AQUADYN® FZ50 Hollow Fiber Module

Operation Manual

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1 Introduction

MICRODYN-NADIR offers a wide variety of hollow fiber modules, including the AQUADYN® FZ50 series.

AQUADYN® modules are encased ultrafiltration hollow fiber membrane modules that effectively reduce micro-organisms and suspended solids from water. The AQUADYN® F50-series offers an extremely hydrophilic membrane for surface water with a very high organic pollution. Due to the optimized design efficient flow distribution, cleaning, minimal pressure drop, and high packing density can be achieved. Moreover, the AQUADYN® FT50 (CTA) materials are superior in their hydrophilic property compared to most other polymeric materials. The enhanced hydrophilic property improves the wettability and reduces operating pressure. Additionally, it makes the membrane more resistant to fouling; resulting in less cleaning cycles and reduced chemical usage. The double asymmetric hollow fiber membranes offer another advantage over single asymmetric membranes. Bacteria, solids, and turbidity can be rejected effectively by backwashing the hollow fiber.

2 Handling & Storage

To ensure proper handling of AQUADYN® FZ50 hollow fiber modules, please refer to the safety and handling instructions below.

2.1 SAFETY INSTRUCTIONS

Having proper equipment is essential for safely executing the following handling instructions. Appropriate gloves, shoes and safety glasses should be worn at all times. The following additional safety measures are recommended:

- Be sure to read appropriate safety data sheets (SDS) before working with the chemicals.
- The modules are shipped and stored in a preservative solution to prevent drying and reproduction of bacteria. Please wear appropriate safety equipment when handling.
- If preservative leaks from the module, avoid splashing. Use adequate protection to cover the module and any other surrounding equipment.
- If cleaning with a combination of acid and sodium hypochlorite, avoid mixing these chemicals as harmful chlorine gas results.
- Use a mask to prevent inhaling the gas from the preservative solution.

2.2 PRESERVATIVE SOLUTION

The module is shipped wet, in a preservative solution to prevent drying and bacteria growth. A solution of sodium hypochlorite and water (10-20 mg/L free chlorine) or ~500 mg/L sodium benzoic acid water solution is used as preservative. The module is filled with ~15 kg of preservative.

2.3 HANDLING

- Avoid exposing the module with material that contains ester plasticizer or e.g. flexible polyvinyl chloride tube etc.
- Avoid exposing the FZ50 modules to organic solvents, cleaning substances, fat, oil or adhesive tape, as these materials may cause damage or cracks of the module.
- Do not affix vinyl tape or packing tape to the module and avoid writing on the module with permanent marker.
- To clean the outside of the module, use water and dry with normal cloth.
- Please handle the modules with care. The module or hollow fibers may break due to heavy impact.

2.4 STORAGE

Avoid exposing the modules to UV rays and direct sunlight as the module casing and resin parts may deteriorate after being exposed to UV rays or high temperatures for long periods of time. Modules should be stored in a place, out of direct sunlight and UV rays and at a temperature between 5°C to 35°C (41°F to 95°F). Ensure that the module's temperature doesn't fall below 5°C (41°F). If necessary, use thermal insulation around the body of the module.

The modules are packaged in a preservative solution to ensure that the hollow fibers inside the modules don't dry out. They are also shipped with protective caps on the feed and permeate ports to protect the modules during storage and transportation. These protective caps are not designed for use during operation, but to prevent the hollow fibers from drying out and protection from bacterial contamination. If the original packaging has been opened, keep the outlets sealed. Insufficient seals may cause the hollow fibers to dry out and and lead to poor module performance.

If storing modules that have been used, implement the disinfection procedure before storing it.

3 Installation

When mounting modules to the system, mount the modules where they are not exposed to direct ultraviolet rays like UV lamps or direct sunlight. The central body of the module and the resin parts may deteriorate in direct ultraviolet rays and high temperatures.

- The piping is connected to the module using grooved-end joints. Please note that the piping connecting the plant may be disconnected if there is another connection.
- When mounting the module, use a chain or U-band to fix the module to the rack. Be sure to avoid over tightening the chain or U-band.
- If you use a pressure proof-hose, make sure that the hose doesn't loosen due to pressure impact. Securely connect it to the equipment.

Be sure to wear all safety equipment when working with the modules.

1. Carefully remove the module from the pallet.
2. Remove the module from packaging and remove the protective cap from each outlet of the module. The plug inserted in the lower port is not pressure-proof; be sure to remove this plug before operation.
3. Position the module vertically to discharge excess preservative. If preservative solution leaks out of the module, wash it away with water and dry with suitable material.
4. Ensure the piping to the feed water inlet nozzle and the concentrate water outlet nozzle of the module correspond to the piping of the system.
5. Fix the module securely to the system rack using a U-band, chain, etc. Avoid tightening the U-band, chain, etc. too tightly to prevent damage to the module.
6. Connect feed, concentrate and permeate ports to system piping using grooved-end joints. Attach a valve for sampling or sealing plug if needed.
7. Test with clean water to check for any leaks in the connections or piping.

3.1 DISASSEMBLING

To remove the module from the system, please follow the below guidelines:

1. Be sure to flush the system with clean water before disassembling the module from the plant.
2. Allow water to drain out of the module through the lower port.
3. Remove all three of the Victaulic joints from the ports.
4. Remove the U-band or chain from the module.
5. Carefully remove the module from the system.

4 Operation

To ensure proper operation of AQUADYN® FZ50 hollow fiber modules, please refer to the operating limits specified on the product data sheet.

4.1 START-UP

A trial run is recommended prior to actual operation. This eases the membranes into operation and allows purging of any remaining air from the system.

At start-up, gradually increase the pressure and flow rate. Then, adjust the flow of the module to approximately 60% of the actual operating flow. Allow the system to operate under this condition for at least half a day (approximately 8 hours) or 1 to 2 days.

TABLE 1. RECOMMENDED START-UP FLOWS & FILTRATION TIMES.

Filtration Time (intervals between backwashes)	30 to 90 minutes
Backwashing Time	> 50 seconds
Backwashing Water Volume	> 200 L

4.1.1 Preservative & Air Purge

1. After start-up, set the permeate flow to 0.5 m^3/h (2.2 gpm) per module and discharge excess water. This will flush out any residual preservative and air from the system.
2. Be sure to purge the air from the piping and backwash pump. Failure to purge air from the system can result in hollow fiber breakages during backwash.

4.2 STANDARD OPERATING CONDITIONS

TABLE 2. STANDARD OPERATION CONDITIONS FOR VARYING FEED WATER TURBIDITIES.

