# PureULTRA PHF-78-V

## Ultrafiltration Modules

### User Manual

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# 1. Introduction

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

UF is a process that uses a physical barrier to separate water from suspended solids, turbidity, silt, bacteria, and viruses in the feed water. In a system using pressurized PureULTRA PHF-78-V hollow-fiber modules, the feed water may come from different sources, including surface water, groundwater, secondary or tertiary treated industrial wastewater, or other sources such as tertiary treated municipal wastewater. PureULTRA PHF-78-V hollow-fiber UF membrane modules feature an "outside-in" hollow-fiber membrane with a nominal pore size of 0.025 µm. This hollow-fiber membrane is made using an innovative modified phase separation method, which results in higher membrane surface porosity, smaller nominal pore size, and robust mechanical properties.

PureULTRA PHF-78-V hollow fibers are produced using nonsolvent induced phase separation (NIPS). Key features of the PureULTRA PHF-78-V hollow-fiber UF modules are as follows:

- **Longevity:** PureULTRA PHF-78-V hollow-fiber UF modules are produced using an advanced membrane-formation technique and a robust module structure, delivering superior filtration efficiency and durability.
- **Robust membrane:** PureULTRA PHF-78-V membrane is made using advanced technology that creates a highly crystalline structure. As a result, the membrane has high chemical resistance, outstanding mechanical strength, and extended membrane life.
- **Permanently hydrophilic membrane:** In most UF or microfiltration (MF) membrane products, stabilized operating flux is much lower than initial start-up flux due to the loss of hydrophilicity from polymer reconfiguration. The PureULTRA PHF-78-V polyvinylidene difluoride (PVDF) UF membrane remains permanently hydrophilic, offering steady flux over time.
- **Oxidation-inert membrane:** Because the PVDF polymer is chemically inert, PureULTRA PHF-78-V membrane modules can be thoroughly cleaned with strong oxidants without compromising membrane integrity.
- **Highly efficient fluid distribution:** The uniquely designed distributor from MANN+HUMMEL Water & Membrane Solutions (WMS) ensures even distribution of feed water and air during filtration and air scouring. It diffuses water or air evenly in both vertical and horizontal directions along with the module tube, which reduces energy consumption during filtration and maximizes air scouring efficiency.
- **Potting protection:** Centrifugal potting (epoxy/polyurethane (PU)) creates dense glue layers with fewer internal defects, a smooth glue surface, and high pressure resistance. The soft PU layer protects the fiber roots—the most vulnerable point of the hollow fiber inside the module—and ensures an extremely low fiber-breakage rate throughout the lifetime of the PureULTRA PHF-78-V module.
- **Low operating pressure:** The PureULTRA PHF-78-V membrane is designed to operate at pressures as low as 0.02 MPa (3.0 psi) while still producing the desired filtrate quality.

# 2. Shipping, handling, and storage

Proper handling of the modules is necessary to maintain the chemical and mechanical integrity of the membrane modules.

## 2.1 Shipping

Every PureULTRA PHF-78-V module undergoes a stringent quality check before leaving the membrane manufacturing site. Each module is preserved for storage, and all open ports are sealed with caps or plugs.

Upon receipt and prior to installation, the modules must be inspected for any physical damage, and the product should be verified to ensure the correct model was delivered. MANN+HUMMEL WMS or its representative must be notified in writing immediately if any damage or leaks are found or if the product identification (e.g., model name, part number, serial number, etc.) does not match the shipping documents. If damage has occurred during third party transportation, damages must be reported and documented to the freight forwarding company, as well.

## 2.2 Handling

Only remove the membrane module from its original packing when ready for commissioning. The membrane module should be handled with care at all times to avoid damage. Personnel handling the membrane module should use appropriate personal protective equipment and follow proper lifting procedures. Do not use the connectors to lift the module. Please ensure that all safety guidelines are followed when handling the membrane modules.

Avoid contact with solvents or any substances that may be harmful to the membrane modules unless such use is approved and specified by MANN+HUMMEL WMS. The module must remain wet at all times as the fibers may dry out and become damaged. Always handle the module with care and protect it from impact or shock to prevent damage to both the membrane and module structure.

## 2.3 Storage

The shelf life of each membrane module is one year from the date of delivery when stored under the recommended storage conditions and without additional preservation measures.

Uninstalled membrane modules should be stored in their original packaging in a cool, dry, and well-ventilated area protected from direct sunlight, at an ambient temperature between 5 and 45°C (41–113°F).

The connection ports of the membrane modules are sealed with caps and plugs at the factory and should be checked for tightness and leaks. Keep these caps and plugs in place until it is time to install the modules.

Membrane modules installed onto a rack but offline (i.e., not in operation) may be stored in place if the storage conditions mentioned above are followed. Used membrane modules may also be removed from the rack and placed into storage. To prevent membrane damage, please be sure to follow the shutdown procedure (see Chapter 6.5). For storage periods exceeding one year, fresh preservative must be added (see Table 1).

### TABLE 1. STORAGE CONDITIONS

<table>
<tr><th>DURATION</th><th>RECOMMENDED PROCEDURES</th></tr>
<tr><td><1 year</td><td>No action required.</td></tr>
<tr><td>>1 year</td><td>Drain out the existing preservative and replace it with a preservative liquid consisting of the following:
<table>
<tr><th rowspan="2">Module</th><th rowspan="2">Preservative liquid volume (L)</th><th colspan="2">Preservative liquid formulation</th></tr>
<tr><th>SMBS* (g)</th><th>Potable water (L)</th></tr>
<tr><td>PHF-78-V</td><td>6</td><td>60</td><td>6</td></tr>
</table>
*SMBS = Sodium metabisulfite<br><br>
Pour in the chemicals from the reject port at the top of the membrane module. Replace the preservatives every 3 months.</td></tr>
</table>

# 3. Fundamentals

## 3.1 What is ultrafiltration?

Ultrafiltration (UF) is a membrane-based filtration process that uses pressure as a driving force to remove a large majority of contaminants—including particulate matter, bacteria, viruses, and high-molecular-weight substances—from water or process feed streams. Depending on the pore size of the UF membrane and the size of the particles suspended in the feed water, certain particles will pass through the membrane (typically low-molecular-weight solutes and dissolved solids) while others are rejected (such as suspended solids, bacteria, viruses, and high-molecular-weight substances). This separation process is widely used in water treatment, industrial applications, and research for purification and concentration of solutions.

UF is not fundamentally different from microfiltration (MF) except in terms of the molecular size of the contaminants removed. A basic membrane filtration process is shown in Figure 1. The process is pressure driven and typically operates with a feed pump that pushes water through the membrane.

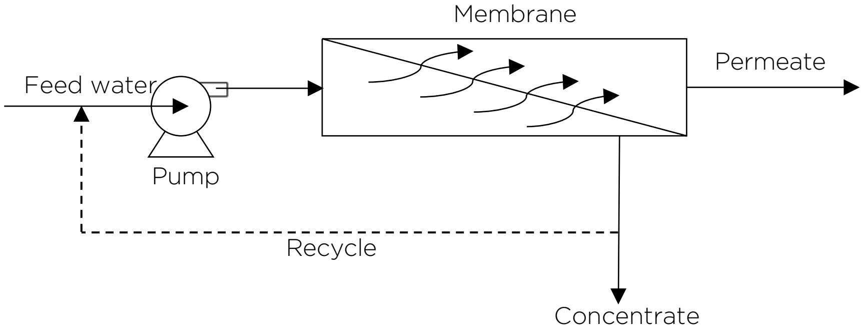


**Figure 1.** Schematic representation of a basic membrane filtration process

The filtration spectrum and the selectivity of various filtration methods are shown in Figure 2. Because UF membranes reject particles based on size-exclusion principles, they are often classified according to the size of the components they separate. UF membranes may be categorized by molecular weight cut-off (MWCO) in Daltons (where 1 Dalton is equivalent to 1 atomic mass unit) or by pore size (the nominal diameter of membrane openings) in microns. The MWCO of a membrane refers to the molecular weight of the molecule of the solute that is 90% retained by the membrane.

Typically, UF membranes are classified within a range of approximately 1,000–500,000 Daltons (Da). However, as the membrane structures become more open (greater than 100,000 Da), they are commonly classified by pore size rather than MWCO.

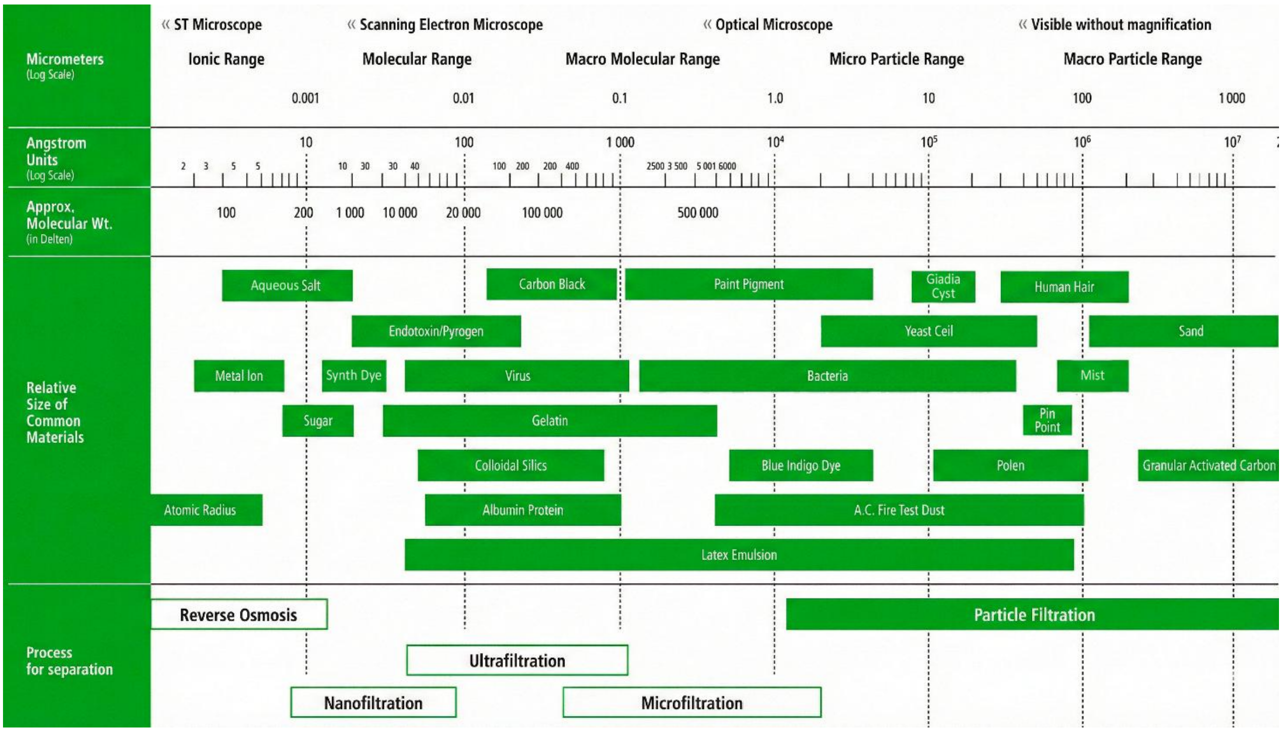


**Figure 2.** Membrane filtration spectrum

## 3.2 Definitions

The following section describes common terms used in UF operations.

