ULTRAFILTERATION TECHNOLOGY

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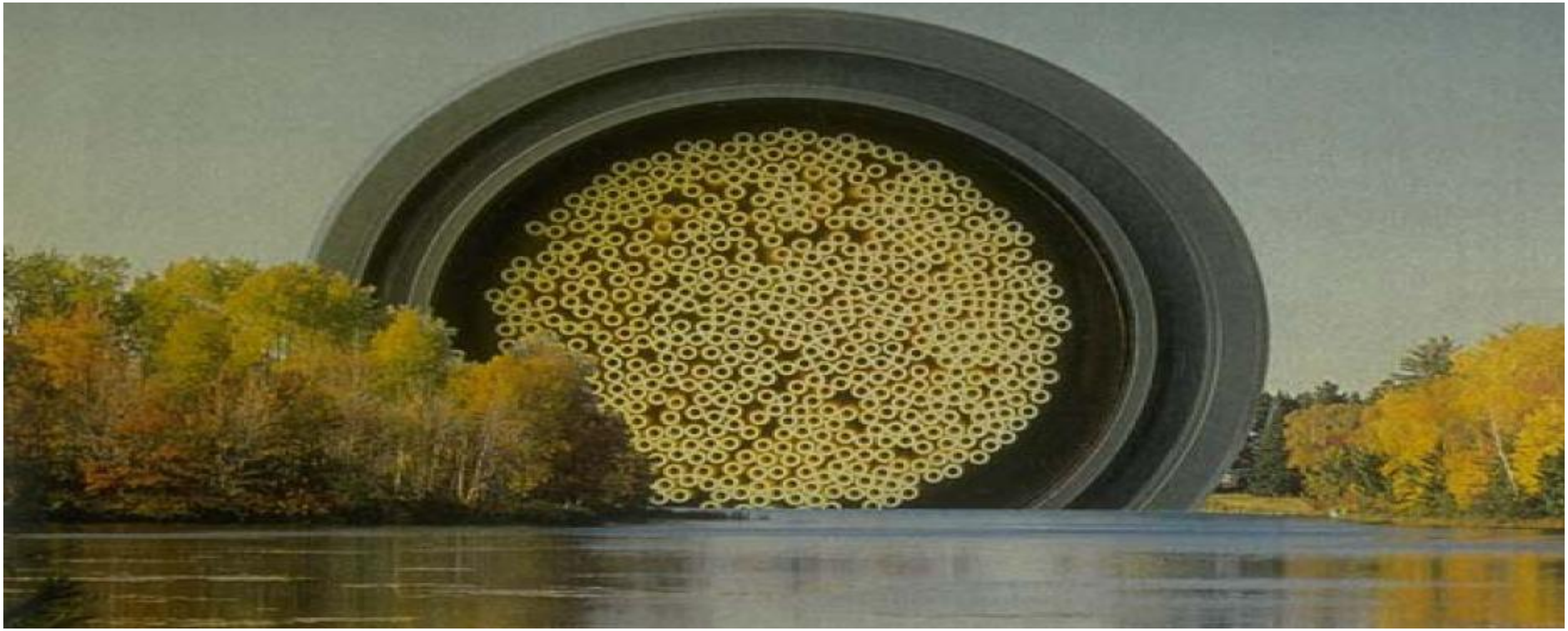

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- UF applications
- UF design parameters
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- UF modules
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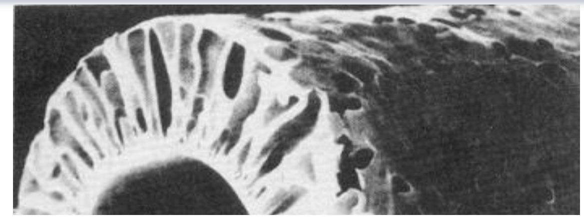
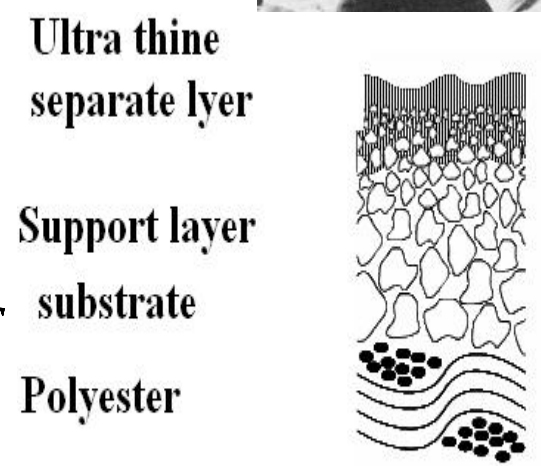
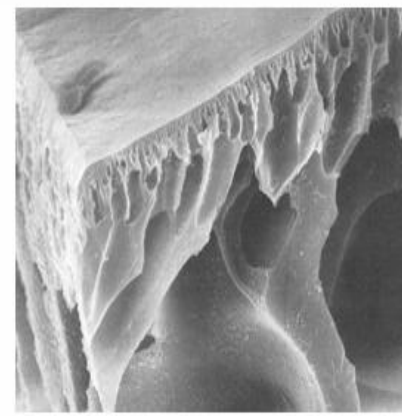
Introduction

- What is UF technology?
  - Mechanism: Molecular sieve
  - Structure: Asymmetric
  - Driving force: Pressure
  - Pore size: 0.1-0.01 µm
  - Molecular weight cutt-off