Type of Feed Water	Water at Low Turbidity Level (≤ 0.5 NTU)	Water at Middle Turbidity Level (0.5 to 5 NTU)	Water at High Turbidity Level (≥ 5 NTU)
Pretreatment	None	100-150 µm filter or screen	100-150 µm filter or screen
Flow Rate [a]	10 m^3/hr (44 gpm)	3.1 to 5.2 m^3/hr (13.6 to 22.9 gpm)	≤ 3.1 m^3/hr (≤ 13.6 gpm)
Circulation Flow Rate (outlet port)	0 to 7.4 m^3/hr (0 to 32.6 gpm)	3.7 to 7.4 m^3/hr (16.3 to 32.6 gpm)	7.4 m^3/hr (32.6 gpm)
Backwash Flow Rate [b]	15 m^3/hr (66 gpm)	15 m^3/hr (66 gpm)	15 m^3/hr (66 gpm)
NaClO Concentration in Backwash Water	3 to 5 mg/L	3 to 5 mg/L	3 to 5 mg/L
Water Temperature	≤ 35°C (95°F) [c]	≤ 35°C (95°F) [c]	≤ 35°C (95°F) [c]
pH Range	4 to 8	4 to 8	4 to 8
Chemical Cleaning	1) Periodical cleaning 2) Implemented when the transmembrane pressure increases to 0.07 MPa (10.2 psi) [d]	1) Periodical cleaning 2) Implemented when the transmembrane pressure increases to 0.07 MPa (10.2 psi) [d]	1) Periodical cleaning 2) Implemented when the transmembrane pressure increases to 0.07 MPa (10.2 psi) [d]

[a] Value based on 20°C (68°F) water temperature.
[b] To be set according to the recovery ratio.
[c] While the data sheet lists a maximum temperature of 40°C, this is for short time periods only. The maximum recommended temperature for long periods of operation is 35°C.
[d] The supply pressure at the general start of operation is approximately 0.01 to 0.03 MPa.
Note: The values above are the standard conditions and they vary depending on the quality of feed water.

4.3 OPERATION

The operating flux largely depends on the quality of the feed water and is usually determined based on test or pilot results. Pilot tests typically last about 6 months and include periods at various temperatures. The feed flow rate, just like the flux, is based on the feed water quality. For standard filtration, set the recovery ratio to 90%. The valves switch and the pump starts and stops automatically in the following order during operation:

1. Filtration for 45 minutes
2. 30-second backwashing is implemented twice

3. Change flow direction for 1 minute
4. Flush for 5 seconds
5. Repeat steps 1-4

4.3.1 Feed pH

Set the feed pH to 4-8 for long-term operation. Regular adjustments of the feed pH are recommended to keep the feed pH inside this range. Operation outside of this suggested range may shorten the module's lifetime due to possible membrane degradation.

4.3.2 Feed Temperature

The maximum feed temperature for long-term operation is 35°C (95°F). However, the UF modules may be operated outside of this range for short periods (up to 3 months per year). In some cases, operation may occur at up to 40°C (104°F). Operation outside of this suggested range may shorten the module's lifetime due to possible membrane or module degradation.

4.3.3 Turbidity Level

Turbidimeters should be used to measure and help maintain acceptable turbidity levels prior to the UF system. If feed water with high turbidity levels is directly sent to the UF modules, the set membrane flux may not be sustainable.

4.3.4 Membrane Flux

Set the module's operating flux within the range described on the product specification sheet. The operating flux depends on the quality of the feed water. If an overly aggressive flux is chosen for a given feed water, the transmembrane pressure will increase in a short period of time.

4.3.5 Flow Rate

Set the flow so that the liquid linear velocity along the membrane surface on the outlet port side (concentration water port) of the module is 0.1-0.2 m/sec. Note that the proper module supply flow rate changes if the permeate flow rate changes. For example, if the permeate flow rate is 3.0 m/day, the proper module flow rate should be 10-14 m^3/h.

4.3.6 Transmembrane Pressure (TMP)

The maximum transmembrane pressure (TMP) a module can tolerate is 0.2 MPa (29 psi). However, UF modules are typically operated at a TMP of 0.01-0.1 MPa (1.5-14.5 psi) and the desirable operation range is 0.01-0.07 MPa (1.5-10.2 psi). If the TMP reaches 0.1 MPa, it is recommended to implement a backwash or chemical cleaning to improve membrane performance. In many cases, the TMP increases at a quicker rate after 0.07 MPa, so it is difficult to keep the membrane flux at the original set value.

4.3.7 Backwash

In order to maintain the operating membrane flux, it is necessary to implement periodic backwashes. For more information on backwashing, please refer to *Chapter 5. Backwash*.

4.3.8 Flushing

The procedure for flushing the module after backwashing without implementing filtration (valve on the pemreate water side is closed) helps clean the feed water side of the hollow fibers more effectively. Flushing washes away the contaminants accumulated in the circulation line on the feed water and concentrate side.

5 Backwash

Contrary to filtration, backwashes are periodically implemented to wash away the contaminants from the membrane surface by implementing flow from the permeate side of the membrane to the feed side. This procedure helps restore membrane performance.

5.1 BACKWASHING WATER

For a chemically enhanced backwash, mix permeate and sodium hypochlorite. Adjust the necessary amount of sodium hypochlorite so that the concentration of free chlorine in the discharged backwash water is 3-5 mg/L. If the free chlorine concentration in the module is continuously higher than this, the chlorine may cause the membrane to deteriorate. However, if the free chlorine concentration is too low, the cleaning may not be effective and cause a decrease in filtration performance.

5.2 BACKWASHING CONDITIONS

Permeate water is used for backwashing and is pulled from the permeate side of the membrane to the feed side. The backwash flow rate highly depends on the quality of the feed water. If the feed water has low turbidity (< 0.5 NTU), the backwash flow rate can be set to 1.5 times the filtration flow rate. If the feed water has high turbidity (> 5 NTU), the backwash flow rate should be four times the filtration flow rate.

To ensure effective cleaning, the TMP during backwash should be more than double the TMP during filtration. However, the maximum backwashing pressure (TMP) should be 0.2 MPa or less. If the backwash pressure exceeds this limit, a chemical cleaning is recommended to help further restore membrane performance.

5.3 BACKWASHING PROCEDURE

In the first step of a backwash cycle, the cleaning solution (permeate water and sodium hypochlorite) is poured in from the filtration water nozzel at the top and the discharge water exits from the feed water nozzel at the bottom. This step should take about 25 seconds and requires about 75 L (19.8 gal) of cleaning solution per module.

In the next step, the cleaning solution is poured in from the filtration water nozzel at the top and the discharge water exists from the concentration water at the top. This step should also take about 25 seconds and requires about 75 L of cleaning solution per module.

Please be sure that air does not get mixed in the module in either of these steps as this may cause the membrane to fracture. Together, the backwash should take about 50 seconds and use up to 150 L (39.6 gal) of cleaning solution per module.

5.4 PERIODICAL STERILIZATION (AT TIME OF OPERATION)

The membrane used in the AQUADYN® FZ50 modules is made of cellulose triacetate (CTA). It is hydrophillic and maintains high filtration performances, stable and long-term. It may deteriorate if bacteria grows during operation, so periodical sterilization is necessary. The periodical sterilization is important to prevent the feed-side reproduction of microorganisms.

The periodical sterilization procedure can be combined with backwashing.

6 Offline Treatment

When operation is stoped for a long period of time, it is necessary to fill the module with a preservative solution to avoid drying of the membrane or bacteria growth. If the sodium hypochlorite is used as a biocide, the effective chlorine may be quickly consumed by soiled material remaining in the system. Measure the free chlorine concentration after a brief interval of filling and check that the effective chlorine is not consumed completely. After this, the module may be stored.

6.1 SHORT-TERM STORAGE (2 DAYS OR LESS)

Backwash the module immediately before stopping operation. The backwash water (free chlorine concentration of 3-5 mg/L) needs to remain in the module. Be sure that liquid does not leak or evaporate during storage.

6.2 SHORT-TERM STORAGE (3-7 DAYS)

Store the module after filling with a sodium hypochlorite water solution (free chlorine concentration between 10-20 mg/L). This can be achieved by backwashing until the chlorine concentration in the discharge water has reached this concentration.

