MICRODYN PureULTRA Hollow Fiber UF Modules

Technical Manual

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Table of Content

1 Introduction

Water resources continue to be one of the top environmental concerns around the world, leading to increased water recycling efforts in water and wastewater treatment facilities globally and reducing the consumption of fresh water. Ultrafiltration (UF) has shown demonstrated success in water reuse applications, as well as in removing harmful pathogens and suspended solids from drinking water.

UF is a process using a physical barrier to separate water and suspended solids, turbidity, silt, bacteria, and viruses from the feed water. In a system using pressurized MICRODYN PureULTRA hollow fiber modules, the feed water may come from different sources such as surface water, groundwater, secondary or tertiary treated industrial wastewater, or other sources like tertiary treated municipal wastewater.

MICRODYN PureULTRA hollow fiber UF membrane modules feature an “outside-in” hollow fiber membrane that has a nominal pore size of 0.075 µm. This hollow fiber membrane is made using an innovative modified Thermally Induced Phase Separation (TIPS) method for membrane production.

PureULTRA hollow fibers produced using the modified TIPS method are superior to fibers made using the NIPS or classical TIPS method using the same materials. Features of the PureULTRA hollow fiber UF modules include:

- **Longevity:** MICRODYN PureULTRA hollow fiber UF modules are produced using an advanced membrane formation technique and a robust module structure providing superior filtration efficiency and durability.
- **Robust membrane:** PureULTRA membrane is made using the modified TIPS technology, which provides the membrane with highly crystalline structure. As a result, the membrane has high chemical resistance, shows mechanical strength, and lasts longer.
- **Permanently hydrophilic membrane:** The stabilized operating flux of most UF or microfiltration (MF) membrane products is much lower than initial / start-up flux, which is a result of loss in membrane hydrophilicity by polymer reconfiguration. PureULTRA PVDF UF membrane remains permanently hydrophilic, and thus, offers a steady flux.
- **Oxidation-inert membrane:** MICRODYN PureULTRA membrane modules can be cleaned thoroughly with strong oxidants because of the chemical inertness of the PVDF polymer.
- **Air lift recirculation:** An air diffuser is installed inside these PureULTRA membrane modules so that air may be evenly distributed around membrane capillaries. Water is “carried” upward by this air flow and “drained” downward through a central pipe, creating a water recirculation current. This air lift recirculation (ALR) current may greatly reduce membrane fouling.
- **Soft potting:** The “roots” of the capillaries (hollow fibers) are the weakest points in a membrane module and are prone to breakage during operation. The roots of the membranes in PureULTRA UF modules are protected by a dual layer of potting – a layer of hard potting followed by a layer of soft potting closer to the hollow fibers (Figure 1).

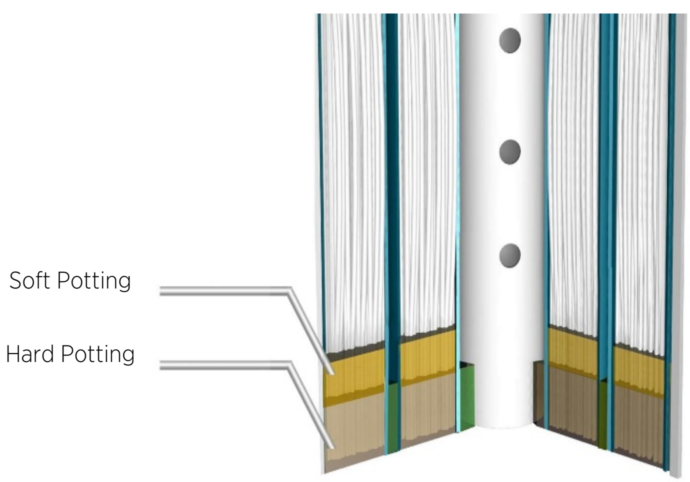


Figure 1. The “roots” of the hollow fibers are protected by a layer of soft potting material

- **Low operating pressure:** Typically, MICRODYN PureULTRA membrane is designed to run at pressures as low as 0.02 Mpa (3.0 psi) to produce desired filtrate.
- **Better filtrate distribution for steady flux:** The "sub-unit" bundle arrangement of the hollow fibers (Figure 2) in a PureULTRA UF module offers a better distribution of water flow in the module.

Figure 2. "Sub-unit" bundle arrangement of hollow fibers

2 Type & Specifications of MICRODYN PureULTRA UF modules

2.1 MEMBRANE SPECIFICATION

TABLE 1. MEMBRANE PARAMETERS

Module	Membrane Area	Inner Diameter	Outer Diameter	Length	Pore Size	Material
PHF-35-V	35 m^2 (376.6 ft^2)	0.7 mm (0.028 inches)	1.3 mm (0.051 inches)	0.75 mm (29.6 inches)	0.075 µm	PVDF
PHF-75-V	75 m^2 (807 ft^2)	0.7 mm (0.028 inches)	1.3 mm (0.051 inches)	1.5 mm (59.1 inches)	0.075 µm	PVDF
PHF-105-V	105 m^2 (1130.2 ft^2)	0.7 mm (0.028 inches)	1.3 mm (0.051 inches)	2.0 mm (78.7 inches)	0.075 µm	PVDF

TABLE 2. PERFORMANCE OF MICRODYN PUREULTRA MODULES

Performance	Index / Value
SDI_{15}	< 3
Filtrate Turbidity [1]	< 0.1 NTU
Removal of more than 0.2 µm diameter particles	99.99%
Removal of total coliform	Below Detectable Limit (BDL) [2]
Removal of fecal coliform	BDL [2]
Removal of bacteria	BDL [3]

[1] Measured online
[2] Detected with 100 mL UF filtrate
[3] Detected with 1 mL UF filtrate