Nanofiltration	10^2-10^4
Reverse osmosis	10^2

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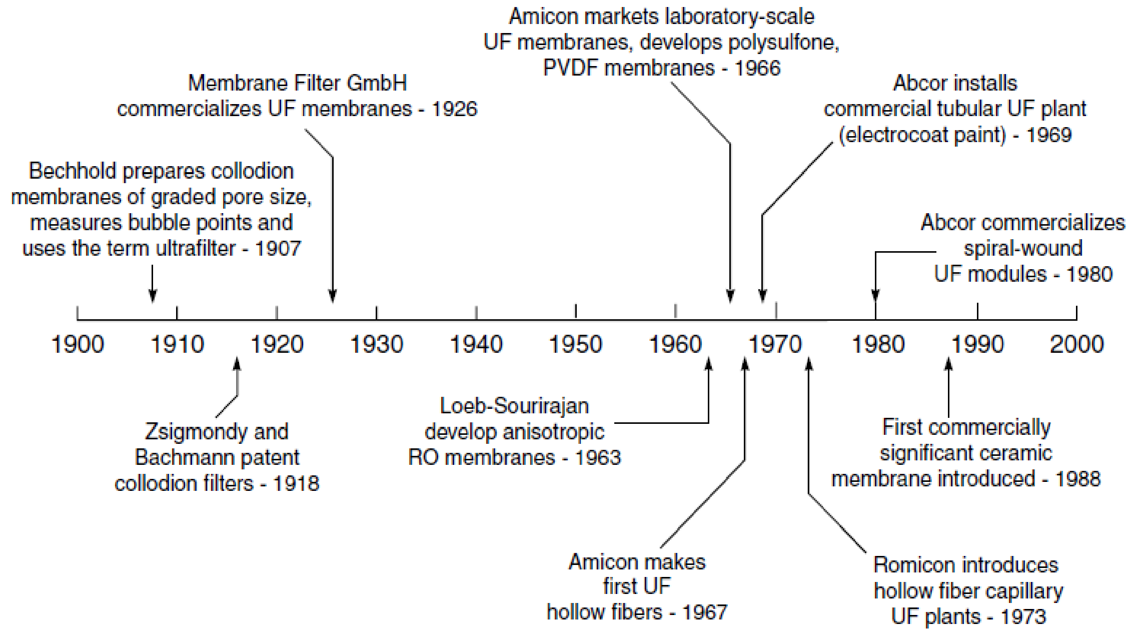
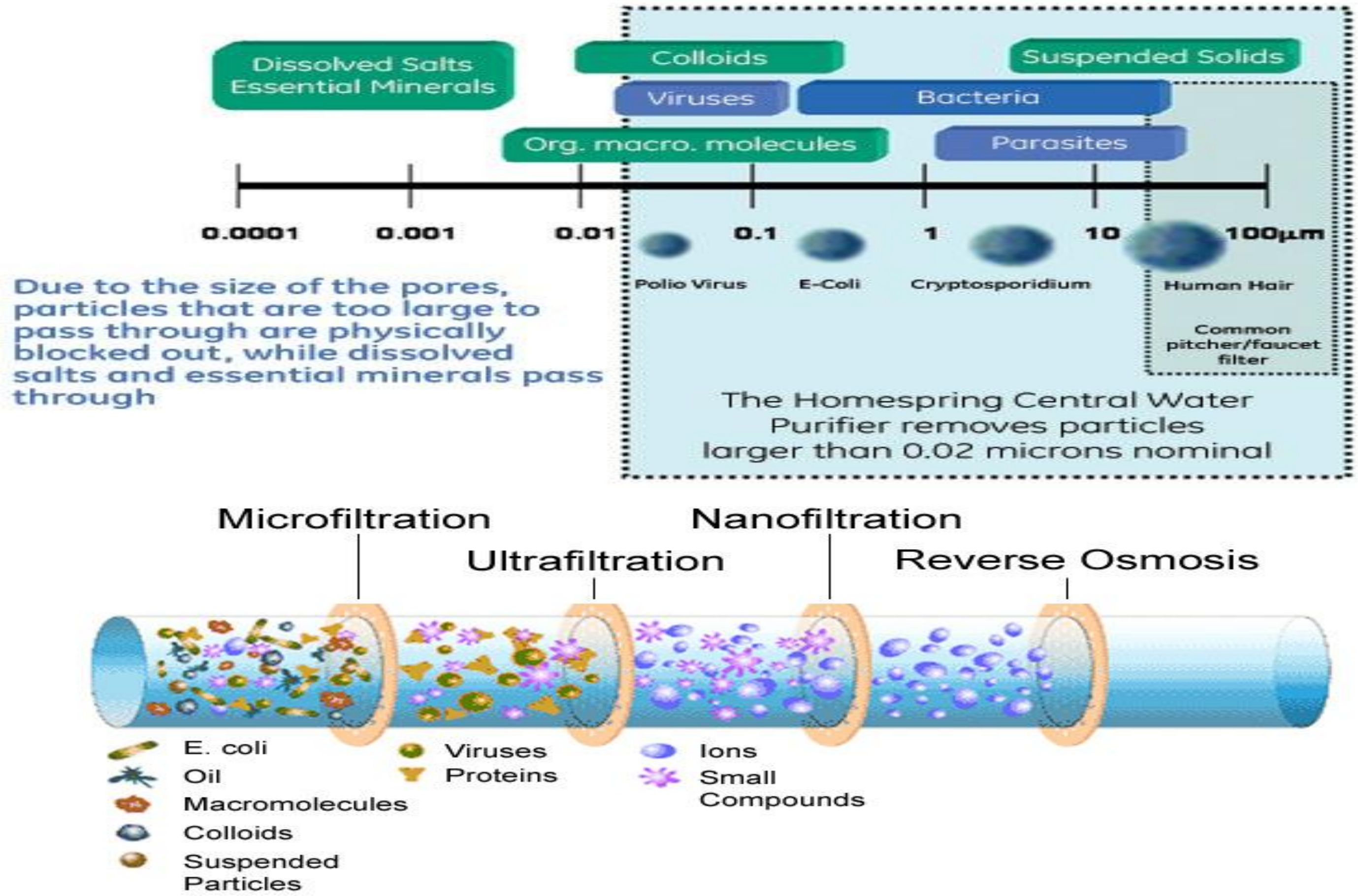
Introduction

- History of UF



UF removal ability



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Introduction

Filter type	Symbol	Pore Size, µm	Operating Pressure, psi	Types of Materials Removed
Microfilter	MF	1.0-0.1	<30	Clay, bacteria, large viruses, suspended solids
Ultrafilter	UF	0.1-0.01	20-100	Viruses, proteins, starches, colloids, silica, organics, dye, fat
Nanofilter	NF	0.01-0.001	50-300	Sugar, pesticides, herbicides, divalent anions
Reverse Osmosis	RO	< 0.0001	225-1,000	Monovalent salts

Why UF?