6.3 LONG-TERM STORAGE (LONGER THAN 7 DAYS)

For long-term storage, it is recommended to use the preservative solution (500 mg/L sodium benzoic acid water solution or formalin 2 wt% sodium sulfate, 0.2 wt% water solution).

If storing the modules for 3 months or longer, please contact MICRODYN-NADIR.

7 Chemical Cleaning

Over time, contaminants may accumulate on the membrane surface and backwashing no longer removes all of the contaminants. If the solids have accumulated on the surface of the membrane, the operating flux of the membrane may decline. In this case, a chemical cleaning is recommended to help remove the contaminants.

There are three types of cleaning: flushing with clean water, physical cleaning via backwash, and chemical cleaning. If membrane performance cannot be recovered by backwashing, or the contaminants cannot be removed, the solubility of the contaminants may be improved by using chemicals. The chemical cleaning decomposes the contaminants and removes it from the membrane surface.

7.1 CHEMICALS USED FOR CLEANING

7.1.1 Type of Chemical & Target Contaminants

The chemical used for the cleaning of the module is selected according to the contaminant present on the membrane surface. However, while chemicals can help remove contaminants, it should be noted that the chemicals may promote deterioration of the membrane. To prevent chemical deterioration of the membrane, please adhere to the recommended cleaning conditions (concentrations and temperatures).

The recommended cleaning chemicals and types of contaminants are listed below in Table 3. In order to determine which chemical may be the most effective, it is recommended to perform a preliminary cleaning test.

TABLE 3. RECOMMENDED CLEANING CHEMICALS FOR AQUADYN® FZ50 MODULES.

Type	Chemical	Concentration	Target Contaminants	Notes
Mixed chemical solution	Citric acid + Ultrasil 53	1% (0.5% + 0.5%)	Metallic oxide such as colloidal Fe and Mn General organic substance, fat	Depending on acidic property and chelate effect Proteolytic enzyme contained
Sodium hypochlorite (NaClO)	Sodium hypochlorite (NaClO)	Effective chlorine concentration ~50 ppm	Low-solubility organic substance Microbially-derived organic substance	Combined with sterilization treatment

7.1.2 Conditions of Chemical Cleaning

The cleaning effect of a given chemical is heavily affected by various conditions including concentration, duration, temperature, and pH. This is because the solubility, diffusion speed (speed at which chemical and contaminants travel throughout the mixture), and the speed of the chemical reaction (oxidative dissolution) are affected by the concentration of a chemical, processing time, and temperature during the processing. Usually, the cleaning efficacy is increased when the chemical concentration is higher, the duration of cleaning is longer, and the temperature is higher.

On the other hand, the pH of the chemical solution affects the solubility of the contaminants and affects the cleaning efficacy by changing the property of the chemical itself.

As mentioned before, the cleaning agent does interact with the membrane itself and may promote membrane deterioration. As such, it is necessary to confirm the chemical's effect on the contaminants as well as its effect on the membrane. To determine which chemicals are compatible with the UF module, please contact MICRODYN-NADIR.

7.2 CLEANING PROCEDURE

If backwashing is performed when the module attached to the equipment, cleaning can be performed during backwash. If the cleaning is combined with backwash, a cyclic chemical cleaning is not necessary.

Typical cleanings include backwash with water, backwash with chemical solution, chemical soak, and flush cleaning with chemicals.

It is recommended to check the cleaning efficacy every once in awhile by performing a clean water flux.

The standard chemical cleaning procedure is also summarized in Table 4 and Figure 1.

TABLE 4. STANDARD CHEMICAL CLEANING PROCEDURE OF AQUADYN® FZ50 MODULES.

Step	Description	Chemical Solution Concentration	Feed Pressure (MPa)	Time (min)	Temperature (°C)	Circulation Flow Rate (m^3/hr)
1	Measurement of flux (before chemical cleaning)	-	-	-	-	-
2	Pure water 2-ports counter pressure cleaning	-	0.1	2	Normal temperature	Max 14.5
3	Measurement of flux	-	0.05	-	-	-
4	Mixed chemical solution 2-ports counter pressure cleaning	1 wt%	0.1	2	35	-
5	Mixed chemical solution soak	1 wt%	-	120	35	-
6	Mixed chemical solution 2-port counter pressure cleaning	1 wt%	0.1	2	35	Max 14.5
7	Mixed chemical solution flushing cleaning	1 wt%	-	20	35	15-20
8	Pure water 2-ports counter pressure cleaning	-	0.1	2	Normal temperature	Max 14.5
9	Measurement of flux	-	0.05	-	-	-
10	NaClO 2-ports counter pressure cleaning	50 ppm *	0.1	2	35	Max 14.5
11	NaClO soak	50 ppm *	-	720	35	-
12	NaClO 2-ports counter pressure cleaning	50 ppm *	0.1	2	35	Max 14.5
13	NaClO flushing cleaning	50 ppm *	-	20	35	15-20
14	Pure water 2-ports counter pressure cleaning	-	0.1	2	Normal temperature	Max 14.5
15	Measurement of flux	-	0.05	-	-	-

* NaClO concentration indicates the effective chlorine concentration.

