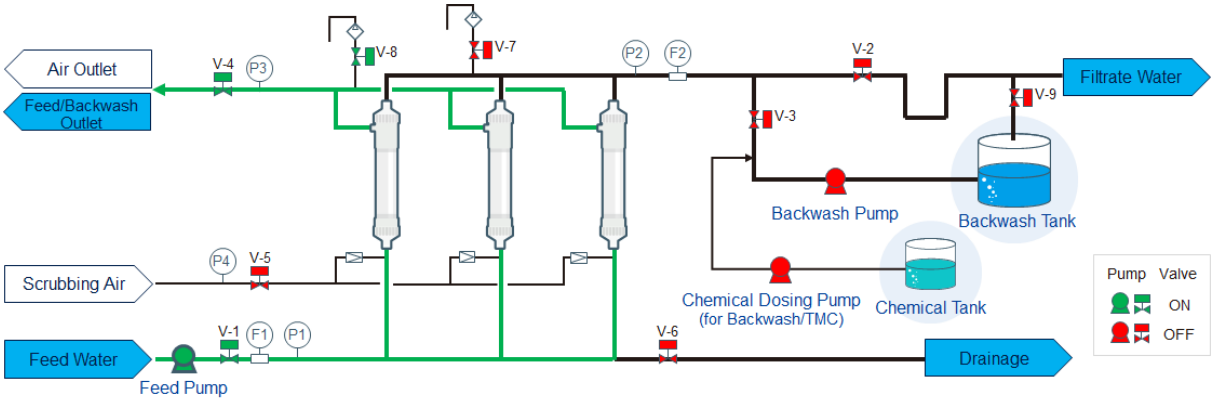


Figure 8.3.1-2

a-1. Make sure Feed/Backwash Outlet Vent Valve (V-8) is opened.

a-2. Open Feed/Backwash Outlet Valve (V-4).

a-3. Start Feed Pump, gradually open Feed Valve (V-1), and fill the modules with feed water during the set Refill time to purge air.

Notes

- Air inside the modules should be completely purged within the set Refill time.
- Once the air has been purged, the sound of overflow water flowing through the backwash outlet piping can be heard.

8.3.1.b. Filtration

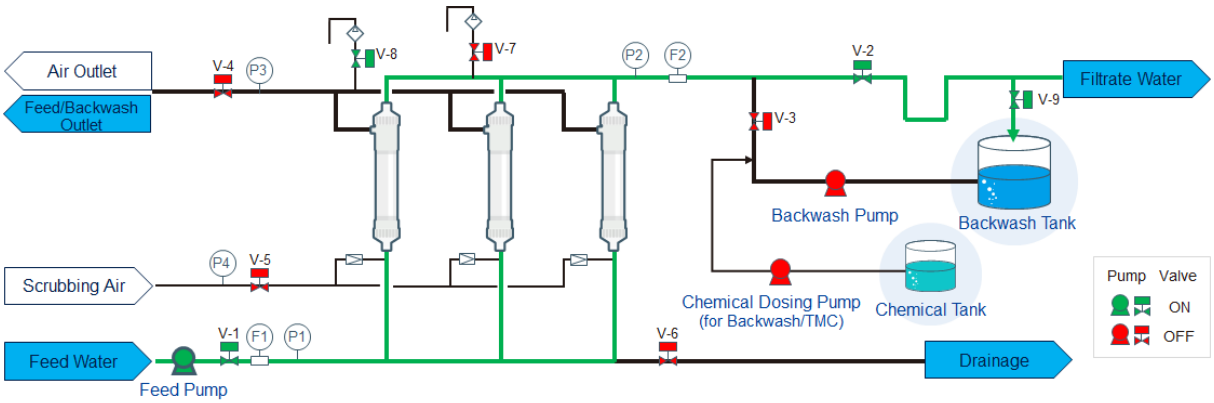


Figure 8.3.1-3

b-1. After Refill timer ends, open Filtrate Valve (V-2) and Backwash Tank Inlet Valve (V-9).
b-2. Close Feed/Backwash Outlet Valve (V-4).
b-3. Ensure that the filtrate flow rate is as the set value.
b-4. Once Backwash Tank is filled, close Backwash Tank Inlet Valve (V-9) to produce filtrate water.
b-5. Perform the filtration during the set Filtration time.

Notes

- Ensure the filtrate water header pipe is filled. If not, open Filtrate Vent Valve (V-7) and purge air until full.

CAUTION

- Do not open Feed Valve (V-1) quickly, or water hammer may occur, and the module could be damaged.
- To prevent damage, do not exceed a maximum feed pressure of 300 kPa (43.5 psi) for the modules except F-HFUG-2020HN, and 600 kPa (87.0 psi) for F-HFUG-2020HN. Additionally, the maximum allowable TMP is 300 kPa for all modules. When the feed pressure of F-HFUG-2020HN exceeds 300 kPa, a corresponding level of back pressure is required. If the filtrate water is supplied to the high-pressure pump of an RO system, the supply pressure to the high-pressure pump becomes the back pressure.
- It is important to set appropriate operating conditions including filtration flow rate and physical cleaning based on observations of TMP increase. Please contact us for any technical support if necessary.

- Continuously monitor the filtrate water quality during filtration and stop the operation if abnormal water quality is detected. In such cases, verify the integrity of the element using a Pressure Decay Test (PDT). The test procedure is provided by Toray as part of technical information.

8.3.1.c. Backwash

The physical cleaning with backwash followed by air scrubbing should be carried out periodically and automatically for the continuous filtration. The frequency of physical cleaning mainly depends on the feed water quality (Typical frequency is once every 30 minutes for the surface water filtration. Please contact us if you need any technical support).

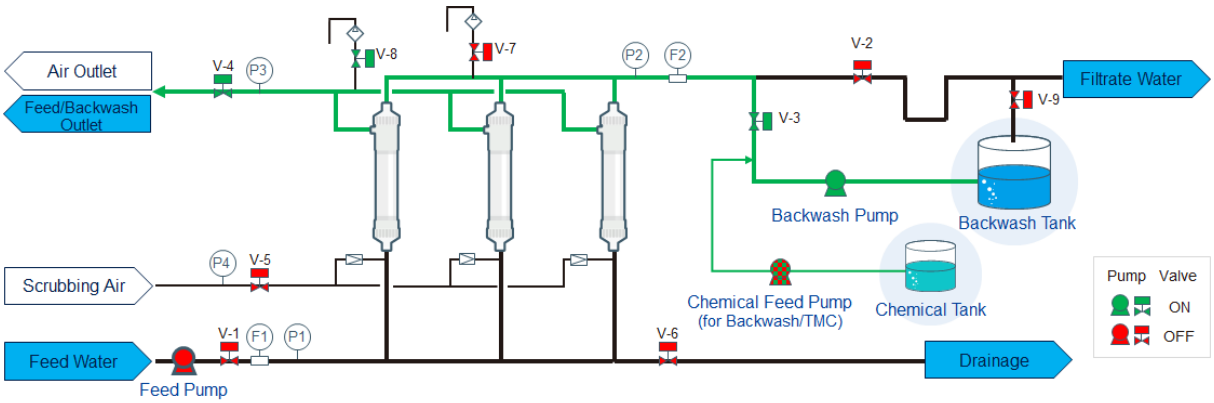


Figure 8.3.1-4

c-1. After Filtration timer ends, stop Feed Pump and close Feed Valve (V-1).
c-2. Open Feed/Backwash Outlet Valve (V-4) and close Filtrate Valve (V-2).
c-3. Open Backwash Valve (V-3) and start Backwash Pump.
Ensure that the backwash flow rate is as the set value.

Notes

- When dosing NaClO into backwash water, ensure that Chemical Dosing Pump operates simultaneously with Backwash Pump.

c-4. After Backwash timer ends, stop Backwash Pump and close Backwash Valve (V-3).

Notes

- When dosing NaClO into backwash water, ensure that Chemical Dosing Pump stops simultaneously with Backwash Pump.

If a filtration cycle does not include TMC, chemical dosing to the backwash water is required. If the cycle includes TMC, chemical dosing to backwash water is not necessary. The chemical is usually sodium hypochlorite, and the dosing rate should be up to 50 mg/L as Cl_2. The flow rate of backwash water is set up in advance for 1.0 to 1.5 times, normally 1.1 times the filtrate flow rate. Do not exceed Max. Backwash Flow described in Table 4-4, Specifications of Modules.

8.3.1.g. Air Scrubbing

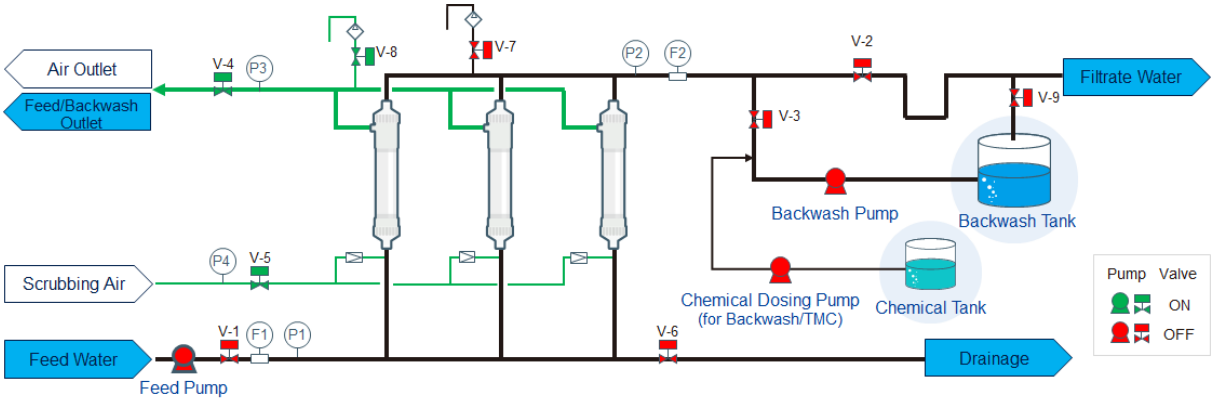


Figure 8.3.1-5

g-1. Open Air Scrubbing Valve (V-5) and start air scrubbing.

Notes

- Air distribution can be verified by listening to the sound of air flow within the module housing.

g-2. After Air Scrubbing timer ends, close Air Scrubbing Valve (V-5) and stop air scrubbing.

CAUTION

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

F-HFUG-2020AN, -2020HN:
4.8 – 9.0 Nm^3/h, normally 6.0 Nm^3/h
(2.8 – 5.3 scfm, normally 3.5 scfm)

F-HFUG-B2315AN: 3.6 – 6.7 Nm^3/h, normally 4.5 Nm^3/h
(2.1 – 3.9 scfm, normally 2.6 scfm)

Normally, the pressure required to supply air for air scrubbing is approximately 40 kPa (6 psi) at the module inlet (not at the blower's source pressure). If the air pressure is higher than this or the air flow is low, it may indicate clogging inside the module caused by improper operation and/or conditions.

8.3.1.h. Drain

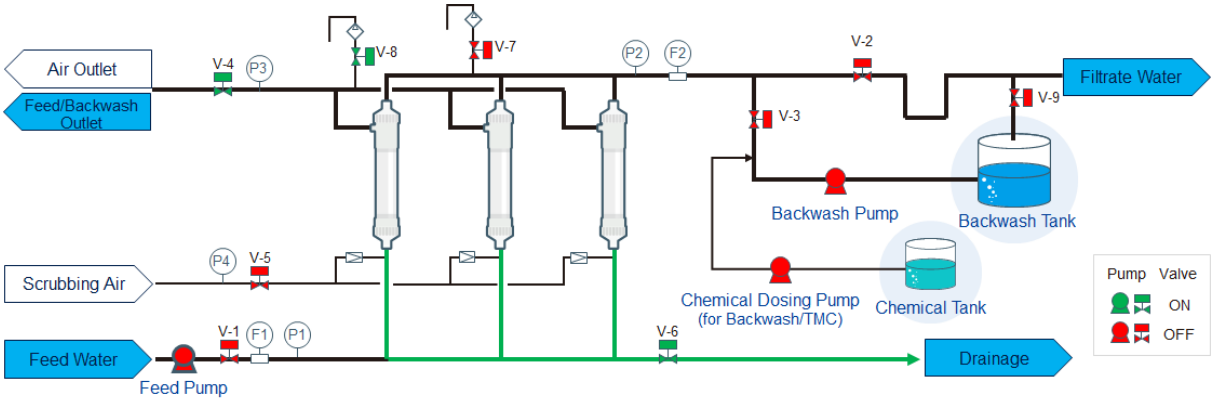


Figure 8.3.1-6

h-1. Open Drain Valve (V-6) and drain the water from the modules.

