TECHNICAL CATALOGUE / ENGLISH

PVDF Technical handbook

Design, installation, operation and membrane care

Technical guidance in clear chapters, with operating tables, process diagrams and maintenance procedures.

30
TECHNICAL CHAPTERS

UF
PVDF TECHNOLOGY

EN
ENGLISH EDITION

TECHNICAL HANDBOOK | NOVEMBER 2026
Companion to the Neptuno PVDF product catalogue

Your handbook at a glance

Design, installation, operation and membrane care.

Use the chapters below to plan, operate and maintain a PVDF ultrafiltration system. Model-specific data and engineering drawings are in the separate Neptuno PVDF product catalogue.

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Ultrafiltration principles and terminology

UF uses a porous asymmetric membrane and differential pressure to separate constituents by mechanical sieving. General background ranges: pressure 0.01-0.3 MPa, pore size 0.002-0.1 µm, molecular weight cut-off 1,000-100,000 Da. Ultrafiltration applications also cover 1,000-500,000 Da and approximately 0.005-0.1 µm. These describe UF technology, rather than model specifications.

Separation occurs without phase change and may operate at ambient temperature, supporting low energy use and heat-sensitive liquids. UF targets microorganisms, colloids, particles, proteins and large organics. Retention also depends on solute size, shape and flexibility; solution pH, charge and composition; and membrane structure, charge and hydrophilicity.

Common membrane materials include PVDF, PES, PP, PE, PS, PAN and PVC. Chemical stability determines exposure tolerance and cleaning choices; hydrophilicity influences organic adsorption. Asymmetric membranes combine a thin dense filtration layer and a porous support, promoting surface filtration and cleaning recovery. Bubble-point testing characterizes pore size and integrity.

Module design balances packing density, concentration polarization, cleanability, feed tolerance and cost. Hollow fibers predominate; tubular and spiral alternatives exist. Outside-in feed flows between fibers with free movement space and higher suspended-solids tolerance. Inside-out feed flows through lumens and requires stronger limits on feed particle size and concentration.

Dead-end filtration suits cleaner, lower-loading feed with simple operation and low energy. Crossflow sends part of the feed tangentially along the surface to carry away retained material, suiting poorer, higher-solids sources. Forward flush, backwash, air scour, CEB and CIP remove accumulated foulants.

Definitions

Term	Meaning
Feed	Water entering UF.
Permeate	Water passing through the membrane.
Flux	Permeate volume per membrane area per hour; LMH = $L/m^2 \cdot h$.
TMP	Average pressure difference across membrane; for dead-end filtration: inlet pressure minus permeate outlet pressure.
Backwash	Water equal to or better than permeate flows from permeate to feed side.
Air scour	Oil-free compressed air on the feed side agitates water and loosens deposits.
Chemical cleaning	Chemicals contact fiber outer surfaces through circulation and soaking.
Recovery	Permeate flow / feed flow × 100%.

PVDF technology

01 Hydrophilic separation

Hydrophilically modified PVDF hollow fibers combine small pores, chemical stability, oxidation resistance and mechanical strength. A stable hydration layer reduces organic adsorption and improves cleaning recovery.

02 Outside-in architecture

Outside-in architecture provides free movement space between fibers, reduced channel-blockage risk and effective air/water scrubbing. Potting and high-strength fibers support cleaning recovery.
Corrosion-resistant housing provides strength without an additional pressure vessel.

03 Selection by duty

Choose area, dimensions, hydraulic performance and equipment arrangement using feed quality, capacity and operating cost. Smaller areas support compact systems; larger modules support large industrial duties.

Pretreatment selection

UF does not directly remove dissolved substances. Dissolved pollutants must first be converted to suspended or colloidal forms for UF removal. For primarily microorganisms and particles, install a 100-400 µm upstream prefilter; self-cleaning, bag, cartridge or disc filters are options.

Coagulation/flocculation, clarification/sedimentation, flotation or granular media filtration may be added for source variability. Coagulation uses rapidly mixed iron/aluminum salts to destabilize particles; gentle flocculation grows removable flocs. Cationic, anionic or nonionic polymers may be used.

1. **Characterise feed**
2. **Prefilter**
3. **Condition if required**
4. **UF filtration**

Prefiltration guidance

Water source	Accuracy
Well / groundwater	≤400 µm
Municipal water	≤400 µm
Surface water	≤400 µm
Seawater	100-400 µm; 100-150 µm to limit pipe/tank biofouling
Wastewater reuse	≤400 µm

Determine actual filtration accuracy from water quality and project requirements.

Clarification, flotation and media filtration

Clarification/sedimentation removes particulate/colloidal material after coagulation or settleable solids. The process is used at average turbidity >30 NTU or peak >50 NTU, typically achieving <2 NTU and SDI <6 with 2-4 h retention.

Inclined-plate settlers use 60° plates at 5 cm spacing, typically reducing footprint 65-80% and suiting turbidity >50 NTU. Ballasted floc systems add fine sand or other high-density insoluble media to accelerate floc growth and settling, with short detention and shock-load tolerance.

DAF uses approximately 50 µm microbubbles to float coagulated solids. It suits slowly settling light particles, NOM, algae or oils in water <50 NTU and typically produces clarified water <0.5 NTU.

Granular media filtration captures particles on sand, pumice, anthracite or other grains. Proper design/operation typically removes 90-99% of particles, suspended solids and colloids.

Media filtration guidance

Arrangement	Design guidance
Single media	Fine sand; feed turbidity <2 NTU and TSS <3 mg/L.
Dual media	Sand effective size 0.35-0.5 mm; anthracite 0.7-0.8 mm. Anthracite over sand improves depth filtration. Minimum total bed depth 0.8 m; typical layers 0.5 m sand + 0.4 m anthracite.
Two stage	Recommended at turbidity >20 NTU and TOC >6 mg/L. Coarse first stage removes 60-80% suspended solids; polishing second stage removes up to 99% of remaining fines. TOC removal 20-30%, or approximately 50% with top GAC layer. Typical effluent <0.1 NTU.

Design basis and data collection

Provide pretreatment, UF modules, backwash, air scour, chemical dosing and CIP. NF/RO may follow for salt removal or ion exchange for selected ions. Evaluate permeate flux, quality and TMP together with feed composition, temperature and pressure. Higher flux increases TMP, fouling and cleaning. Comparable operating experience and pilot testing are recommended, particularly for difficult waters or large projects.

Record project name/contact/location, new/pilot/upgrade/expansion status, industry, design production and requirements. Identify groundwater, river, lake/reservoir, seawater, municipal water, municipal wastewater or industrial wastewater source. Document pretreatment and flocculant/coagulant aid/disinfectant addition.

Design-report metadata: project name, record date, contact name, phone, email, project location, designed water production (m^3/h), other requirements/instructions and project status (new, pilot, upgrade, expansion or other).

Application selections: power, petrochemical, metallurgical, electronics, food and drinks, pharmaceutical, municipal tap water and wastewater reuse. Water-source selections also include “other”. Record water-source overview, analysis-unit name, analyst, sample date and other/remarks; describe the pretreatment process and current operating status.

Raw-water report

Fields	Record basis
Conductivity, pH, sample temperature; analytical unit, analyst and date	Design, minimum, maximum and remarks.
Temperature, pH, TDS, TSS, turbidity, oil & grease, COD, BOD5, TOC, DOC, total iron and total manganese	Use °C, NTU and mg/L as appropriate.

System operating conditions

Design basis / maximum limits

Parameter	Design basis	Maximum limit
TSS	<50 mg/L	100 mg/L
Turbidity	<50 NTU	300 NTU
TOC	<10 mg/L	40 mg/L
Feed particle size	150 µm	400 µm
Continuous-operation pH	6-9	1-11
Short-term-cleaning pH	1-12	1-13
Temperature	25 °C	1-40 °C
Operating pressure	3 bar	6 bar
TMP	0.4-2.0 bar	3.0 bar
Short-term free chlorine	2000 mg/L	5000 mg/L

Optimize design basis for source type; assess performance impacts at maximum water-quality loads. COD influence varies with water source.