2.2 MODULE SPECIFICATION

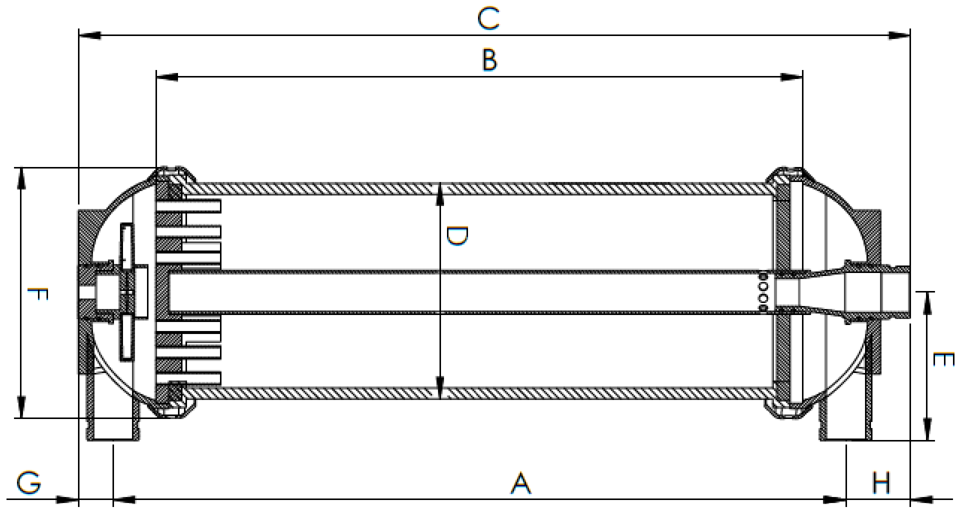


Figure 3. Diagram of MICRODYN PureULTRA module with dimensions

TABLE 3. DIMENSIONS OF MICRODYN PUREULTRA MODULES

Module	A	B	C	D	E	F	G	H
PHF-35-V	850 mm (33.5“)	750 mm (29.6“)	965 mm (38.0“)	250 mm (9.8“)	172 mm (6.8“)	277 mm (10.9“)	40 mm (1.6“)	75 mm (3.0“)
PHF-75-V	1600 mm (63.0“)	1500 mm (59.1“)	1715 mm (67.5“)	250 mm (9.8“)	172 mm (6.8“)	277 mm (10.9“)	40 mm (1.6“)	75 mm (3.0“)
PHF-105-V	2100 mm (82.7“)	2000 mm (78.7“)	2215 mm (87.2“)	250 mm (9.8“)	172 mm (6.8“)	277 mm (10.9“)	40 mm (1.6“)	75 mm (3.0“)

TABLE 4. MODULE HOUSING MATERIAL & CONNECTIONS

Module	PHF-35-V	PHF-75-V	PHF-105-V
Housing Material	PVC / ABS		
Potting Material	Epoxy		
Feed, Product, & Concentrate Connections	Victaulic 2“		
Air Inlet	3/8 inch threaded		

2.3 APPLICATION AND OPERATING PARAMETERS

TABLE 5. TYPICAL OPERATING PARAMETERS

Module	PHF-35-V	PHF-75-V	PHF-105-V
Operating Temperature	1 – 40 °C (41 – 113 °F)		
Operating pH	1 – 12		
Operation Mode	Dead-end or Cross-flow		
Filtration Flowpath	Outside to inside		
Filtrate Flux	30 – 120 lmh (29 – 71 gfd)		
Backwash Flux	70 – 150 lmh (41 – 88 gfd)		
Maximum Applied Feed Pressure	5.0 bar (73 psi)		
Maximum TMP [1]	2.0 bar (30 psi)		
Air Scour Flowrate	5 – 12 Nm^3/h		
Air Scour Pressure	≤ 1.0 bar (≤ 14.5 psi), oil-free compressed air		
Backwash Frequency	15 – 60 minutes		
Backwash Duration	30 – 120 seconds		
CEB [2] Frequency	Minimum once per day		
CEB Duration	2 – 20 minutes		
CEB Chemicals	NaClO (≤ 1000 ppm) NaOH (pH ≤ 12) HCl (pH ≥ 1)		
CIP [3] Frequency	30 – 180 days		
CIP Duration	60 – 180 minutes		
CIP Chemicals	NaClO or H_2O_2 NaOH HCl Citric acid or oxalic acid		
CIP Flow	2.5 – 3.5 m^3/h (11.0 – 15.4 gpm)		

[1] TMP = Transmembrane pressure

[2] CEB = Chemical enhanced backwash

[3] CIP = Clean-in-place

3 MICRODYN PureULTRA UF Process & System Design

This section provides recommended guidelines when designing the UF system. When designing a UF system, it is important to keep the feed source water quality in mind.

3.1 PROCESS DESIGN GUIDELINES

TABLE 6. MICRODYN PUREULTRA PROCESS DESIGN GUIDELINES

Parameter	Ground Water	City Water		Surface Water		Treated Industrial Wastewater	Treated Municipal Wastewater	Seawater	
Turbidity (NTU)	< 5	< 5		< 25	< 5	< 5	< 20	< 50	< 5
Pretreatment	Optional	No	Yes	Yes	No	Yes	Yes	Yes	No
Filtrate Flux	70 – 90 lmh (41 – 53 gfd)	60 – 80 lmh (35 – 47 gfd)	65-80 lmh (38 – 47 gfd)	50 – 70 lmh (29 – 41 gfd)	60 – 80 lmh (35 – 47 gfd)	40 – 65 lmh (24 – 38 gfd)	45 – 65 lmh (26 – 38 gfd)	50 – 65 lmh (29 – 38 gfd)	60 – 80 lmh (35 – 47 gfd)
Particle Size	< 150 µm								
Backwash Frequency (minutes)	30 – 60	30 – 45	30 – 60	20 – 40	25 – 50	20 – 50	20 – 50	20 – 45	30 – 50
Operation Mode	Dead-end / cross-flow								
CEB Frequency (days)	1 – 4	2 – 6	1 – 4	2 – 8	2 – 6	2 - 10	2 - 10	2 – 8	2 – 6
CIP Duration (minutes)	60 - 90	30 – 60	45 – 90	20 – 60	45 – 90	20 – 90	20 – 90	20 – 60	30 - 90

3.2 SYSTEM DESIGN GUIDELINES

3.2.1 UF System Components

The MICRODYN PureULTRA UF system (including the pretreatment, chemical dosing system, backwashing / cleaning) is designed based on the feed water source.