- Advantages
  - Low pressure
  - High permeation
  - Easy cleaning
  - Low cost
  - Low energy
  - Low spacing
  - High efficiency

UF application

- Pretreatment for Reverse Osmosis (RO) and DI system
- Post-treatment for micro-organism & turbidity removal for
  - Iron removal & de-mineralize process in underground water treatment
  - Water softening application
  - Ultra-pure process water for production and rinsing, i.e. food processing, laboratory, etc.
  - Drinking water and mineral water treatment
  - Secondary wastewater treatment for disposal
  - Recycling of wastewater as potable water.
- Separation/ purification & concentration for
  - Food & Beverages, dairy, wine and fruit juice industry
  - Pharmaceutical industries

UF materials

- Ceramics
  - Comparatively fragile
  - Narrow operating pH range
  - Low flux
  - High chemical& thermal stability
- Polymers
  - Durability
  - High flux
  - Processability

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UF polymer materials

- PVDF
  - strong and very tough material
  - resistant to abrasion, acids, bases, solvents and much more
  - usable to *280ºF (138ºC)*
  - usable in laboratory plumbing
- PES
- PS
  - rigid, high-strength
  - highly resistant to mineral acids, alkali
- PAN
- PP
  - lightweight
  - temperature up to *180ºF (82ºC)*
  - highly resistant to acids, bases and many solvents
  - usable in laboratory plumbing
- CA
  - Expensive
  - Low chemical resistant
  - High chlorine resistant
- PVC
  - strong and rigid
  - resistant to a variety of acids and bases
  - may be damaged by some solvents and chlorinated hydrocarbons
  - maximum usable temperature *140ºF (60ºC)*
  - usable for water, gas and drainage systems
  - not useable in hot water systems

UF modules

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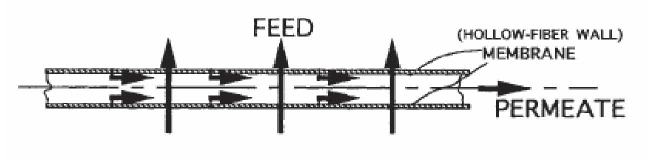
Hollow fiber



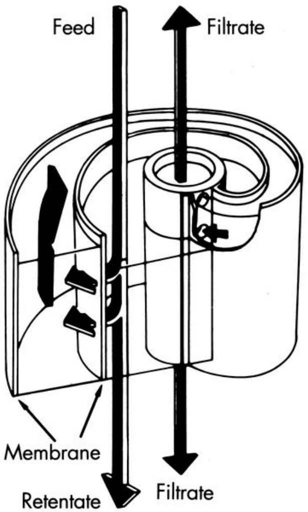
- High efficiency

-High packing density

-Susceptible to structural deformation

- Cleanable

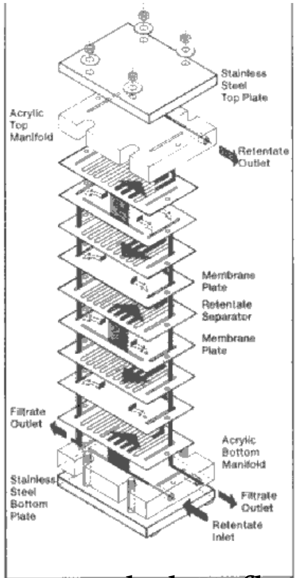
Spiral wound



-Cannot produce turbulent flow with the flowrates at which we are operating

-Small footprint

Cassette

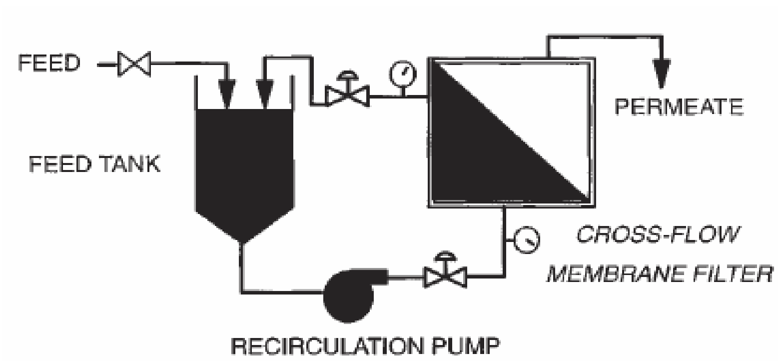


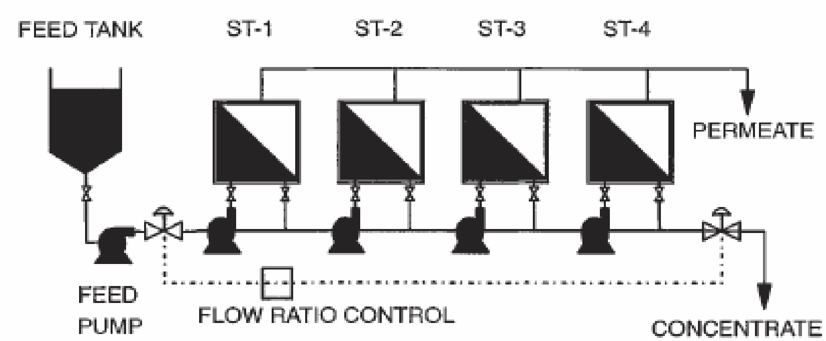
-Produces turbulent flow for better medium-membrane communication.

-Small footprint

-Large membrane surface area

Operation Set-up





Batch, Semi-Batch Operation

tank volume and membrane area required.