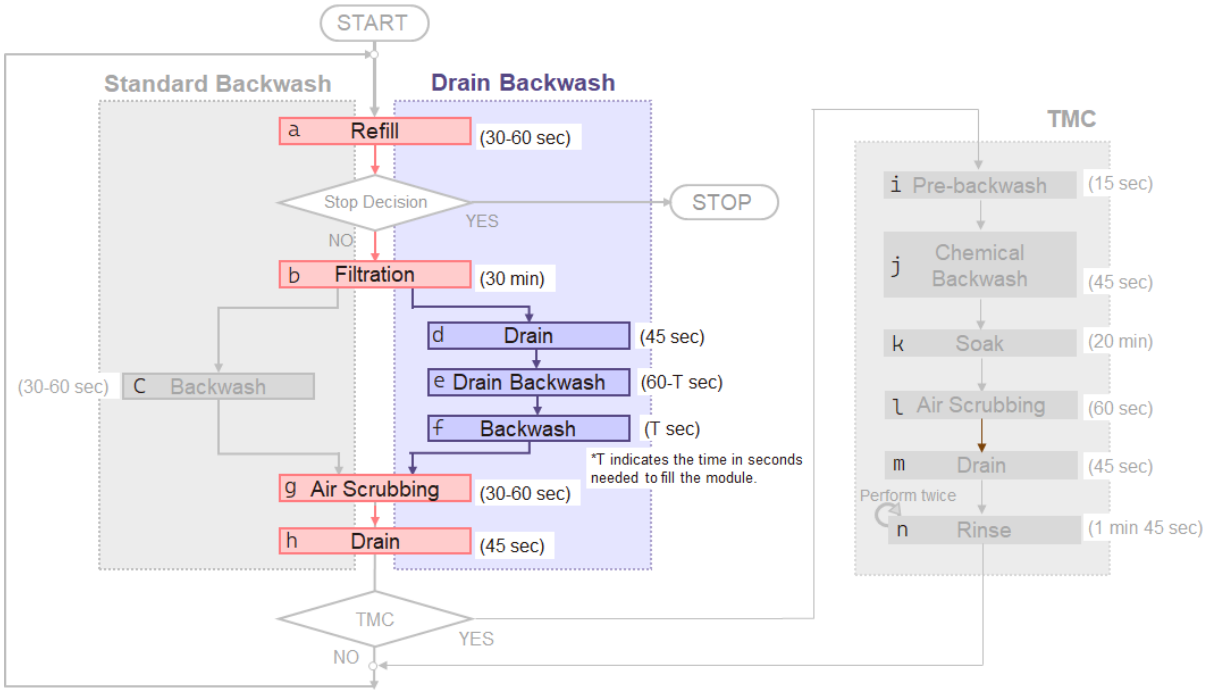
Notes

- Water in the bottom header should be drained out within the set Drain time.
- Configure the piping so that water can be completely drained by gravity from the module and feed line, ensuring that no sections with upward slopes are included. Confirm that the drainage is fully completed.

h-2. After Drain timer ends, close Drain Valve (V-6).

8.3.2. Drain Backwash Processes

The operating flow during a Drain Backwash cycle is as shown in the following flow chart: a. Refill → b. Filtration → d. Drain → e. Drain Backwash → f. Backwash → g. Air Scrubbing → h. Drain.



The durations listed for each process represent standard times. Actual times may vary depending on the plant scale, the feed water quality, and other operating conditions.

Figure 8.3.2-1: Drain Backwash Flow Chart

8.3.2.a. Refill

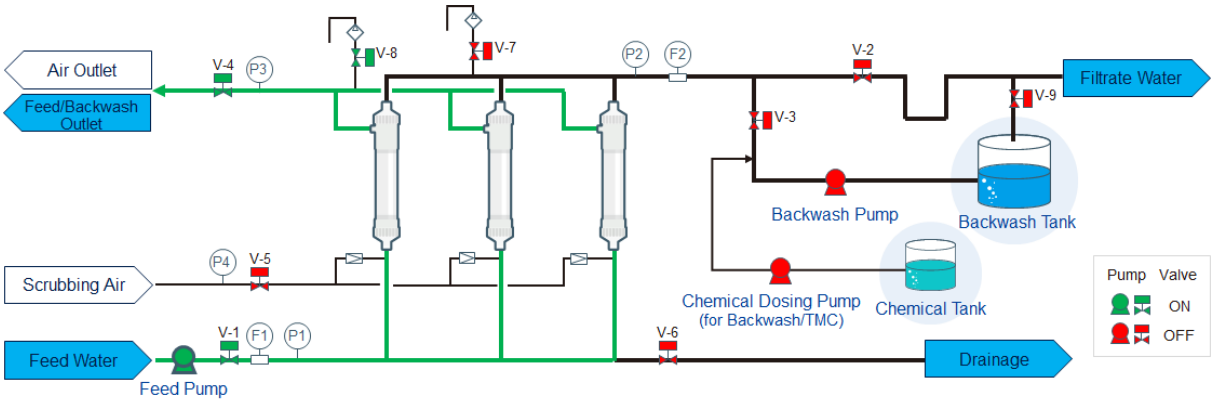


Figure 8.3.2-2

a-1. Make sure Feed/Backwash Outlet Vent Valve (V-8) is opened.

a-2. Open Feed/Backwash Outlet Valve (V-4).

a-3. Start Feed Pump, gradually open Feed Valve (V-1), and fill the modules with feed water during the set Refill time to purge air.

Notes:

- Air inside the modules should be completely purged within the set Refill time.
- Once the air has been purged, the sound of overflow water flowing through the backwash outlet piping can be heard.

8.3.2.b. Filtration

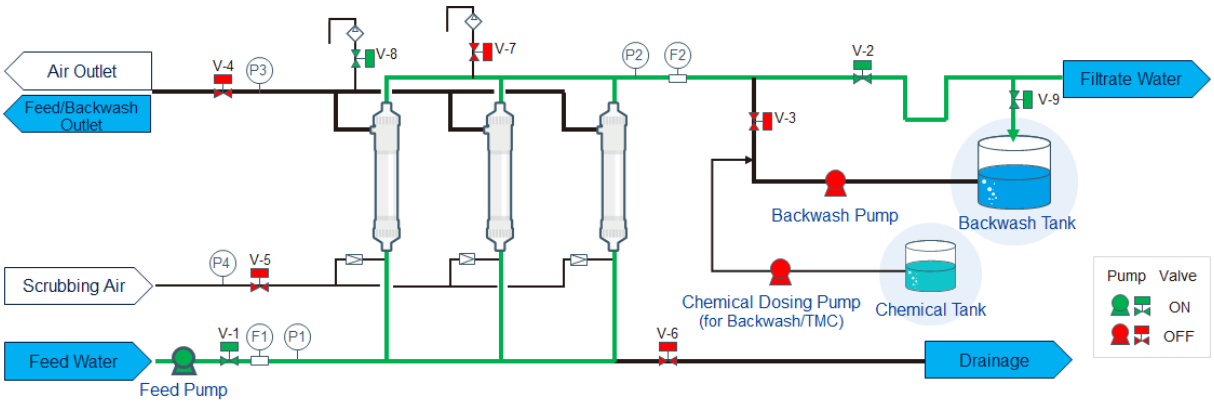


Figure 8.3.2-3

b-1. After Refill timer ends, open Filtrate Valve (V-2) and Backwash Tank Inlet Valve (V-9).
b-2. Close Feed/Backwash Outlet Valve (V-4).
b-3. Ensure that the filtrate water flow rate is as the set value.
b-4. Once Backwash Tank is filled, close Backwash Tank Inlet Valve (V-9) to produce filtrate water.
b-5. Perform the filtration during the set Filtration time.

Notes

- Ensure the filtrate water header pipe is filled. If not, open Filtrate Vent Valve (V-7) and purge air until full.

CAUTION

- Do not open Feed Valve (V-1) quickly, or water hammer may occur, and the module could be damaged.
- To prevent damage, do not exceed a maximum feed pressure of 300 kPa (43.5 psi) for the modules except F-HFUG-2020HN, and 600 kPa (87.0 psi) for F-HFUG-2020HN. Additionally, the maximum allowable TMP is 300 kPa for all modules. When the feed pressure of F-HFUG-2020HN exceeds 300 kPa, a corresponding level of back pressure is required. If the filtrate water is supplied to the high-pressure pump of an RO system, the supply pressure to the high-pressure pump becomes the back pressure.
- It is important to set appropriate operating conditions including filtration flow rate and physical cleaning based on observations of TMP increase. Please contact us for any technical support if necessary.

- Continuously monitor the filtrate water quality during filtration and stop the operation if abnormal water quality is detected. In such cases, verify the integrity of the element using a Pressure Decay Test (PDT). The test procedure is provided by Toray as part of technical information.

8.3.2.d. Drain

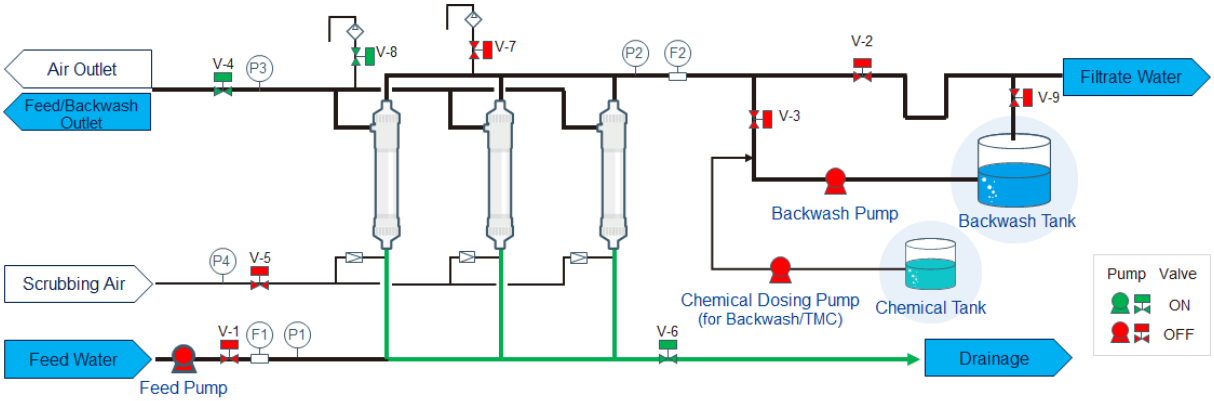


Figure 8.3.2-4

d-1. After Filtration timer ends, stop Feed Pump and close Feed Valve (V-1).

d-2. Open Feed/Backwash Outlet Valve (V-4) and close Filtrate Valve (V-2). Then open Drain Valve (V-6). Drain for the set period.

Notes

- Water in the bottom header should be drained out within the set Drain time.
- Configure the piping so that water can be completely drained by gravity from the module and feed line, ensuring that no sections with upward slopes are included. Confirm that the drainage is fully completed.