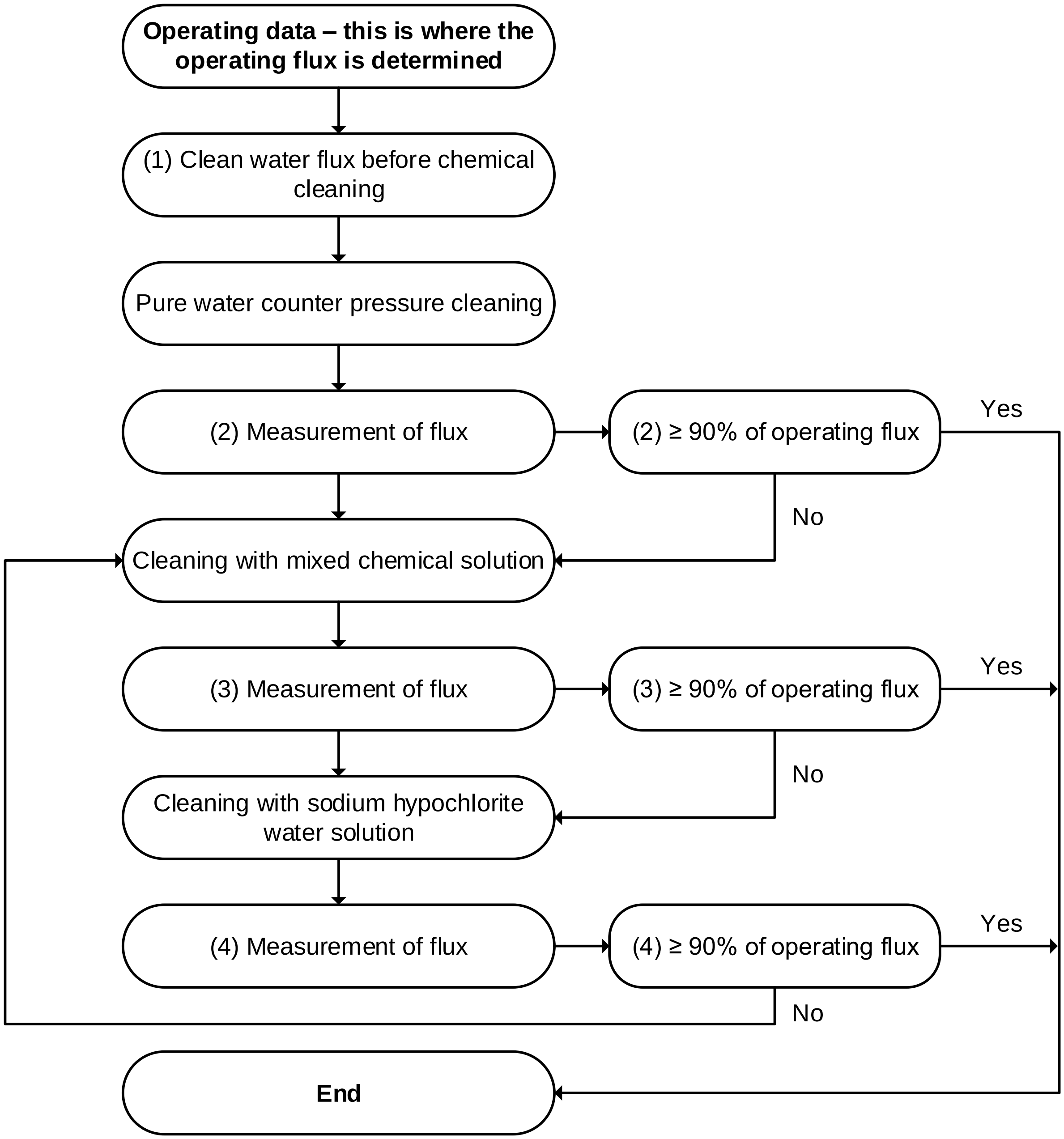


Figure 1. By measuring the flux between each cleaning step, it is easy to determine if further or more intense cleaning is necessary in order to restore membrane performance.

7.2.1 Cleaning Steps

1. Discharge feed water from the module.
   a. Fill the chemical solution tank with clean water.
   b. Pump water to the feed water inlet port of the module and discharge it from the feed water outlet port and the permeate port to discharge the feed water completely.
   c. Then, discharge the pemreate fluid from the permeate port at the top of the module so that all air is purged from the module. This prevents damage to the hollow fibers.
2. Water backwash
   a. Feed the water into the permeate port (at the top of the module) at up to 0.1 Mpa for approximately one minute (approximately 300 L or 80 gal) and discharge it from the inlet feed water port (see Figure 2). At this time, close the permeate port at the bottom of the module and the outlet feed water port.

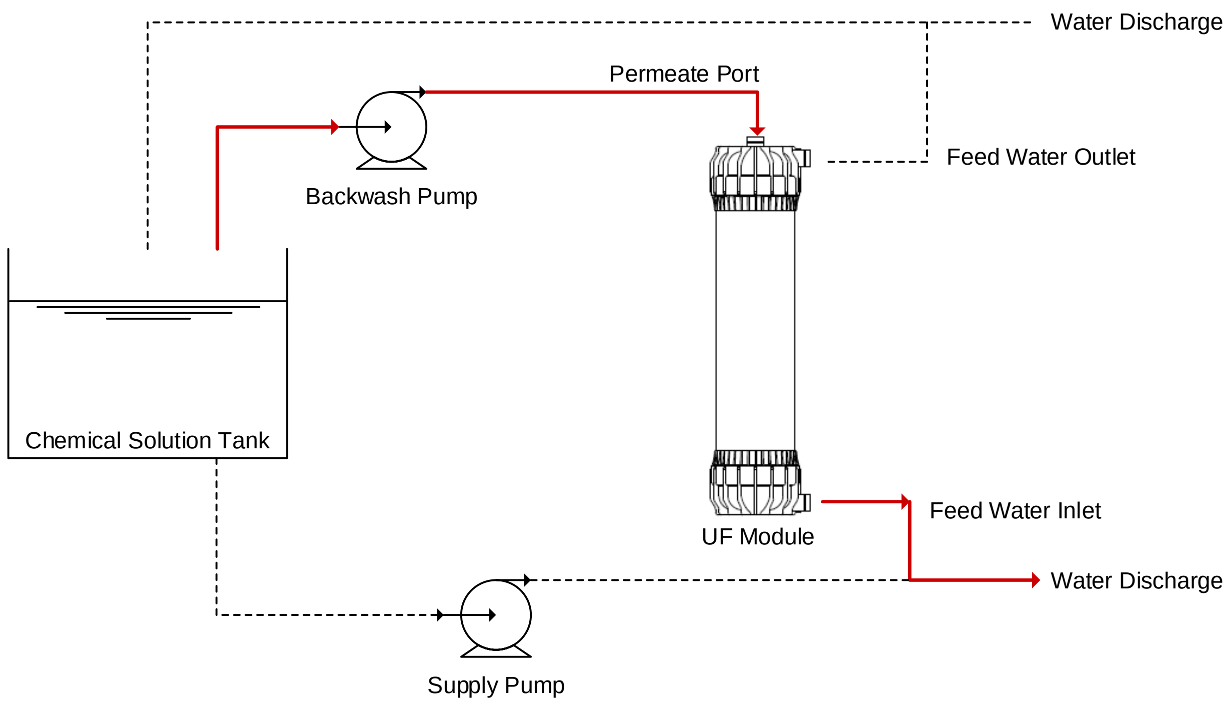


Figure 2. Backwash flow where discharge water exists the feed water inlet port.

   b. Next, feed the water from the permeate port at up to 0.1 Mpa and discharge it from the outlet feed port and close the inlet feed port (see Figure 3). This should take about one minute (approximately 300 L or 80 gal).

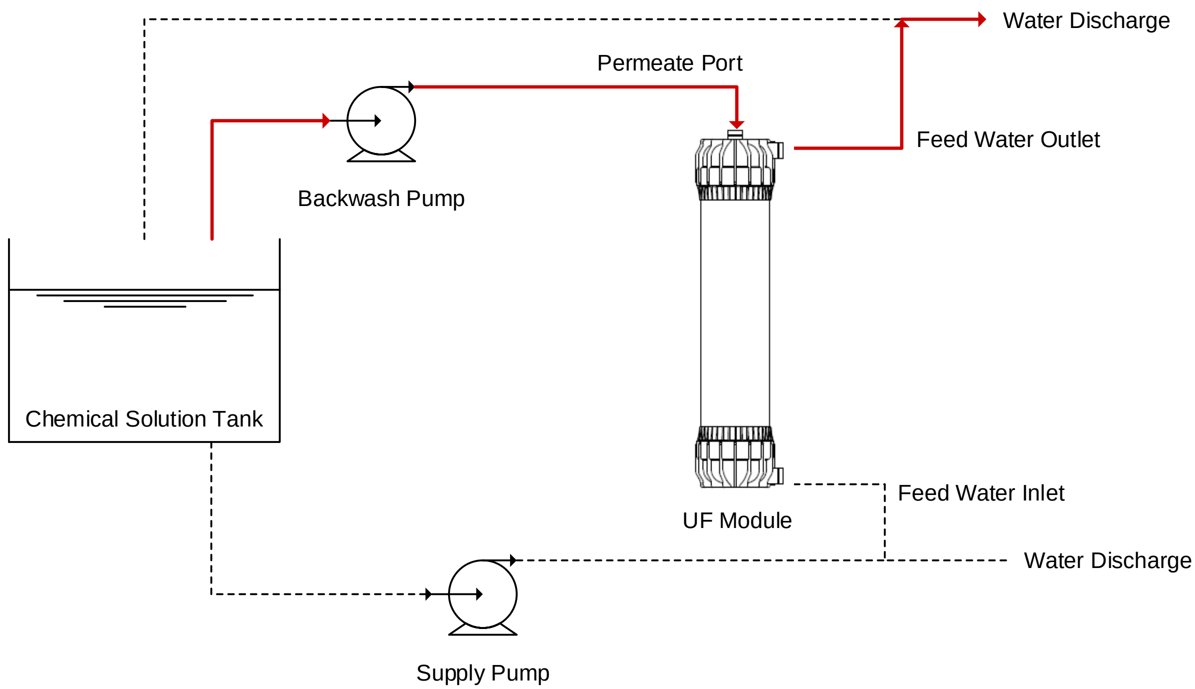


Figure 3. Backwash flow where discharge water exists the feed water outlet port.