-Conversion per pass is low, but with multiple passes, virtually any concentration can be achieved

Series Operation

-Fresh medium continually added to feed tank

-Continual re-pressurization require

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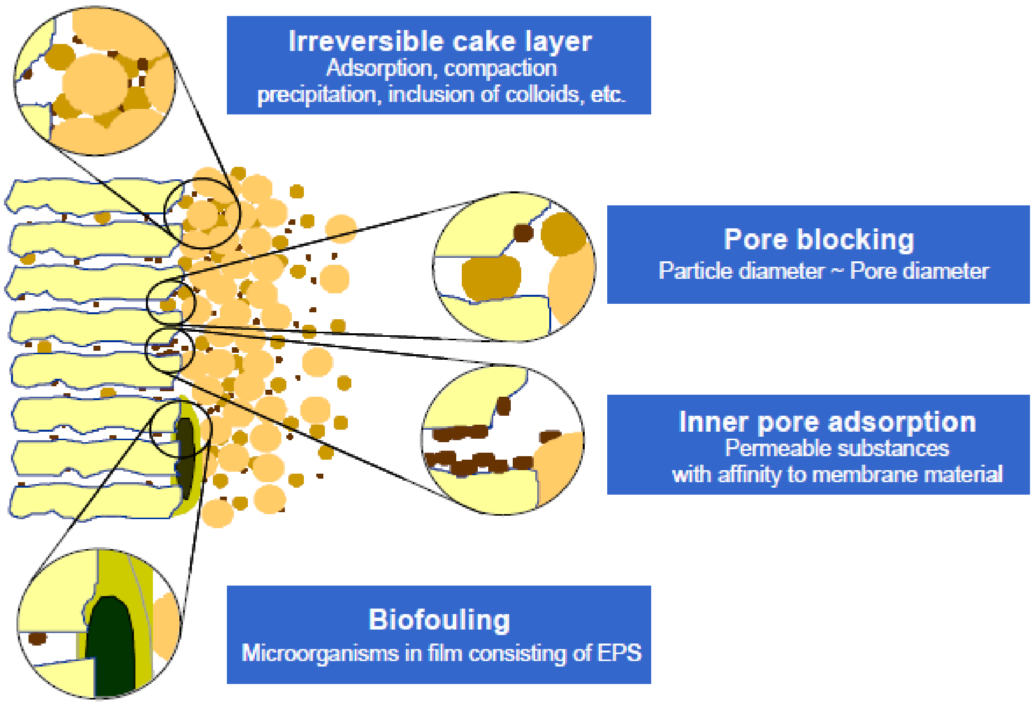
Fouling

- Permeability reduction
- Plants, algae, microorganism and humic acids
- Solutions:
  - Backwash
  - CEB
  - CIP



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UF theory

- **Mass balance**
  - Feed= Filteration + cleaning+ concentrate
- **Recovery**
  - R = [feed-(filterated volume+cleaning volume)]/feed
- **Kinetics**

$$\mathbf{J = Q_p/A_{mem} = TMP/(\nu.R_{tot})}$$

J = flux [m3/(m2·h)]

Q_p = permeate flow [m3/h]

A_{mem} = membrane surface area [m2]

TMP = transmembrane pessure [Pa]

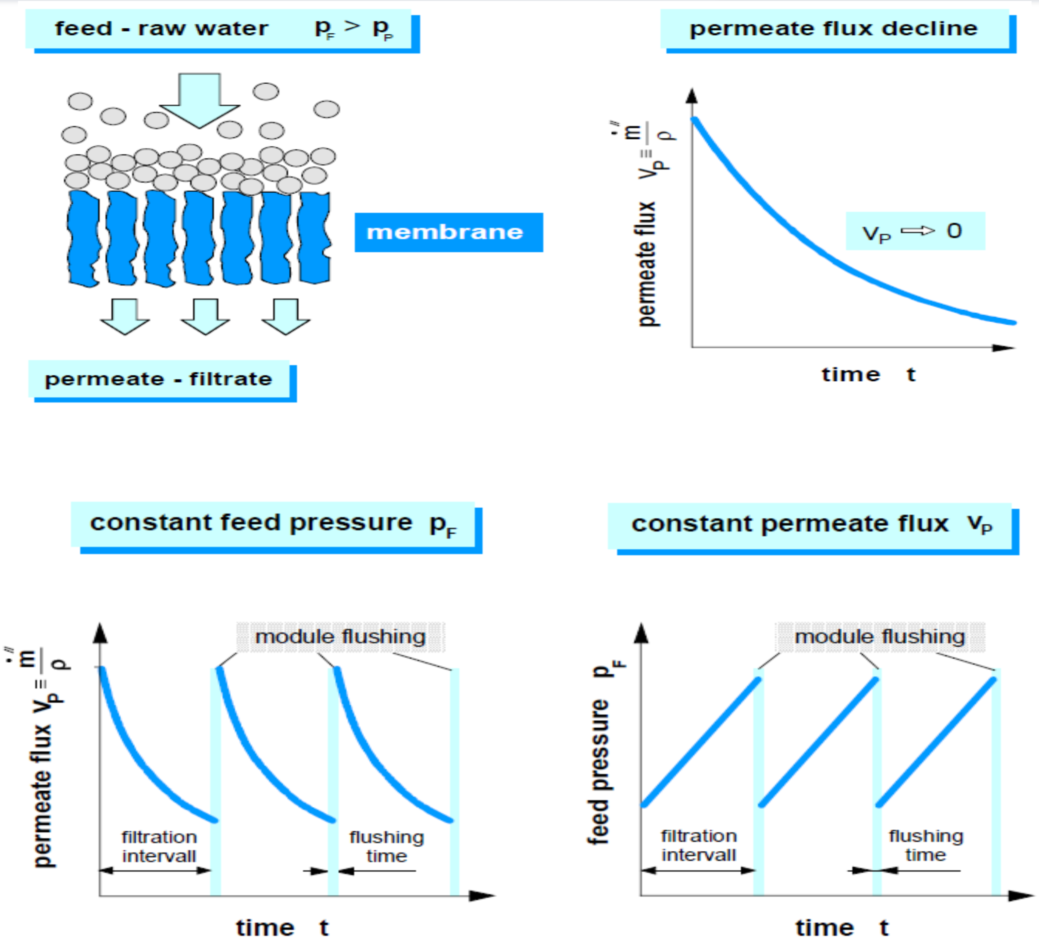
R_{tot} = totale resistance

ν = dynamic viscosity [Pa/s]