Typical cleaning conditions

Physical cleaning

Operation	Parameter	Value
Backwash	Interval	20-60 min
Backwash	Duration	0.5-2 min/cycle
Backwash	Flux	100-150 LMH
Backwash	Maximum pressure	2.5 bar
Forward flush, 8 in module	Flow	1.8-4.0 m^3/h
Forward flush	Duration	20-60 s/cycle
Forward flush	Frequency	Combined with filtration/backwash
Air scour	Maximum inlet pressure in table	2.5 bar/module
Air scour	Flow	5-12 Nm^3/h/module
Air scour	Duration	20-60 s/cycle
Air scour	Frequency	Generally synchronized with backwash
Air scour	Inlet-pressure guidance	≤1.0 bar; oil-free air

Chemical cleaning

Operation	Parameter	Value
CEB	Frequency	Optimize from trials and operation
CEB	Soak	5-10 min
CEB	Acid	0.1% HCl, pH 2
CEB	Alkali	0.05% NaOH + 0.1% NaClO, pH 12

Typical cleaning conditions

Operation	Parameter	Value
CIP	Trigger	Normalized TMP +1.0 bar or permeate -25%, unrecovered by backwash/CEB; or operating TMP 2.1 bar
CIP	Duration	60-90 min; extend for severe fouling
CIP	Acid	1-2% citric acid OR 1-2% oxalic acid OR 0.2% HCl, pH 2
CIP	Alkali	0.1% NaOH + 0.2% NaClO as active chlorine, pH 12
CIP, 8 in module	Flow	1.5-2.0 m^3/h/module
CIP	Chemical temperature	10-40 °C
CIP	Recommended acid wash	30-40 °C
CIP	Recommended alkali wash	30-35 °C

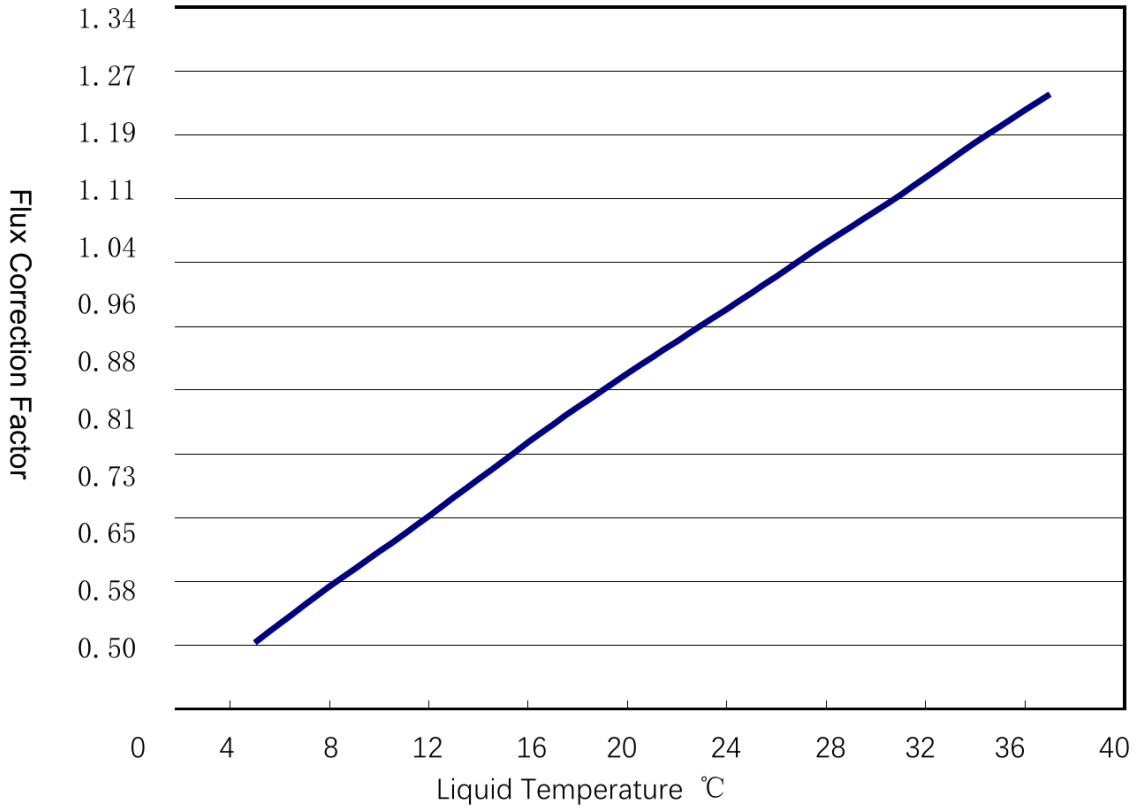
Adjust chemical selection to feed/fouling. Excess temperature may cause irreversible damage or leakage.

Temperature normalization

Water viscosity varies with temperature, affecting flux and required TMP. The temperature-correction curve uses 25 °C as baseline, correction factor 1. Normalized flux = actual-temperature flux / flux correction factor.

At constant TMP: design flux 80 LMH at 25 °C; correction factor at 14 °C = 0.776; flux = 80 × 0.776 = 62.08 LMH.

At constant 80 LMH: TMP 0.5 bar at 30 °C; TMP correction factor 0.92 at 30 °C and 1.25 at 15 °C; TMP at 15 °C = 0.5 / 0.92 × 1.25 ≈0.68 bar.



Temperature-correction curve. Baseline: 25 °C, factor 1.

Backwash and chemical dosing equipment

Provide backwash, CEB dosing as needed, CIP and compressed air. Backwash equipment comprises a tank, pump and NaClO dosing unit. Prefer UF permeate; the product-water tank may also supply backwash water.

Size pump flow from flux × total membrane area; design backwash flux 100-150 LMH. Include piping losses, generally targeting approximately 2.0 bar at the UF inlet. Stainless-steel wetted pump parts are recommended.

NaClO dosing options: continuous 1-5 ppm in feed; daily shock 10-15 ppm for 30-60 min; or 10-15 ppm in backwash water. Provide >24 h chemical storage, low-level alarm/pump stop and dosing-pump pressure above injection-point pressure.

Acid CEB targets Fe/Al colloids and hardness. Dosing-pump sizing is based on backwash flow to achieve 0.5-1% oxalic acid, 0.5-1% citric acid or 0.1% HCl. Severe fouling may require stronger/longer treatment within CIP concentrations. Provide >24 h storage and low-level alarm/interlock.

Alkali/biocide CEB targets organic/biological fouling: 0.1% NaClO + 0.05% NaOH. Severe fouling may require longer soaking or higher NaClO, recommended not above 0.2%. Provide >24 h storage, low-level alarm/interlock and adequate injection pressure.

Acid and alkali/biocide dosing may use a metering pump or, where a higher flow is required, a magnetic-drive pump. Size the pump from backwash flow and target soaking concentration.

CIP skid and compressed air

CIP is required when normalized TMP rises 1.0 bar or normalized permeate declines 25-35% and routine backwash/CEB cannot restore performance. Take the unit offline. The cleaning skid normally comprises tank, pump and filter; manual or automatic operation may be used.

Size cleaning tank for module internal water volume plus piping/filter volume and margin. Cleaning-pump design flow 1-2 m^3/h per module × number of modules. Include piping losses and generally keep inlet pressure ≤3 bar. Use stainless-steel or corrosion-resistant wetted pump parts. Select filter flow to match pump; stainless-steel/corrosion-resistant plastic construction.

Use clean compressed air; remove entrained oil, solids and moisture. Piston/screw positive-displacement compressors are common. The compressed-air equipment design uses a maximum air-inlet pressure of 1.5 bar and air intensity 5-12 Nm^3/h per module.

Air compressors may be positive-displacement or dynamic machines; piston and screw positive-displacement designs are commonly used.

Handling, installation and removal

Prepare rubber safety boots, gloves, goggles, wrenches, screwdrivers, rubber mallet and safety utility knife. Support piping so modules carry no added loads. Remove dust, abrasives, grease and metal chips. Confirm pretreatment, auxiliary equipment and chemicals are ready. Open packaging only shortly before commissioning.