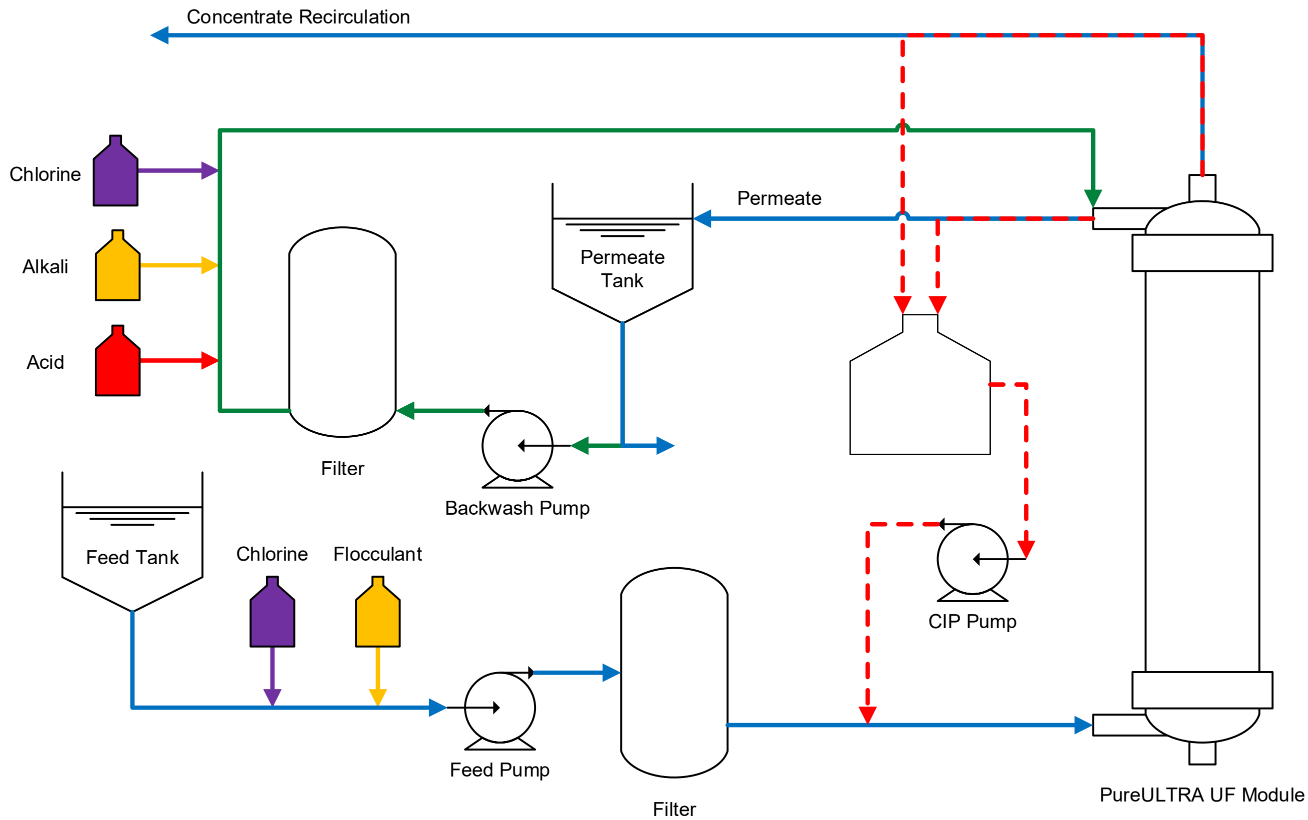


Figure 4. Process Flow Diagram

1. **Prefilter:** The prefilter stage is key to safeguarding the UF modules from large and more abrasive particles or debris. To prevent the UF hollow fibers from getting damaged, a 100 – 300 µm screen / automatic strainer / self-cleaning filter is recommended.

2. **Dosing system (in operation mode):** If required, disinfectant and/or flocculant may be dosed into the feed water flow before it flows into the UF module. Flocculants are chemicals that promote flocculation by causing colloids and other suspended particles in liquids to aggregate, forming a floc. These flocs can be then easily removed with UF.

   The dosage of disinfectant and flocculant required are determined by the raw water quality, including turbidity and pH. The disinfectant can prevent the membrane from being fouled by microbes and organic substances. At the same time, the disinfectant residue can help inhibit contamination in the pipes and tanks.

3. **Backwash system:** The backwash system is an essential part of the UF system. Backwashing can remove the foulants from the surface of the membrane and thereby help recover the performance of the membrane. The backwash system consists of a filtrate tank, a backwash pump, an air feed system, and a dosing system. The backwash system is controlled automatically.

   The backwash process is divided into water backwash, air scour, and chemical enhanced backwash. During the chemical enhanced backwash (CEB), a disinfectant (of low concentration), acid, or alkaline chemical may be used. The optimized process is based on the water quality. Typically, CEB is the critical step in restoring the performance of membrane.

Efficient and timely CEBs can prolong the duration between Clean-In-Place (CIP).

4. **CIP system:** The CIP system consists of a cleaning tank, a cleaning pump, filter, and a heater. When the membrane is heavily fouled or the TMP is too high and the performance of the membrane cannot be recovered after performing a CEB, a CIP is recommended.

3.2.2 Operating Process

The operating process consists of filtration, flush, and CIP. This section outlines the filtration mode and flush process. CIP will be discussed in detail in subsequent section(s).

1. **Filtration mode:** Filtration flowpath in MICRODYN PureULTRA modules is outside to inside i.e. the feed water is exposed on the outside of the hollow fiber and the filtrate is collected from inside (lumen) of the hollow fiber. PureULTRA modules can be operated in dead-end and cross-flow (Figure 5) modes.

   Dead-end operation means that feed water filters through the membrane and most of the suspended solids and colloids remain on the feed side of the membrane (outside the hollow fiber). At a preset time, the backwash begins automatically, flushing away the foulants on the feed water side of the membrane. If the suspended solids, turbidity, and COD values are low, dead-end operation may be used.

   Cross-flow operation means most of the water filters through the membrane, while some water along with the particles rejected by the membrane (known as concentrate) is drained out of the module. Cross-flow can enhance the flow velocity and reduce contamination on the membrane surface, but it does require more energy than dead-end operation. The concentrate flow depends on the feed water quality; however, it is recommended that the concentrate flow accounts for 5-15% of the total feed flow. All or part of the concentrate flow can be sent back to the UF feed tank or pumped back to the UF modules.

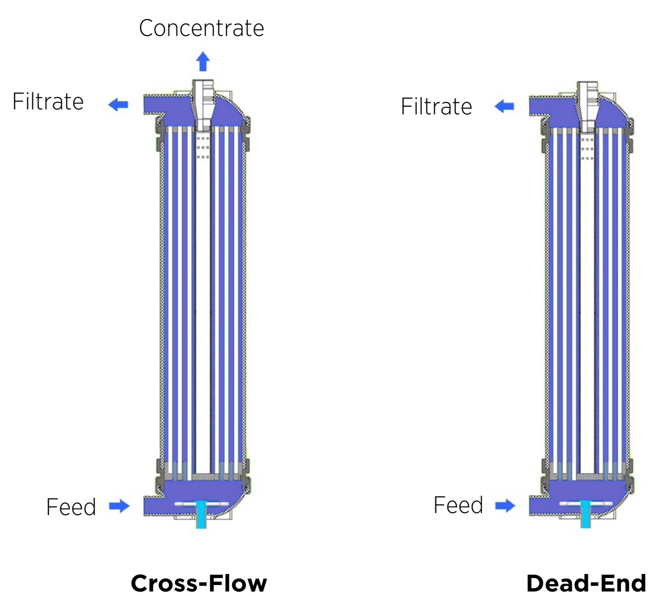


Figure 5. Diagrams of cross-flow and dead-end operation modes

2. **Flush process:** Suspended solids, colloids, and bacteria are rejected by the membrane. Impurities will foul the membrane surface after a period of operation time. To maintain the performance of the UF modules, a backwash occurs every 20 – 60 minutes.