3. Measurement of module performance
    a. Measure the flux before cleaning.
    b. For information on measuring module performance, please refer to *Section 7.2.2 Measuring the Flux.*
4. Chemical Backwash
    a. Prepare the chemical solution using the recommended concentrations. Make enough of the chemical solution taking into account the volume of the module, piping, etc. Fill the chemical solution tank.
    b. At this time, it is necessary to consider if additional chemcial solution is necessary to prevent the fluid level in the tank to drop below the feed port.
    c. Pressurize the chemical solution to the permeate port as done with backwashing. It is recommended to discharge from the raw water side for about the same duration as backwashing, however, discharge at least twice the module's volume. This ensures the module is completely full of chemical solution.
    d. Close the raw water inlet valve, feed outlet valve, and permeate port. Leave the module filled with the chemical solution for a predefined time.
    e. After the soak is complete, carry out the backwash using the chemical solution.
5. Flush cleaning using chemical solution
    a. Prepare the chemical solution using the recommended concentrations. Make enough of the chemical solution—about twice the volume needed to fill a module and the surrounding piping. Fill the chemical solution tank.
    b. Close the upper and lower permeate ports.
    c. Begin the flush cycle. The chemical solution enters the inlet feed port and discharges it from the outlet feed water port to the chemical solution tank for a predefined time.
    d. At this time, the cleaning is more effective if a flow rate with higher linear speed is used within the hollow fibers. A linear speed of about 0.5 to 1 m/sec (considering the pump capacity and pump consumption) is recommended.
6. Water backwash
    a. Perform a water backwash in the same way as Step 2 above. If the chemical solution isn't washed out entirely after the first water backwash, repeat the water backwash until all of the chemical solution is washed out.
7. Flux measurement
    a. Measure the flux of the module using the same procedure as outlined in Step 3 above.
8. Evaluation of celaning efficacy and replacement of chemical solution
    a. Compare the operating data to the flux data obtained before and after the cleaning to evaluate cleaning efficacy.

b. If the membrne performance is not sufficiently restored after one chemcial cleaning, repeat the cleaning procedure (Steps 1-8).

7.2.2 Measuring the Flux

The clean water flux for AQUADYN® FZ50 modules is measured using ultrafiltered water at 0.05 MPa feed pressure, an average transmembrane pressure (TMP) of 0.1 MPa and a temperature of 25°C (77°F).

The efficacy of the chemical cleaning is determined by comparing the clean water flux values before after chemical cleaning (see Figure 4).

Flux Measurement Conditions

- Feed water: ulltrafiltered pure water
- Filtration mode: dead-end filtration by fully closing the feed water outlet port
- Inlet pressure: approximately 0.05 MPa

Measurements

- P1: Module inlet pressure (refer to Figure 4)
- P2: Module outlet pressure
- P3: Module permeate pressure
- F1: Water quantity filtered by module (should be equivalent to quantity of supplied water)
- T1: Water temperature
- t: Factor for correcting the temperature from T1 based on the viscosity change of water (refer to Table 5)

Calculation of Flux

The flux converted per 25°C and 0.1 MPa is calculated with the following formula:

Average TMP difference, P0 = {(P1+P2)/2} - {P3/2}

Flux, F = (F1*t) / (P0/0.1 MPa)

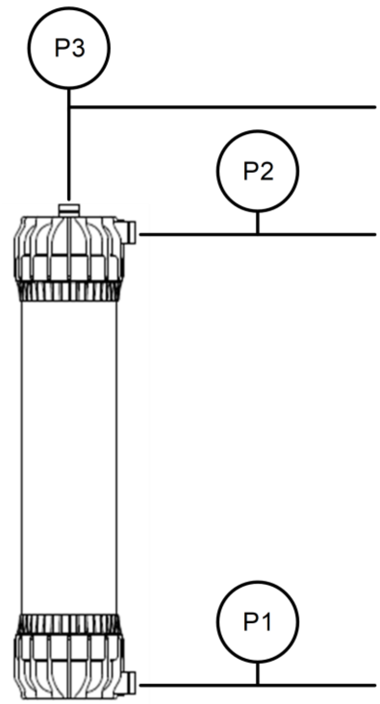


Figure 4. This diagram shows the three different points on the module where pressure is measured.

TABLE 5. WATER TEMPERATURE CONVERSION TABLE (CONVERSION TO WATER TEMPERATURE 25°C).