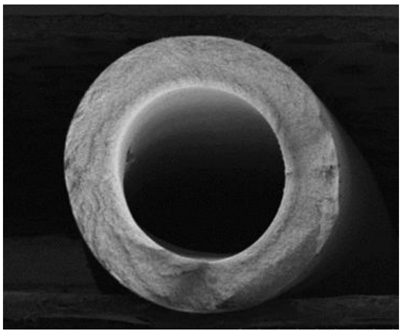

**Figure 3.** A scanning electron microscope (SEM) image featuring the cross section of a hollow-fiber membrane

### HOLLOW FIBER (HF)

UF membranes are commercially available in a variety of configurations, including hollow-fiber, flat-sheet (or plate-and-frame), spiral-wound, and tubular modules. The advantages of hollow-fiber membrane modules include high membrane packing density, the ability to backwash, high permeability, and good mechanical strength.

Hollow-fiber membrane modules consist of numerous thin (1–3 mm in diameter) and long fibers (see Figure 3). These fibers are fixed at one or both ends of the module in a potting material, with one end of the module open for permeate collection.

There are two modes of filtration based on the direction of permeate flow: inside-out or outside-in. In inside-out operation, feed water enters the lumen (interior) of the fibers and permeate exits into the shell (exterior) of the membrane module. In outside-in operation, feed water enters the shell and permeate is collected inside the lumen of the fibers. The latter is the most common operation mode.

During outside-in filtration, the fibers are surrounded by feed water, allowing very uniform flow distribution along each fiber and across the entire module. Permeate is collected inside the fibers.

Inside-out operation is the opposite: Feed water enters the fibers and permeate surrounds the fibers. This operation mode allows for low-pressure operation and frequent, efficient backwashing because the volume on the feed side is much smaller compared to the outside-in operation. However, inside-out filtration is more sensitive to higher solids load or peak solids load in the feed water.

### DEAD-END VS. CROSS-FLOW FILTRATION MODE

Membrane systems can operate either in dead-end filtration or cross-flow filtration mode.

1. **Dead-end filtration**
   Dead-end filtration is the simplest form of filtration and is used in many filtration processes. Feed water is forced through the filter surface under applied pressure. Retained particles accumulate on the membrane surface while water flows through (see Figure 4A). As solids build up on the membrane, the water experiences greater resistance to passing through the filter, which may reduce flux. Because solids accumulate on the filter surface, filters/screens must be periodically cleaned to restore performance.

   Dead-end filtration is a batch process and is useful for concentrating compounds. It has two streams: feed (i.e., raw water entering the filter/screen) and permeate (i.e., treated water free from solids).

2. **Cross-flow filtration**
   Cross-flow filtration (also called tangential-flow filtration) is a technique in which the feed solution flows parallel to the membrane surface (see Figure 4B). The constant turbulent flow along the membrane surface prevents solids from accumulating on the membrane surface. A pressure differential across the module drives permeate through the membrane while retained particles continue to pass along the membrane surface as concentrate. The process is referred to as “cross-flow” due to the perpendicular orientation (90°) between the feed/concentrate flow the and permeate flow.

   Cross-flow filtration has three streams: feed, permeate, and concentrate (i.e., water with retained particles).

   This mode is well suited for liquids with high concentrations of filterable matter. The continuous movement of feed and concentrate helps keep the membrane surface cleaner so the membrane can perform with fewer cleanings.

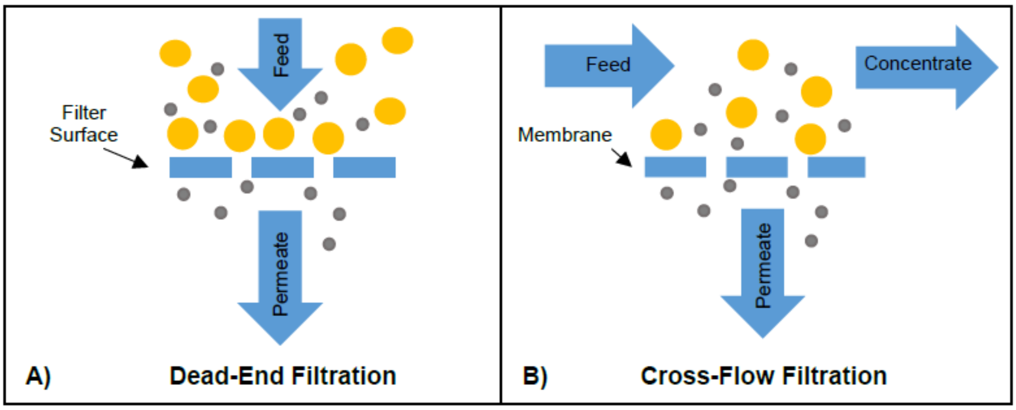


**Figure 4.** Diagrams showing the difference between cross-flow and dead-end filtration

### TRANSMEMBRANE PRESSURE (TMP)

Transmembrane pressure (TMP) is the pressure difference between the feed pressure and the permeate pressure. It is the driving force for filtration, describing how much force is needed to push water through a membrane. Low TMP typically indicates a clean, efficient membrane, while high TMP indicates fouling or reduced performance.

TMP is measured by pressure sensors in the feed and permeate headers. Generally, it is calculated as follows:

$$\text{TMP} = \text{Feed Pressure} - \text{Permeate Pressure} + \text{CF}$$

If the pressure sensors are at different heights, the above calculation must include a correction factor (CF). For example:

- If the feed sensor is 50 cm higher than the permeate sensor, then CF = + 0.05 bar.
- If the permeate sensor is 80 cm higher than the feed sensor, then CF = - 0.08 bar.

### GROSS FLUX

Gross flux represents the absolute hydraulic flow in relation to the active membrane area that is used for filtration. Increasing flow also increases flux. Reducing the active membrane area (e.g., isolating a module) also increases flux. See the formula below:

$$\text{Gross flux} = \frac{\text{Feed Flow}\left[\frac{\text{L}}{\text{h}}\right]}{\text{Membrane Area}\,[\text{m}^2]}\left[\frac{\text{L}}{\text{m}^2\cdot\text{h}}\ \text{or LMH}\right]$$

Gross flux is the instantaneous, actual flux through the available membrane surface area. For feed pump flow rate sizing, gross flux is used and multiplied by the total (maximum) membrane area.

### NET FLUX

Net flux is the average flux based on net permeate production flow (considering permeate production stops during backwash and chemical cleaning periods). Net flux depends on filtration time, air scouring cycles, backwash flow and duration, and cleaning frequency and duration. The formula below can be used to calculate net flux:

$$\text{Net Flux} = \frac{\text{Net Permeate Production Flow}\left[\frac{\text{L}}{\text{h}}\right]}{\text{Membrane Area}\,[\text{m}^2]}\left[\frac{\text{L}}{\text{m}^2\cdot\text{h}}\ \text{or LMH}\right]$$

### AVERAGE FLUX

Average flux is the specific flux over a longer period (e.g., a week, month, or year). It can be calculated using the following formula (using the example of an operating period of one week):

$$\text{Average Flux (week)} = \frac{\text{Filtered Water During One Week}}{\text{Total Membrane Area Used}\cdot\ 168\ \text{hours}}\ [\text{LMH}]$$

### PERMEABILITY

Permeability is a membrane's ability to allow fluids to pass through it and is a key performance indicator. It is expressed as the ratio of gross flux to TMP.

$$\text{Permeability} = \frac{\text{Gross Flux}}{\text{TMP}} \left[\frac{\text{L}}{\text{m}^2 \cdot \text{h} \cdot \text{bar}}\right]$$

#### NORMALIZED PERMEABILITY

Permeability strongly depends on the viscosity of the medium, which is temperature dependent. To compare membrane modules operated under different temperature conditions, permeability is normalized to 25˚C. The following equation can be used for that purpose, where T is the actual temperature of the medium:

$$\text{Normalized Permeability} = \frac{\text{Gross Flux}}{\text{TMP}} \cdot 1.024^{(25-\text{T})} \left[\frac{\text{L}}{\text{m}^2 \cdot \text{h} \cdot \text{bar}}\right]$$

#### RECOVERY

Recovery (or recovery rate) is the percentage of feed water that becomes permeate. The longer the measurement period, the more accurate the recovery calculation is. This is because all water losses and non-productive time for backwashes and chemical cleanings are accounted for.

$$\text{Recovery} = \frac{\text{Net Product Flow}}{\text{Feed Flow}} \cdot 100\%$$

## 3.3 Types of membrane fouling

During operation, membrane surfaces can be subject to fouling by mineral scale, biological matter, colloidal particles, and insoluble organic materials. “Fouling” refers to the build-up of any type of material on the membrane surface, including mineral scaling, effectively plugging the membrane. The three general types of fouling include particulate or colloidal fouling, inorganic fouling (scaling), and organic fouling.

### 3.3.1 PARTICULATE OR COLLOIDAL FOULING

Particulate or colloidal fouling is caused by suspended solids, colloids, and turbidity in the feed water (e.g., dirt, silt, clay, etc.). This type of fouling is managed through hydraulic cleanings, such as regular air scouring and backwashing.

### 3.3.2 INORGANIC FOULING (SCALING)

Most inorganic fouling, or scaling, occurs during the filtration of ground water or alkaline industrial wastewater. Scaling may occur when the concentration of certain dissolved inorganic compounds exceeds their solubility limits and precipitates onto the membrane surface as scale.

Acid cleaning is used to remove scale. Hydrochloric acid (HCl) and citric acid are commonly used for low-pH cleanings. The required concentration depends on the nature and severity of the inorganic deposits, as well the length of time they may have been present on the membrane surface.

### 3.3.3 ORGANIC FOULING

Organic fouling typically occurs when feed water contains organic matter. Common organic foulants include alginates, humic acids, fulvic acids, and fatty acids. Bacteria are among the most common contributors to fouling, as microorganisms can attach to the membrane surface, multiply, and form biofilms, resulting in heavy fouling. Alkaline solutions, such as sodium hypochlorite (NaOCl), are commonly used to remove organic fouling.

### 3.3.4 REVERSIBLE AND IRREVERSIBLE FOULING

All three of the aforementioned types of fouling may occur during the lifetime of a membrane module. The type of foulants present depends on the characteristics of the feed water. With the proper pretreatment and appropriate cleaning methods, foulants may be removed and membrane performance restored. This is known as reversible fouling.