   The flush process consists of a forward flush, backwash, and air scour.

The backwash can be performed as top backwash, bottom backwash, or a combination of both top and bottom backwash. A combination of these flush modes may be used based on the quality of the feed water and cleaning sequence (Table 7).

TABLE 7. BACKWASH, AIR SCOUR, & CEB MODES

Backwash Mode	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Backwash	Flush	Top Backwash	Bottom Backwash			
Backwash & Air Scour	Air Scour	Drain	Top Backwash	Bottom Backwash		
CEB	Air Scour	Drain	Dosing Chemicals	Soak	Top Backwash	Bottom Backwash

Each specific cleaning procedure is described as follows:

Forward flush: UF feed water or filtrate water can be used to flush the membrane modules. The forward flush can remove most of the foulants to reduce backwash resistance and water consumption. The filtrate port is closed in this step to ensure that forward flush is drained through the concentrate port and to keep the water from filtering through the membrane (Figure 6). The duration of forward flush is 10 – 15 seconds.

Top backwash: It is recommended to use filtrate water for backwashing (both top & bottom backwash). While the feed port is closed in this step, the water is pumped through the filtrate port and drained out through the concentrate port (Figure 6). Backwashing can remove the foulants present on the surface and in the pores of the membrane. Performing a top backwash helps increase the cleaning efficiency of hollow fibers towards the top-end of the module. The recommended duration of a top backwash is 15 – 30 seconds.

Bottom backwash: The purpose of a bottom backwash is the same as the top backwash. In a bottom backwash, the backwash water is drained through the feed port of the module (Figure 6). A bottom backwash helps increase the cleaning efficiency of hollow fibers towards the bottom-end of the module. The recommended duration of a bottom backwash is 15 – 30 seconds.

Air scour: The air produced by an oil-free air compressor flows into the membrane through the air port located at the bottom-end of module and then shakes the fibers to create a scrubbing effect, removing the foulants attached to the outside of membrane surface (Figure 6). This step occurs alone or in combination with backwash. The suggested duration of air scour is 30 – 60 seconds.

Top and bottom backwash: A top and bottom backwash is most commonly combined with CEB. To distribute the chemicals evenly and quickly, the water is pumped into the filtrate side and drained out through the concentrate side and feed side. The suggested duration of this step is 20 – 50 seconds.

Soak: To enhance the effect of CEB, the membrane must be soaked in a chemical solution. The recommended duration of such a soak is 60 – 120 seconds.

A backwash that uses a low concentration chemical solution is called a chemical enhanced backwash (CEB). If most of the foulant is organic, sodium hypochlorite or an alkaline solution are recommended. Moreover, if the foulants are metallic ions, an acid should be used. The operator may choose the duration of backwash, top backwash, bottom backwash, and the frequency of CEB according to the feed water quality.

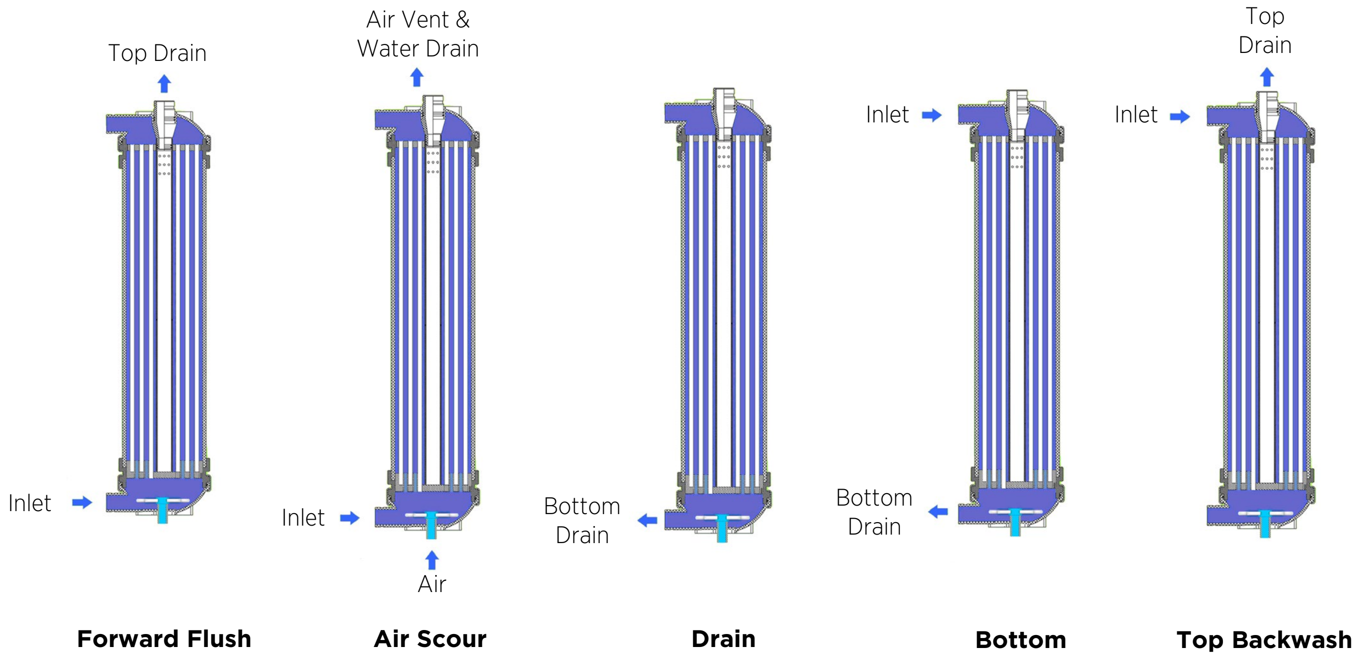


Figure 6. Diagrams of forward flush, air scour, drain, and backwash processes

3.2.3 Key Design Points

Reasonable and efficient pretreatment is critical for longevity of the UF system. Most municipal wastewater sources must be treated before feeding to a UF system. Flocculation, coagulation, and filtration (of flocs, larger particles) are all necessary steps. All UF systems should be installed with a prefilter with a pore size of ~150 µm to prevent damage to the hollow fibers.