Handle without drops/impact; check accessories. Drain shipping preservative through plugged/clamped ports and dispose correctly. Retain plugs for future isolation or returns. Use installation detail drawings for mounting.

Procedure

01. Bolt base plate to support frame.

02. Install pad-block feet in drilled holes with rubber mallet.

03. Fix one clamp-strap end; leave the second loose.

04. Place drained module on base plate and align axially.

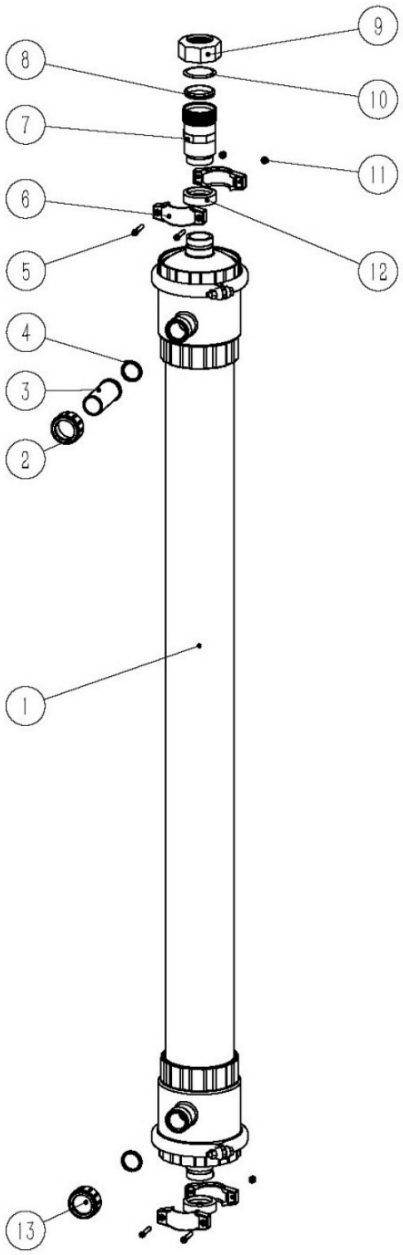
05. Secure strap with full rubber surface against module body.

06. Fit optional top cover if required.

07. Connect inlet/outlet pipes with clamp sleeves/gaskets without torsion/tension on ports. Remove bottom air-port plug; fit quick connector/combination washer and air pipe.

08. Repeat for all modules. For removal, use two people, disconnect water/air connections, release strap and lift carefully. Seal exposed module/pipe ports with retained plugs where needed.

Module assembly



1	Module Body
2	Side Nut
3	Side Joint
4	Side O Ring
5	Hex Socket Bolt
6	Coupling
7	TP Joint
8	TP Gasket
9	TP Nut
10	TP Pad
11	Hexagon Nut
12	Coupling Gasket
13	Blind Plate

Exploded module assembly and component key.

Fouling mechanisms and response

Fouling produces rising TMP at constant flux, or declining flux at constant pressure. Mechanisms include surface cake, pore-wall adsorption and pore blockage. A loose layer of large particles washes away more easily; the fine gel layer directly at the membrane covers pores and increases resistance. Fine-particle entry/adsorption may become irreversible.

Causes include poor pretreatment, excess coagulant, unsuitable pump/piping materials, dosing malfunction, insufficient backwash/CEB, excessive flux/pressure, long-term deposits, seasonal algae, feed changes, oil/inorganic deposits, biofilms and poor shutdown preservation/drying.

Identify foulants from normalized operating data, feed analysis, past cleaning effectiveness, SDI filter deposits, wash waste and module inlet deposits. Reddish brown may indicate iron; sludge/gel suggests biological/organic fouling. Delayed cleaning may make deposits resistant and damage modules/equipment.

Fouling prevention and cleaning

Type	Prevention	Cleaning
Particulate: suspended solids, colloids, turbidity	Coagulation, clarification, media filtration	Air scour / backwash
Biological: organisms and sticky biofilm	Microbial control, online chlorination, nutrient removal with PAC/GAC, coagulation	CEB/CIP with oxidants/biocides; examples include NaClO, Cl2, H2O2, NaHSO3
Inorganic: Ca, Mg, Fe, Mn deposits	Oxidation/precipitation + filtration; low-hardness alkaline CEB water where relevant	Acid CEB/CIP: HCl, H2SO4, citric or oxalic acid
Organic: silt, organic acids, humics, surfactants, detergents, polymers, tannins	Coagulation, PAC/GAC	Alkaline CEB/CIP, e.g. NaOH

Contact Neptuno before selecting PAC grades, as unsuitable grades may damage membranes.

Routine filtration and cleaning flow paths

1	2	3	4	5	6
Filtration	Air scour	Drain	Top backwash	Bottom backwash	Forward flush

Normal operation is typically dead-end at constant flux. Retained solids raise TMP, so execute timed air-scour-assisted backwash. During instantaneous dead-end filtration, all feed is filtered.

Startup forward flush: 2-3 min, from lower inlet along fiber outer surfaces to top concentrate outlet without filtration, removing chemicals and trapped air. Filtration generally lasts 30-60 min, adjusted to feed and cleaning regime.

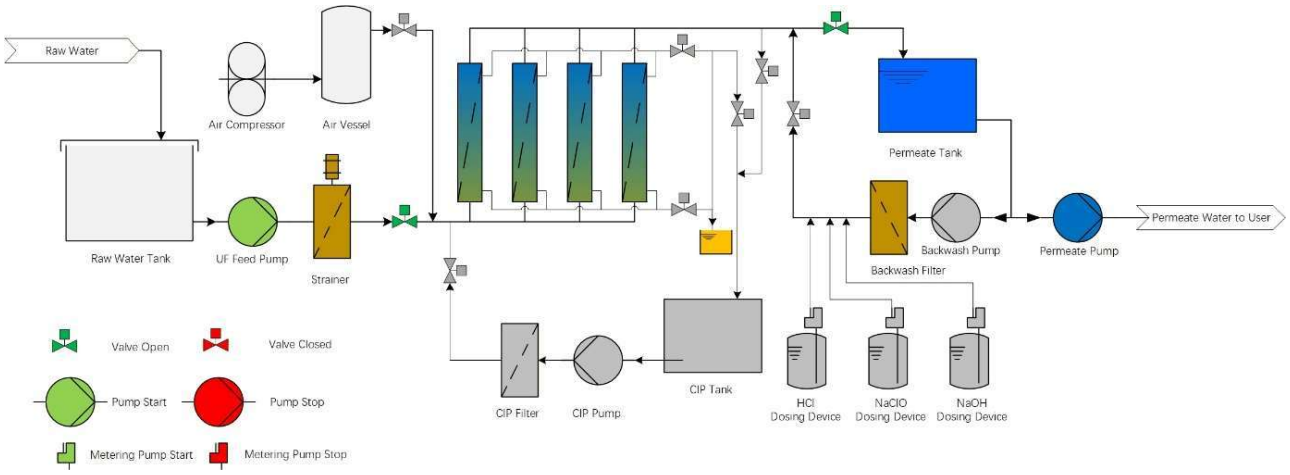
Air scour enters the bottom shell side, creates rising bubbles and vents from top concentrate outlet. Stop air before draining. Open bottom drain to remove shell water and loosened foulants by gravity; dispose waste correctly.

Upper backwash: permeate-quality water enters lumens from upper permeate port, reverses through fiber walls and exits upper concentrate outlet. Lower backwash: upper permeate supply continues, with wastewater discharged from lower feed inlet. Adjust duration/flow/pressure to fouling without overstressing fibers.