8.3.2.e. Drain Backwash

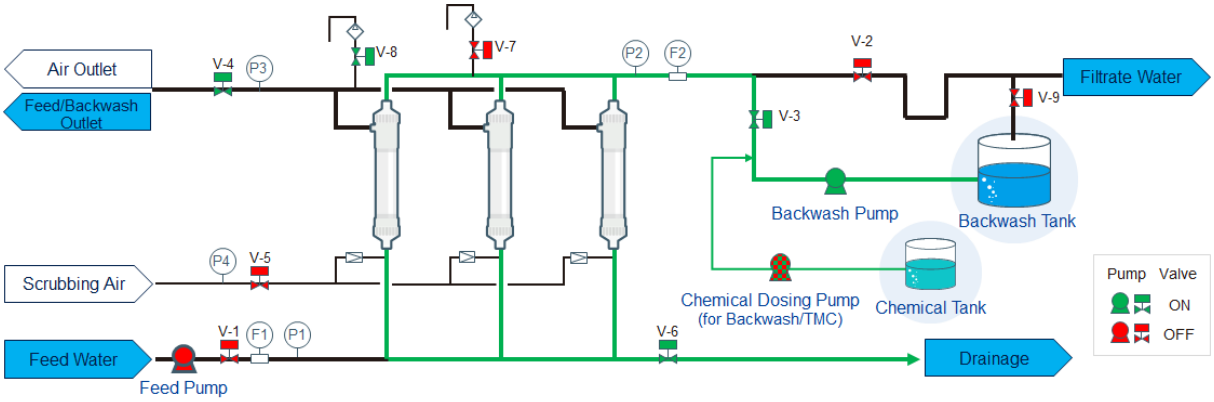


Figure 8.3.2-5

e-1. After Drain timer ends, open Backwash Valve (V-3) and start Backwash Pump.

e-2. Ensure that the backwash flow rate is as the set value.

e-3. Continue the Drain Backwash as per the timer setting (60 - T seconds).

Notes

- When dosing NaClO into backwash water, ensure that Chemical Dosing Pump operates simultaneously with Backwash Pump.
- The total time of Drain Backwash and Backwash is typically 60 seconds. Therefore, if the Backwash time is T seconds, the Drain Backwash time will be calculated as (60 - T) seconds.

If a filtration cycle does not include TMC, chemical dosing to the backwash water is required. If the cycle includes TMC, chemical dosing to backwash water is not necessary. The chemical is usually sodium hypochlorite, and the dosing rate should be up to 50 mg/L as Cl_2. The flow rate of backwash water is set up in advance for 1.0 to 1.5 times, normally 1.1 times the filtrate flow rate. Do not exceed Max. Backwash Flow described in Table 4-4, Specifications of Modules.

8.3.2.f. Backwash

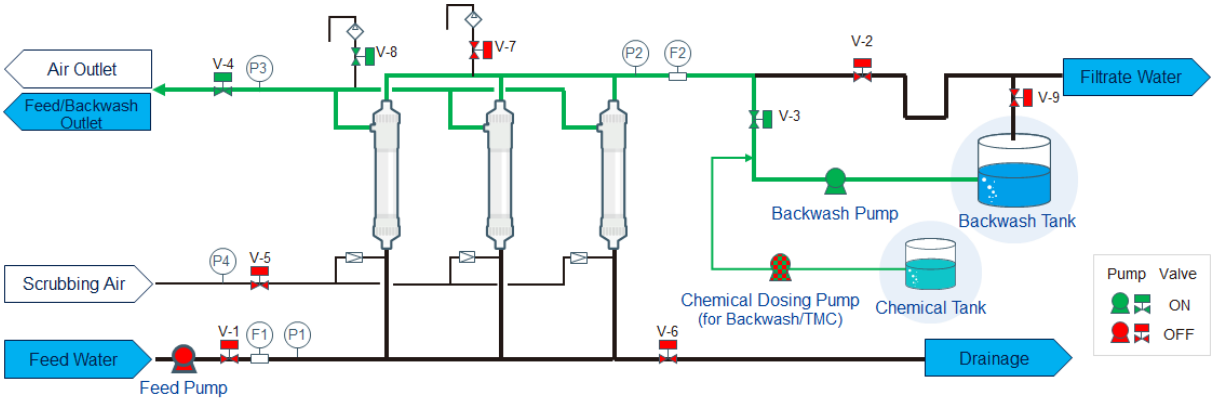


Figure 8.3.2-6

f-1. After Drain Backwash set time up, close Drain Valve (V-6).

f-2. Continue the backwash as per the timer setting (T seconds).

Notes

- When dosing NaClO into backwash water, ensure that Chemical Dosing Pump operates simultaneously with Backwash Pump.
- In the backwash process following the Drain Backwash, set the time T so that the module is filled with water (overflow into the Feed/Backwash outlet).

f-3. Once the set time has passed, stop Backwash Pump and Chemical Doing Pump, then close Backwash Valve (V-3).

8.3.2.g. Air Scrubbing

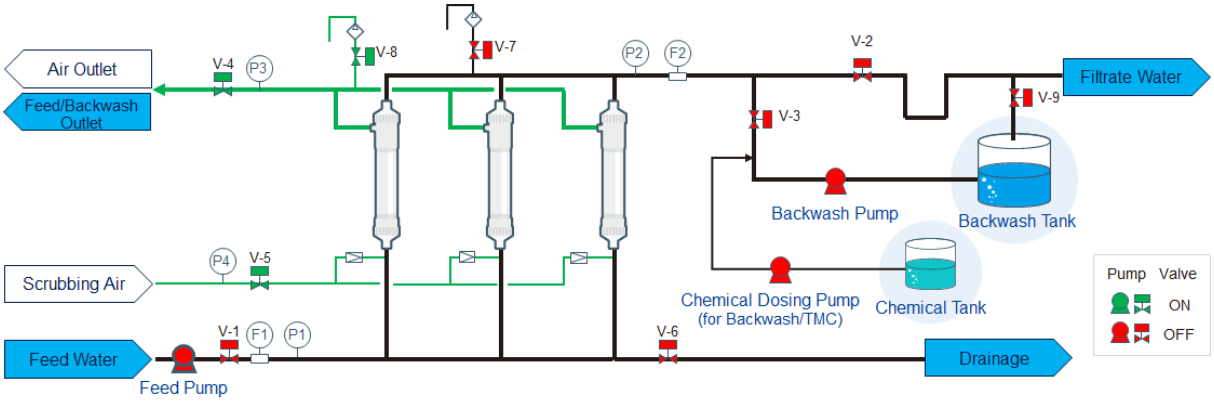


Figure 8.3.2-7

g-1. Open Air Scrubbing Valve (V-5) and start air scrubbing.

Notes

- Air distribution can be verified by listening to the sound of air flow within the module housing.

g-2. After Air Scrubbing timer ends, close Air Scrubbing Valve (V-5) and stop air scrubbing.

CAUTION

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

F-HFUG-2020AN, -2020HN:
4.8 – 9.0 Nm^3/h, normally 6.0 Nm^3/h
(2.8 – 5.3 scfm, normally 3.5 scfm)

F-HFUG-B2315AN: 3.6 – 6.7 Nm^3/h, normally 4.5 Nm^3/h
(2.1 – 3.9 scfm, normally 2.6 scfm)

Normally, the pressure required to supply air for air scrubbing is approximately 40 kPa (6 psi) at the module inlet (not at the blower's source pressure). If the air pressure is higher than this or the air flow is low, it may indicate clogging inside the module caused by improper operation and/or conditions.

8.3.2.h. Drain

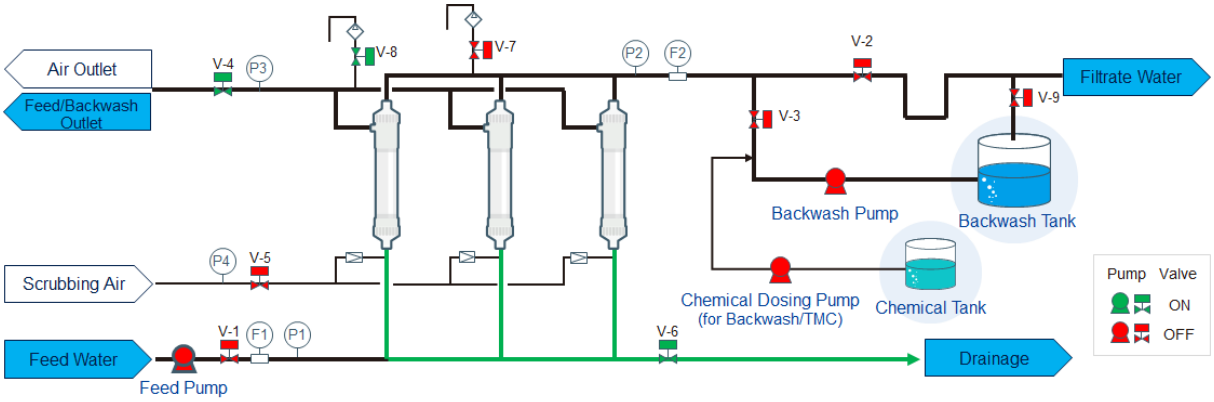


Figure 8.3.2-8

h-1. Open Drain Valve (V-6) and drain the water from the modules.

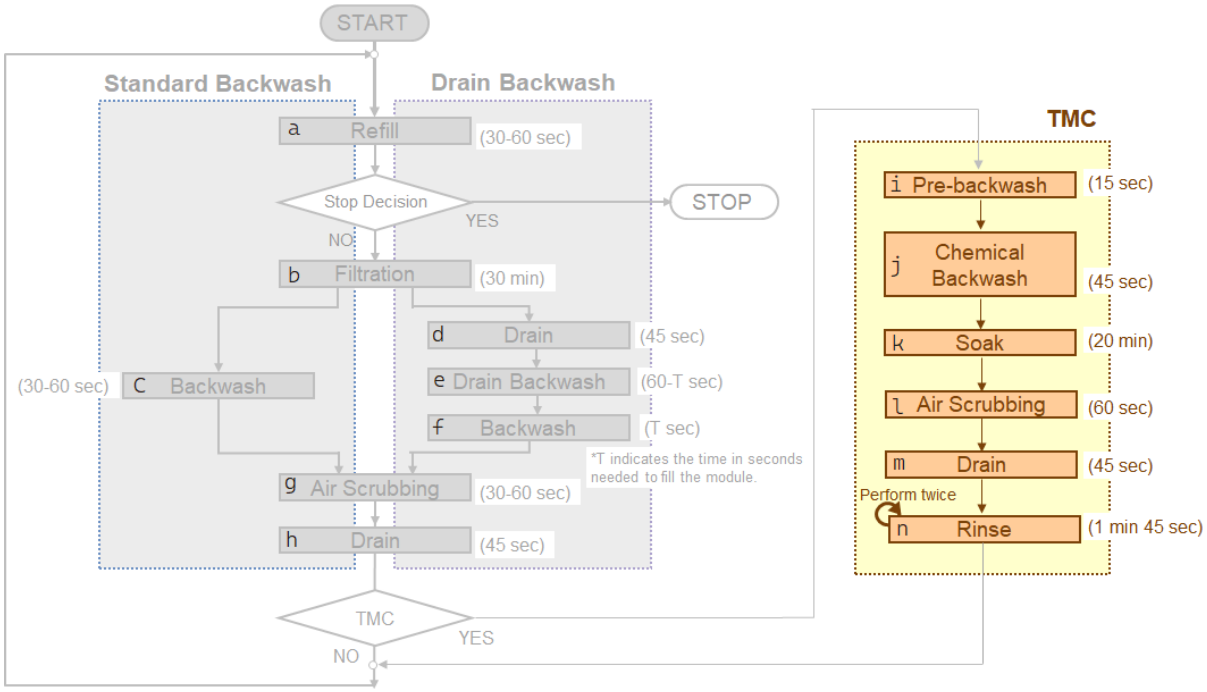
Notes

- Water in the bottom header should be drained out within the set Drain time.
- Configure the piping so that water can be completely drained by gravity from the module and feed line, ensuring that no sections with upward slopes are included. Confirm that the drainage is fully completed.

h-2. After Drain timer ends, close Drain Valve (V-6).

8.3.3. TMC Processes

Instead of chemical dosing for every backwash, soaking the membrane in a 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 performed after the processes of Backwash (without chemical addition), Air Scrubbing, and Drain. The frequency and soaking time of the TMC mainly depends on the feed water quality (Normally once a day for 20 minutes. Please contact us if you need any technical support.). Figure 8.3.3-1 shows a standard flow diagram for the TMC.