The design should be completed by professionally trained and experienced engineers. A small design mistake may lead to overall system failure, so the following steps are recommended when designing a system:

1. **Collect feed water information:** Feed water information is very important for system design. The type of water source, turbidity levels, suspended solids, COD, and BOD concentrations all must be considered. Variations in the feed water quality must also be considered when designing a system. Other data, such as colloidal matter content, the types of organic pollutants, and the contents of bacteria, may be hard to determine but are still important.

2. **Selection of operation modes & flux:** The operation mode can be determined by referring to the design guidelines mentioned in section 3.1. The flux is mainly determined by the feed water source and quality. For MICRODYN PureULTRA UF modules, the recommended flux range is 40 – 90 lmh (24 – 53 gfd) in ordinary conditions, when the membrane modules are selected according to the feed water qualities as described in Table 6. Flux higher than 90 lmh (53 gfd) is not typically recommended.

   The flux, duration of filtration, backwash, etc. should be determined based on the quality of the feed water. Piloting is always encouraged for unique feed water types.

3. **Number of modules:** To determine the number of modules a system requires, other factors that must be considered include the idle time when the membrane is undergoing a backwash and the amount of water needed for backwashing. For example, if a flux of 60 lmh (35 gfd) has been selected for MICRODYN PureULTRA PHF-75-V modules for a 100 m^3/h (440 gpm) system, the following should be noted:

   a. **Confirmation of parameters:** The backwash program is designed to run every 45 min as: air scour for 30 seconds, bottom draining for 15 seconds, top backwash for 15 seconds, and bottom backwash for 20 seconds.

The total backwash time is 80 seconds long.

The CEB program is designed to occur every 10th backwash as: air scour for 20 seconds, bottom draining for 15 seconds, backwash and dosing chemicals for 25 seconds, soak for 60 seconds, top backwash for 20 seconds, and bottom backwash for 25 seconds. The total CEB run time is 165 seconds.

b. Calculation of service efficiency: The service / time efficiency is calculated as:

Time efficiency = [filtration time] / [filtration time + backwash time + CEB time]

So in the example above, the time efficiency would be:

(45 x 10)/[(45 x 10) + (80 / 60 x 9) + (165 / 60)] = 96.83%

10 filtration cycles of 45 mins each
9 backwash cycles of 80/60 mins each
1 CEB sequence of 165/60 mins each

c. Calculation of production efficiency (assuming the backwash flow is 1.5 times that of filtration): The filtrate / water production efficiency is calculated as:

Production efficiency = [total production – backwash water consumption – CEB water consumption] / [total production]

So, again referring to the above example, the water production efficiency would be:

[10 x 45 x 4.5] – [9 x ((15 + 20) / 60) x 1.5 x 4.5] – [((25 + 20 + 25) / 60) x 1.5 x 4.5] / [10 x 45 x 4.5] = 97.86%

4.5 = 4.5 m^3/hr filtrate flow per module
9 X ((15+20)/60) = 9 backwash cycles including 15 + 20 secs of water use
((25+20+25)/60) = CEB cycle that includes 25+20+25 secs of water use

d. Calculating the number of modules: The number of modules can be calculated as follows:

Number of modules = (required production) / (production efficiency x service efficiency x filtrate flow of each module)

The number of modules required for the above example is:

100 / (97.86% x 96.83% x 4.5) ≈ 24

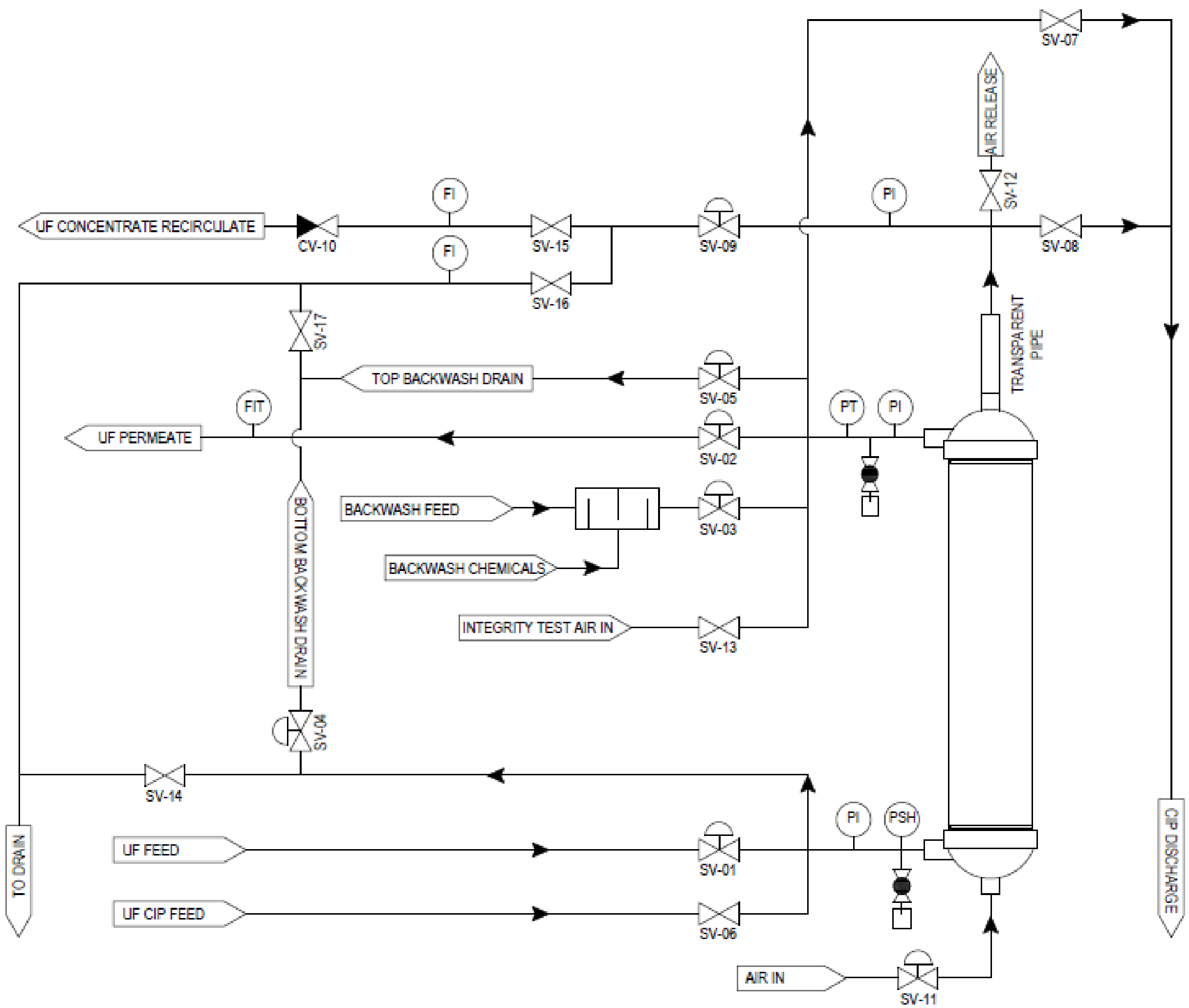
e. Backwash system design: Backwash occurs separately for each system according to the time setting. If it is a small-scale system, the backwash pump is chosen by the flow of the UF unit backwash, and the backwash pump can be used for both backwash and CEB.