Temperature (°C)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
5	1.707	1.701	1.696	1.691	1.685	1.680	1.675	1.670	1.664	1.659
6	1.654	1.649	1.644	1.639	1.634	1.629	1.624	1.619	1.614	1.609
7	1.604	1.599	1.595	1.590	1.585	1.580	1.576	1.571	1.566	1.561
8	1.557	1.552	1.548	1.543	1.539	1.534	1.529	1.525	1.520	1.516
9	1.511	1.507	1.503	1.498	1.494	1.490	1.485	1.481	1.477	1.472
10	1.468	1.464	1.460	1.456	1.451	1.447	1.443	1.439	1.435	1.431
11	1.427	1.423	1.419	1.415	1.411	1.407	1.403	1.399	1.395	1.391
12	1.387	1.383	1.380	1.376	1.372	1.368	1.364	1.361	1.357	1.353
13	1.350	1.346	1.342	1.338	1.335	1.331	1.328	1.324	1.320	1.317
14	1.313	1.310	1.306	1.303	1.299	1.296	1.292	1.289	1.286	1.282
15	1.279	1.275	1.272	1.269	1.265	1.262	1.259	1.255	1.252	1.240
16	1.245	1.242	1.239	1.236	1.233	1.229	1.226	1.223	1.220	1.217
17	1.214	1.211	1.207	1.204	1.201	1.198	1.196	1.192	1.189	1.186
18	1.183	1.180	1.177	1.174	1.171	1.168	1.165	1.162	1.160	1.157
19	1.154	1.151	1.148	1.145	1.142	1.140	1.137	1.134	1.131	1.128
20	1.126	1.123	1.120	1.117	1.115	1.112	1.109	1.107	1.104	1.101
21	1.099	1.096	1.093	1.091	1.088	1.085	1.083	1.080	1.078	1.075
22	1.072	1.070	1.067	1.065	1.062	1.060	1.057	1.055	1.052	1.050
23	1.047	1.045	1.042	1.040	1.038	1.035	1.033	1.030	1.028	1.026
24	1.023	1.021	1.019	1.016	1.014	1.012	1.009	1.007	1.005	1.002
25	1.000	0.998	0.995	0.993	0.991	0.989	0.986	0.984	0.982	0.980
26	0.978	0.975	0.973	0.971	0.969	0.967	0.965	0.962	0.960	0.958
27	0.956	0.954	0.952	0.950	0.948	0.946	0.943	0.941	0.939	0.937
28	0.935	0.933	0.931	0.929	0.927	0.925	0.923	0.921	0.919	0.917
29	0.915	0.913	0.911	0.909	0.907	0.905	0.903	0.901	0.899	0.898
31	0.896	0.894	0.920	0.890	0.888	0.886	0.884	0.882	0.881	0.879
32	0.877	0.875	0.873	0.871	0.870	0.868	0.866	0.864	0.862	0.861
33	0.859	0.857	0.855	0.853	0.852	0.850	0.848	0.846	0.845	0.843
34	0.841	0.840	0.838	0.836	0.834	0.833	0.831	0.829	0.828	0.826
35	0.824	0.823	0.821	0.819	0.818	0.816	0.814	0.813	0.811	0.810
36	0.808	0.806	0.805	0.803	0.802	0.800	0.798	0.797	0.795	0.794
37	0.792	0.791	0.789	0.787	0.786	0.784	0.783	0.781	0.780	0.778
38	0.777	0.775	0.774	0.772	0.771	0.769	0.768	0.766	0.765	0.763
39	0.762	0.760	0.759	0.757	0.756	0.755	0.753	0.752	0.750	0.749
40	0.747	0.746	0.745	0.743	0.742	0.740	0.739	0.738	0.736	0.735
41	0.733	0.732	0.731	0.729	0.728	0.727	0.725	0.724	0.723	0.721
42	0.720	0.719	0.717	0.716	0.715	0.713	0.712	0.711	0.709	0.708
43	0.707	0.705	0.704	0.703	0.702	0.700	0.699	0.698	0.697	0.695
44	0.694	0.693	0.691	0.690	0.689	0.688	0.687	0.685	0.684	0.683
45	0.682	0.680	0.679	0.678	0.677	0.676	0.674	0.673	0.672	0.671
46	0.670	0.668	0.667	0.666	0.665	0.664	0.663	0.661	0.660	0.659
47	0.658	0.657	0.656	0.654	0.653	0.652	0.651	0.650	0.649	0.648
48	0.647	0.645	0.644	0.643	0.642	0.641	0.640	0.639	0.638	0.637
49	0.636	0.634	0.633	0.632	0.631	0.630	0.629	0.628	0.627	0.626
50	0.625	0.624	0.623	0.622	0.621	0.620	0.619	0.618	0.616	0.615
51	0.614	0.613	0.612	0.611	0.610	0.609	0.608	0.607	0.606	0.605
52	0.604	0.603	0.602	0.601	0.600	0.599	0.598	0.597	0.596	0.595
53	0.594	0.593	0.592	0.592	0.591	0.590	0.589	0.588	0.587	0.586
54	0.585	0.584	0.583	0.582	0.581	0.580	0.579	0.578	0.577	0.576
55	0.575	0.575	0.574	0.573	0.572	0.571	0.570	0.569	0.568	0.567
56	0.566	0.565	0.565	0.564	0.563	0.562	0.561	0.560	0.559	0.558

7.3 FREQUENCY OF CHEMICAL CLEANING

The frequency of chemical cleanings largely depends on the feed water quality, the operating flux and how much the feed pressure has increased by. As a rule of thumb, it is recommended to clean at least every 6 months.

8 Return Shipment

If a module is to be returned to MICRODYN-NADIR, please fill the module with preservative solution.

If a sodium hypochlorite water solution is used, the effective chlorine may be consumed by the remaining contaminants. After filling the module with the preservative solution, please check the free chlorine concentration.

If there’s a chance that the preservative may freeze during storage or transportation, please be sure to adopt a measure to prevent freezing. If the module freezes, the membrane or casing may be damaged.

In order to prevent leakage or damage during transportation, carefully pack the module.

Please contact MICRODYN-NADIR if there are any questions about packaging or transportation of the module.

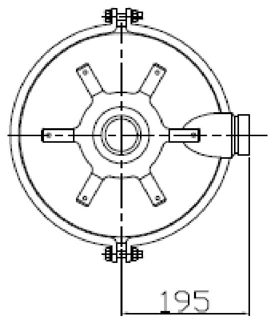
9 Disposal of the Module

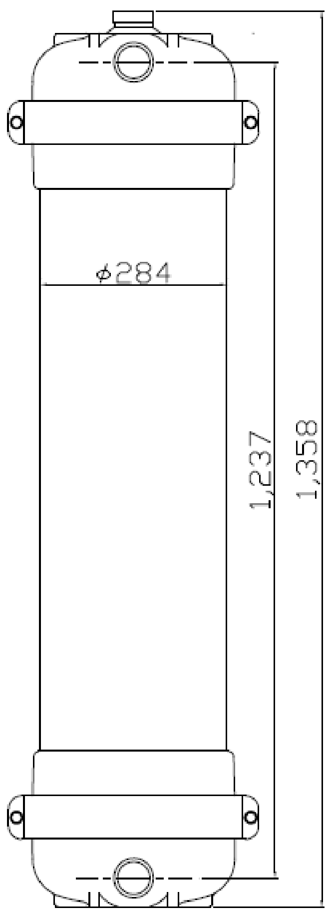
Always follow proper disposal processes when discharging wastewater or preservative solution or when disposing a UF module. If hazardous substances remain in the module, adopt a necessary measure to dispose of the module properly.