$$\mathbf{R_{tot}=R_{mem}+R_{fouling}}$$

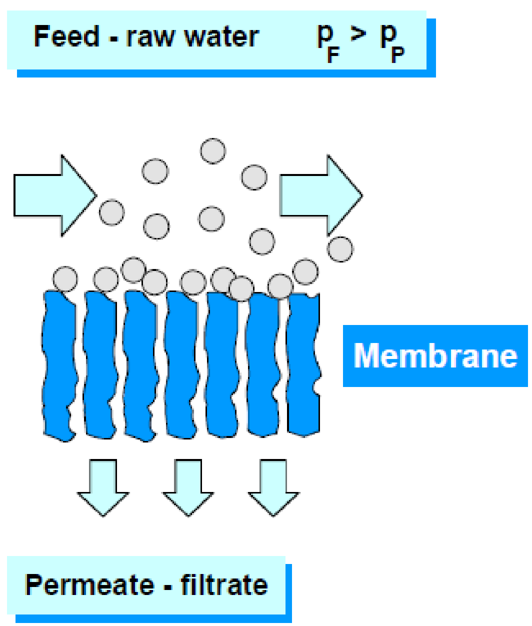
Operation mode

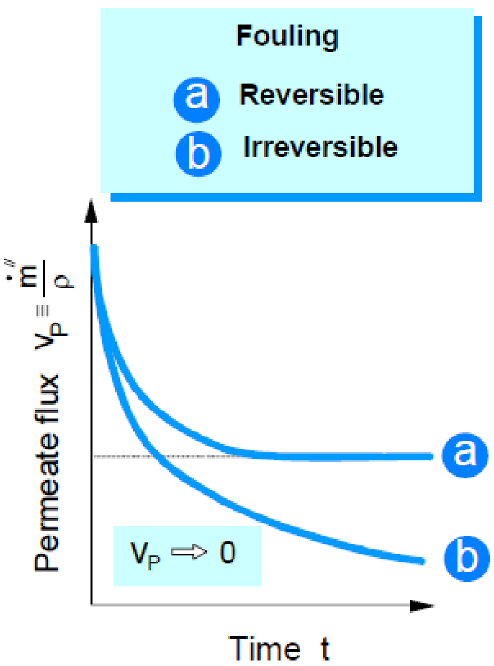
- Dead end
  - Module blocking
  - Low solid content



Operation mode

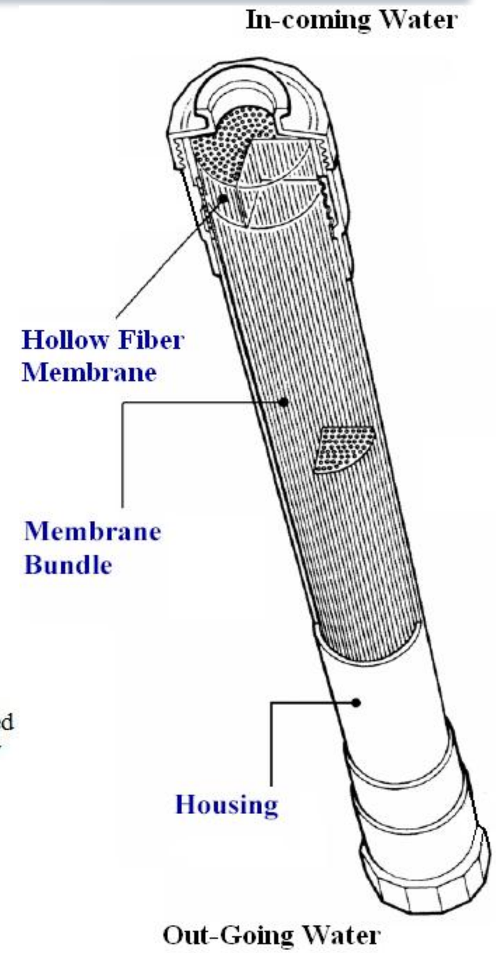
- Cross-Flow
  - High solid
  - High energy
  - High velocity