If it is a large-scale system, two pumps may be needed for backwash. One of the pumps can be shut down during CEB (if the CEB is designed at ½ of backwash flow). Water hammer must be avoided during the transition between different operation modes.

f. CEB Chemicals: During CEB, chemicals are added to the backwash water to enhance the efficacy of backwash. The following chemicals are often used:

i. Injection of HCl to target a pH of 2 for the backwash water. HCl is often used when the hardness of the feed water is high or when there is coagulant-related fouling of the membrane.
ii. Injection of NaOH to target a pH of 12 for the backwash water. NaOH addition is often effective when the feed water has organic foulants.
iii. Injection of NaClO to target a free chlorine concentration of 500 ppm in the backwash water. NaClO is often used when the feed water is fouled by organics and bacteria.

3.3 TYPICAL P&ID FOR MICRODYN PUREULTRA UF SYSTEM



TAG	DESCRIPTION	OPERATION
SV-01	FEED VALVE	AUTO
SV-02	PERMEATE VALVE	AUTO
SV-03	BACKWASH FEED VALVE	AUTO
SV-04	BOTTOM BACKWASH DRAIN VALVE	AUTO
SV-05	TOP-BACKWASH DRAIN VALVE	AUTO
SV-06	CIP FEED VALVE	MANUAL
SV-07	CIP PERMEATE VALVE	MANUAL
SV-08	CIP CONCENTRATE VALVE	MANUAL
SV-09	CONCENTRATE RECIRCULATE VALVE	AUTO
CV-10	CONCENTRATE RECIRCULATE CHECK VALVE	NRV
SV-11	AIR FEED VALVE	AUTO
SV-12	AIR RELEASE	MANUAL
SV-13	AIR FEED (INTEGRITY TEST)	MANUAL
SV-14	BOTTOM DRAIN VALVE	MANUAL
SV-15	CONCENTRATE REGULATION VALVE (RECIRC)	MANUAL
SV-16	CONCENTRATE REGULATION VALVE (DRAIN)	MANUAL
SV-17	BACKWASH REGULATION VALVE	MANUAL

LEGEND	DESCRIPTION
	MANUAL VALVE
	ACTUATED VALVE
	SAMPLING VALVE
	NRV/ CHECK VALVE
	STATIC MIXER
FIT	FLOW TRANSMITTER
PI	PRESSURE GAUGE
PT	PRESSURE TRANSMITTER
PSH	HIGH PRESSURE SWITCH
FI	FLOW INDICATOR

Figure 7. Typical P&ID of UF system using PureULTRA hollow fiber UF modules

TABLE 8. VALVE ACTIVITIES OF A TYPICAL UF SYSTEM

		Series													
Process		**SV-01**	**SV-02**	**SV-03**	**SV-04**	**SV-05**	**SV-06**	**SV-07**	**SV-08**	**SV-09**	**SV-10**	**SV-11**	**SV-12**	**SV-13**	**SV-14**
Stand-by		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operation	Flush	1	0	0	0	1	0	0	0	0	0	0	0	0	0
	Operation (dead-end / cross-flow)	1	1	0	0	0	0	0	0	0/1 *	0/1 *	0	0	0	0
Backwash	Air scour	0	0	0	0	1	0	0	0	0	0	1	0	0	1
	Draining	0	0	0	0	1	0	0	0	0	0	0	0	0	1
	Top backwash	0	0	1	0	1	0	0	0	0	0	0	0	0	0
	Bottom backwash	0	0	1	1	0	0	0	0	0	0	0	0	0	0
CEB	Dosing chemcials	0	0	1	1	1	0	0	0	0	0	0	0	0	0
	Soaking	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Top backwash	0	0	1	1	0	0	0	0	0	0	0	0	0	0
	Bottom backwash	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Integrity test		0	0	0	0	0	0	0	0	0	0	0	0	1	0
CIP		0	0	0	0	0	1	1	1	0	0	0	0	0	0

1 = Open valve
0 = Closed valve
* = Closed for dead-end; Open for cross-flow

4 MICRODYN PureULTRA Module Installation, Operation & Maintenance

4.1 MODULE INSTALLATION

The following procedure is recommended prior to installing PureULTRA UF modules:

1. Before installation, flush the feed piping thoroughly with water to make sure it is free of particles, sand, and debris.
2. Remove the modules from their packaging.
3. To prevent the module from drying out, install the modules as quickly as possible after removing them from their packaging.
4. Keep the concentrate and filtrate valves fully open while keeping the feed valve half open to allow air to release before starting up the modules.
5. Flush the module until the preservative solution is completely drained from the module.

4.2 SYSTEM ADJUSTMENT

The system may be adjusted after the modules have been installed. First, it is important to check that the auto-valves, switches, and alarm system are all working properly. Additionally, it is advised to keep detailed operating and cleaning data including the feed water quality, filtrate quality, operating parameters, etc. for future reference.