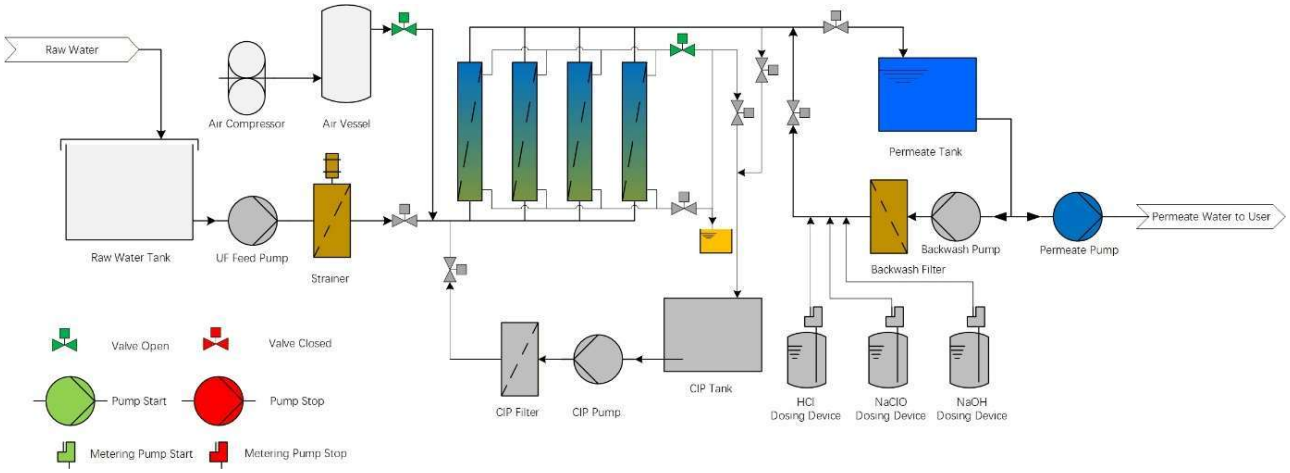
Forward flush after backwash runs from lower feed inlet to top concentrate outlet, removing residual foulants, chemicals and trapped air before filtration or standby.