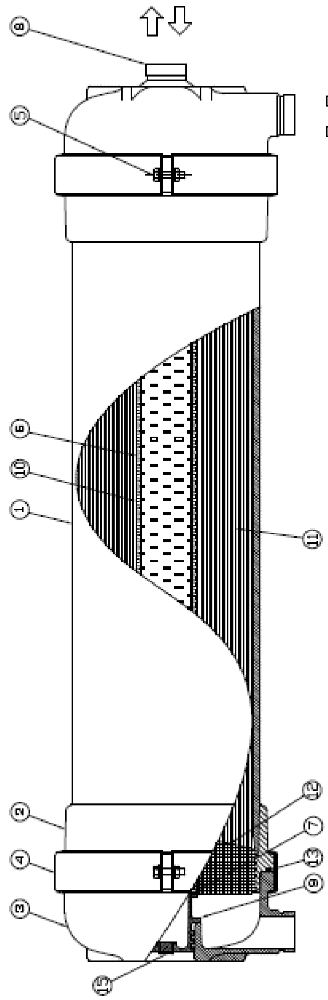
10 Appendix

10.1 DIMENSIONS OF AQUADYN™ FZ50-AC-FUC1582 MODULE

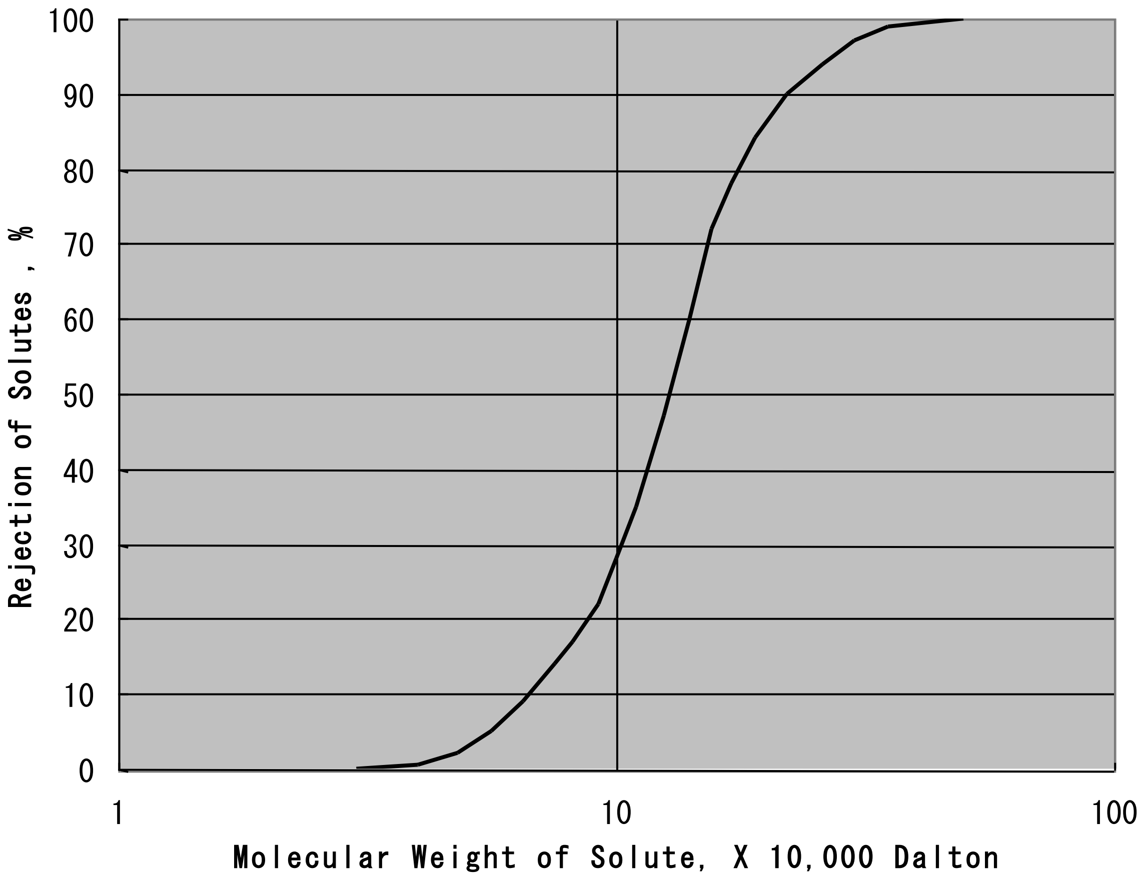
No.	Name	Material	Num.	
15	Plug	PP	1	G1/2
14	O ring	EPDM	8	P-75
13	O ring	EPDM	2	G-300
12	Potting Resin	Urethan	1	
11	HollowFiber	CTA	1	FUC1582
10	Gard Net	PET	1	
9	Joint Pipe B	ABS	1	
8	Joint Pipe A	ABS	1	
7	Urethan ring	Urethan	2	
6	Inner Pipe	HDPE	1	
5	Bolt・Nat	SUS304	2	
4	V Band	SUS304	4	
3	Cap	ABS	2	
2	Header	ABS	2	
1	Housing Case	ABS	1	