Irreversible fouling, on the other hand, may permanently reduce membrane performance and may only be recovered by replacing the affected membrane module(s). To prevent irreversible fouling from occurring, MANN+HUMMEL WMS strongly recommends implementing robust pretreatment and cleaning regimes for the hollow-fiber UF system.

1. Reversible fouling: Foulants can be removed via cleaning; membrane performance may be substantially restored.
2. Irreversible fouling: Foulants cannot be removed via cleaning; membrane performance is compromised and may not be restored.

# 4. PureULTRA PHF-78-V module design

## 4.1 Pretreatment of feed water

The type and extent of pretreatment required largely depend on the feed water source, water composition, and the application, as certain materials can accelerate the fouling process or even cause immediate damage to membrane modules. Proper pretreatment therefore plays a critical role in the performance and life expectancy of PureULTRA PHF-78-V membrane modules.

Typical pretreatment processes include:

- Fat, oil, and grease removal
- Pre-screening
- Coagulation and flocculation
- Flow (load) equalization

### FAT, OIL, AND GREASE (FOG) REMOVAL

PureULTRA PHF-78-V membrane modules can tolerate a maximum concentration of 2 mg/L emulsified fat, oil, and grease (FOG) but no free FOG. If the feed water exceeds this limit, it is recommended to install an additional pretreatment step upstream of the UF system. FOG is typically removed by flotation or skimming. The type of flotation may vary based on availability and the concentration of FOG in the raw feed water.

### PRE-SCREENING

Most UF plants use basic pre-screening to prevent larger particles from entering the membrane module. The type of pre-filtration depends on the feed water source, application, total plant flow rate, and particle size. The most common screens for basic pre-screening are auto self-cleaning filters with 100–300-µm openings. For seawater applications, MANN+HUMMEL WMS recommends 100–150-µm screens. For most other applications, 150–300-µm screens are sufficient. For questions, additional information, or to confirm the type and size of pre-screening equipment, please contact your MANN+HUMMEL WMS representative.

If the pretreatment process includes a final filtering/straining step of particles larger than 300 µm, a protective in-line UF feed strainer can be omitted.

When a strainer is used, materials that degrade over time (e.g., stainless steel wire mesh) should be avoided as degraded material can lead to membrane damage. Alternatives include bag filters, wedge wire strainers (or similar), drum filters, or disc filters.

If the customer chooses not to install a UF feed strainer, MANN+HUMMEL WMS is not responsible for membrane failure or consequential damage caused by harmful external materials entering the system.

### COAGULATION AND FLOCCULATION

Coagulation and flocculation are two pretreatment methods in which chemicals are added to the raw feed water to remove specific particles/foulants that may negatively affect downstream modules.

Coagulation occurs when a chemical (coagulant) is added to water to destabilize colloidal suspensions. In a colloidal suspension, particles will settle very slowly or not at all because the particles carry electrical charges on the surface that mutually repel each other. A coagulant (typically a metallic salt) with the opposite charge is added to the water to overcome the repulsive charge, destabilize the suspension, and allow the colloidal particles to stick together and form flocs.

Conversely, flocculation uses polymers to clump small, destabilized particles together into larger flocs, which can be separated from the water easily. Flocculation is a physical process and does not involve neutralization.

Please note: Polymer-based flocculants and coagulants—especially the cationic type—are not compatible with PureULTRA PHF-78-V membrane modules. Carryover of these chemicals may cause severe and potentially irreversible fouling.

Coagulation and flocculation are often used together to create the largest possible flocs for easy removal via filtration or sedimentation. Please consult MANN+HUMMEL WMS before dosing coagulants, aluminum salts, or ferric-based salts into the UF feed flow.

### FLOW EQUALIZATION

Flow equalization reduces or eliminates peak flux periods so that the average flux becomes the main driving force for determining the required membrane surface area. The removal of highly variant peak fluxes drastically reduces both the stress on the membrane and the fouling potential, resulting in a more stable overall process flow with fewer backwash cycles and chemical cleanings.

Flow equalization is used when it can reduce overall plant costs. Key factors to consider are the frequency, volume, and duration of peak flows, as well as the availability of space. Flow equalization also enables consistency in raw UF feed and greater process stability.

## 4.2 Membrane fiber and membrane module specification

PureULTRA PHF-78-V modules (see Figure 5) consist of polyvinylidene fluoride (PVDF) hollow-fiber membranes. The hydrophilic-modified PVDF material is widely used in many applications (e.g., produced water treatment) due to its high mechanical strength with excellent chemical resistance, providing long membrane life and reliable operation. Additionally, the membrane modules are optimized for low-pressure operation, which results in reduced operating expenses (OPEX) for the entire membrane filtration system.

The UF fibers developed by MANN+HUMMEL WMS are assembled into a membrane cartridge. Once the cartridge is filled with the hollow-fiber membranes, it becomes a complete PureULTRA PHF-78-V module.

The membrane modules are designed for vertical installation and operation. Each module contains four ports: two on the bottom cap and two on the top cap. During filtration, feed water enters through the bottom connection of the membrane module. The air feed, also located at the bottom connection, is used for air scouring during hydraulic cleaning cycles. The permeate port is located on the bottom cap, as well. The vertical port on the top cap serves as the reject port.


**Figure 5.** PureULTRA PHF-78-V module

# 5. UF system design

The most important aspect of UF system design is choosing the appropriate operating flux for the specific water source, application, and parameters. If seasonal temperature fluctuations are expected, the lowest operating temperature should be considered when choosing an operating flux. Once chosen, the required membrane area can be determined. System design must also account for any potential disruptions and shutdowns due to cleaning, disturbances, and impacts from both upstream and downstream processes (e.g., RO system operations and cleaning-in-place (CIP) downstream).

For specific applications or processes, MANN+HUMMEL WMS may recommend pilot testing prior to designing a full-scale plant. For questions or additional information about certain applications or processes, please contact your MANN+HUMMEL WMS representative.

A basic piping and instrumentation diagram (P&ID) of a system using PureULTRA PHF-78-V membrane modules can be found in Appendix 1.

## 5.1 Auxiliary equipment

### 5.1.1 TANKS

To avoid frequent system start-ups and shutdowns, both the feed tank upstream and the permeate tank downstream of the UF system should be sized appropriately. Each tank should be designed with inlet and outlet valves, drain valves, open overflow pipes, and level switches and transmitters to ensure proper liquid level control in the tanks. The level switch should have the ability to detect both high liquid levels to prevent the tanks from overfilling and low liquid levels to stop system operation to prevent damage to equipment, such as pumps and membrane modules.

It is recommended that the permeate/backwash tank be equipped with a level transmitter to ensure sufficient water is available for hydraulic cleanings or chemically enhanced backwashes (CEBs).

The permeate and backwash tanks can be combined into a single tank for easier operation. In this case, the tank should be sized to accommodate both the amount of water calculated in the above guidelines as well as the amount of water used in at least one backwash cycle.

It is recommended that the feed and permeate/backwash tanks be constructed from non-corroding materials. The water in the permeate/backwash tank should also be protected from direct sunlight to minimize bacterial or algae growth.

#### DOSING TANKS

Dosing tanks are necessary to store the chemicals used for CEB and CIP. Each chemical must be stored in its individual dosing tank. For safety reasons, dosing tanks should be placed in individual bunds to contain possible leaks.

Dosing tanks should have enough storage capacity to hold a minimum of one week's worth of chemicals. Please consult the chemical supplier for suitable tanks, dosing pumps, piping, valves, and instrumentation materials that are compatible with CEB and CIP chemicals.

If NaOCl is one of the cleaning chemicals used, it is important to remember that this chemical loses strength over time (especially at higher temperatures). The degradation rate increases with increasing temperature and direct sunlight. Because of this, it is recommended to use a non-translucent (opaque) tank and to check the chemical strength frequently. Additionally, due to off-gassing, tanks must also be designed to allow gas to vent. It is recommended to store NaOCl under dark, cool (≤15°C (≤59°F)) conditions.

### CLEANING-IN-PLACE (CIP) TANK

If intensive cleaning is needed, a CIP tank may be required. Each CIP tank should be sized to hold approximately 70 L (18.5 gallons) of CIP solution per module. Please keep in mind that the tanks should also be sized to account for the additional volume of water in the piping. It is also recommended that the tank have 20% freeboard allowance.

## 5.1.2 PUMPS AND BLOWERS

### FEED PUMP

The feed pump can be designed based on the gross filtration flux. Pump head can be determined by the amount of pressure upstream of the pump. The flows and pressures for any pre-filtration equipment upstream of the pump, such as auto-filters, must also be accounted for when sizing the pump.

A centrifugal pump with a frequency inverter is recommended for flow control and smooth ramp up/down. To prevent cavitation, large suction piping should be used.

For CIP or seawater applications, ensure the pump materials of construction can tolerate chemicals or deteriorating materials to prevent premature pump failure.

A single feed pump can serve several lines. However, redundancy is required to avoid single-point failure.

### BACKWASH PUMP

The backwash pump should be equipped with a frequency inverter for smooth ramp up/down and to maintain a constant backwash flow during the hydraulic and CEB cleaning procedures. Furthermore, the same design considerations for the feed pump apply to the backwash pump.

### AIR BLOWER

Air blowers or pressurized air systems can be used with PureULTRA PHF-78-V modules. Air is used to agitate the membrane fibers during the backwash process. The air blower should be designed with a blower discharge flow rate of 12 $Nm^3/h$ (7.1 SCFM) per module and a maximum air scouring pressure of 1 bar (14.5 psi).

### DOSING PUMP

The chemical dosing pump supplies chemicals to the membrane modules during CEB. Each chemical requires its own dedicated dosing pump to prevent cross-mixing. Depending on the application and dosage of chemicals into the system, a solenoid- or motor-driven dosing pump may be used.

The dosing pump capacity is normally determined by the following parameters:

- Target concentration
- Source concentration
- Backwash flow rate (directly related to backwash flux and installed membrane area in the UF rack)

### 5.1.3 VALVES

Pneumatic or electric actuated valves are recommended. However, ensure that the opening and closing of the valves is well controlled to help prevent water hammer, or the sudden pressure surge forced onto the membranes. It is recommended to add air supply and release any restriction on the valve actuators.

Valves should include position indicators, which should be connected to a control panel to ensure all valves are in the correct open/close position before transitioning to the next operation step.

#### REJECT OUTLET VALVE

The reject outlet valve is an open/close device that is closed during filtration and opened only during forward flush, backwash, CEB, and CIP. Therefore, the sizing of the valve must be designed for the maximum expected flow depending on the backwash and forward flush flux.

#### PERMEATE OUTLET VALVE

The permeate outlet valve is an open/close device that is opened during filtration and closed during backwash, CEB, and CIP. When closed, it prevents backwash water from entering the permeate line. It should be designed for the maximum flow possible depending on the filtration flux.

#### FEED INLET VALVE

The feed inlet valve is required when feed water could enter the membrane modules unintentionally and create excess hydraulic pressure, which could affect the backwash efficiency of the cleaning process. This is because there is additional backpressure when the backwash water is sent from the backwash pump to the membrane modules.