Flow paths

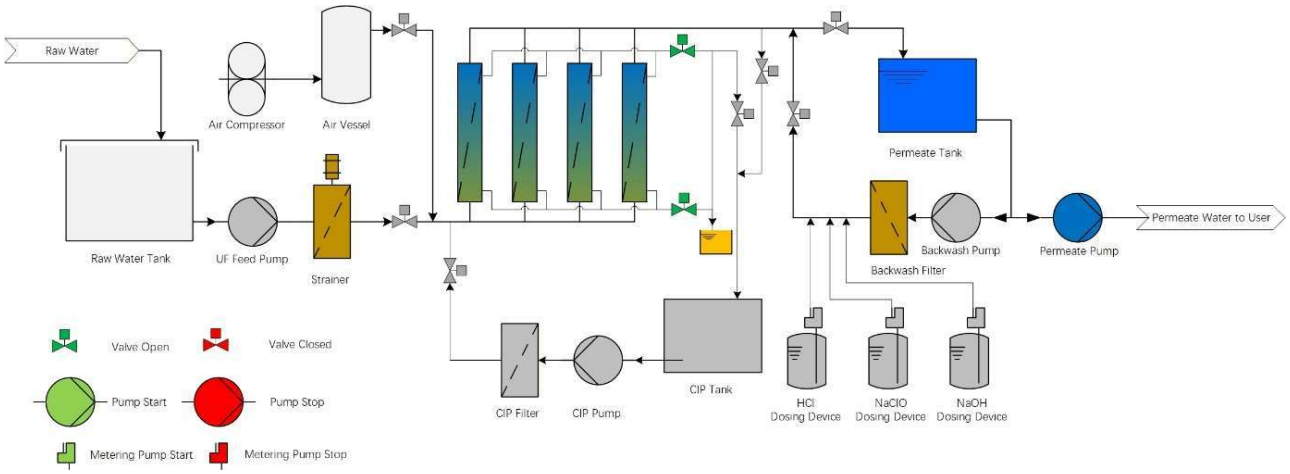
Filtration



Air scrubbing

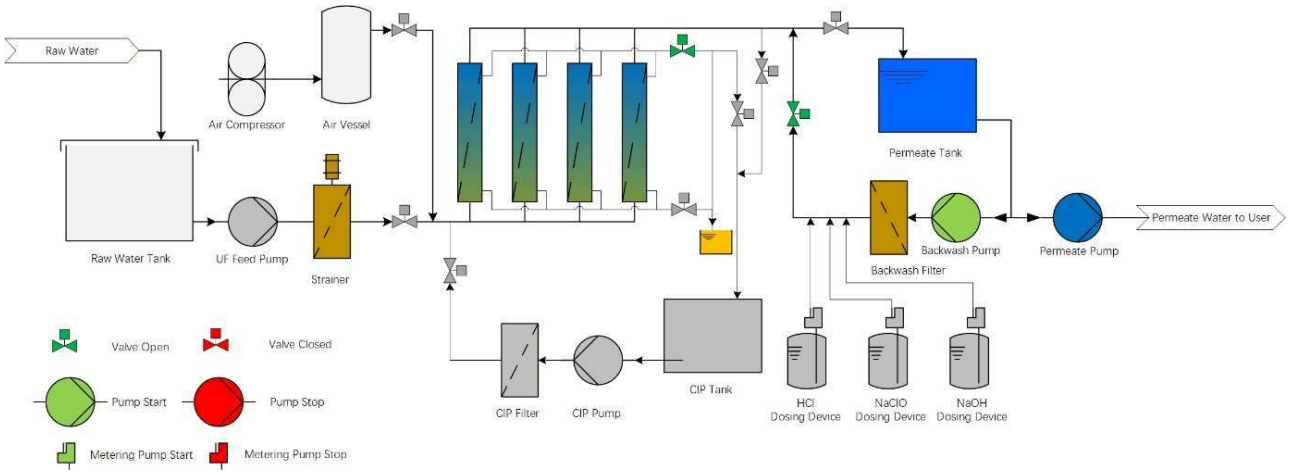


Bottom drain

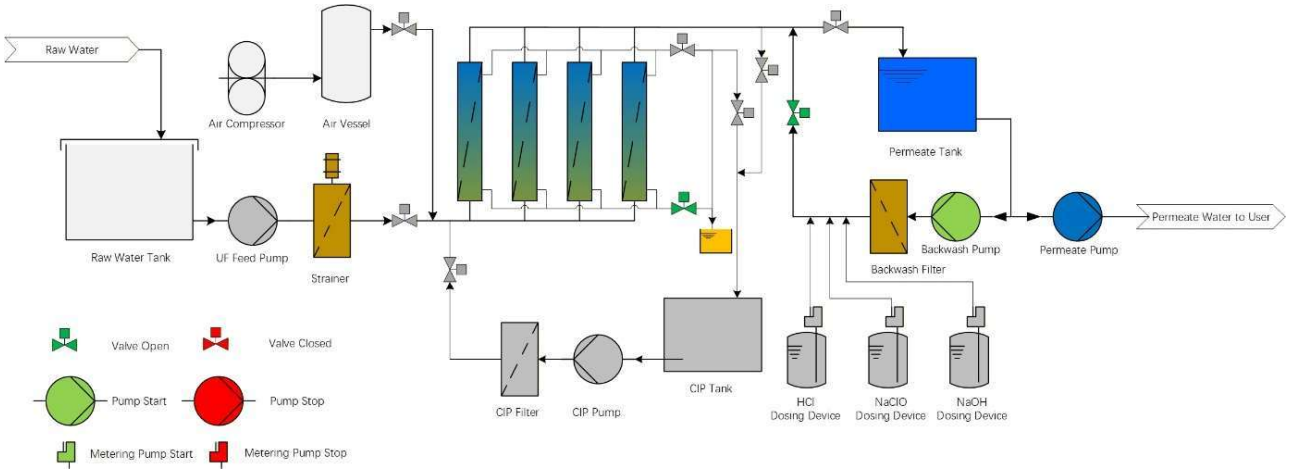


Flow paths

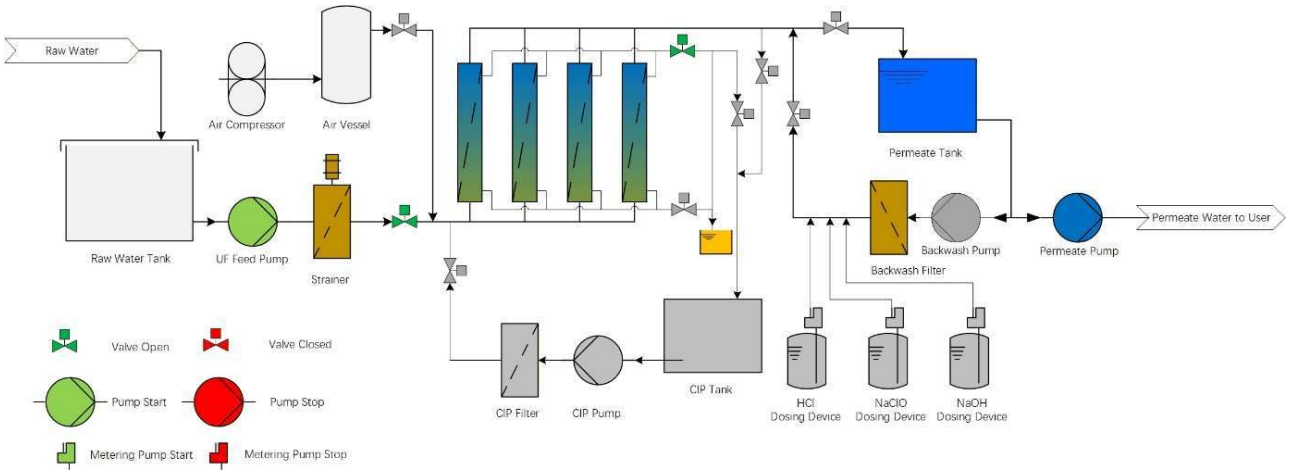
Top backwash



Bottom backwash



Forward flush



Routine control sequence

Operating program

Step	Duration	Flow	On / open
Initial forward flush	2-3 min	2.0-4.0 m^3/h	Feed pump; forward-flush valve; forward-flush discharge
Filtration	30-60 min	40-120 LMH	Feed pump; feed inlet; permeate valve
Air scour	30-60 s	5-12 Nm^3/h/module	Air inlet; forward-flush discharge
Drain	30-30 s	Gravity	Forward-flush discharge; backwash discharge
Backwash 1	30-60 s	100-150 LMH	Backwash pump; backwash inlet; forward-flush discharge
Backwash 2	30-60 s	100-150 LMH	Backwash pump; backwash inlet; backwash discharge
Forward flush	30-60 s	2.0-4.0 m^3/h	Feed pump; forward-flush valve; forward-flush discharge
Filtration	30-60 min	40-120 LMH	Feed pump; feed inlet; permeate valve
Stop	-	-	All off/closed

Finalize the sequence and settings during commissioning. Repeat filtration→air→drain→BW1→BW2→flush→filtration; repeat cleaning stages as needed. Concentrate crossflow opens only for crossflow operation. Include valve travel time. CEB/CIP pumps remain off in routine sequence.

CEB and enhanced-flux maintenance

CEB adds chlorine, acid or alkali according to foulants and season. Typical frequency daily to weekly; very good feed may not require CEB. Trigger by timer, operational experience or TMP. Perform routine backwash first, then dose and completely fill the module, soak and execute full physical cleaning.

Main CEB process describes 5-10 min soaking; overview permits 5-20 min. Intermittent air scour, e.g. 5-10 s every 5 min, can improve contact. CEB may use lower flux, e.g. 80 LMH. After soaking, run air scour, drain, upper/lower backwash and forward flush; divert initial filtrate to waste when required.

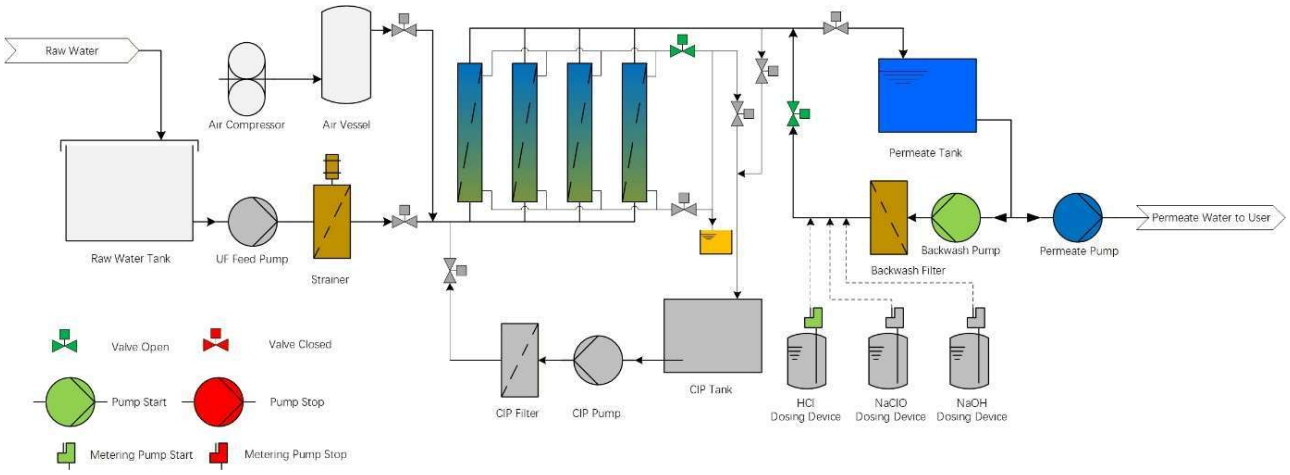
Alkaline CEB: 0.1% NaClO + 0.05% NaOH, pH 12 for organic/biological fouling. Acid CEB: 0.1% HCl or H2SO4, pH 2 for colloidal Fe/Al or hardness. Upper/lower chemical backwash follows corresponding physical-backwash outlet selection.

Enhanced-flux maintenance (EFM) uses existing CIP equipment for shorter, more frequent cleaning instead of CEB. Typically 1-3 times weekly, approximately 30 min including routine backwash, preheated circulation-soak-circulation with intermittent air, and final backwash. Automation is recommended. Full periodic CIP may still be needed.

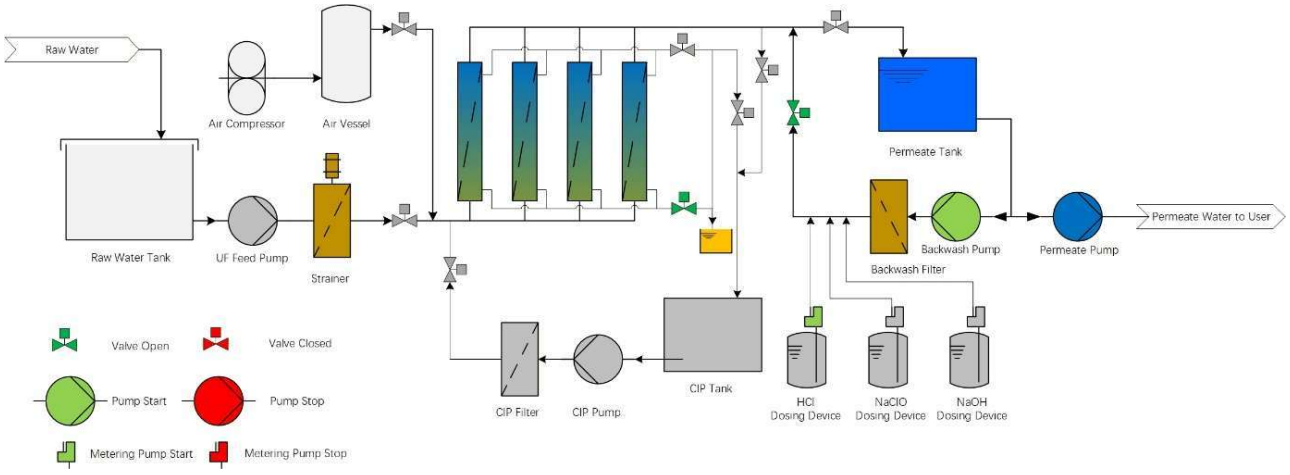
EFM benefits: improved recovery/availability, fewer CEB components, smaller footprint, heated circulation and chemical flexibility, possible RO/softened preparation water, reduced chemical use/wastewater and reduced downstream RO oxidation exposure.