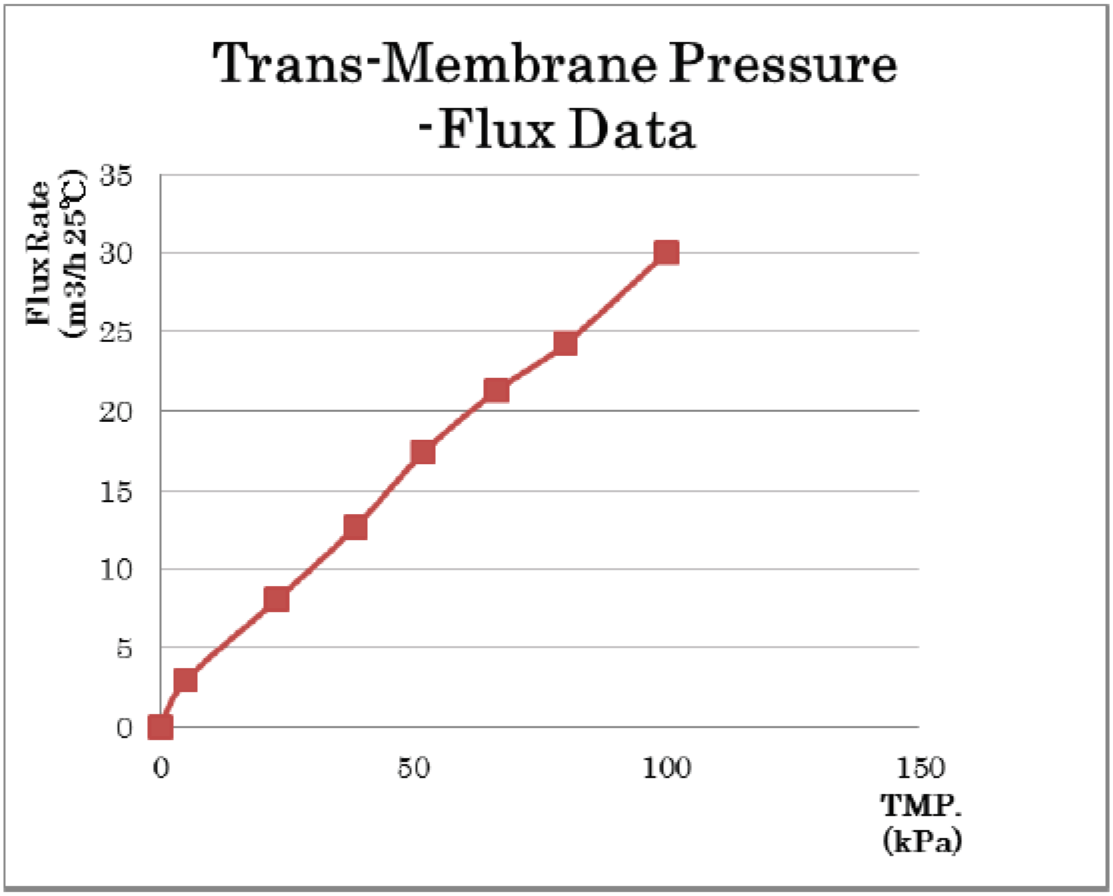




10.2 CUT-OFF CURVE FOR AQUADYN™ FZ50-AC-FUC1582 MODULE



10.3 TRANSMEMBRANE PRESSURE VS. PERMEATE RATE

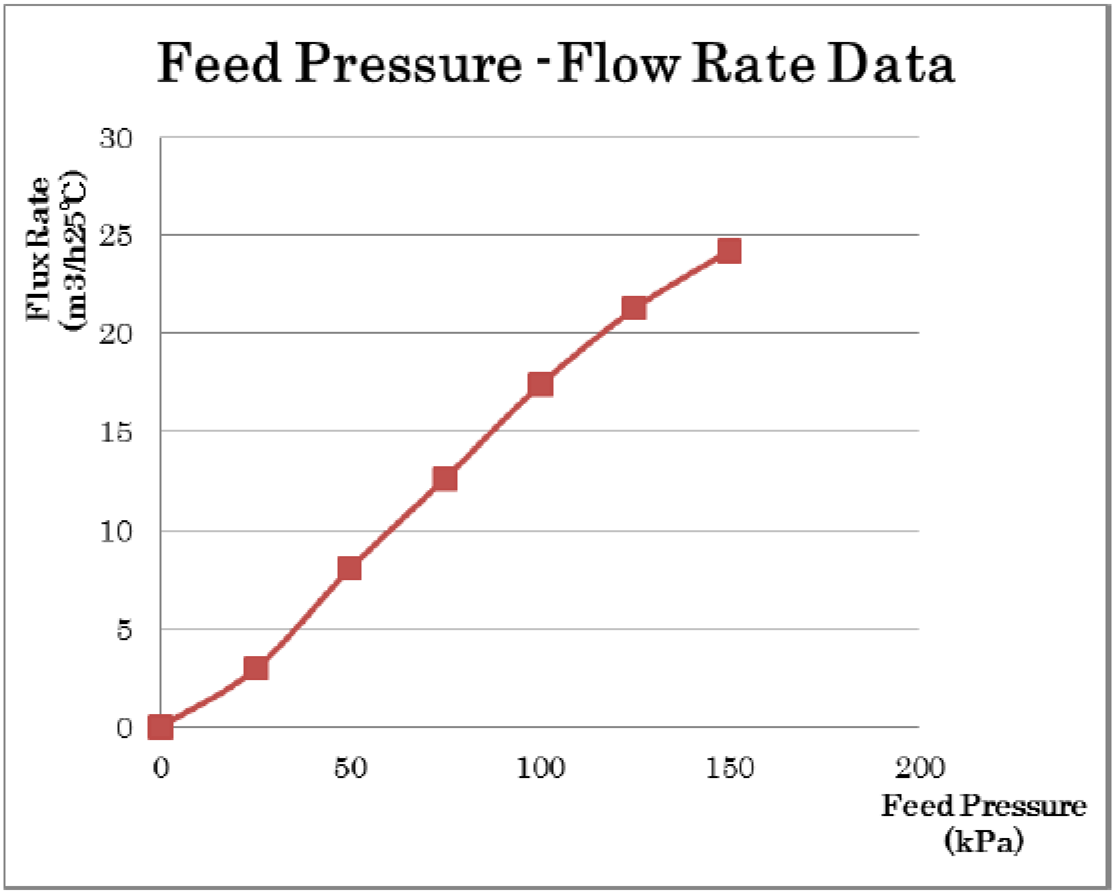


Transmembrane Pressure = (Feed Pressure + Concentrate Pressure)/2 - Permeate Pressure

Module: AQUADYN™ FZ50-AC-FUC1582
Feed: Pure Water
Conditions: Dead End Filtration (100% Recovery)

Lower feed port was opened and upper one (concentrate port) was closed.

10.4 FEED PRESSURE VS. PERMEATION RATE

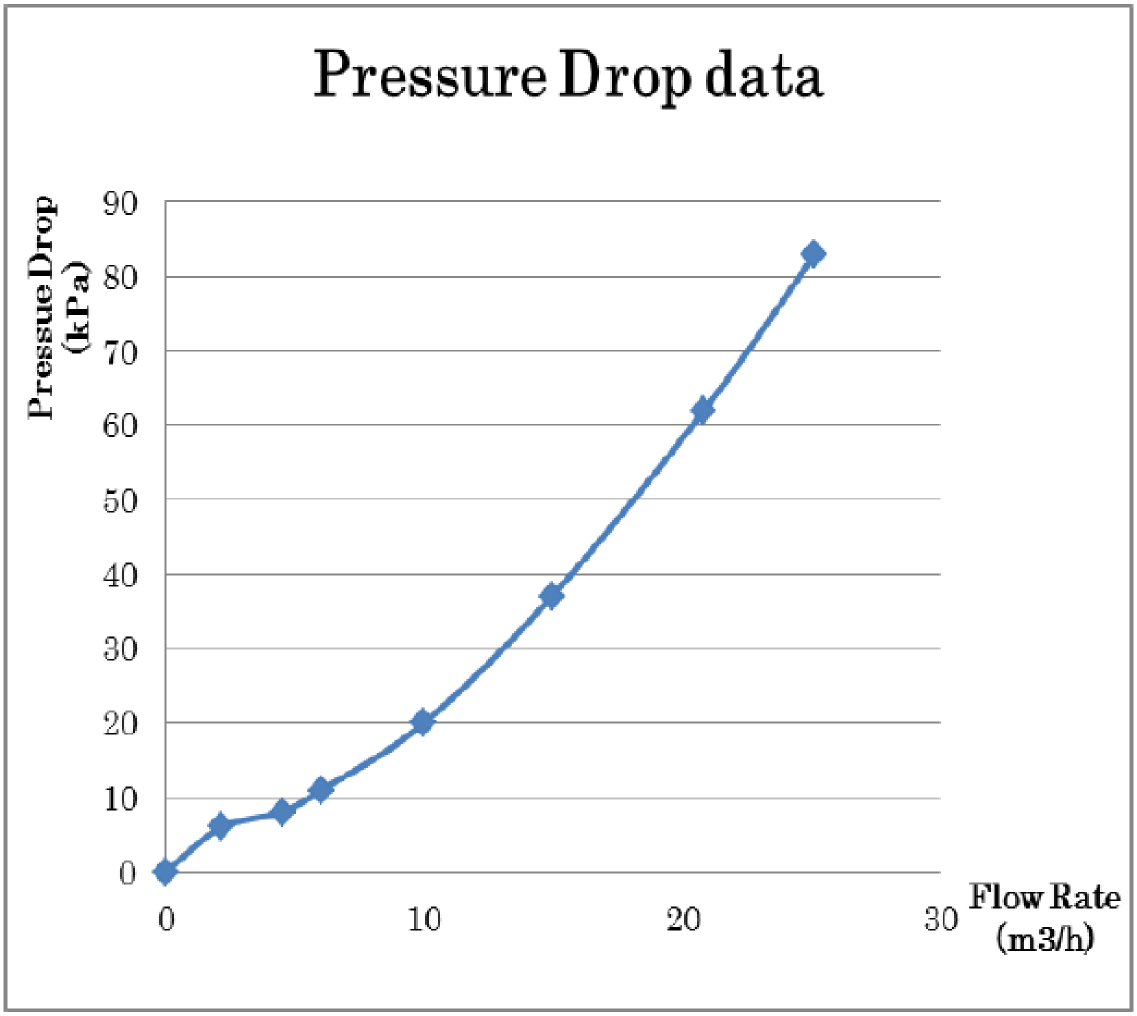


Feed Pressure: Inlet Pressure at Lower Feed Port

Module: AQUADYN® FZ50-AC-FUC1582
Feed: Pure Water
Conditions: Dead End Filtration (100% Recovery)

Lower feed port was opened and upper one (concentrate port) was closed.

10.5 FEED FLOW VS. MODULE PRESSURE DROP



Module Pressure Drop = Feed Pressure at Lower Feed Port - Feed Pressure at Upper Feed Port

Module:	AQUADYN® FZ50-AC-FUC1582
Feed Water:	Pure Water
Water Temperature:	21.3°C
Conditions:	No Filtration

1. Permeate ports were closed.
2. Water fed to lower feed port and flowed out of upper one (concentrate).