#### AIR BLOWER INLET VALVE

An air blower inlet valve is recommended inside the air pipe to fully isolate the air blower section from the rest of the water-filled piping. This can prevent water from entering the air blower. The valve should be installed as close as possible to the junction where the air pipe joins the feed inlet of the UF membranes modules in order to minimize the risk of flooding the line.

#### DRAIN OUTLET VALVE

A drain outlet valve can be added wherever necessary to allow the heavier solids to be drained from the bottom of the membrane module in case the solids are unable to be pushed out via the reject line. Draining is performed by opening both the drain outlet valve and reject outlet valve simultaneously.

#### CHECK VALVES

Check valves should be installed in pipes wherever backflow may occur or where multiple lines converge. For example, a check valve in the air pipe will prevent water from entering the air blower when the air blower line/valve is open but not enough pressure has been built up to push air toward the membrane modules.

#### SAMPLING AND DRAIN VALVES

Sampling and drain valves are recommended and can be placed near the system water drains that are used for system maintenance. Sampling valves can be added upstream or downstream of the membrane modules to collect samples for water analysis.

### 5.1.4 INSTRUMENTATION

A set of monitoring equipment is necessary to ensure that the entire system works correctly, safely, and within permissible limits. Digital process monitoring equipment (e.g., pressure gauges and flow meters) is recommended for optimum monitoring and control of the process.

#### PRESSURE MEASUREMENTS

TMP is measured according to the equation given in Chapter 3.2. Pressure sensors should be installed at the feed and on the permeate headers in each UF rack. For smaller UF racks without headers, pressure sensors should be located near the membrane module to reduce the influence of pressure loss caused by piping.

The pressure during backwash should be monitored to ensure that the backwash is carried out correctly and within the allowed pressure limit of the UF modules. The backwash TMP should be similar for each backwash cycle.

Feed pressure should be measured before and after the pretreatment filters to determine the differential pressure. This may indicate whether cleaning or replacement of the pre-filters is necessary. Maintaining the pre-filters is important to help protect the membrane from harmful particulate matter.

Air blower pressure should be monitored closely to ensure that there is enough pressure to push air into the modules without exceeding 1 bar (14.5 psi).

#### FLOW MEASUREMENT

A flow meter should be installed on the permeate line to monitor flow during filtration and backwash. If the UF plant includes multiple UF racks using a common backwash pump, the backwash flow transmitter may be located at the backwash pump.

#### TURBIDITY MEASUREMENT

A turbidity meter may be used to monitor permeate turbidity and detect potential fiber breakages or system failures. However, periodic sampling and turbidity analysis using a hand-held analyzer is generally sufficient for monitoring UF system performance.

#### PH MEASUREMENT

During the CEB soak period, the operator should take samples and verify that the recommended pH (see Chapter 6.2) is achieved to ensure effective cleaning. Additionally, the pH must remain within the module's allowable range (2–12).

### 5.1.5 PIPING

A plumbing system is essential to ensure optimal UF system performance. A series of pipes and fittings is required to connect the PureULTRA PHF-78-V modules and auxiliary equipment. To avoid piping dead legs and minimize pressure losses across the UF rack, the number of fittings (such as elbows) should be kept to a minimum.

The feed and permeate piping should be designed with a maximum flow velocity of 1 m/s ($V_p$ <1 m/s, or $V_p$ <3.3 ft/s). Backwash piping should be designed with a maximum flow velocity of 2 m/s ($V_b$ <2 m/s, or $V_b$ <6.6 ft/s), taking into account that air from air scouring is present. Air pockets in the piping upstream, within the UF rack, and downstream of the UF rack should be avoided. If air pockets accumulate, vent valves should be installed for regular venting.

### 5.1.6 AIR QUALITY REQUIREMENT

During UF system operation, compressed air is required for pneumatic valves, air scouring, and integrity testing (if applicable). The compressed air supply should meet the following specifications:

- **Pneumatic valve operation:** ISO 8573-1, class 2/3/2 (oil/water/particles) at a minimum pressure of 6 bar (87.0 psi)
- **Air scouring:** ISO 8573-1, class 1/3/1 (oil/water/particles) at 1.0–2.0 bar (14.5–29.0 psi)
- **Integrity testing:** ISO 8573-1, class 1/3/1 (oil/water/particles) at 1.0 (±0.1) bar (14.5 (±1.5) psi)

The air source rate range is provided in the datasheet.

## 5.2 Cleaning strategy

Depending on the water source, specific application, and water quality, it is possible that organic and biological fouling, as well as inorganic scaling, may occur and require different cleaning regimes.

Organic and biological fouling is typically caused by the growth of microorganisms and the adsorption of organics on the membrane surface. These foulants may be removed by performing a CEB or CIP with NaOCl, with caustic soda (NaOH) added if necessary. The pH must never exceed 12 during these cleanings.

Inorganic scaling is caused by the precipitation of metal salts on the membrane surface. Such scale may be removed by a CEB or CIP with acid. Commonly used acids include citric acid and/or HCl at pH ≥2.

Depending on the feed water quality and application, either a CEB, CIP, or combination of both may be used. Different chemicals may also be selected for optimal cleaning efficiency. Cleaning frequency depends on site-specific conditions.

#### CHEMICALLY ENHANCED BACKWASH (CEB)

During a CEB, backwash water is delivered to the membrane module via the backwash pump. At the same time, chemicals are injected through a dosing pump into the pipeline and mixed thoroughly by a static mixer before entering the membrane module. Once the chemicals have reached the UF modules, the backwash pump is stopped and the soak timer begins. This process cleans the lumen side of the fibers as the chemically mixed water flows from the inside of the fibers outward to the reject port.

After the soak period ends, the backwash pump rinses out the chemicals. The process is described in Chapter 6.2.1.

#### CLEANING-IN-PLACE (CIP)

For a CIP, a cleaning solution is prepared with clean water in the CIP tank. A pH meter may be used to verify that the correct amount of chemicals has been added. Before circulating the CIP solution, it is strongly recommended to replace the pre-screen with a tighter screen (1–5 µm) or to add an additional safety screen (also 1–5 µm). This helps capture material removed from the UF modules and prevents it from re-entering the system.

Before starting the CIP feed pump, ensure that all valves required for circulation across the CIP tank are open and all other valves are closed.

Once the CIP solution has reached the desired pH, the pre-screen (bag filter) is replaced and the valves are confirmed to be in the correct positions. The CIP feed pump can then be started at a low speed. The CIP solution is drawn from the CIP tank into the UF system and enters the modules through the feed port at the bottom. It exits the modules via both the permeate and reject ports at the top, returning to the CIP tank.

The entire procedure takes several hours and may be repeated with soak and circulation intervals to improve cleaning effectiveness. It is advisable to check the pH of the CIP return stream during the initial stage and add more chemicals if it deviates from the target value. When NaOCl is used, the free-chlorine concentration may be measured instead of pH. The full process is described in Chapter 6.2.2.

# 6. Operation procedures for PureULTRA PHF-78-V UF modules

This chapter describes the start-up and operation guidelines for PureULTRA PHF-78-V membrane modules. Before start-up begins, it is strongly recommended to verify that the feed water composition has not changed.

MANN+HUMMEL WMS recommends that operation and maintenance staff be involved in the commissioning process. Additionally, start-up should be carried out in manual mode for all functional tests before switching to automatic operation. This allows any anomalies to be identified and addressed early.

## 6.1 Start-up checks

Before start-up (i.e., before beginning any water-based operations), ensure the following:

1. The equipment (e.g., valves, pumps, air blowers, dosing pumps, etc.) is installed correctly and in proper working condition.
2. All measuring instruments are calibrated and properly installed.
3. The program controlled by the programmable logic controller (PLC) is functional and runs without errors. This will prevent unnecessary on/off switching of the system.
4. The membrane modules are installed correctly.

Ensure the entire system is clean—especially piping and tanks—to prevent contamination of the membrane modules.

## 6.2 Regular operating procedures

Regular operating procedures include:

1. Filtration
2. Hydraulic cleaning
3. CEB
4. CIP

During filtration, feed water is treated by applying pressure across the ultrafiltration membrane fibers from the shell side (exterior of the fibers) to the lumen side (interior of the fibers). Particulates rejected by the fibers accumulate on the exterior surface, forming a filtration layer.

Permeate water flows to the permeate/backwash tank, where it is stored until needed downstream (for further treatment) or used for backwash. If the product and backwash tanks are separate, ensure that sufficient water is always available in the backwash tank.

Flux should remain constant during operation. It is recommended to install the feed pump with a frequency inverter, or to use a feed-flow control valve with safety interlocks, to prevent over-pressurizing. Depending on the feed water quality and flux, a filtration duration of 30–60 minutes can be expected between hydraulic cleaning cycles. This 30–60-minute period is referred to as a filtration cycle.

During dead-end filtration, rejected particulate matter accumulates on the membrane surface. This may result in a gradual increase in TMP after each filtration and hydraulic cleaning cycle. After a predefined number of filtration/hydraulic cleaning cycles—or once TMP reaches the maximum allowable pressure—the membrane module should be chemically cleaned via CEB or CIP.

Excessive build-up over prolonged periods will negatively affect membrane performance and recoverability. Foulants should therefore be removed regularly using the cleaning methods described in the next section. Figure 6 illustrates the operating mode during filtration.

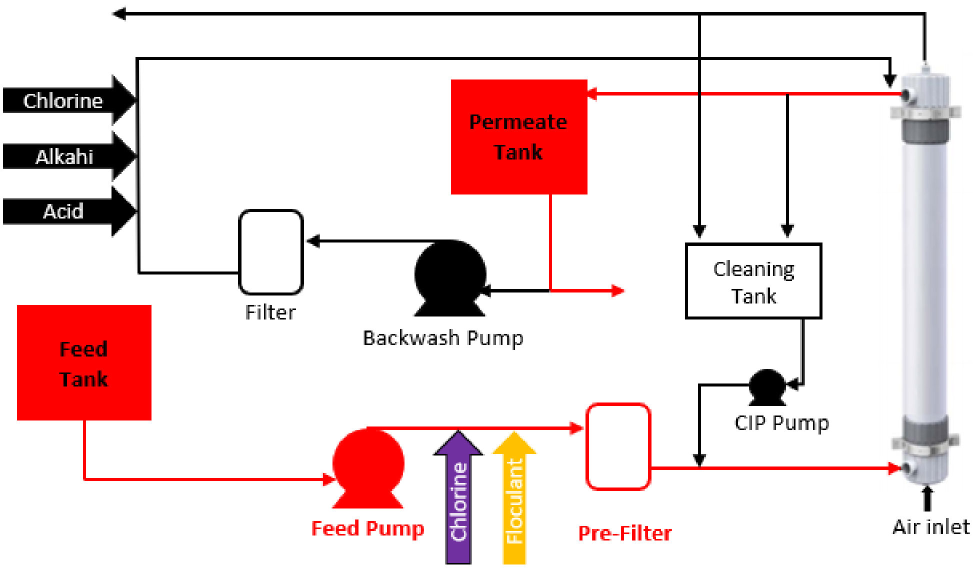


**Figure 6.** Filtration mode

### 6.2.1 OPERATION OF HYDRAULIC CLEANING

A hydraulic cleaning cycle typically involves four steps:

- Air scouring
- Drain
- Backwash
- Forward flush

The sequence of these steps can be altered to improve hydraulic cleaning efficiency.