The durations listed for each process represent standard times. Actual times may vary depending on the plant scale, the feed water quality, and other operating conditions.

Figure 8.3.3-1: TMC Flow Chart

8.3.3.i. Pre-backwash

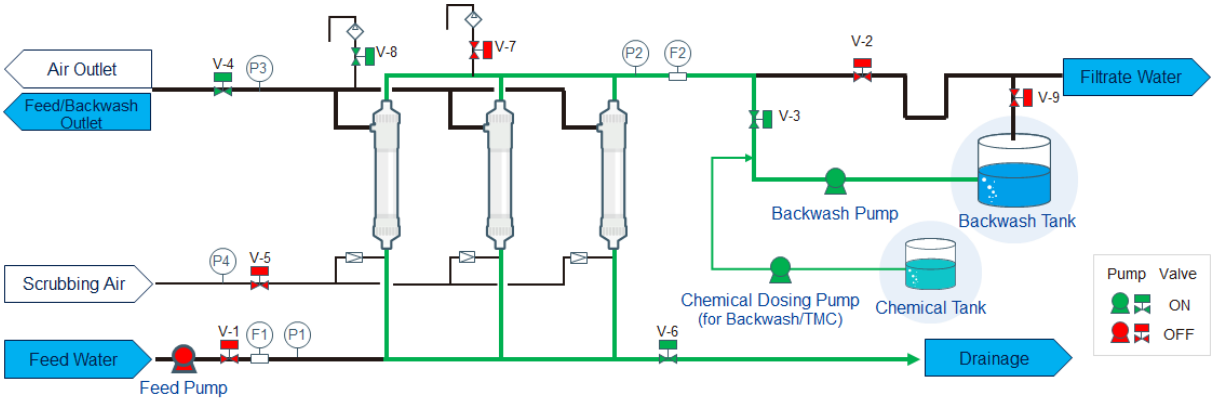


Figure 8.3.3-2

i-1. The timer sets the TMC to standby mode. The system waits until the Drain process in the Standard Backwash or Drain Backwash is complete; at that point, the TMC is in the start condition. Once this condition is satisfied, the TMC process begins.

i-2. Open Backwash Valve (V-3) and start Backwash Pump and Chemical Dosing Pump.

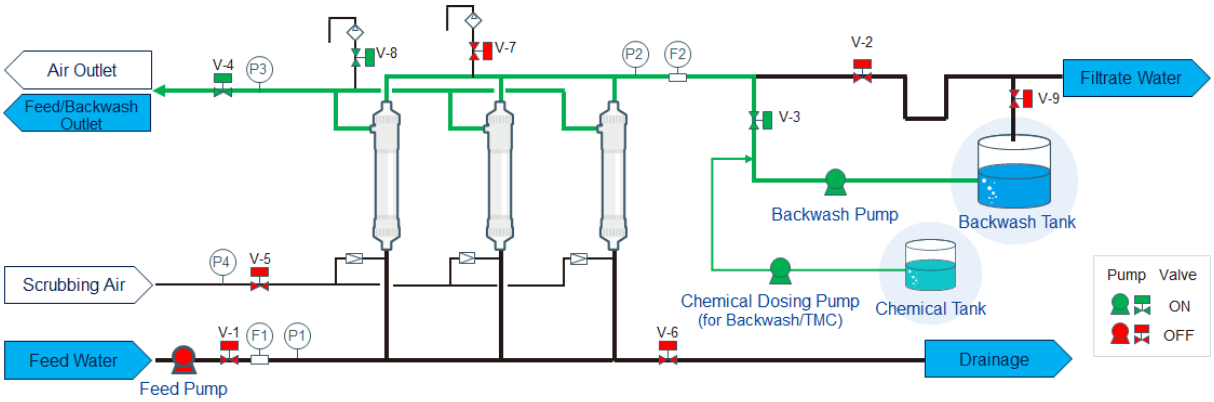


Figure 8.3.3-3

i-3. Check that the chemical concentration in the backwash water is proper.
Close Drain Valve (V-6) as soon as chemicals are detected in the drainage.

Notes

- If the operating conditions have been set appropriately during commissioning or at the initial stages of operation, Step i-3 (checking chemical concentrations) is not required to be performed during every TMC sequence.

8.3.3.j. Chemical Backwash

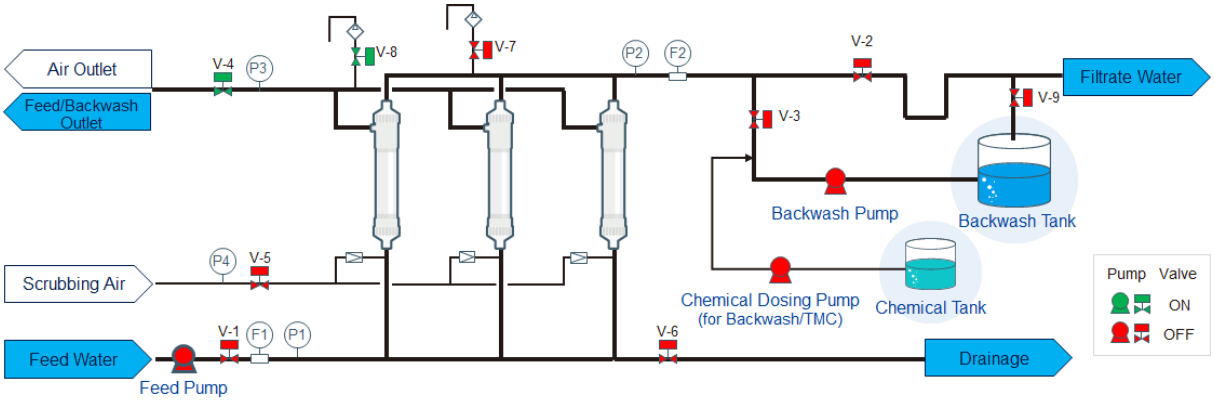


Figure 8.3.3-4

j-1. Following Pre-backwash, perform backwashing using a chemical.

Standard chemicals for TMC are as follows.
For organic matter: Sodium Hypochlorite concentration 300 mg/L as Cl_2
For inorganic matter: Citric Acid concentration 3,000 mg/L

Additionally, the standard amounts of the required chemicals are as follows.

Table 8.3.3-1: Total Chemical Volume in TMC (Pre-backwash + Chemical Backwash)

	F-HFUG-2020AN	F-HFUG-B2315AN	F-HFUG-2020HN
Total Chemical Volume *1) (L/module)	125	104	125

*1): This table indicates the standard chemical volumes. Actual required volumes may differ depending on plant scale, piping layout, and other operating conditions.

j-2. After backwashing with the specified amount of chemical, stop Backwash Pump and Chemical Dosing Pump, and close Backwash Valve (V-3).

8.3.3.k. Soak

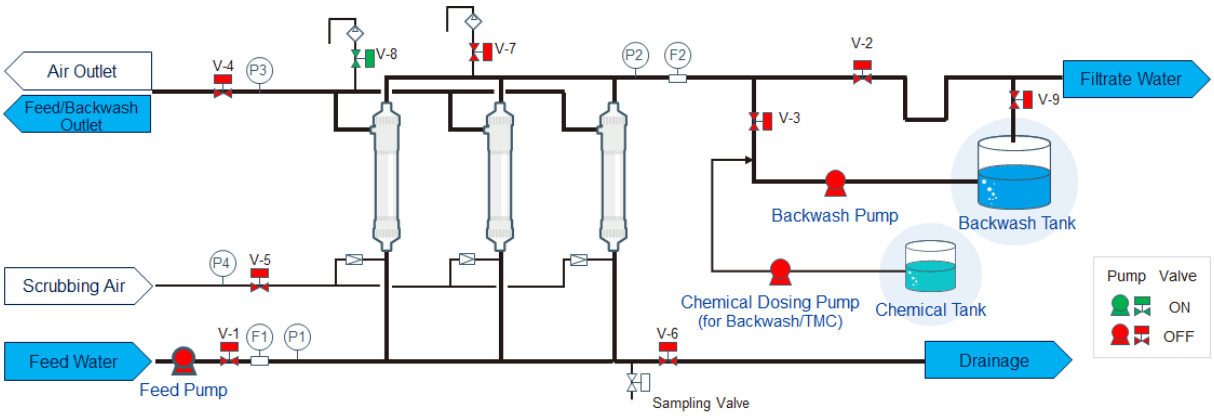


Figure 8.3.3-5

k-1. Close Feed/Backwash Outlet Valve (V-4).

k-2. Soak the membrane in the chemical for a fixed period (typically 20 minutes).

Notes

- Check the concentration of the soaking chemical periodically through Sampling Valve. If the dosing concentration is not correct, adjust it accordingly.

8.3.3.l. Air Scrubbing

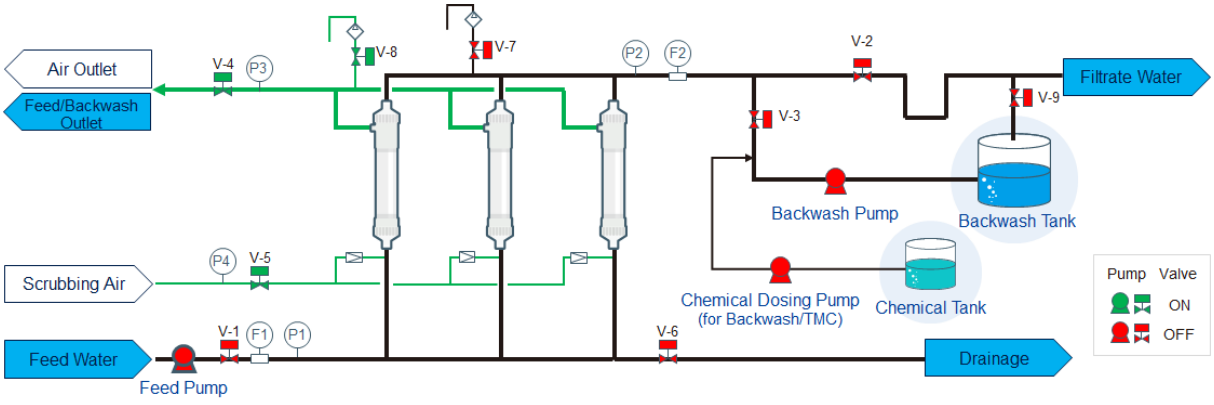


Figure 8.3.3-6

l-1. After Soak timer ends, open Feed/Backwash Outlet Valve (V-4).

l-2. Open Air Scrubbing Valve (V-5) for a fixed period (typically 1 minute).

8.3.3.m. Drain

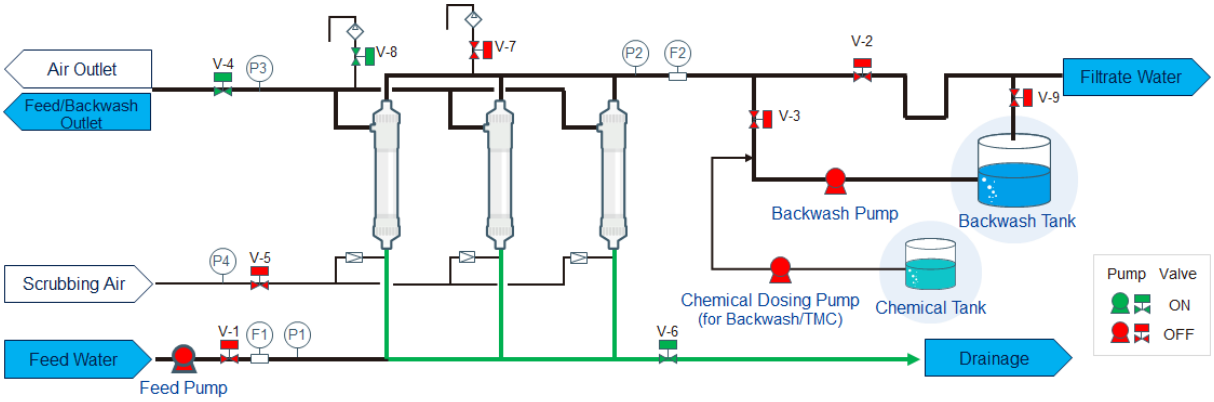


Figure 8.3.3-7

m-1. After Air Scrubbing timer ends, close Air Scrubbing Valve (V-5).

m-2. Open Drain Valve (V-6) to drain the soaking chemical.