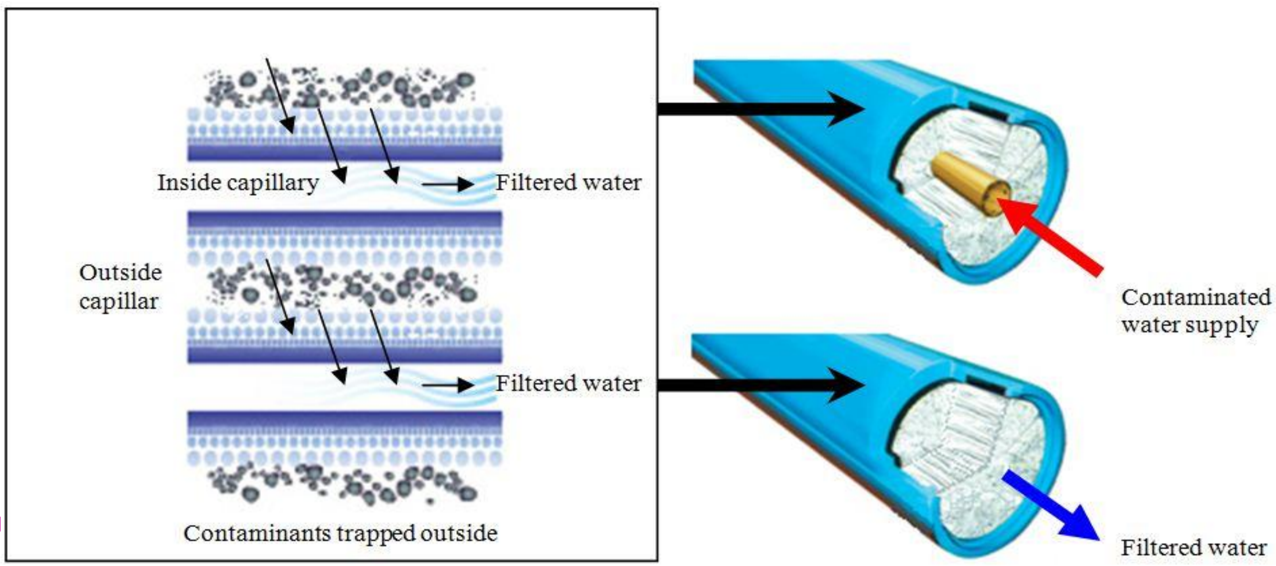




Operation mode

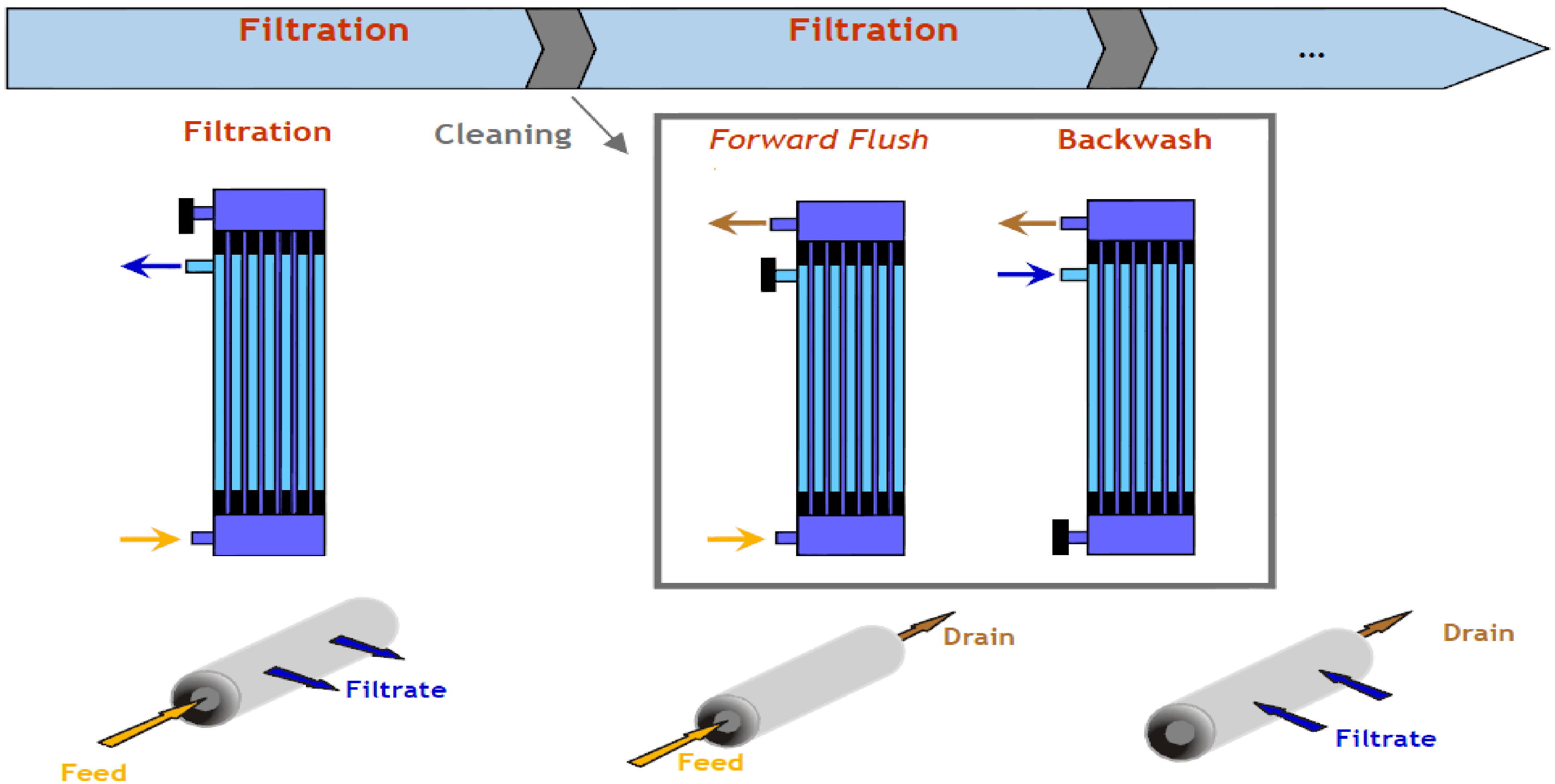
- Outside-In
  - Lower plugging risks
  - Higher solids loading
  - Higher area
  - Easier cleaning





Operation mode

- Inside-out



Why UF should be cleaned?