## AIR SCOURING (AS)

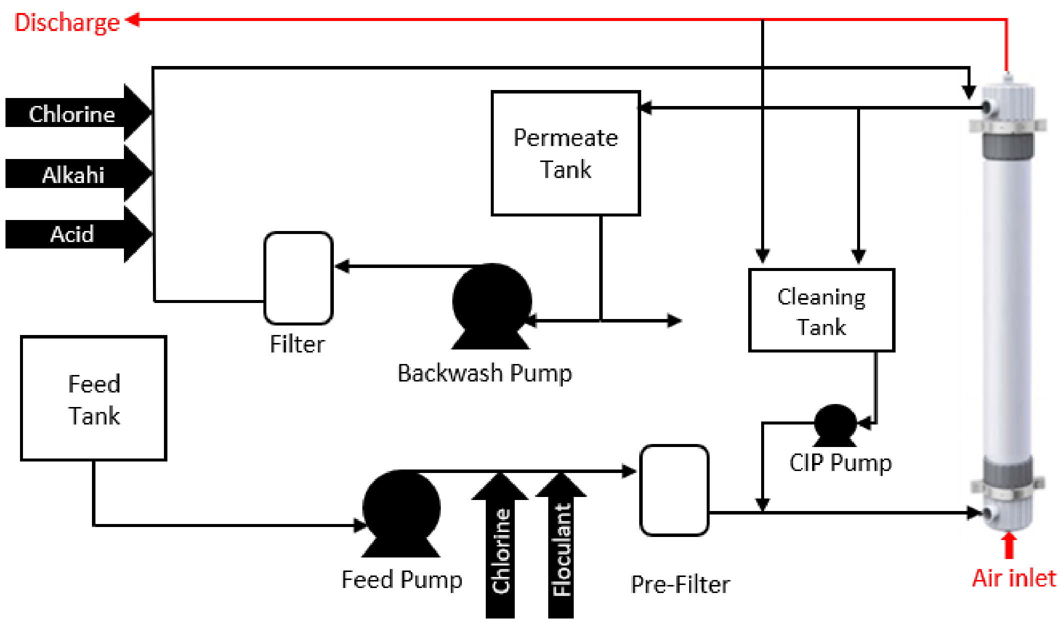


**Figure 7.** Air scouring

Air scouring is essential because the injected air agitates and dislodges accumulated particles on the exterior of the membrane fibers (i.e., the membrane surface). Air is delivered via the air blower or pressurized airline to the inlet located at the bottom of the membrane module. Ensure that the inlet air pressure is higher than the feed pressure.

As the air bubbles rise, sufficient turbulence is created to dislodge the foulants from the membrane surface without damaging the fibers. The air-scouring duration should typically be set to approximately 30-60 seconds.

## DRAIN

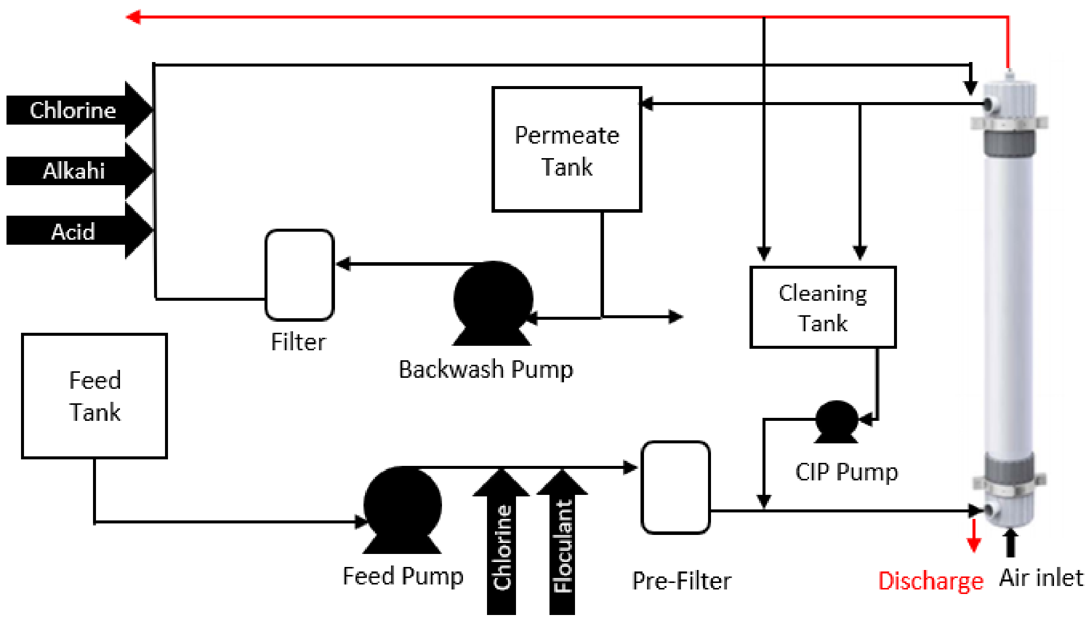


**Figure 8.** Drain mode

A drain step may be added after air scouring to allow the denser solids loosened during the previous step to be removed through the feed line at the bottom. Depending on system size, the drain step may take approximately 30–60 seconds or longer. The exact duration should be established during commissioning.

## BACKWASH

The backwash cycle consists of two steps—top backwash and bottom backwash—to effectively remove remaining suspended particles from the membrane modules.

During backwash, permeate water is drawn from the product/backwash tank and forced through the modules from the filtrate side (inside the fiber lumen) outward through the fiber walls toward the module shell side. This is accomplished using the backwash pump. The flow direction during backwash is therefore opposite that of filtration.

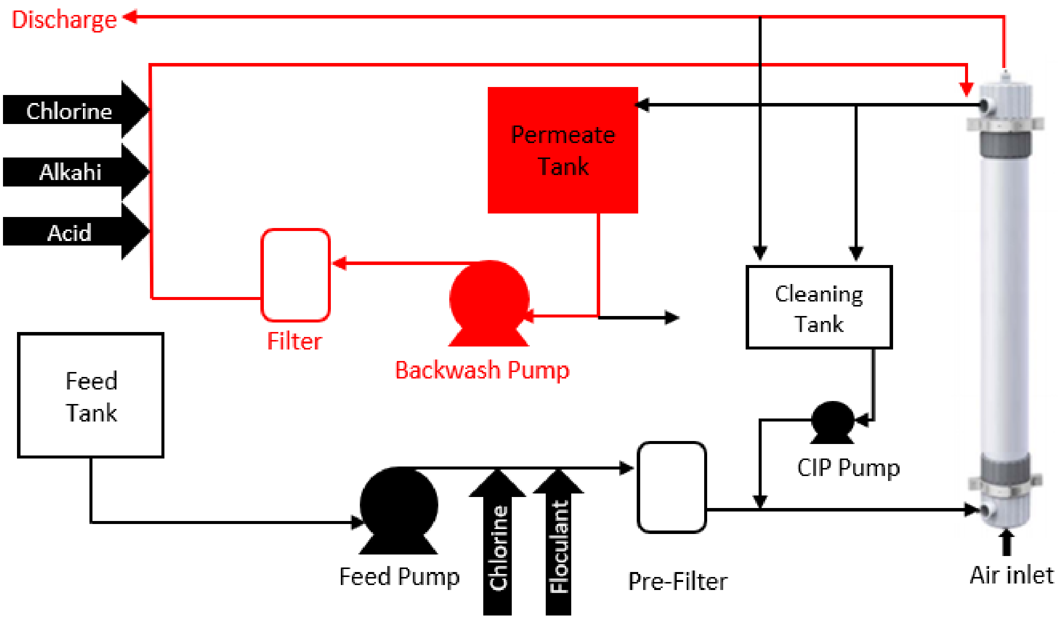


**Figure 9.** Top backwash

During the top backwash step, backwash water is fed through the permeate port, passes through the fiber wall from the lumen side, and is discharged through the reject port. This step effectively removes fouling or suspended particles inside the module, particularly in the upper portion.

During the bottom backwash step, backwash water is again fed through the permeate port, passes through the fiber wall from the lumen side, and is discharged through the feed port. This step effectively removes fouling or suspended particles in the lower portion of the module.

The backwash should be performed at a flux of 80–150 LMH (47–88 gfd). Effective backwash duration is at least 30–60 seconds, excluding the time needed for the pump to ramp up and down. The exact duration and frequency may be adjusted depending on the installation size and feed water quality.

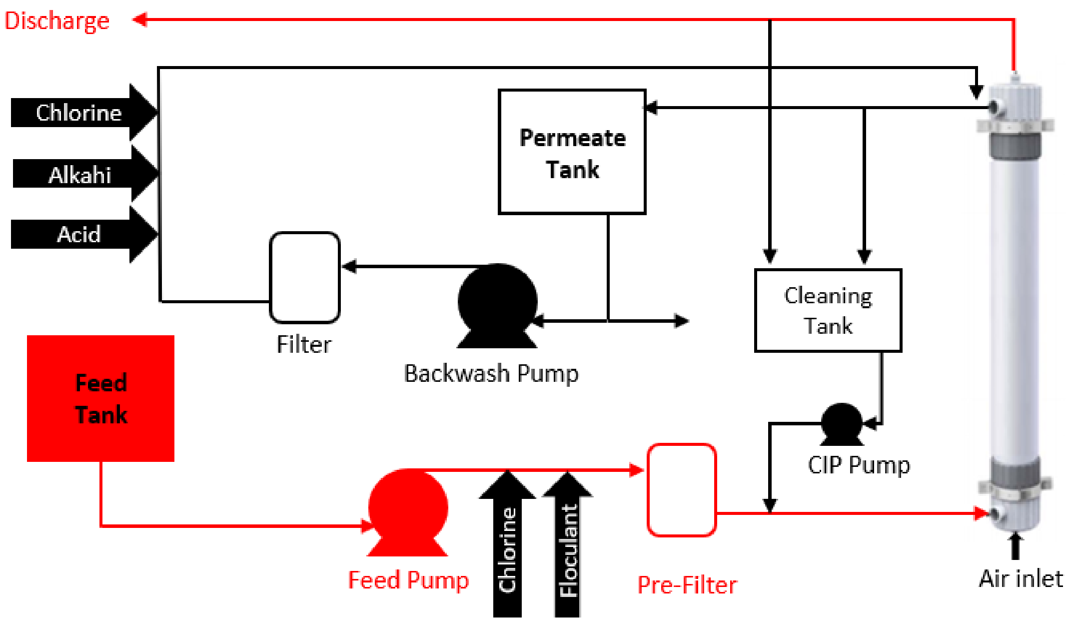


**Figure 10.** Bottom backwash

A reliable cleaning regime is highly recommended. A constant backwash flow rate should be maintained using an inverter-controlled backwash pump. The pump should ramp up progressively to the desired backwash flow set-point and ramp down at the end of the step, avoiding pressure spikes or water hammer.