8.3.3.n. Rinse

8.3.3.n.1. Rinse

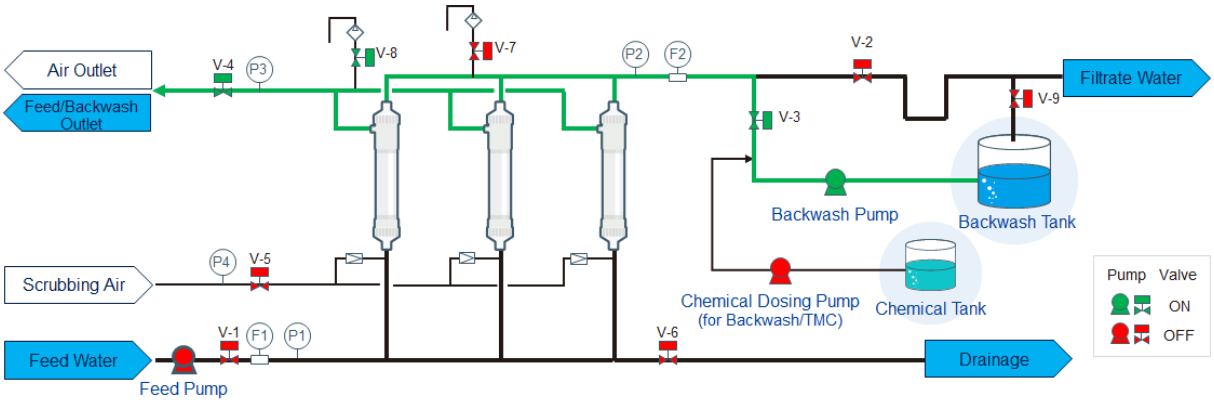


Figure 8.3.3-8

n.1-1. After Drain timer ends, close Drain Valve (V-6).

n.1-2. Open Backwash Valve (V-3) and start Backwash Pump for a fixed period (typically 30 seconds).

8.3.3.n.2. Air Scrubbing

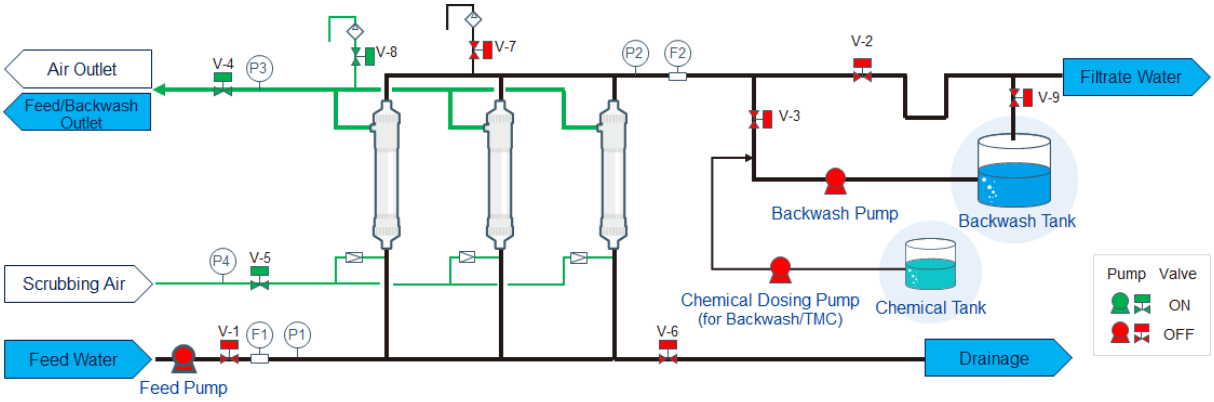


Figure 8.3.3-9

n.2-1. After Rinse timer ends, stop Backwash Pump and close the Backwash Valve (V-3).

n.2-2. Open Air Scrubbing Valve (V-5) for a fixed period (typically 30 seconds).

8.3.3.n.3. Drain

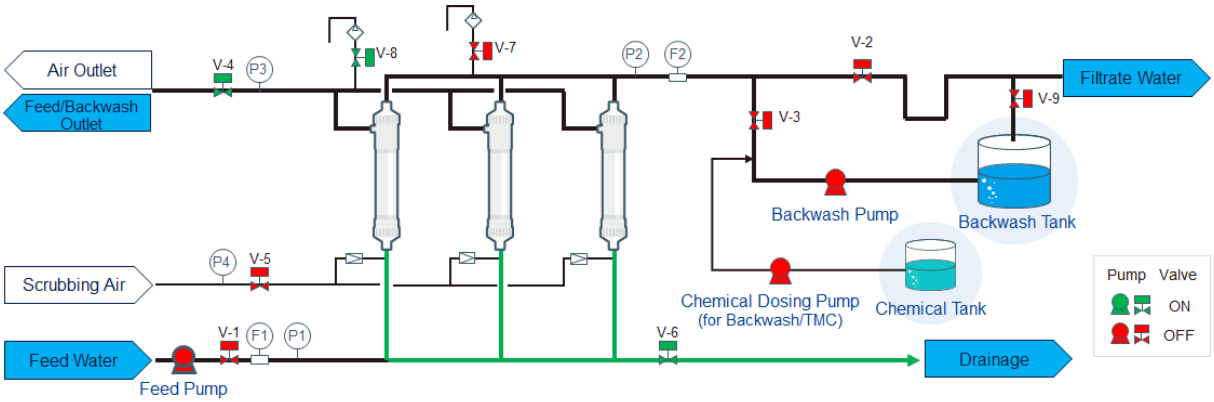


Figure 8.3.3-10

n.3-1. After Air Scrubbing timer ends, close Air Scrubbing Valve (V-5) and open Drain Valve (V-6).

n.3-2. Repeat Rinse processes again.

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

F-HFUG-2020AN, -2020HN:
4.8 – 9.0 Nm^3/h, normally 6.0 Nm^3/h
(2.8 – 5.3 scfm, normally 3.5 scfm)

F-HFUG-B2315AN: 3.6 – 6.7 Nm^3/h, normally 4.5 Nm^3/h
(2.1 – 3.9 scfm, normally 2.6 scfm)

8.3.4. Timing Chart

Tables 8.3.4-1 through 8.3.4-3 present timing charts detailing the operational sequences of equipment ON/OFF states and valve actuation (open/close) for the Standard Backwash, Drain Backwash, and TMC operations described in the previous section.

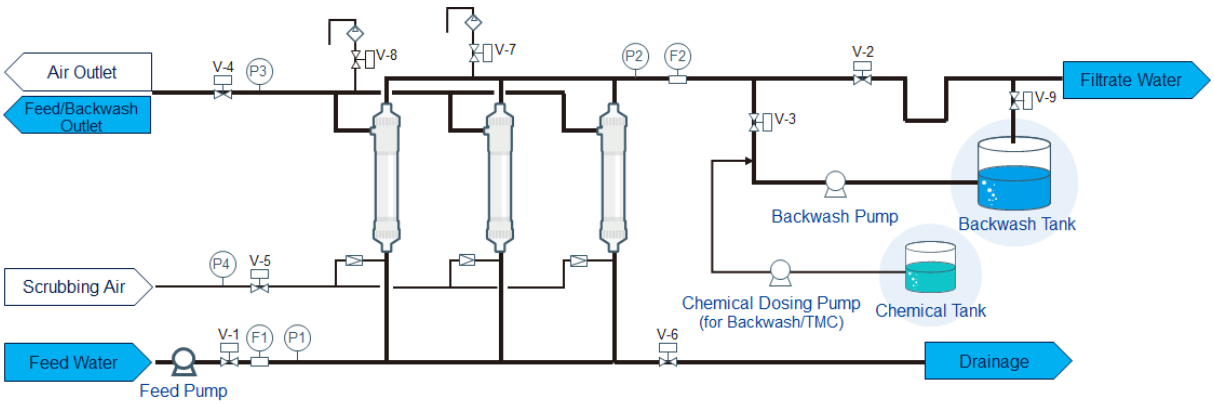


Figure 8.3.4-1

8.3.4.1. Filtration Cycle with Standard Backwash

Table 8.3.4-1: Timing Chart of Standard Backwash

	Refill 30~60 sec	Filtration 30 min	Backwash 30~60 sec	Air Scrubbing 30~60 sec	Drain 45 sec
Feed Pump	**ON**	**ON**	OFF	OFF	OFF
Backwash Pump	OFF	OFF	**ON**	OFF	OFF
Chemical Dosing Pump	OFF	OFF	**ON** *1) OFF *1)	OFF	OFF
V1 (Feed)	**OPEN**	**OPEN**	CLOSE	CLOSE	CLOSE
V2 (Filtrate)	CLOSE	**OPEN**	CLOSE	CLOSE	CLOSE
V3 (Backwash)	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE
V4 (Feed/BW Outlet)	**OPEN**	CLOSE	**OPEN**	**OPEN**	**OPEN**
V5 (Air Scrubbing)	CLOSE	CLOSE	CLOSE	**OPEN**	CLOSE
V6 (Drain)	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**
V7 (Filtrate Vent)	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE
V8 (Feed/BW Outlet Vent)	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**

The durations listed for each process in this table represent standard times. Actual times may vary depending on the plant scale, the feed water quality, and other operating conditions.

*1): When dosing NaClO into backwash water, ensure that Chemical Dosing Pump operates simultaneously with Backwash Pump.

8.3.4.2. Filtration Cycle with Drain Backwash

Table 8.3.4-2: Timing Chart of Drain Backwash

	Refill 30~60 sec	Filtration 30 min	Drain 45 sec	Drain BW 60~T *1) sec	BW w/o Drain T *1) sec	AS 30~60 sec	Drain 45 sec
Feed Pump	**ON**	**ON**	OFF	OFF	OFF	OFF	OFF
Backwash Pump	OFF	OFF	OFF	**ON**	**ON**	OFF	OFF
Chemical Dosing Pump	OFF	OFF	OFF	**ON** *2) / OFF *2)	**ON** *2) / OFF *2)	OFF	OFF
V1 (Feed)	**OPEN**	**OPEN**	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE
V2 (Filtrate)	CLOSE	**OPEN**	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE
V3 (Backwash)	CLOSE	CLOSE	CLOSE	**OPEN**	**OPEN**	CLOSE	CLOSE
V4 (Feed/BW Outlet)	**OPEN**	CLOSE	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**
V5 (Air Scrubbing)	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**	CLOSE
V6 (Drain)	CLOSE	CLOSE	**OPEN**	**OPEN**	CLOSE	CLOSE	**OPEN**
V7 (Filtrate Vent)	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE
V8 (Feed/BW Outlet Vent)	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**

BW: Backwash, AS: Air Scrubbing

The durations listed for each process in this table represent standard times. Actual times may vary depending on the plant scale, the feed water quality, and other operating conditions.

*1): T indicates the time in seconds needed to fill the module.

*2): When dosing NaClO into backwash water, ensure that Chemical Dosing Pump operates simultaneously with Backwash Pump.

8.3.4.3. Filtration Cycle with TMC

Table 8.3.4-3: Timing Chart of TMC

	Drain	Pre-BW	Chemical BW	Soak	AS	Drain	Rinse			Rinse		
							BW	AS	Drain	BW	AS	Drain
	45 sec	15 sec	45 sec	20 min	60 sec	45 sec	30 sec	30 sec	45 sec	30 sec	30 sec	45 sec
Feed Pump	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
BW Pump	OFF	**ON**	**ON**	OFF	OFF	OFF	**ON**	OFF	OFF	**ON**	OFF	OFF
Chemical Dosing Pump	OFF	**ON**	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
V1	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE
V2	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE
V3	CLOSE	**OPEN**	**OPEN**	CLOSE	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE
V4	**OPEN**	**OPEN**	**OPEN**	CLOSE	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**
V5	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE	**OPEN**	CLOSE
V6	**OPEN**	**OPEN**	CLOSE	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE	**OPEN**
V7	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE
V8	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**	**OPEN**

BW: Backwash, AS: Air Scrubbing

The durations listed for each process in this table represent standard times. Actual times may vary depending on the plant scale, the feed water quality, and other operating conditions.