Start-up

After start-up

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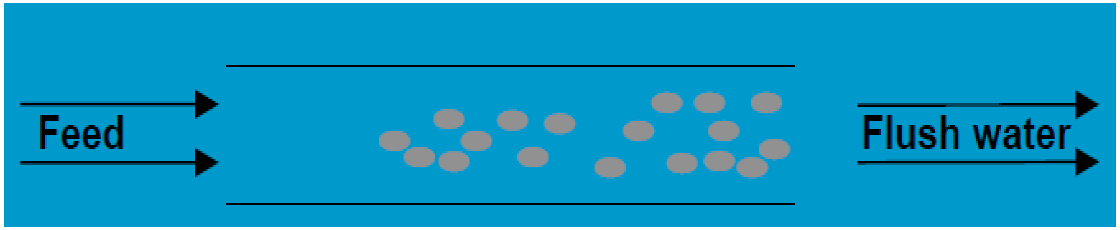
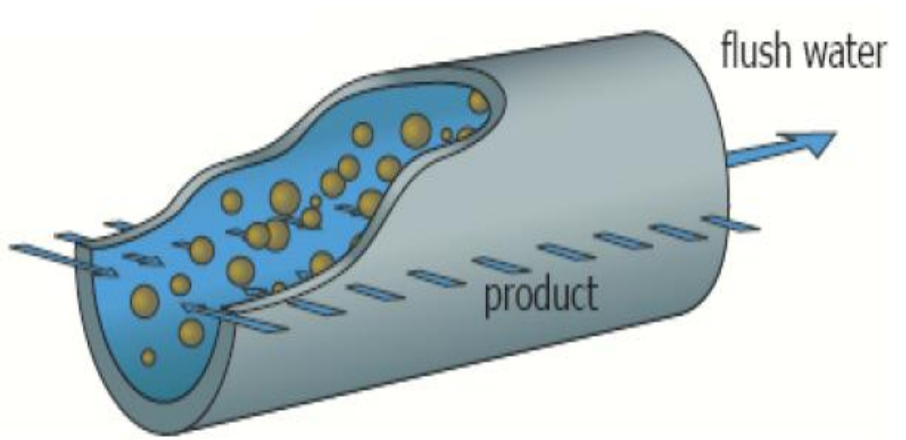
UF cleaning

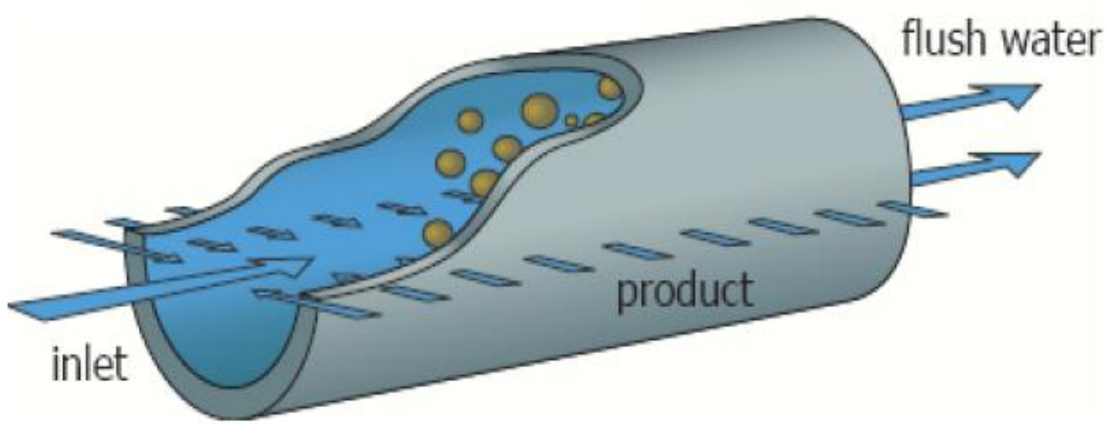
- Forward-flushing
  - Solid removal
  - Fouling reduction
- Condition
  - High velocity
  - Turbulent flow
  - Time



UF cleaning

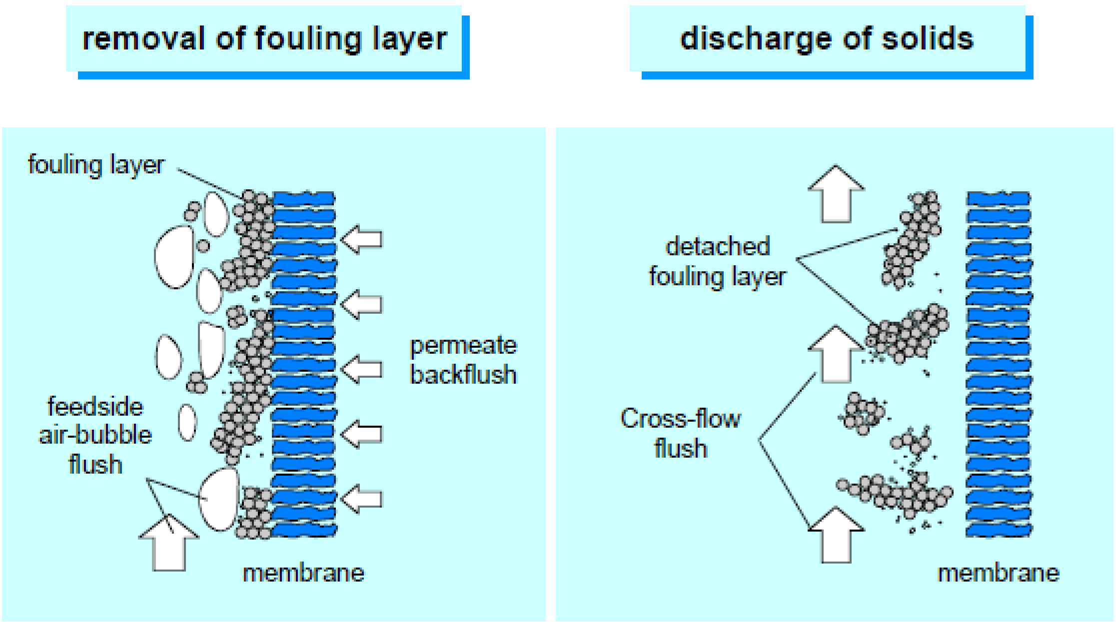
- Backward-flushing
  - Flow rate
  - Time
- Backward & forward flushing





UF cleaning

- Air flushing
  - Movement of HF
  - Shearing effect
  - Free solids removal
- Condition
  - Pressure
  - Flow rate
  - Time