## FORWARD FLUSH

A forward flush is used to remove solids or residual chemicals from the system and to eliminate any remaining air in the module before filtration begins.

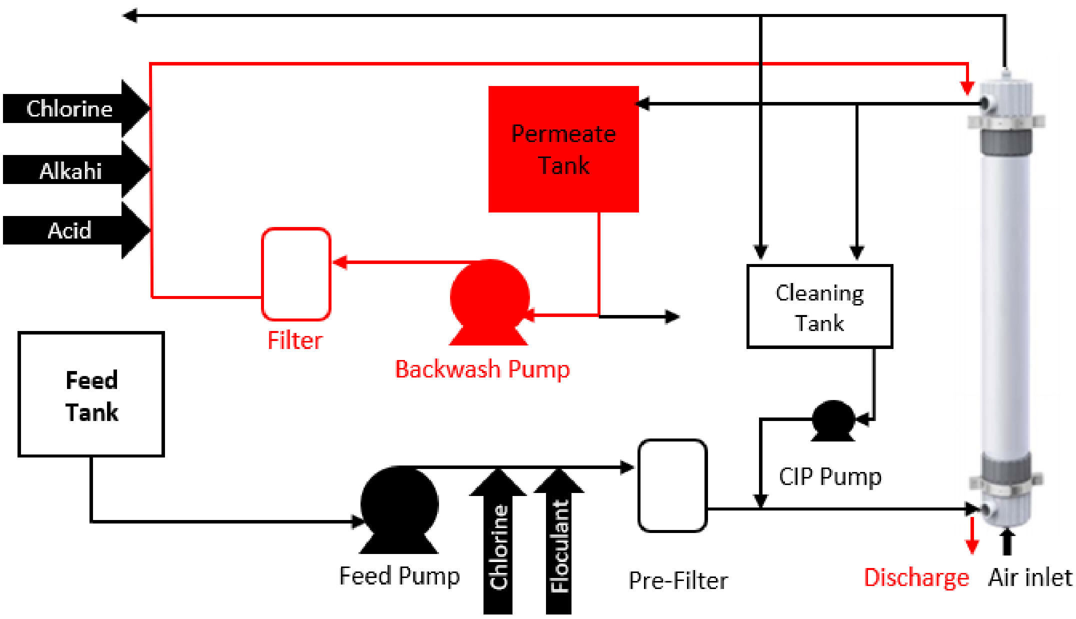


**Figure 11.** Forward flush

A forward flush is highly recommended because the product line is closed during this step, forcing water to flow lengthwise along the exterior of the membrane fibers. This creates a scrubbing effect on the membrane surface. The forward flush typically lasts 30–60 seconds.

## CHEMICALLY ENHANCED BACKWASH (CEB)

A CEB is a maintenance cleaning procedure designed to quickly remove inorganic particulate matter and microbial growth from the membrane surface. These short “mini cleans” help prolong run time between major cleanings. Depending on feed water characteristics, CEBs may occur once every few hours or once every few days. NaOCl (≤1,000 ppm), NaOH (pH ≤12.0), and HCl (pH ≥2.0) are commonly used for CEB cleaning.

A CEB consists of a hydraulic cleaning cycle with the addition of chemicals. Chemicals are introduced into the backwash water to enhance cleaning effectiveness. Five steps are incorporated into the backwash cycle:

1. Air scouring
2. Drain
3. Chemical dosing during backwash (top and/or bottom backwash; see Figures 12 and 13)
4. Soaking the modules
5. Final backwash to rinse out chemicals

Whenever possible, at least one normal backwash cycle should be performed before starting a CEB to remove larger suspended particles. This increases the effectiveness of the chemical cleaning.

Below is a description of the CEB sequence:

1. Air scouring loosens the foulants from the membrane fibers.
2. The drain step removes loosened particles from inside the module.

3. The backwash pump ramps up, and the dosing pump injects the required chemicals into the backwash line. The flux during CEB is typically lower than during a standard backwash.
4. Once the chemicals reach the UF modules, the backwash pump is stopped and the soak timer is started. The soak duration is typically 5–20 minutes.
5. When soaking is complete, the chemicals are rinsed out by performing a backwash at the normal backwash flux without chemical dosing. The rinse duration must be established during start-up to ensure all chemicals are fully removed.
6. If possible, the initial permeate produced after a CEB should be discarded, as it may contain residual chemicals that could negatively affect downstream processes.

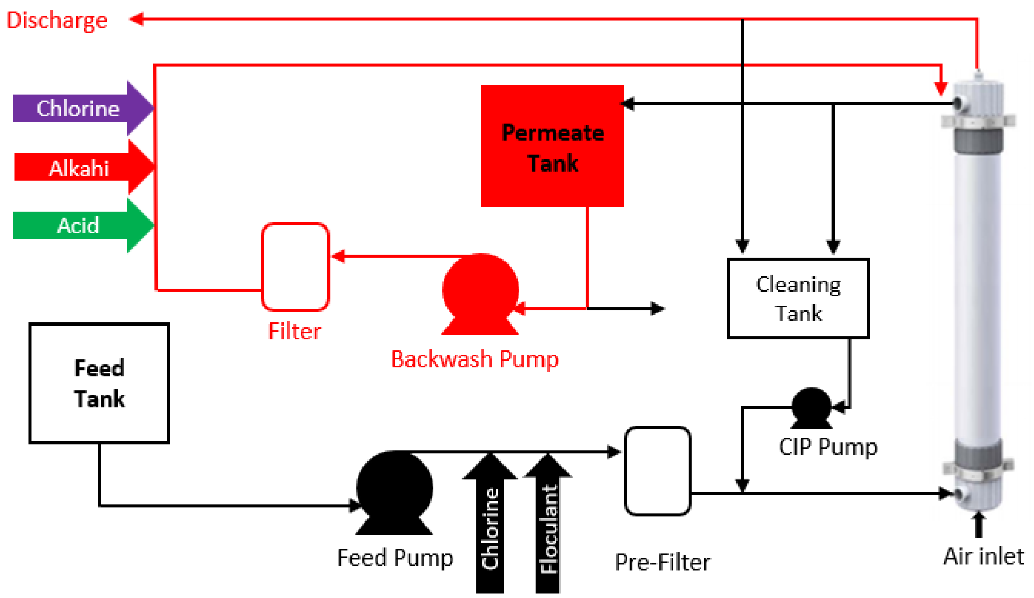


**Figure 12.** Introduction of chemicals during CEB (top)

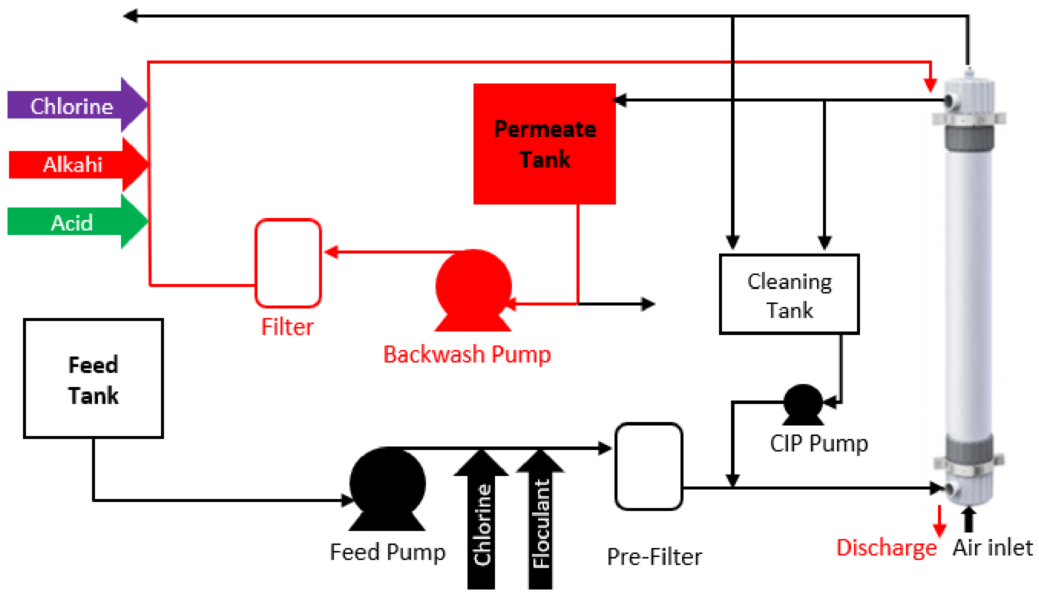


**Figure 13.** Introduction of chemicals during CEB (bottom)

### 6.2.2 OPERATION OF CIP (CLEANING-IN-PLACE) STAGE

When foulants or scalants can no longer be effectively removed by hydraulic cleaning or CEB—due to changes in feed water quality, difficult operating conditions, insufficient pretreatment, or incorrect chemical dosage—a CIP is recommended.

The main differences between a CEB and a CIP are that a CIP requires a dedicated circulation system and typically takes longer. A CIP cycle is usually carried out once every few months, although challenging feed water conditions may require more frequent cleaning, even weekly.