8.4. Basic Trans-Membrane Pressure Calculation

To calculate accurate Trans-Membrane Pressure (TMP), it is necessary to involve the height difference of inlet and outlet pressure gauges (see Figure 8.4-1).

Example calculation of TMP (The specific gravity of water is set to 1)

TMP = $(P_{in} - H_{in}) - (P_{out} - H_{out})$

= (70 - 10) - (20 - (- 25))

= 60 - 45

= 15 kPa

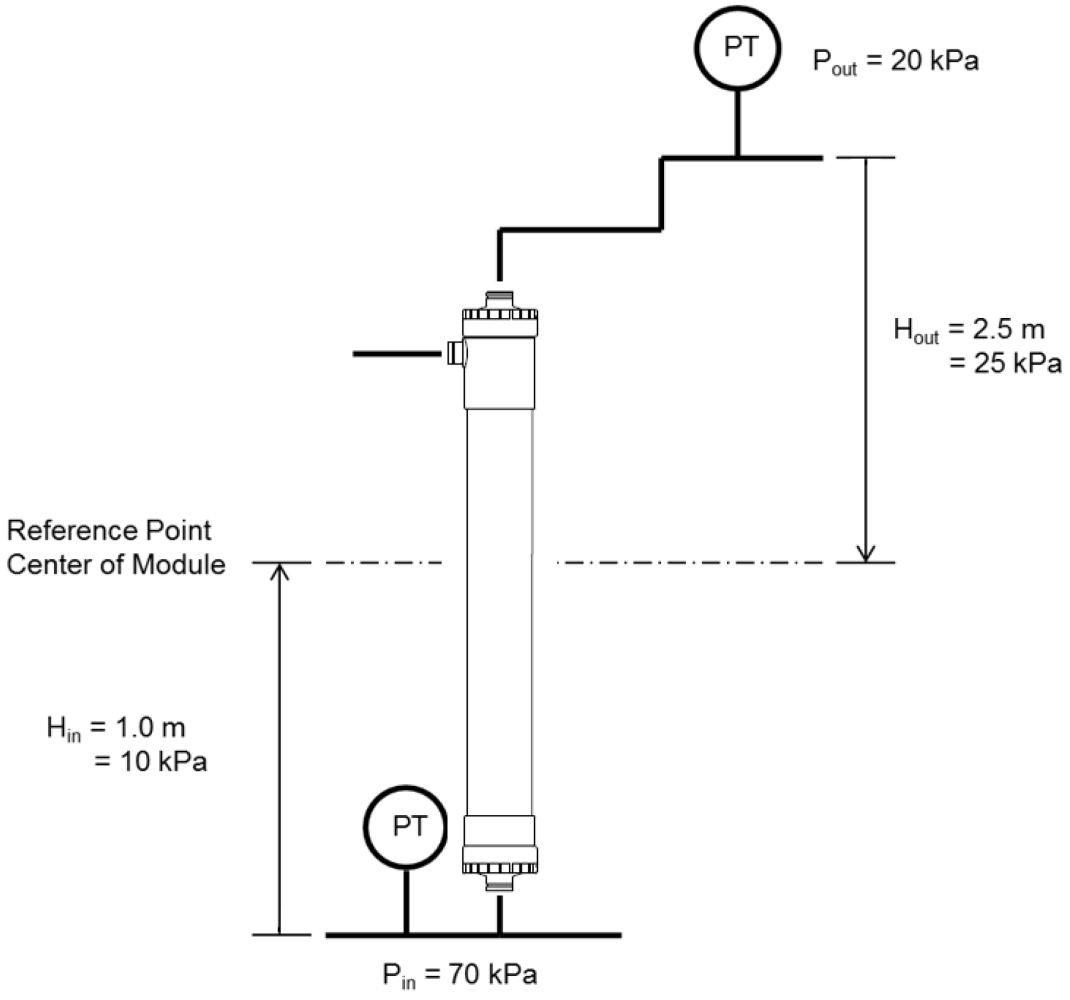


Figure 8.4-1: Basic TMP Calculation

Note, the following formula may also be used:

TMP = $P_{in} - P_{out}$ - total delta H

= 70 - 20 - (10 – (- 25)) = 15 kPa

8.5. Temperature Correction Factor

The permeability of the membrane is influenced by temperature mainly because the water viscosity changes with temperature. It is necessary to eliminate the temperature effect with the Temperature Correction Factor (TCF) shown in Figure 8.5-1 to evaluate the permeability correctly.

A TMP measured at some real temperature can be converted to 25 °C corrected TMP with multiplying by TCF at real temperature.

A filtrate flow rate measured at some real temperature can be converted to 25 °C corrected filtrate flow rate with divided by TCF at real temperature.

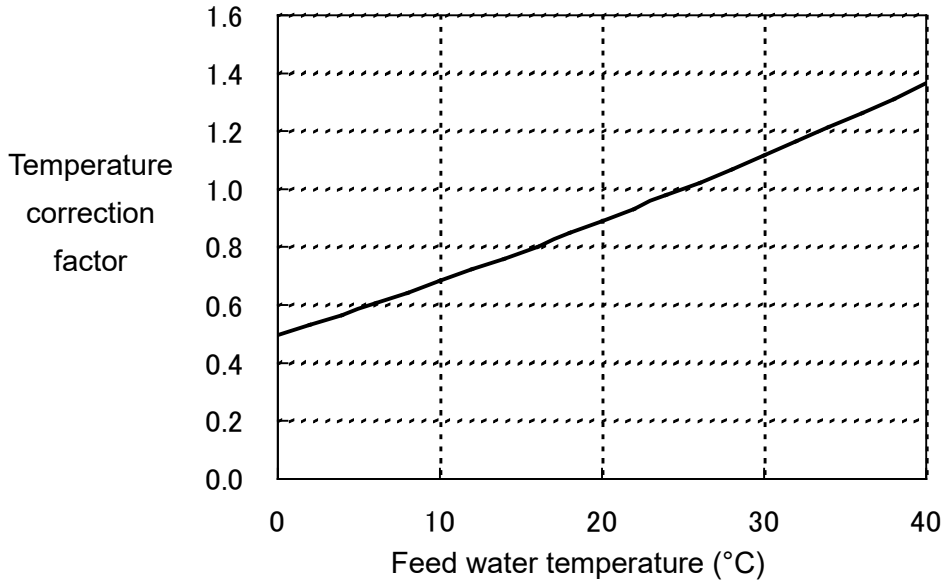


Figure 8.5-1: Temperature Correction Factor (TCF)

The equation for calculating TCF at a temperature (T °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)

Toray UF Normalization Sheet

This tool has been developed to standardize the operational data of Toray UF modules. It includes automatic temperature correction, permeability calculations, and unit conversions, with operational trends displayed in clear, easy-to-read graphs. By using this sheet, users can efficiently evaluate the performance of Toray UF modules, helping to optimize system operation and maintenance.
Toray strongly recommend utilizing this tool for optimal performance.

URL: https://www.water.toray/knowledge/tool/ufsoftware/

Input item image

	A	B	C	D	E	F
1	**1. Configuration**					
2	Select	UF Module Type			F-HFUG-2020AN	
3	Input	Number of Modules per Skid			1	[module]
4		Total UF Membrane Area			90	[m2]
5						
6	**2. Unit Setting**				Input Unit	Output Unit
7	Select	Temperature Unit			deg.C	deg.C
8	Select	Pressure Unit			psi	bar
9	Select	Flow Unit			gpm *US	m3/hr
10						
11	**3. Elevation of Each Position (from Ground Level)**					
12	Input	UF Feed Inlet Pressure Gauge			1	[m]
13	Input	UF Feed Outlet Pressure Gauge			1	[m]
14		Total Delta H			0	[m]
15						
16	**4. Temperature**					
17	Input	Normalization Temperature			25	deg.C
18						
19	**5. Flow Rate**					
20	Input	Design Flow Rate per Train			20	gpm *US
21						

- Input plant configuration
- Module type
- The number of modules
- Input and output units
- Etc.

	A	B	C	D	E	F	G	H
1	Skid No.	A						
2								
3	Date	UF Feed				UF Filtrate		
4		Temp.	Press.	Flow rate	Turb.	Press.	Flow rate	Turb.
5	[yyyy/mm/dd]	[deg.C]	[psi]	[gpm *US]	[NTU]	[psi]	[gpm *US]	[NTU]
6								
7								
8								
9								
10								
11								
12								

Input operation data

- Feed temperature
- Feed and filtrate pressure
- Feed or filtrate flow
- Feed and filtrate turbidity

Output image

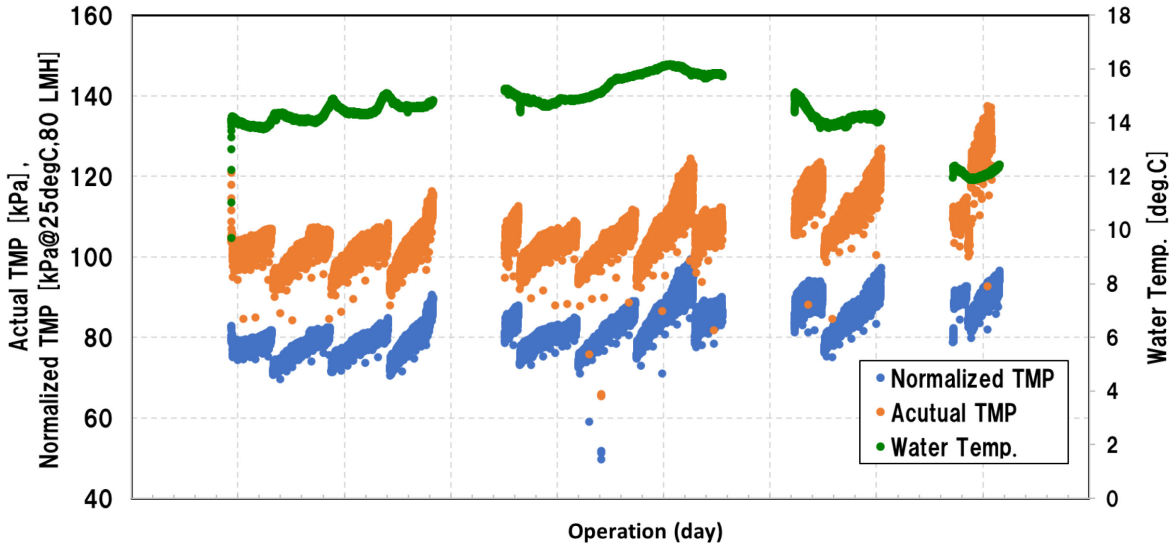


Figure 8.5-2: Output Graph Example of Normalized Data

The graph above plots both the measured TMP variations under fluctuating feed water temperature conditions and the temperature-corrected TMP values. As the water temperature gradually decreases, the measured TMP—which reflects the increase in water viscosity—shows an upward trend, whereas the temperature-corrected TMP remains more stable. This demonstrates that applying temperature correction enables estimation of membrane performance changes independent of temperature effects.