Chemical cleaning flow paths

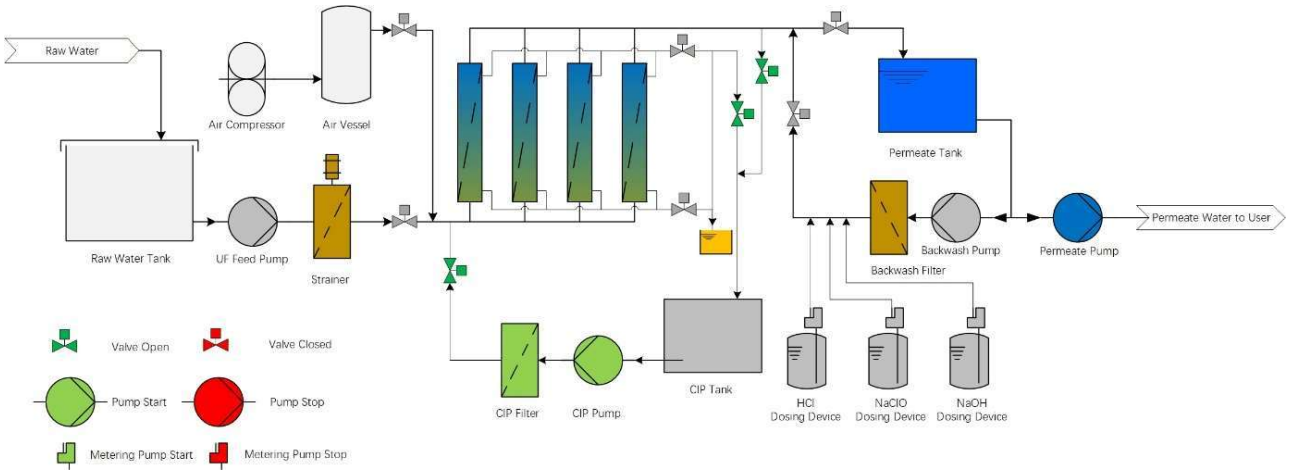
Upper chemical backwash



Lower chemical backwash



Cleaning in place



Commissioning, startup and shutdown

Procedure

01. Check pretreatment performance, drainage, module installation, piping cleanliness, instrument calibration, PLC logic, electrical and compressed-air systems.

02. Start with pumps off and valves closed. For preservative removal, open permeate and forward-flush discharge valves; start feed pump and slowly regulate flushing at feed pressure <1.5 bar until discharge is foam-free.

03. Commission manually. Establish maximum flow, pressure and backwash interval from feed/design. Initially produce 30-60% of design flow; after 24 h gradually increase to full design.

04. Open permeate valve and gradually regulate feed to production target. If used, slowly set crossflow/concentrate discharge. Startup text specifies TMP ≤2.1 bar.

05. With forward-flush discharge fully open, start backwash pump and gradually regulate backwash to ≤2 bar. With air inlet closed, set regulator to 1.0 bar.

06. Set backwash/air intervals; stagger parallel units. After manual settings, stop and restart in automatic. Verify permeate-pressure protection, opening forward-flush drain as required.

07. Manual stop: open forward-flush discharge for 15 s, then slowly close feed. Automatic shutdown occurs for pump non-start/not-auto, excessive inlet pressure or permeate backpressure and other interlocks.

08. For long shutdown prevent drying, microbes and temperature extremes; switch off control-cabinet power. Unprotected maximum downtime is 24 h. For 1-2 days, run 30-60 min daily or backwash daily. Detailed longer-term preservation follows in storage section.

09. After prolonged shutdown, flush continuously until foam-free and all preservative is removed.

Operating parameters and control states

Stable permeate requires qualified feed, appropriate parameters and timely cleaning. Set flux from feed loading. Excess backwash flow or air may rupture fibers. Operating guidance specifies backwash 100-150 LMH at inlet <2.0 bar; air 5-12 Nm^3/h/module at approximately 1.0 bar, maximum 2.5 bar.

Operating pressure limits: maximum TMP 2.1 bar, maximum feed 6.0 bar dependent on temperature, normal backwash 2.0 bar and maximum 2.5 bar, recommended air 1.0 bar and maximum 2.5 bar. Set backwash interval by commissioning/feed variability, typically 20-60 min.

Control states: standby (all valves closed, awaiting command), filtration and backwash. Stagger parallel-unit cleaning. Use manual control for commissioning, maintenance or special duties. Automatic PLC control stops feed/dosing pumps and closes valves on power loss; restored power returns system to standby.

Automatic shutdown: local/remote stop, feed-pump fault/not-auto, control-valve fault/not-auto, high inlet pressure, high permeate backpressure or high backwash pressure. Instruments supply switches or 4-20 mA signals to PLC.

Alarms and interlocks

PLC protection schedule

Signal	Trigger setting	Delay / action
Feed pressure	Normal inlet +2.0 bar; adjust range if needed, maximum 6.0 bar	5 s; alarm and standby
Permeate pressure	Normal outlet +2.0 bar	5 s alarm and open forward-flush drain; 10 s standby
TMP	Initial TMP +1.0 bar or 2.1 bar maximum	30 s; cleaning alarm; standby recommended if production allows
Backwash pressure / flow	Pressure at minimum backwash flow or maximum 2.5 bar; pump-specific	10 s; alarm and stop backwash pump
Chemical tank low level	Tank/application-specific	Alarm and stop dosing pump; UF may continue with dosing monitored
Automatic valve feedback	Expected feedback absent or lost	5-10 s per valve speed; alarm and standby
Air-scour pressure	Commissioned pressure +0.5 bar or 2.5 bar	10 s; alarm and skip air-scour step
Instrument air	<5.0 bar or valve minimum requirement	10 s; alarm and standby

Settings require equipment-specific commissioning.

Operating logs and maintenance records

Preserve data for traceability, troubleshooting and maintenance planning; follow the specific system O&M manual. Normalize performance to distinguish temperature effects from fouling.

Pretreatment: analyze inlet/outlet COD, turbidity, Fe/Mn and oil/fat at least weekly; log filter pressure loss twice daily; measure flocculant/coagulant/other chemical consumption daily; calibrate instruments at least quarterly; log abnormalities and shutdowns.

UF: at least once per shift record date/time/hours, feed temperature, feed/permeate/concentrate flow and pressure, inlet/permeate turbidity and product SDI. Analyze inlet/permeate at startup and weekly. Calibrate instruments quarterly and log abnormal SDI, turbidity, pressure or shutdowns.

Maintenance: date/work/personnel; fault symptoms/cause/remedy; replaced parts (date/name/specification/brand); added/replaced membranes (model/quantity/reason); calibration method/results/operator; pretreatment/instrument replacement (date/brand/grade/reason); chemical-cleaning date/duration/agent/concentration/pH/temperature/flow/pressure and before/after results.

Operator log fields

System details	Shift measurements
Pretreatment process; chemical type/dose; UF model; rack count; modules/rack; total area; date/time; cumulative operating hours; recorder	Feed temperature; prefilter inlet/outlet pressure; UF feed/permeate/concentrate pressure; permeate/concentrate/backwash/forward-flush flow; backwash and air-scour intervals; feed/permeate turbidity; feed TSS; permeate SDI.

Maintenance and troubleshooting

Gradual flow decline/TMP rise generally indicates fouling treatable by physical cleaning, CEB and CIP. Sudden changes suggest faults, operating errors or severe fouling requiring prompt action.

Calibrate pressure gauges regularly; correct abnormal readings. Inspect centrifugal-pump temperature, gaskets and leaks. Calibrate flow meters quarterly. Inspect automatic valves monthly for leaks/feedback. Monitor feed quality, UF flow/pressure and module leakage. Electrical work requires trained qualified personnel.