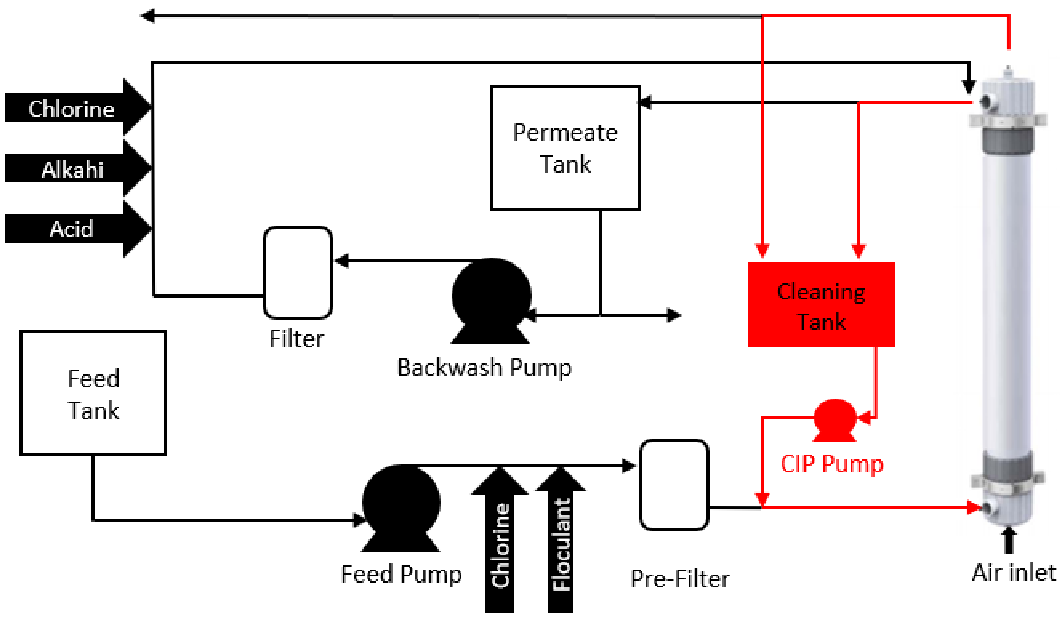


**Figure 14.** CIP mode

The following are important considerations before performing the CIP:

1. A CIP should be performed when hydraulic cleanings and CEBs no longer adequately restore membrane performance. A CIP is considered effective if it restores at least 75% of performance.
2. Recommended CIP chemicals are listed in Chapter 5.2.
3. The water used to prepare the CIP solution must be particle-free and have an alkalinity below 70 mg/L (tap water or RO permeate is suitable). This is especially important for caustic/high-pH cleaning. It is also recommended to flush the modules with water after a high-pH clean and before an acid/low-pH clean.
4. A typical CIP may take up to 12 hours (and should not exceed 12 hours).
5. The CIP solution may be heated to 40°C to enhance cleaning efficiency; do not exceed this temperature. At 40°C, pH must not exceed 12.
6. The CIP solution must enter the feed side of the membrane modules to prevent contaminants from reaching the permeate side.
7. It is strongly recommended to isolate the UF rack undergoing CIP from other racks and from up- and downstream processes.
8. Replace the standard fine screen at the feed with a finer 5–10-µm pre-screen.
9. Prepare the CIP solution in a separate CIP tank and verify concentration by measuring pH (or free chlorine when using NaOCl).
10. The ratio of CIP tank volume to the total system volume (modules, piping, CIP tank, etc.) must be considered when preparing the solution. The CIP solution concentration may require adjustment once circulation begins.

The following steps are performed manually during CIP and should be closely monitored:

1. Fill the CIP tank with water before adding any chemicals.
2. Add chemicals and mix thoroughly. Verify concentration and ensure maximum allowable limits (see datasheet) are not exceeded.
3. To prevent contamination, isolate the feed tank and product/backwash tank by closing the appropriate valves.
4. The chemical solution is either drawn into the UF system (if the individual rack is equipped with a feed pump) or pushed into it (by a CIP pump as part of the CIP system). Monitor flow to ensure the solution circulates throughout the entire system. Verify that the recirculated solution maintains the intended concentration and pH.
5. During soaking, air scouring may be performed intermittently to enhance cleaning effectiveness.
6. Circulate and soak the solution for 30–180 minutes (usually 60 minutes). Duration may vary by site.
7. After soaking, return the solution to the CIP tank. Take samples of the return water to confirm sufficient chemical concentration remains. If the water becomes dirty, replace the solution and repeat the cycle.
8. Once cleaning is complete, drain and dispose of chemicals safely. Clean the CIP tank and refill with clean water to rinse the modules.
9. Perform one or more standard hydraulic cleaning cycles before returning the system to normal filtration. Ensure foulants and scalants are fully removed and that permeate chemical levels meet downstream requirements.

## 6.3 Integrity test

During operation, the hollow fibers may become damaged due to heavy fouling, pressure fluctuations, or water hammer. This can impair the integrity of the membrane module. When fiber breakage occurs, impurities may pass through the membrane and into the filtrate. To ensure the system remains in proper condition, periodic integrity tests are recommended to identify potential fiber breakage.

The integrity test requires oil-free pressurized air, an air-adjusting valve, and a transparent pipe (>10 cm (4 inches)) installed on the permeate side.

Automated integrity test systems can perform module testing at regular intervals. An integrity test generally includes the following steps:

1. Stop the system and close all valves.
2. Introduce air: Slowly open the air-adjusting valve (V3) and release valve (V2) to allow air to flow into the module from the filtrate pipe. Close valve V3 once the pressure stabilizes at 1.0 bar (14.5 psi).
3. Pressure hold/decay: The monitoring system (PLC) records the pressure change. The pressure decay should be less than 5% over 5 minutes if no leaks are present. This indicates that the membrane is in good condition.
4. Check for bubbles in the permeate pipe. If continuous bubbles are observed, mark the module and perform repairs offline.

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

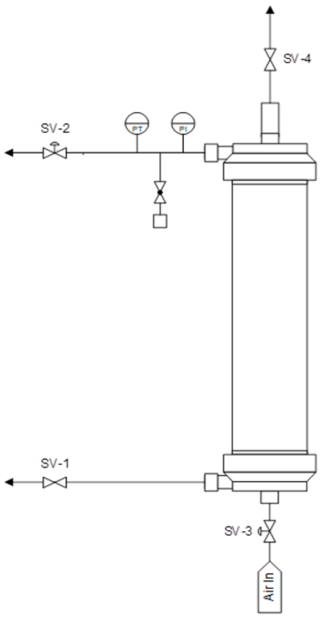


**Figure 15.** Integrity test flow diagram

## 6.4 Module repair

Membrane repair requires specialized training and tools. Contact MANN+HUMMEL WMS to obtain proper membrane repair training, tools, and plugs.

## 6.5 Shutdown/preservation

UF systems are typically designed for continuous operation. If a shutdown is required, the system must be cleaned to prevent bacterial growth. After backwashing, all valves on the UF system should be closed to isolate the system completely from any source of external contamination. At no point should the fibers be allowed to dry out, as this will cause irreversible deterioration of membrane performance.

If the membrane modules are installed in a rack and not blanked off, the preservation procedure must also be followed. If the shutdown exceeds seven days, the addition of chemical preservatives is necessary.

**TABLE 2. SHUTDOWN CONDITIONS**

| DURATION | RECOMMENDED PROCEDURES |
|---|---|
| <2 days | ▪ Complete at least one backwash cycle per 24 hours.<br>▪ Close all valves. |
| >2 days | ▪ Complete at least one backwash cycle and perform CEB with 500 ppm NaOCl, followed by usual backwash, without chemicals.<br>▪ Add preservatives (according to Table 1) and renew preservatives every three months. |

If the module is removed from the skid and stored for an extended period, it should be flushed thoroughly with permeate water and stored in an upright position.

The membranes must be stored free of any oxidizing agents during system shutdowns.

If the module is expected to be exposed to freezing conditions, please contact MANN+HUMMEL WMS.

## 6.6 Operating and cleaning logs

Operation and cleaning logs are essential for tracking operating conditions and optimizing system performance. Appendix 3 contains three record forms for cleaning monitoring:

- The first form is used to collect data during filtration and hydraulic cleaning.
- The second and third forms are maintenance/cleaning logs for recording CEB and CIP data.

Data should be recorded from the moment the modules are placed into operation. The customer should maintain complete documentation of all operating and cleaning conditions, as well as total operating hours for the plant.

Chemical usage for feed water pretreatment and CEB/CIP must be monitored closely, and this information should also be recorded. While the forms list key recommended data points, additional information may be included to provide further insight into membrane performance.

## 6.7 Troubleshooting

If an operational issue occurs, a general troubleshooting procedure is recommended to determine the root cause and the appropriate solution. In general, review the recommendations provided in this manual. Additionally, ensure that all pumps, valves, blowers, and sensors are regularly calibrated and function properly.

The following table lists potential operational issues and suggested solutions:

**TABLE 3. TROUBLESHOOTING**

| TROUBLE | ISSUE | RECOMMENDATIONS |
|---|---|---|
| **Low chemical cleaning effect** | Sodium hypochlorite (NaOCl) stock concentration | It is recommended to check the stock concentration once a month in colder regions or once a week in warmer regions due to degradation over time (tests available—for example, from Hach Lange). |
| | Delivery of chemical | Make sure the proper amount of chemicals is pumped into the system (metering of pump, check volume removed from stock tank). |
| | Biofouling | Use NaOCl or hydrogen peroxide. |
| | Scaling | Use acids at low pH (pH 1.0) according to datasheet. Check the total alkalinity of the influent. More frequent acid cleanings are required for high alkalinity (i.e., hard) feed waters. |
| | Chemicals | Chemicals used should be approved for membrane compatibility. |
| | CEB not effective | Consider the volume of piping for the dosing time that the chemical is entering the modules. Make sure the correct amount of chemicals reaches the modules.<br>Increase dosing time, soaking time, chemical concentration, or frequency between CEBs. |
| | CIP not effective | Check the turbidity of the reject flow after CIP is performed. Increase flow and/or time of backwash if turbidity is high.<br>Increase recirculation time, soaking time, chemical concentration, temperature, or frequency between CIPs.<br>Clean in two steps and renew the chemical solution in-between for removal of accumulated particles.<br>Use a fine strainer bag during CIP recirculation to prevent accumulation of particles during CIP. |

| TROUBLE | ISSUE | RECOMMENDATIONS |
|---|---|---|
| Performance | High pressure | Note that pressure is temperature-dependent. (High temperature often means low pressure.)<br>Check if pretreatment is working properly.<br>Check design for:<br>▪ Additional backpressure, which may increase feed pressure.<br>▪ Check for high pressure loss due to piping.<br>Make sure no air is accumulated in the fibers. |
| | Effluent quality | Disinfect piping and all tanks.<br>Measure turbidity or silt density index (check Troubleshooting Measuring Silt Density Index TSG-T-010 for more information). |
| | Improper pretreatment | Clean and improve pretreatment.<br>If additives are dosed, check the dosage. (Overdosage should be avoided.) |
| | Influent quality | Check the influent quality—specifically BOD, COD, TSS, and total alkalinity—to make sure that substances are not entering the modules (which may decrease performance).<br>When influent concentrations are higher than designed, performance may vary. |
| | Low hydraulic cleaning effect | If the backwash efficiency is lower than expected, increase the backwash flow first, if possible.<br>If flow must be decreased due to high pressure, increase the time to obtain the same volume as used before. |
| Malfunctions | Water hammer<br>Temperature too high<br>pH or chemical cleaning concentration out of range<br>TMP too high | In most cases, the module should be replaced.<br>Check all operation procedures and safety shut down scenarios again if the reason for malfunction is unknown. |