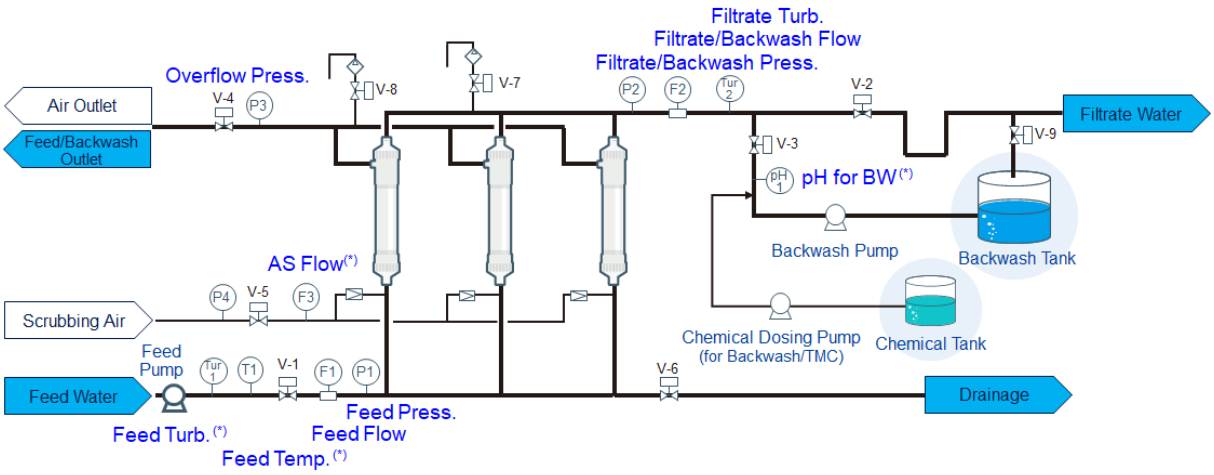
8.6. Performance Recording

To effectively evaluate the current performance of the UF system, including prompt identification of undesirable operational trends and implementation of appropriate countermeasures, it is essential to compare current operating data with the baseline data recorded at initial start-up.

Record all data relevant to UF operation, ensuring that it includes regular information on flow rate, TMP, contractually specified feed water quality parameters, temperature, and elapsed time since start-up (in days).

The following operating data is recommended for this purpose.

8.6.1. Continuous Recording by On-line Recorders



*: Sensors marked with an asterisk are common to multiple trains.

Figure 8.6.1-1: Online Sensors Layout

Table 8.6.1-1: On-line Measurement and Recording Items

Objects/Position		Items		Sampling interval
Common to Multiple Trains	Feed	T1	Temperature	1 min
		-	pH	1 min
		Tur1	Turbidity	1 min
		-	Electro-conductivity	1 min
		-	Flow rate	1 min
	Filtrate	-	Flow rate	1 min
	Backwash	pH1	pH	During backwash, preferably 2 sec, but at least 10 sec or less
Each Train	Feed	F1	Flow rate	1 min
		P1	Pressure	1 min
	Filtrate	F2	Flow rate	1 min
		P2	Pressure	1 min
		Tur2	Turbidity	1 min
	Backwash	F2	Flow rate	During backwash, preferably 2 sec, but at least 10 sec or less
		P2	Pressure	During backwash, preferably 2 sec, but at least 10 sec or less
	Air Scrubbing	F3	Flow rate	During air scrubbing, preferably 2 sec, but at least 10 sec or less
	Overflow	P3	Pressure	During filtration, 1 min During backwash, preferably 2 sec, but at least 10 sec or less

SCADA / PLC Setting for Filtration Process and TMC Process	-Filtration process Feed Time, Filtration Time Backwash Time Air Scrubbing Time Drain Time etc. -TMC process TMC Interval Soaking Time etc.	1 min

1. Manuscript measurement at least once a day
   - All items of continuous recording
   - Oxidant dosing rate (if used)
   - Coagulant dosing rate (if used)
   - TMP before and after operational events (such as backwash, TMC)
   - Backwash residual chlorine (if applicable)
   - Concentration and pH of each TMC chemical

2. Laboratory measurement at least once a day
   - Mn and Oil & Grease concentrations of UF feed
   - TSS concentration of UF feed and filtrate

3. Laboratory measurement at least once a month
   - Complete water analysis for the listed items of UF feed water
   - TOC concentration of UF feed and filtrate
   - COD concentration of UF feed and filtrate

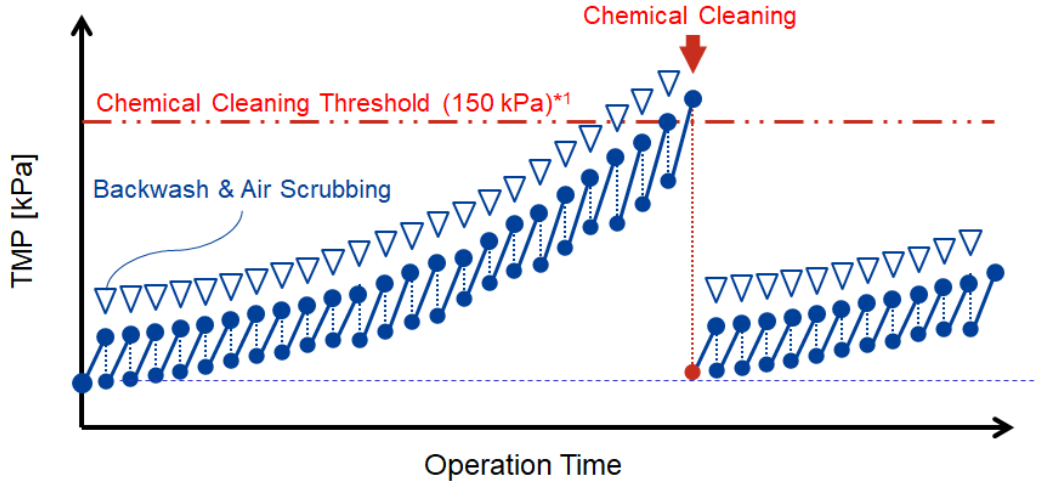
4. Calibration check of all sensors of continuous recording devices shall be performed in accordance with the manufacturer’s instructions every 3 months (or more frequently if recommended by manufacturer). A record of each calibration should be saved.

9. CHEMICAL CLEANING

Chemical cleaning should be performed to remove foulants that have accumulated in the membrane pores or adhered to the membrane surface.

9.1. Timing for Chemical Cleaning

Chemical cleaning should be performed when the TMP reaches 150 kPa (21.8 psi), and at the latest before reaching 200 kPa. Also, chemical cleaning should be performed once a year even if there is no significant increase in TMP. Failure to do so may result in a significant decrease in the filtration performance of the module.



*1: Chemical cleaning is recommended when the TMP reaches 150–200 kPa.

Figure 9.1-1: Variation in TMP during Standard Backwash Operation

CAUTION

- Perform the chemical cleaning when the TMP reaches 150 kPa (21.8 psi) or at the latest, 200 kPa (29.0 psi), as failure to do so may result in a significant reduction in module filtration performance. In addition, chemical cleaning should be carried out at least once per year, even if there is no substantial increase in TMP.

9.2. Chemical Cleaning Process Flow Chart and Conditions

Eliminate foulants that cannot be removed by physical cleaning such as backwash or air scouring through chemical cleaning. These foulants can be mainly organic, mainly inorganic, or a combination of both components. Since the degree of fouling also varies, chemical cleaning must be tailored accordingly.

9.2.1. Chemical Cleaning Process Flow Chart

Chemical cleaning is performed using chemical solutions intended for either organic or inorganic foulants. In cases of severe fouling, this process may need to be repeated multiple times to achieve effective cleaning.
The choice of chemical solution should consider feed water composition and past operational experience, and cleaning should be continued as necessary until the specified recovery is achieved. The flow chart below summarizes the standard chemical cleaning process.

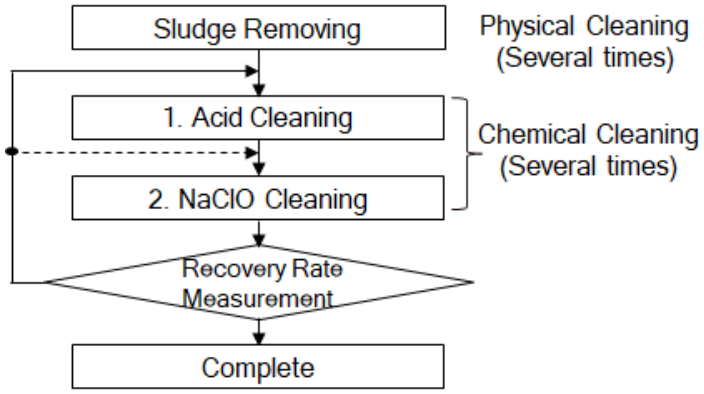


Figure 9.2.1-1: Standard Chemical Cleaning Process Flow Chart

9.2.2. Chemical Cleaning Condition

The standard conditions for chemical cleaning are shown in Table 9.2.2-1.

- The concentration and the circulation time shown in Table 9.2.2-1 should be observed. Otherwise, the membrane module may get damaged and/or the life of membrane may be shortened.
- The cleaning temperature should be 20 to 40 °C.

Table 9.2.2-1: Standard Conditions for Chemical Cleaning *1)

Pollutants	Chemicals	Maximum Concentration	Circulation Time (hr)
Inorganic matters	Citric acid *2)	3.0 wt%	1 – 3
Organic matters	Sodium hypochlorite *3)	3,000 mg/L as Cl_2 ($10 \leq pH \leq 12$)	1 – 3

*1): The cleaning mechanisms and effectiveness of each chemical solution, including the standard solution, differ individually and are affected by the environment and operating conditions in which the product is used. Please select the chemical solution that provides optimal performance under your actual operating conditions.

*2): Besides citric acid, hydrochloric acid, oxalic acid, sulfuric acid, and nitric acid are acceptable for use within the limits specified in Table 4-3, Chemical Limits.

*3): Besides sodium hypochlorite, peracetic acid, and hydrogen peroxide are acceptable for use within the limits specified in Table 4-3, Chemical Limits.

9.3. Chemical Cleaning Flow Diagram and Procedure

This section describes the standard flow diagrams and procedures for chemical cleaning process and rinsing process after chemical cleaning, along with timing charts indicating the operation of pumps and valves.

9.3.1. Chemical Cleaning Flow Diagram

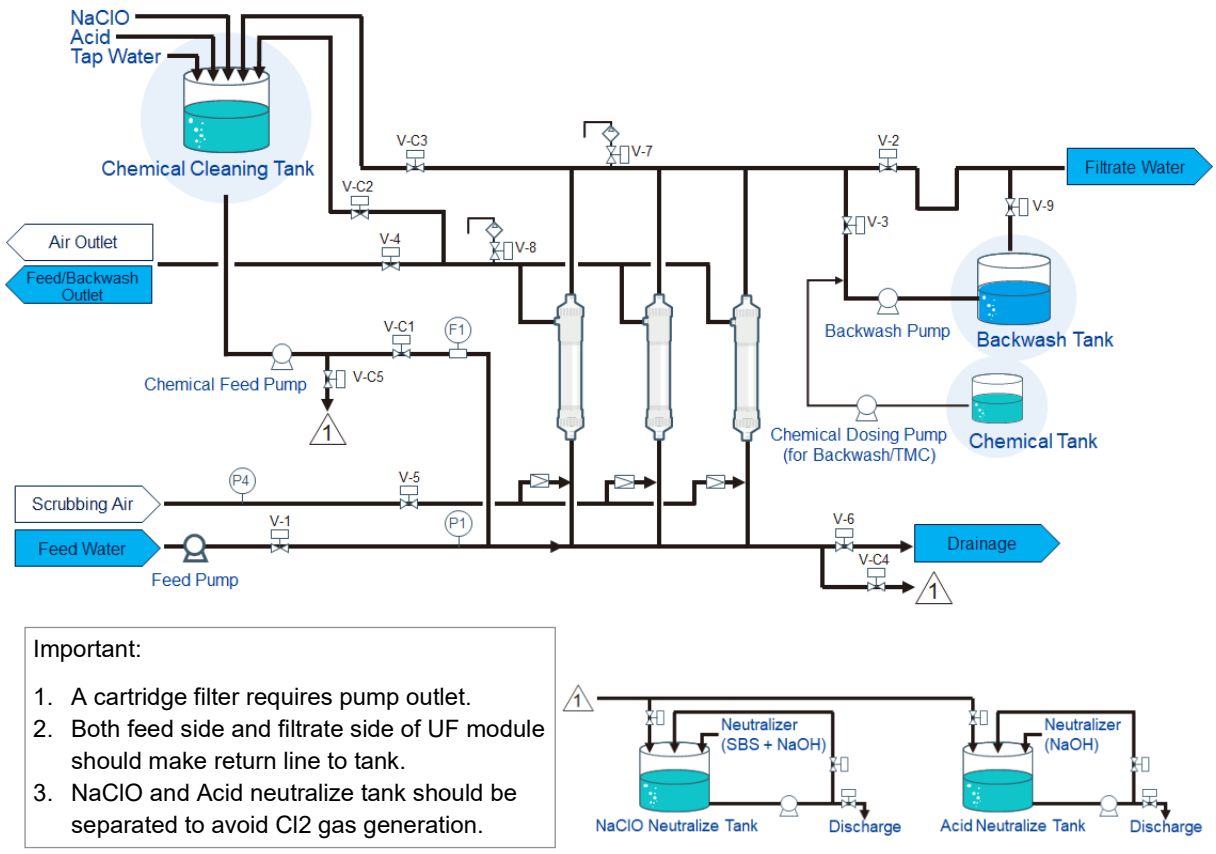


Figure 9.3.1-1: Chemical Cleaning Standard Flow Diagram

Table 9.3.1-1: Chemical Cleaning Pump and Each Tank Parameters

Equipment	Module Type (F-HFUG)	
	-2020AN/HN	-B2315AN
Chemical Feed Pump	= N *1) x 62.5 L/min	= N x 52.5 L/min
Chemical Cleaning Tank *2) (Full drain type)	= N x 50 L x 2.5	= N x 42 L x 2.5
NaClO Neutralize Tank *2)	>= N x 50 L x 12.5	>= N x 42 L x 12.5
Acid Neutralize Tank *2)	>= N x 50 L x 12.5	>= N x 42 L x 12.5

*1) N: The number of modules

*2): This table indicates the standard tank size. Actual required tank sizes may differ depending on a project.