Fault diagnosis

Symptom	Causes / checks	Response
High TMP	Fouling; poor feed; incomplete backwash; high flux; cold water	Identify foulants; improve pretreatment; targeted acid/alkali cleaning; reduce flux; shorten backwash interval; normalize temperature effect.
Low permeate	Fouling/clogging; low feed pressure; leaks; meter fault; incorrect valve position; cold feed	Clean/replace modules as needed; regulate pressure; repair leaks; calibrate/replace meter; correct valves; account for temperature.
Poor permeate quality	Module damage; seal/connector leakage; broken fibers; poor pretreatment; cleaning residues	Integrity-test; repair/replace elements/seals; improve pretreatment; rinse fully.
Automatic operation failure	Pump wiring/not-auto; high feed pressure/switch fault; closed permeate valve/downstream not started; wrong setpoints; PLC fault	Check wiring/manual pump operation then auto; inspect pumps/switches; correct valves/downstream state; repair PLC logic.

Integrity testing

Fully wet pores before testing. Below bubble point, normal wet pores pass minimal diffusive air; broken fibers/defects pass air rapidly. Bubble-point equation: P = 4 cos(θ) B γ / d. Continuous bubbles or excessive gas-side pressure loss indicate leakage.

Bubble observation: fill/saturate module. Slowly introduce oil-free air on feed side from 0 bar while keeping permeate valve open. Observe permeate side as pressure rises to 1.5 bar; continuous bubbles indicate defect. Pressure-decay testing complements detection of small defects.

Pressure decay: fill/wet module. Slowly introduce oil-free air on feed side to 2.0 bar with permeate valve open; liquid displacement takes approximately 2 min. Once stable, stop/isolate air supply and retain permeate side vented. Hold 10 min. Pressure decline ≤0.2 bar satisfies integrity-test criterion; >0.2 bar indicates defect/leak. Applicable to individual modules or complete systems.

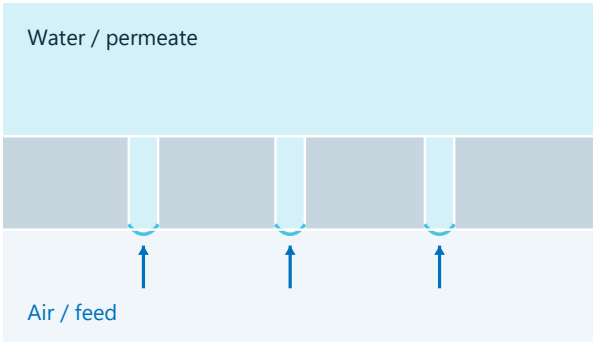
EQUATION

Bubble point

$$P = \frac{4 \cos(\theta)\, B\, \gamma}{d}$$

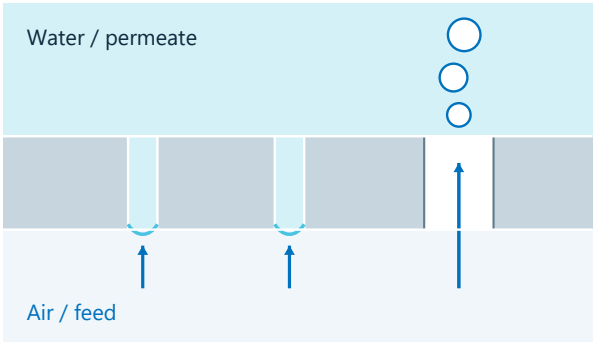
Wetted membrane: pressure below the bubble point

01 Intact pores



No continuous bubbling through wetted pores.

02 Defect or break



Continuous bubbling through the defect.

PRESSURE-DECAY TEST

Stabilise	Air supply	Hold	Acceptance limit
2.0 bar →	**Isolated** →	**10 min** →	**≤0.2 bar**

Keep the permeate side vented during the hold.

Fiber repair

Breakage may result from transport vibration/impact, abrasive sand, excessive TMP/flux/temperature, water hammer, thermal shock or chemical attack. Repair prevents feed bypass into permeate.

Prepare a membrane repair kit (concentrate-pipe blind plate, glue, needles), water at least UF-permeate quality, oil-free air (ISO8573-1 class 1/3/1 for oil/water/particles), connection piping if off-skid, gloves and goggles.

Procedure

01. Drain feed side; remove top cap, leaving bottom cap intact; close valves and seal other openings.

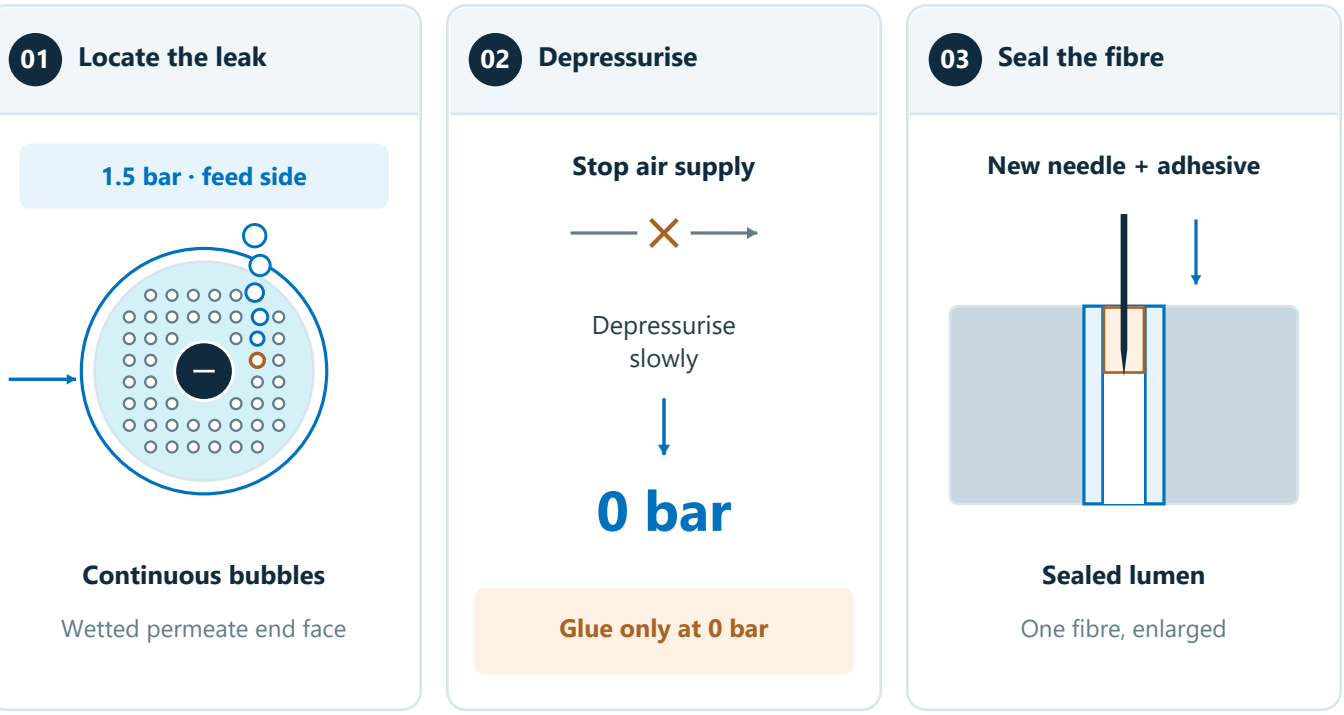
02. Fit positioning block, clamping nut and plug in concentrate center pipe; tighten leak-detection assembly clamping bolt.

03. Connect air; slowly raise to 1.5 bar (21 psi). Rinse permeate fiber end face to locate continuous bubbles.

04. Mark leaks with needles; continue water/air until all leaks are identified.

05. Slowly depressurize through relief valve before gluing. Remove leak-detection plug if access is obstructed.

06. Dip new needle in glue; quickly replace marking needle and insert tightly into leaking fiber to seal.



CIP selection and chemical envelope

When backwash/CEB cannot restore performance, clean at normalized permeate decline 25%, normalized TMP rise 1.0 bar, or operating TMP 2.1 bar. Check temperature normalization first; cold-water flow decline alone need not indicate fouling. Use a normalization tool to assess operating performance.