UF cleaning

- Chemical cleaning
  - CEB
  - Acids&base
  - NaOCl
  - H_2O_2
  - Cl_2

- CIP
  - Chlorines
  - Acids&base

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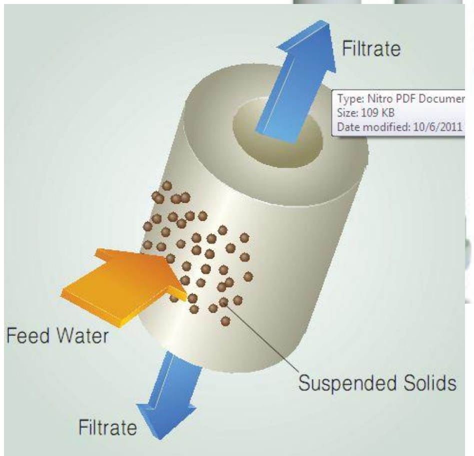
CSM UF membranes

- Spiral-wounded Module
  - PSF
  - Size: 8×40 in
  - MWCO: 50-100 kDa
  - Permeate flow rate≈ 52 m^3/d
  - Application

- Hollow Fiber Module

CSM UF membranes

- High chemical resistant
  - PVDF membrane
  - Acids& base& cholrine& …
- High mechanical resistant
- Good pore size: 0.05 µm
- Slick membrane surface
  - Low fouling
  - Microbial removal
- Out-In type
- Two-end storage type



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UF module

Model		HFTS 7090
Dimension	Diameter	194 ㎜
	Length	2,270 ㎜
Effective Area		60 ㎡
Effective Length		1,900 ㎜
Material	Membrane	PVDF
	Potting	Poly-urethane
	Housing	ABS
Filtration Type		Out-in
Permeate Flow rate		1.3 ~ 5.0 ㎥/hr
Max. Inlet Pressure		3 kgf/㎠
Max. Operating TMP		2 kgf/㎠
Operating Temperature		1 ~ 40 ℃
pH Range		2 ~ 11

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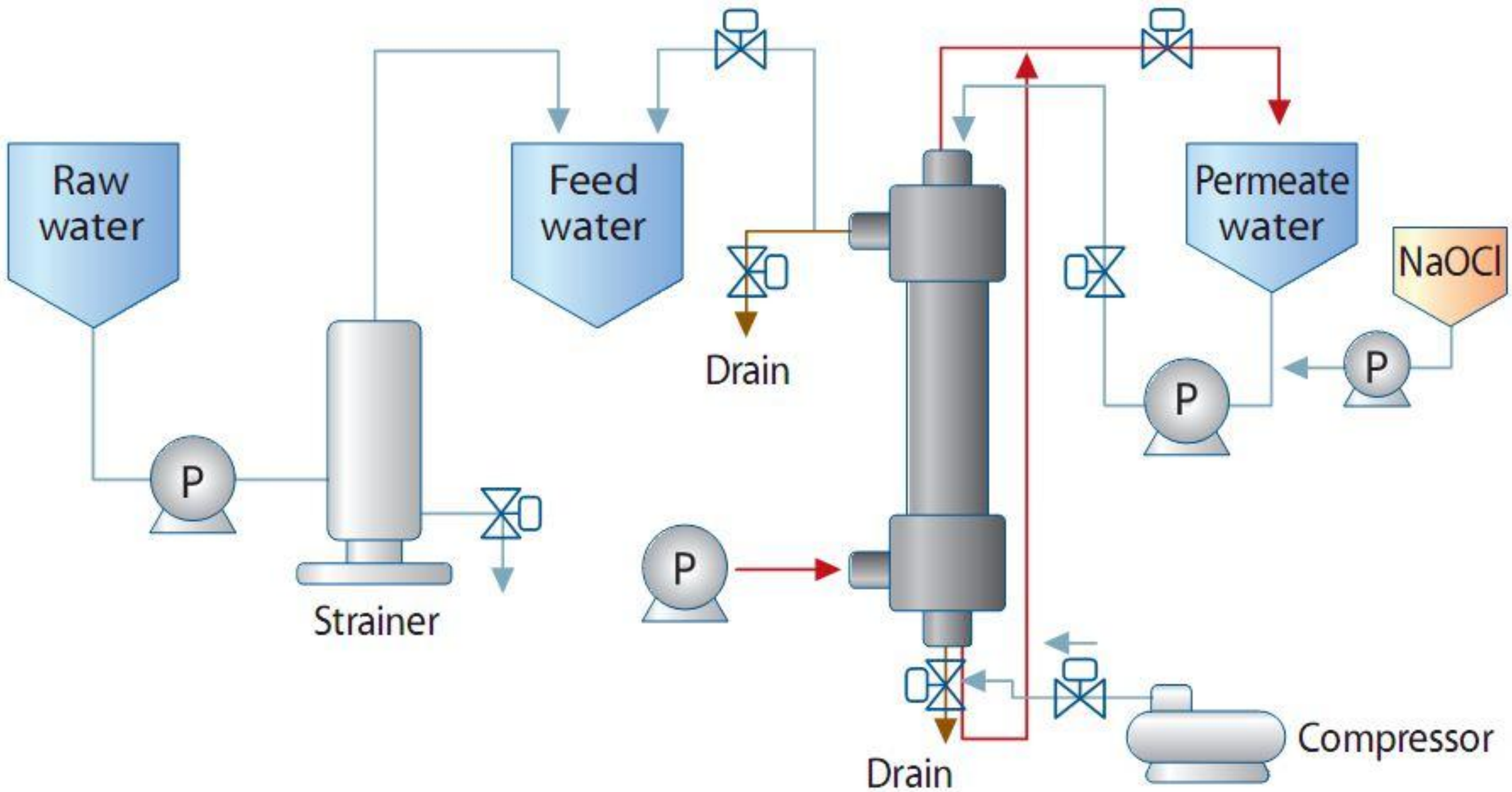
UF Plant



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Conclusion

- Monitoring of raw water quality (turbudity, microbiology, phys.chem. Parameters, dissolved organic compounds)
- Determination of site conditions
- Applying of pre-treatment
- Pilot plant investigations
  - Membrane materials (PP, PVDF, PS, ...)
  - Size of module
  - Membrane module (cross-flow and dead-end)
  - Operating type? (out/in and in/out)
  - Optimal conditions for backwash and chemical cleaning