After final adjustments have been made, it is time to start up the UF system. During start-up, it is important to keep the following points in mind:

1. Check the meters, pumps, and filtrate quality regularly. If anything appears abnormal, stop the system immediately and resolve the issue.
2. Monitor the equipment and record operating parameters. The feed water quality (e.g. temperature, turbidity, TSS, COD, BOD, etc.), operating conditions (e.g. pressures and flows of the feed, filtrate, concentrate, flush and backwash, CEB chemicals, pH, duration of CEB, etc.), and filtrate quality (e.g. turbidity, TSS, SDI, etc.). are all important parameters to monitor and record.
3. Clean and sterilize the UF system regularly.
4. Check the vent auto-valve regularly to make sure air is exhausted.

4.3 CLEAN-IN-PLACE CHEMICAL CLEANING

Periodically backwashing the membrane module may remove most of the foulants, but sooner or later, the membrane may need a more aggressive chemical cleaning in the form of Clean-In-Place (CIP). When the transmembrane pressure (TMP) exceeds 1.5 bar (21.8 psi) at the designed flow rate and cannot be reduced by CEB, a CIP is necessary. A CIP system should be installed with the UF system to facilitate such an extended chemical cleaning process.

The cleaning formulation may be selected according to the foulants and operation experience. The following may be considered:

1. A HCl solution at pH ≥ 1
2. A caustic solution of 0.04% NaOH with 200 ppm NaClO at pH ≤ 12
3. Choose a surfactant based on the feed water quality.

Note:
1. Always check the pH using a pH meter rather than test paper.
2. Avoid having the HCl and NaClO in contact with one another during cleaning.
3. HCl, NaOH, and NaClO are corrosive, so please exercise proper handling techniques.

4.3.1 Cleaning Procedure

The following cleaning procedure is recommended:

1. Record the operating parameters before performing a CIP.
2. Open the CIP feed valve and the CIP concentrate recycle valve. Circulate the chemical solution for 30 minutes by turning on the circulation pump.
3. Check the pH of the solution. If there is a significant change in the pH, add the appropriate chemical to obtain the proper chemical concentration. Circulate the solution for another 30 minutes.
4. Repeat step 2 until there is no significant change in the pH. Change the cleaning solution if it gets too dirty or too many chemicals are added.

5. Stop the circulation pump and let the membrane module(s) soak in the solution for 30 minutes.
6. Close the CIP concentrate recycle valve and open the CIP filtrate recycle valve. Circulate the chemical solution for 30 minutes by turning the circulation pump on.
7. Repeat steps 2-4.
8. Drain the solution tank and run the system while sending the filtrate to drain until the filtrate pH is neutral.
9. Record the operating parameters after chemical cleaning. Compare the recorded operating parameters before and after CIP. If the system has not resumed to its normal operating conditions (i.e. if the TMP is not restored), consider using another cleaning formulation or reach out to your MICRODYN-NADIR representative for alternative solutions. Ensure the CIP feed pressure is lower than 0.8 bar (11.6 psi).

Note: When sending streams to drain, be sure that the solution has been treated according to appropriate discharge requirements.

4.4 INTEGRITY TEST

During operation, the hollow fibers may get damaged due to heavy fouling, pressure variation, or water hammer. This may result in impairment of the integrity of membrane module. When fiber breakage occurs, impurities will start to pass through the membrane and into the filtrate. To ensure the system is in proper condition, it is recommended to perform periodic integrity tests to identify possible fiber breakage.

The integrity test requires oil-free pressurized air (> 1.0 bar or > 14.5 psi), an air adjusting valve, and a transparent pipe (> 10 cm or > 4 inches) installed on the concentrate outlet on top of the module.

Auto integrity test systems can test the modules in a system periodically. An integrity test includes the following steps:

1. Stop the system. Close all valves.
2. Introduction of air: Slowly open the air adjust valve (V_5) to let the air flow into the module from the filtrate water pipe. Close the air valve (V_5) when the pressure increases to 1.0 bar (or 14.5 psi).
3. Pressure holds or decays: The pressure change will be recorded and analyzed by the monitoring system (PLC). The pressure decay should be less than 5% in 2 minutes if there are not any leaks present. This suggests the membrane is in good condition.
4. Check for bubbles in the concentrate pipe. Mark the module if there are continuous bubbles and repair the module offline.

Integrity tests should be performed every day for drinking water systems.

4.5 MODULE REPAIR

Membrane repair requires special training and tools. Contact a contractor to get proper membrane repair training, tools, and plugs.

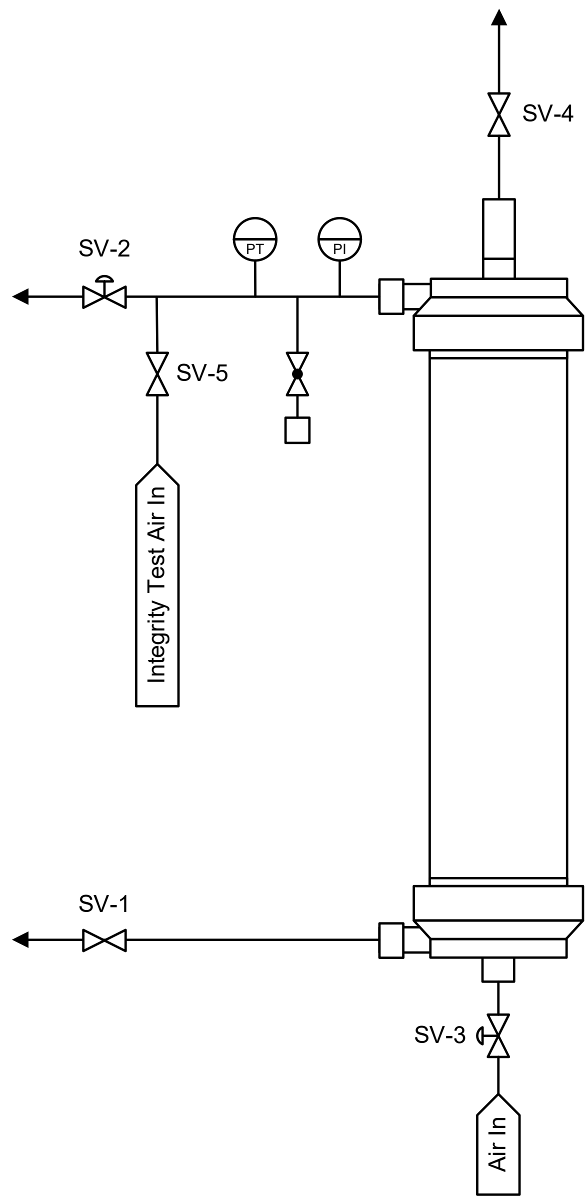


Figure 8. Integrity test flow diagram.