Follow approved chemical handling/disposal procedures. Fully dissolve/mix solution before contact. The cleaning safety section specifies alkaline pH ≤12 and temperature ≤35 °C; acidic pH ≥2 and temperature ≤40 °C.

For desalination, prefer RO permeate for solution preparation. Assess potable or UF water alternatives. Account for buffering/alkalinity when adjusting acid to pH 2 or alkali to pH 12. Measure permeability before/after cleaning.

Cleaning-agent selection

Agent	Cleaning recipe	Application
1	0.2% w/w HCl	Inorganic fouling; also colloidal deposits
2	2% w/w citric acid	Alternative for inorganic/metal deposits; some colloidal fouling
3	2% w/w oxalic acid	Alternative for inorganic fouling
4	0.2% w/w NaClO + 0.1% w/w NaOH; pH 12, maximum 35 °C	Organic/microbial fouling. For metal/organic mixed fouling: acid first, followed by this alkaline step.

CIP operational overview

CIP frequency typically 1-3 months, depending on feed and performance. First repeat air scour, drain, upper/lower backwash 3-8 times to remove loose deposits. Gravity-drain residual water to prevent chemical dilution.

Operational overview: circulate from feed side to cleaning tank for 30 min, returning some permeate; solution may be heated to 40 °C. Soak ≥60 min depending on fouling, then recirculate 30 min. Air scour/drain, upper/lower backwash and forward flush remove residues.

Discharge initial permeate before downstream RO after cleaning, because oxidants can remain on the permeate side. When both acid and alkali are needed, execute separate complete cleaning steps.

Detailed CIP execution

1	2	3	4	5	6
Prepare	Backwash	Circulate	Soak	Rinse	Restart

Allow approximately 6 h per chemical-cleaning cycle including preparation/setup. Record online permeability before/after cleaning.

Assess the change in membrane permeability before and after cleaning using the a normalization tool or an estimate from feed and permeate pressures and flows.

Procedure

01. Install and verify a 5 or 10 µm cartridge in cleaning filter.

02. Prepare/preheat solution; open cleaning recirculation valve to mix. Prefer RO permeate for desalination applications; potable or UF water may be alternatives.

03. Perform routine backwash.

04. Shut down UF by standard procedure; confirm valve positions.

05. Open forward-flush/backwash drains, empty water, then close drains.

06. Slowly open chemical feed, concentrate-return and permeate-return valves; start CIP pump; gradually close recirculation/bypass to introduce warm solution at low flow/pressure and displace water.

07. Adjust circulation to cleaning flow. At stable temperature, check/adjust pH if deviation is ±1. With NaClO, check residual chlorine and replenish below 75% of target. Typical circulation 1 h according to fouling.

08. Stop CIP pump and tank heater; close relevant valves. Typical soak 2 h, extend overnight for severe fouling. Extended soaking may use low-flow circulation at 10% of cleaning flow. Apply 5 min air scour every 30 min, with forward-flush drain open for venting.

09. Recirculate 30 min at same flow as step 7.

10. Drain/refill tank with RO, potable or UF water. Repeat low-flow introduction/recirculation for 10 min to rinse.

11. Perform routine backwash.

12. Return to operation or standby.

CIP equipment matrix

CIP equipment status

Step	UF feed	UF BW	UF drain	CIP pump	Heater	CIP feed	Conc. return	Perm. return	Recirc.
1 Filter check	O	X	X	X	X	X	X	X	X
2 Prepare solution	O	X	X	O	O	X	X	X	O
3 Routine backwash	X	O	X	O	O	X	X	X	O
4 Shutdown	X	X	X	O	O	X	X	X	O
5 Drain	X	X	X	O	O	X	X	X	O
6 Low-flow fill	X	X	X	O	O	O	O	O	O
7 Recirculate	X	X	X	O	O	O	O	O	O
8 Soak	X	X	O	X	X	X	X	X	X
9 Recirculate	X	X	X	O	O	O	O	O	O
10 Rinse	X	X	X	O	X	O	O	O	O
11 Routine backwash	X	O	X	X	X	X	X	X	X
12 Operation/standby	O	X	X	X	X	X	X	X	X

O = open/on; X = closed/off. Status depends on previous sequence steps and changes for low-flow recirculation during extended soak. Open forward-flush drain during intermittent air scour.

Packaging, transport and new-module storage

Keep membranes hydrated; preserve original factory packaging until immediately before commissioning. Contact Neptuno for long-term preservation guidance and train operators/engineers. Follow preservative SDS and wear eye protection.

Individual modules are enclosed in moisture-protective plastic bags and shock-protective rigid cardboard boxes. Factory preservative: 1% wt food-grade sodium metabisulfite. Keep bags/seals intact to prevent leakage and contamination.

Transport flat, avoid impacts/drops, protect from sun/rain, and stack at most 4 layers. Transport environment must be above 0 °C; contact Neptuno if freezing is possible.

Store unopened modules flat indoors on clean floor, away from heat/cold/corrosives/contaminants. Storage 5-40 °C, ideal 20-35 °C. Under these conditions unopened new modules may be stored up to 18 months.

Shutdown preservation and restart

Preservation plan

Shutdown	Preservation procedure
1-2 days	Run 30-60 min daily or backwash once daily.
2-7 days	Thorough air scour/backwash; close inlet/outlet and operate 30-60 min daily; alternatively fill with preservative and close valves.
>7 days	Perform 3-8 air scours and complete backwash. If heavily fouled, complete CIP. Fill with 0.5-1.0% NaHSO3 and close inlet/outlet. Check pH monthly; replace when pH <3.
Restart	Continuously flush until foam-free and preservative completely removed.

Prevent freezing and temperature >40 °C; within this condition lower ambient temperature is preferred. Always keep modules completely flooded with water or preservative to prevent irreversible drying-related loss.

Freeze protection

The minimum allowable storage temperature for freeze protection is 1 °C (33.8 °F). For anticipated subfreezing exposure, contact Neptuno for preservation guidance. Food-grade glycerol can be added to the preservation solution before packaging. Onsite preservation also requires food-grade glycerol at the dosage below.

Glycerol antifreeze solution

Glycerol wt%	Viscosity cP	Temperature °C
0.5	1.011	-0.07
3.0	1.074	-0.63
5.0	1.127	-1.08
9.0	1.256	-2.06
12.0	1.365	-2.88
14.0	1.445	-3.47
16.0	1.533	-4.09
20.0	1.737	-5.46
24.0	1.988	-7.01
28.0	2.279	-8.77
32.0	2.637	-10.74
36.0	3.088	-12.96
40.0	3.653	-15.50
44.0	4.443	-17.73
48.0	5.413	-20.39
52.0	6.666	-23.22
56.0	8.349	-26.23
60.0	10.681	-29.41

Recovery methods for dried modules

Soaking: immerse fibers in 50/50 ethanol-water or propanol-water for 15 min. Alternatively immerse module in 1% HCl or 4% HNO3 for 24 h, keeping it vertical to vent entrained air.

Compression: install on rack; use feed pump and slowly close permeate valve to reach 4.75 bar (68.9 psi). Close permeate/feed valves and hold 30 min. Slowly reopen feed valve for depressurization while maintaining TMP ≤2.1 bar (30.5 psi).

These methods cannot guarantee full performance restoration, and strict safety precautions are required for onsite solutions.

Technical support & next steps

Neptuno Water Technology supports the selection, application and care of PVDF ultrafiltration systems. Bring the operating data below to a technical review.

Prepare for a technical review

Review item	Information to provide
Application	Water origin, treatment objectives, process arrangement and downstream requirements.
Membrane configuration	Module model, number of racks, modules per rack and total membrane area.
Operating history	Feed quality and temperature; flow, pressure and normalized performance trends.
Cleaning history	Backwash and chemical-cleaning sequence, recipes, temperatures and before/after performance.
Observed condition	Alarm history, changes in permeate quality, leaks, integrity-test results and repair records.

Before starting or returning to service

Check water quality and instrumentation, confirm the applicable operating conditions, and complete the startup checks. Keep membranes wet, prevent freezing and remove preservation chemicals before returning permeate to service.

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