9.3.2. Chemical Cleaning Process

Table 9.3.2-1: Timing Chart of Chemical Cleaning Operation

Cleaning Time (= 129.5 min)

	Drain 3 min	Air Purge 1.5 min	Filtrate Side Cleaning 58.5 min	AS 1 min	Feed Side Cleaning 1 hr	AS 1 min	Chemical Discharge 1.5 min	Chemical Drain 3 min
V4 (Feed/BW Outlet)	**OPEN**	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE
V5 (Air Scrubbing)	CLOSE	CLOSE	CLOSE	**OPEN**	CLOSE	**OPEN**	CLOSE	CLOSE
V6 (Drain)	**OPEN**	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE
V7 (Filtrate Vent)	**OPEN**	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**
V8 (Feed/BW Outlet Vent)	**OPEN**	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE
Chemical Feed Pump	OFF	**ON**	**ON**	OFF	**ON**	OFF	**ON**	OFF
V-C1 (Chemical Feed)	CLOSE	**OPEN**	**OPEN**	CLOSE	**OPEN**	CLOSE	CLOSE	**OPEN**
V-C2 (Chemical Feed Return)	CLOSE	**OPEN**	CLOSE	**OPEN**	**OPEN**	**OPEN**	CLOSE	**OPEN**
V-C3 (Chemical Filtrate Return)	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**
V-C4 (Chemical Drain)	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**
V-C5 (Chemical Discharge)	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**	CLOSE

Proceed to Rinse Process

BW: Backwash, AS: Air Scrubbing

The durations listed for each process in this table represent standard times. Actual times may vary depending on the plant scale, the feed water quality, and other operating conditions.

1. Preparation

   Before performing chemical cleaning, prepare the required amount and concentration of chemical solution in Chemical Cleaning Tank in advance.

2. Chemical Cleaning Procedure

   i. Drain

   Open V-4, V-6, V-7, and V-8 to drain all water from the equipment in the train where chemical cleaning will be performed.

   ii. Air Purge

   Turn on Chemical Feed Pump, open V-C1 and V-C2, and circulate the prepared chemical solution through the feed-side piping to fill the feed-side path completely (air removal).

iii. Filtrate Side Cleaning
Open V-C3 and close V-C2 to switch circulation to the filtrate side and perform chemical cleaning on the filtrate side.

iv. Air Scrubbing (AS)
Turn off Chemical Feed Pump, open V-C2, close V-C1 and V-C3 to stop chemical circulation, and open V-5 to perform air scrubbing.

v. Feed Side Cleaning
Switch circulation to the feed side for chemical cleaning by turning on Chemical Feed Pump and opening V-C1 and V-C2.

vi. Air Scrubbing (AS)
Turn off Chemical Feed Pump, close V-C1 to stop chemical circulation, then open V-5 to perform air scrubbing.

vii. Chemical Discharge
After completing cleaning on both filtrate and feed sides, close V-5, open V-C5, and operate Chemical Feed Pump to discharge the chemical solution from Chemical Cleaning Tank to the Neutralization Tank.

viii. Chemical Drain
Turn off Chemical Feed Pump, open V-7, V-C1, V-C2, V-C3, and V-C4, close V-C5, and drain the remaining chemical solution from the entire train (inside modules, piping, etc.) to the Neutralization Tank.

After completing the Chemical Cleaning Process, proceed to the process 9.3.3 Rince Process.

9.3.3. Rinse Process

Table 9.3.3-1: Timing Chart of Rince Operation

← Perform twice (= 31min) → ← Perform twice or more (= 31min or more) →

	Rinse Filling 5 min	Feed Side Rinse 5 min	AS 1 min	Rinse Discharge 1.5 min	Rinse Drain 3 min	Rinse Filling 5 min	Air Purge 1.5 min	Filtrate Side Rinse 3.5 min	AS 1 min	Rinse Discharge 1.5 min	Rinse Drain 3 min
V4 (Feed/BW Outlet)	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE
V5 (Air Scrubbing)	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE
V6 (Drain)	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE
V7 (Filtrate Vent)	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**
V8 (Feed/BW Outlet Vent)	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE
Chemical Feed Pump	OFF	**ON**	OFF	**ON**	OFF	OFF	**ON**	**ON**	OFF	**ON**	OFF
V-C1 (Chemical Feed)	CLOSE	**OPEN**	CLOSE	CLOSE	**OPEN**	CLOSE	**OPEN**	**OPEN**	CLOSE	CLOSE	**OPEN**
V-C2 (Chemical Feed Return)	CLOSE	**OPEN**	**OPEN**	CLOSE	**OPEN**	CLOSE	**OPEN**	CLOSE	**OPEN**	CLOSE	**OPEN**
V-C3 (Chemical Filtrate Return)	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE	**OPEN**
V-C4 (Chemical Drain)	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**
V-C5 (Chemical Discharge)	CLOSE	CLOSE	CLOSE	**OPEN**	CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	**OPEN**	CLOSE

BW: Backwash, AS: Air Scrubbing

The durations listed for each process in this table represent standard times. Actual times may vary depending on the plant scale, the feed water quality, and other operating conditions.

1. Feed Side Rinse Procedure

   i. Rinse Filling

   Fill Chemical Cleaning Tank with rinse water.

   ii. Feed Side Rinse

   Turn on Chemical Feed Pump and open V-C1 and V-C2 to circulate rinse water through the feed-side piping and perform rinsing on the feed side.

   iii. Air Scrubbing (AS)

   Turn off Chemical Feed Pump, close V-C1 to stop rinse water circulation, then open V-5 to perform air scrubbing.

   iv. Rinse Discharge

   Close V-5 and V-C2, open V-C5, and turn on Chemical Feed Pump to discharge rinse water from Chemical Cleaning Tank to Neutralization Tank.

v. Rinse Drain
Open V-7, V-C1, V-C2, V-C3, and V-C4, close V-C5, and drain rinse water from the entire train (inside modules, piping, etc.) to Neutralization Tank.

Repeat the above steps (i through v) to perform feed side rinsing twice.

2. Filtrate Side Rinse Procedure

vi. Rinse Filling
Fill Chemical Cleaning Tank with rinse water.

vii. Air Purge
Turn on Chemical Feed Pump and open V-C1 and V-C2 to circulate rinse water through the feed side piping and completely fill the feed side path (air removal).

viii. Filtrate Side Rinse
Open V-C3 and close V-C2 to circulate rinse water through the filtrate side piping and perform rinsing on the filtrate side.

ix. Air Scrubbing (AS)
Turn off Chemical Feed Pump, open V-C2, close V-C1 and V-C3 to stop rinse water circulation, then open V-5 to perform air scrubbing.

x. Rinse Discharge
Close V-5 and V-C2, open V-C5, and turn on Chemical Feed Pump to discharge rinse water from Chemical Cleaning Tank to Neutralization Tank.

xi. Rinse Drain
Open V-7, V-C1, V-C2, V-C3, and V-C4, close V-C5, and drain rinse water from the entire train (inside modules, piping, etc.) to Neutralization Tank.

Repeat the above steps (vi through xi) to perform filtrate side rinsing twice or more.

DANGER

- Pay full attention when handling chemicals and be sure to wear safety gear such as glasses and gloves. The chemicals used for 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 SDS.
- 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.
- Do not use any other chemicals than those indicated in this manual.

CAUTION

- Take appropriate measures to prevent incorrect operations or accidents that could allow chemicals to enter the filtrate water. Before starting chemical cleaning, check the piping and ensure that each valve is in the correct position.
- Follow the instructions described in this manual when you carry out the chemical cleaning. If you use unacceptable chemicals or perform the cleaning altered from the recommended procedure, the membrane could be seriously damaged.
- In the case of cleaning with acid and with sodium hypochlorite alternately, rinse the cleaning line and the module with clean water thoroughly after each cleaning. Make sure that the pH of the water in the module is in the range between pH 6.5 and 7.5 after rinsing.

10. STORAGE OF MEMBRANE MODULE

Follow the instruction below when you store the modules.

CAUTION • Be careful not to freeze the modules.

10.1. Storage of New Membrane Module

Keep the modules in the original packing in a dark and cool place (1 to 40 °C). Avoid direct sunlight and moisture.

10.2. Storage of Membrane Modules after Use

10.2.1. Short-term, or Temporary Shutdown or Storage

If the operation is suspended for less than four days, stop the feed water and keep the modules filled with water. Maintain the modules at a temperature between 1 and 40 °C.

If the suspension lasts from four days up to seven days, fill the module with the chemical specified in Table 10.2.1-1 and use filtrate-quality water. Maintain the modules at a temperature between 1 and 40 °C.

Table 10.2.1-1: Storage Conditions for Membrane Modules (Up to Seven Days)

Maximum Storage Period	Preservative Chemical	Concentration of the Chemical
7 days	Sodium hypochlorite	20 mg/L as Cl_2

10.2.2. Long-term Storage

First, perform chemical cleaning using sodium hypochlorite, following the instructions in Chapter 9.

After cleaning, fill the modules with the preservative solution specified in Table 10.2.2-1 and keep them sealed. Use filtrate-quality water for dilution. If removing modules from the system, seal them and store them away from direct sunlight. Maintain the modules at a temperature between 1 and 40 °C.

Table 10.2.2-1: Storage Conditions for Membrane Modules (More than Seven Days)

Storage Period	Preservative Chemical *1)	Concentration of the Chemical
More than 7 days	Sodium hypochlorite	10 mg/L as Cl_2 *2)
	Sodium bisulfite	1,000 mg/L

*1): Select either sodium hypochlorite or sodium bisulfite chemical solution.

*2): Be careful not to exceed the sodium hypochlorite contact upper limits shown in Table 4-3, Chemical Limits.

DANGER

- When using sodium bisulfite for preservative solution, rinse the module thoroughly with clean water after the chemical cleaning with sodium hypochlorite and fill the module with sodium bisulfite solution. Toxic chlorine gas is generated in the case of mixing sodium hypochlorite with sodium bisulfite without first flushing with water.

10.3. Replace Preservative Chemical

Check the pH value of sodium bisulfite solution as the preservative and replace the chemical if the pH is below three (3.0). Sodium bisulfite solution with a pH of 3 to 6 is active for the preservation. Sodium bisulfite reacts with oxygen and forms sulfuric acid which results in a lower pH. In case that sodium hypochlorite is being used as the preservative, replace it if the sodium hypochlorite concentration is less than 0.1 mg/L as Cl_2.

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