5 MICRODYN PureULTRA Module Storage & Shipping

To control bacterial growth and prevent damage caused by the fibers drying out, the modules must be stored in a preservative solution.

5.1 MODULE STORAGE

5.1.1 New Module

1. Prior to shipment, the modules are tested for permeability and integrity. They are then stored in a preservative solution consisting of sodium bisulfite, glycerin, and water.
2. The modules must be kept wet. New modules should be kept in its original packaging until installation.
3. The modules should be stored in a horizontal position and should be kept indoors, out of direct sunlight, at 5 – 40°C (41 - 104°F).
4. The modules should be kept at the appropriate temperatures to prevent freezing of the fibers.

5.1.2 Used Module

The storage guidelines for new modules are also suitable for used modules; however, additional steps are recommended:

1. Rinse the module out prior to storage. After the module has been completely rinsed, add the preservative solution to the module.
2. Update the preservative regularly.
3. Always keep the module wet.
4. Rinse out the preservative before using the modules again.

5.2 MODULE PRESERVATION

If the system is shut down for less than seven days, the modules can be preserved by flushing the system for 10 – 30 minutes every day.

When the system is shut down for longer periods of time, perform a CIP and sterilization, and then seal all of the outlets to keep the modules wet and to prevent bacteria and algae growth. The preservative solution is a ratio of water and sodium bisulfite (99:1). Check the pH of the preservative every three months and replace the solution if the pH is less than 4.

The modules will irreversibly lose flux if the modules dry out; the modules must be kept wet.

5.3 MODULE SHIPPING

Each module is packed in a special cardboard box and shipped on a wooden / plastic pallet. Avoid collision, direct exposure to sun, rain, and mechanical damage. Avoid freezing conditions.

6 Appendices

6.1 APPENDIX 1. MICRODYN PUREULTRA UF MEMBRANE MODULE PACKAGING WEIGHT & SIZE

TABLE 9. MODULE PACKAGING WEIGHT & SIZE

Module	Dry Weight, kg (lb.)	Packaging Size (Length x Width x Height) (mm / inches)
PHF-35-V	23 (51)	1070 x 330 x 340 (42.1 x 13.0 x 13.4)
PHF-75-V	35 (77)	1820 x 330 x 340 (71.7 x 13.0 x 13.4)
PHF-105-V	50 (110)	2320 x 330 x 340 (91.3 x 13.0 x 13.4)

Note: "Dry weight" of the membrane module means that this is the weight of the module without preservative. The wet weight would refer to the weight of the module filled with water.

6.2 APPENDIX 2. TEMPERATURE CALIBRATION CURVE

When the operating temperature is 25°C (77°F), the correction factor is 1. When the actual temperature varies from 25°C, the corresponding correction factor may be found in the chart below.

Actual flux = correction factor x design flux under 25°C

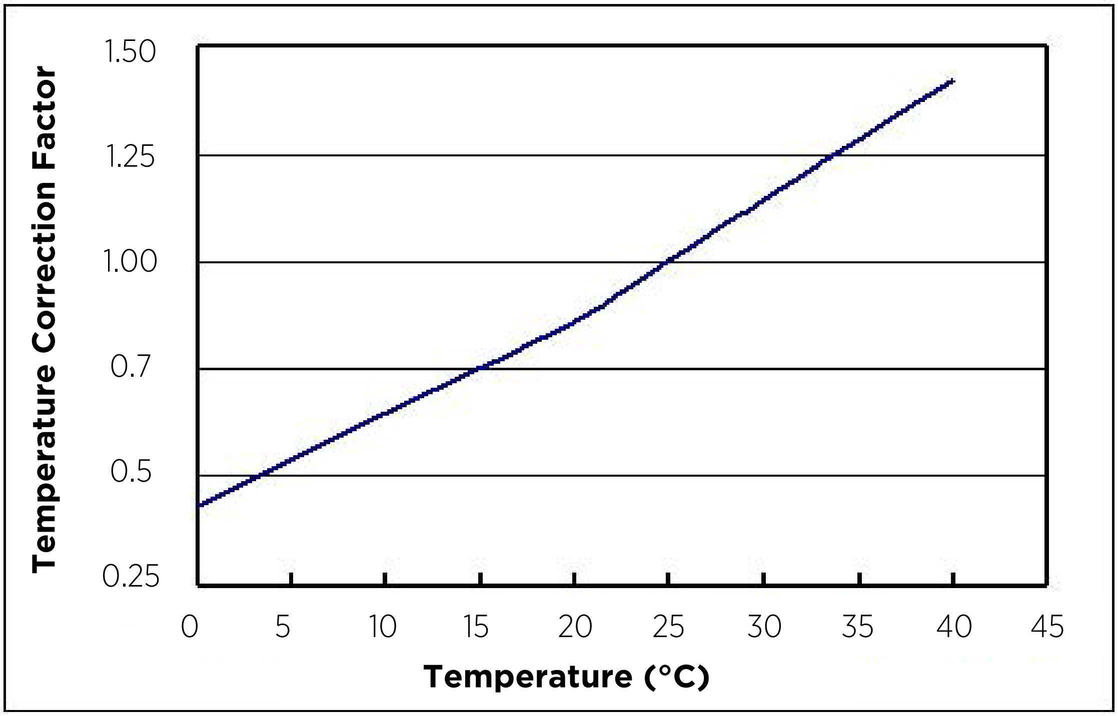


Figure 9. Temperature-flux correction factor curve

6.3 APPENDIX 3. UF SYSTEM OPERATING & CLEANING LOG SHEET

TABLE 10. UF SYSTEM OPERATING & CLEANING LOG SHEET

Date / Time										
Feed Temperature (°C)										
Feed pH										
Feed Turbidity (NTU)										
Feed COD (mg/L)										
Feed Flow (m^3/h)										
Feed Pressure (MPa)										
Filtrate Pressure (MPa)										
Concentrate Pressure (MPa)										
Filtrate Turbidity (NTU)										
Filtrate SDI										
Filtrate COD (mg/L)										
Filtrate ORP (ORP)										
Air Flow (Nm^3/h)										
Air Drained Duration (seconds)										
Backwash Flow (m^3/h)										
Backwash Pressure (MPa)										
Backwash Cycle (minutes)										
Backwash Duration (seconds)										
CEB Dosing (ppm)										
CEB Frequency (minutes)										
CEB Duration (seconds)										
CIP Frequency										
CIP Temperature (°C)										
CIP pH										
CIP Flow (m^3/h)										
CIP Pressure (MPa)										
CIP Chemical 1										
CIP Chemical 2										
Other										