# 7. Appendices

## Appendix 1. Typical P&ID for PureULTRA PHF-78-V system

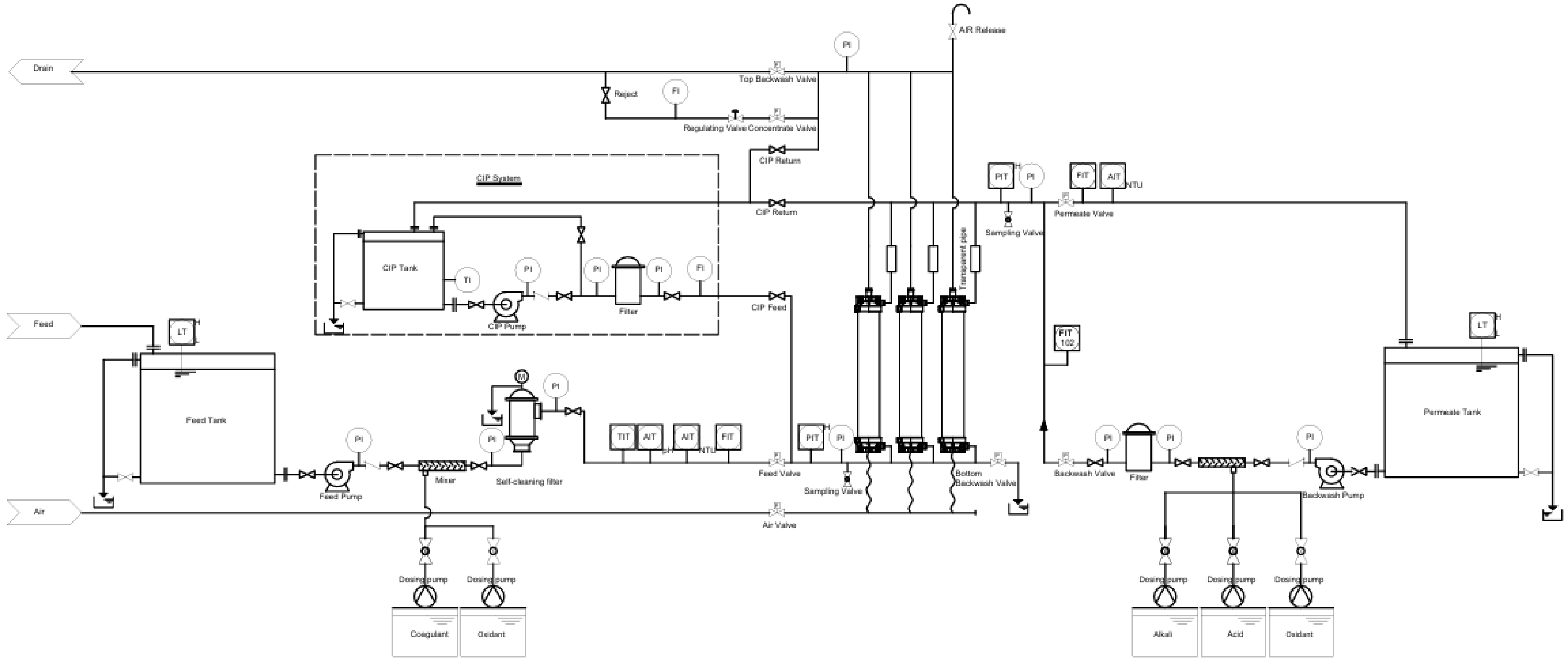


**Figure 16.** Typical P&ID of UF system using PureULTRA PHF-78-V hollow-fiber UF modules

## TABLE 4. VALVE ACTIVITIES OF A TYPICAL UF SYSTEM

| | STEPS | 1 FORWARD FLUSH | 2 FILTRATION | 3 AIR SCOURING | 4 DRAIN | 5 TOP BACKWASH | 6 BOTTOM BACKWASH | 7 CIP[4] |
|---|---|---|---|---|---|---|---|---|
| Valve and pump status | Feed pump | O | O | | | | | |
| | Feed water dosing pump | | Op[1] | | | | | |
| | Backwash pump | | | | | O | O | |
| | CEB dosing pump | | | | | Op[2] | Op[3] | |
| | CIP pump | | | | | | | O |
| | Feed valve (FV) | O | O | | | | | |
| | Permeate valve (PV) | | O | | | | | |
| | Top backwash valve (TBV) | O | | O | O | O | | |
| | Bottom backwash valve (BBV) | | | | O | | O | |
| | Backwash Valve (BV) | | | | | O | O | |
| | Air Valve (AV) | | | O | | | | |

**Notes**:
O: Open status for pump and valve
Op: Optional open based on conditions
1: Feed water dosing pump open for the conditions that need feedwater adjustment before the membrane
2, 3: If performing CEB, open the chemical dosing pump, normal backwash, dosing pump should be closed
4: For CIP mold, all auto-valves close, open CIP manual valves

# Appendix 2. Installation guidance

Refer to the PureULTRA PHF-78-V datasheet for detailed module specifications.


**Fig. 17.** Module Assembly Instruction

### TABLE 5. MODULE PACKAGING LIST

Applicable module: PHF-78-V

| NO | Parts | PCS |
|---|---|---|
| 1 | PureULTRA PHF-78-V module | 1 |
| 1 | DN50 coupling, feed/permeate/reject (plastic part is fragile—disposable accessories without warranty） | 3 |
| 2 | DN50 coupling plug | 3 |
| 2 | Accessary package (optional) | 1 |
| 1 | Air tube quick connector | 1 |
| 2 | Module tube bracket | 2 |
| 3 | Module fixing belt | 2 |

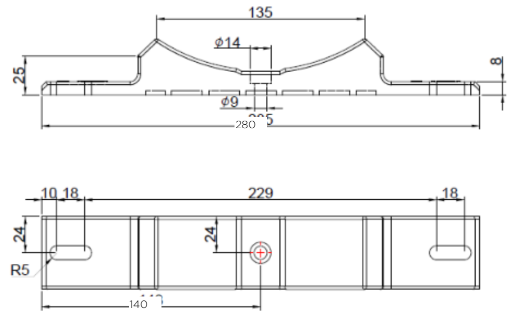


**Fig. 18.** Module Tube Bracket

### INSTALLATION INSTRUCTIONS

1. Maintain a bottom support 100–150-mm center-to-center distance to seat the module on the skid.
2. Fixing belt installation: Drill two Ø10-mm holes on the skid frame (see Fig. 18). Install the fixing belt with an M8 bolt (optional 90-mm bolt is supplied by MANN+HUMMEL).
3. Disassemble the coupling plugs on the feed, permeate, and reject ports. Drain the preservatives from the module. Keep the coupling plugs for future use.
4. Install the module on the skid for bottom support.
5. Connect the module feed, permeate, and reject ports to the skid with DN50 coupling connectors and EPDM sealings.
6. Remove the air inlet plug on the bottom cap and connect the air tube quick connector. Keep the air inlet plug for future use.
7. Ensure the module tube is seated on the bracket, tighten the bolts, and secure the module to the skid using the fixing belts.

### NOTES

1. Properly handle the module during transportation and installation. Add or replace the preservatives following the guidance in the user manual if leakage occurred.
2. Flush and clean the skid pipeline system before module installation.
3. The protection liquid is 1% sodium metabisulfite. For both the installation workers and the environment, please carry out the necessary precautions according to the chemical safety instructions.

# Appendix 3. UF system operating and cleaning log sheet

## OPERATION RECORD FORM

| | | |
|---|---|---|
| Project Name: | | |
| System: | | |
| Rack No: | | |
| Total System Me | | $m^2$ |

## FEED WATER QUALITY

Date Collected:

| | Nominal | Max | | Nomina | Max |
|---|---|---|---|---|---|
| TDS (ppm) | | | Conductivity (µs/cm) | | |
| TSS (ppm)** | | | Turbidity (NTU)** | | |
| COD (ppm) | | | $SDI_{15}$** | | |
| BOD (ppm) | | | pH** | | |
| Hardness (ppm) | | | Temperature (°C)** | | |
| Others: | | | Others: | | |

| | | | OPERATION SETTING | | | | | FILTRATION CYCLE | | | | | | | | | | | HYDRAULIC CLEANING | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SN | Date | Time | Filtration Time | Air Scouring Time | Drain Time | Backwash Time | Forward Flush Time | Product Flow | Filtration Flux* | Pressure (Before Pre-Filter) P0 | Pressure (Before Feed Port) P1 | Pressure (After Reject Port) P2 | Pressure (After Permeate Port) P3 | TMP* (P1+P2)/2-P3 | Turbidity (NTU) | | $SDI_{15}$ | | Air Scouring Flow | Pressure (Air Blower) P4 | Back wash Flow | Back wash Flux | Pressure (BW Inlet) P3 | Pressure (BW outlet) P4 | TMP* (P3-P4) | Forward Flush Flow |
| | dd:mm:yy | hh:mm | min | sec | sec | sec | sec | $m^3/h$ | lmh | psi/bar g | psi/bar g | psi/bar g | psi/bar g | ΔP psi/ bar g | Feed | Permeate | Feed | Permeate | $Nm^3/h$ | psi/bar g | $m^3/h$ | lmh | psi/bar g | psi/bar g | psi/ ba | $m^3/h$ |
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Footnote:

1) $System\ Flux = \frac{Product\ Flow\ Rate\ \left(\frac{m^3}{h}\right)}{Total\ System\ Cardridge\ Surface\ Area\ (m^2)} x \frac{1000L}{1m^3}$

2) Grey shaded cells are to be calculated

## CIP

| SN | Date | Time | Op. Day after last CIP | Temp | Solution pH | NaClO Concentration | Feed Flow (Recirc.) | Feed Time (Recirc.) | Pressure (CIP In) PI | Reject Flow (Recirc.) | Permeate Flow (Recirc.) | Air Scouring Time | Air Scouring Flow | Pressure (Air Blower) P4 | Soaking Duration | Chem. Vol | Acid | Caustic | NaClO | Others | Water Source | Flow | Duration | Reject NaClO Concentration | Reject pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Operation Setting** | | | | | | | | | | | | | | | | **Cleaning Chemicals** | | | | **Final Rinse** | | | | |
| | dd:mm:yy | hh:mm | day | °C | - | ppm | $m^3/h$ | min | psi/bar g | $m^3/h$ | $m^3/h$ | sec | $Nm^3/h$ | psi/bar g | min | L | (%/L) | (%/L) | (%/L) | (%/L) | - | $m^3/h$ | min | ppm | - |
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## CEB

| | | | | | | | | | | | Operation Setting | | | | | | | | | | Cleaning Chemicals | | | | | Final Rinse | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SN | Date | Time | Op. Hr after last CEB | Temp | Air Scouring Time | Air Scouring Flow | Pressure (Air Blower) P4 | Drain Time | Solution pH | NaClO Concentration | CEB Flowrate | Backwash Time | Pressure (BW Inlet) P3 | Pressure (BW outlet) P4 | TMP* (P3-P4) | Dosing Pump Rate | Duration (Dosing) | Duration (Soaking) | Chem. Vol | Acid | Caustic | NaClO | Others | Water Source | Flow | Duration | Reject NaClO Concentration | Reject pH |
| | dd:mm:yy | hh:mm | Hr | °C | sec | Nm$^3$/h | psi/bar g | sec | - | ppm | m$^3$/h | sec | psi/bar g | psi/bar g | ΔP psi/ bar g | L/h | sec | min | L | (%/L) | (%/L) | (%/L) | (%/L) | - | m$^3$/h | min | ppm | - |
| 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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