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THE SCIENCE OF A PURE ENVIRONMENT

Certified ISO9001

Via Pietro Nenni, 15 - 27058 – VOGHERA – ITALY
Tel. +39 0383 3371 – Fax +39 0383 369052
E-mail: info@idreco.com

PRESENTATION OF DESALINATION VIA REVERSE OSMOSIS

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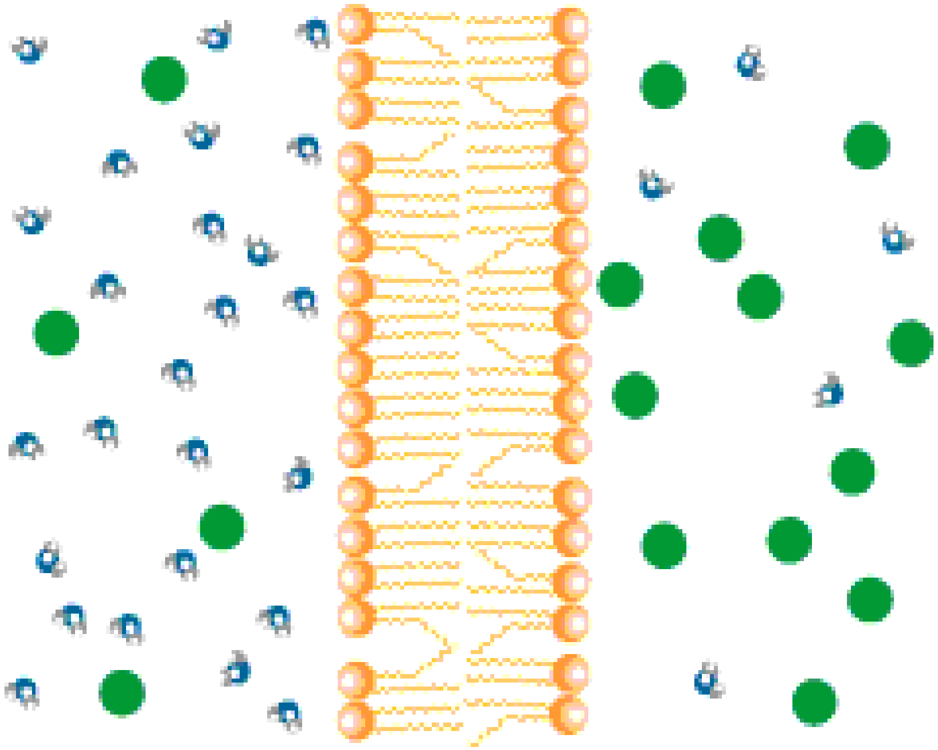
DESALINIZATION VIA REVERSE OSMOSIS



Reverse osmosis is the finest level of filtration available. The RO membrane acts as a barrier to all dissolved salts and inorganic molecules, as well as organic molecules with a molecular weight greater than approximately 100. Water molecules, on the other hand, pass freely through the membrane creating a purified product stream. Rejection of dissolved salts is typically 95% to greater than 99%. Transmembrane pressures for RO typically range from 5 bar for brackish water to greater than 84 bar for seawater.

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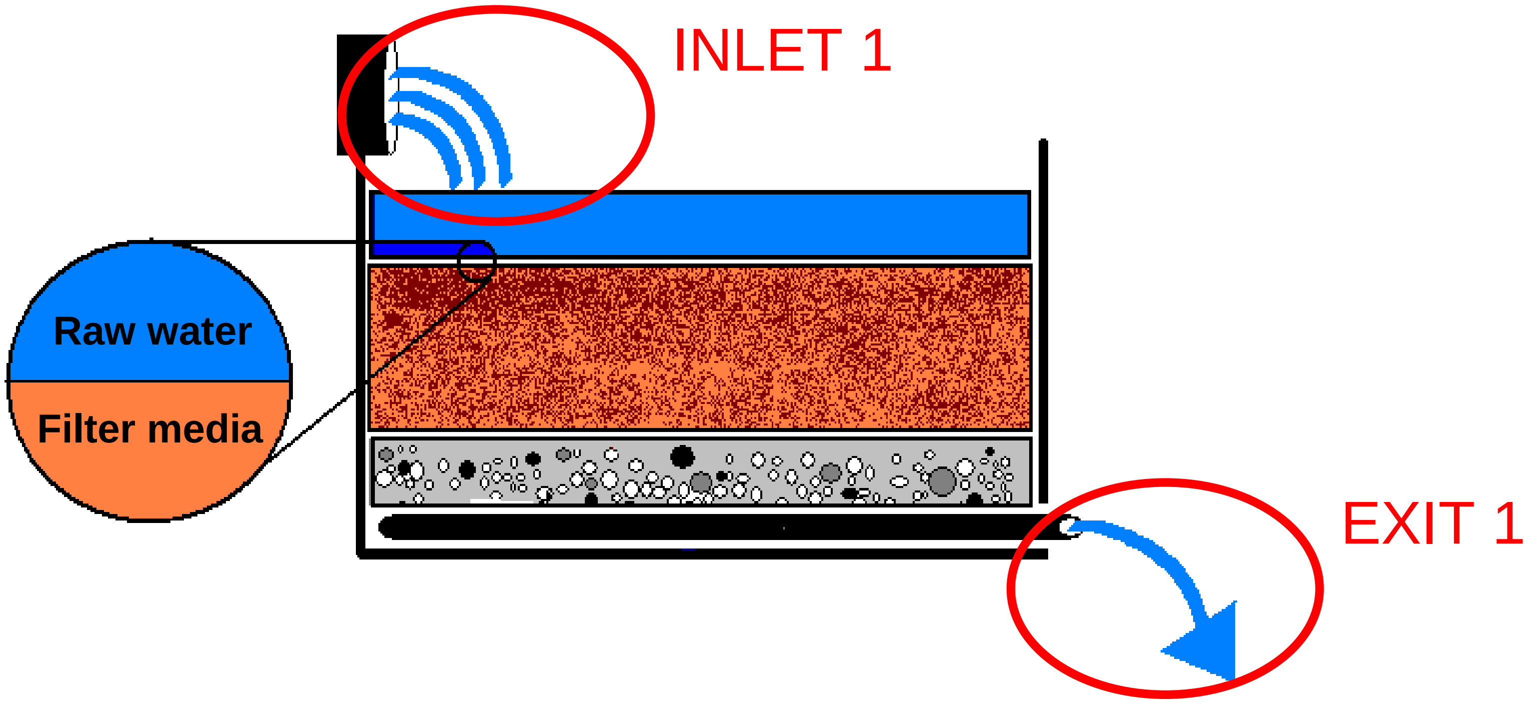
DESALINIZATION VIA REVERSE OSMOSIS

Conventional macrofiltration of suspended solids is accomplished by passing a feed solution through the filter media in a perpendicular direction.



The entire solution passes through the media, creating only one exit stream.

DESALINIZATION VIA REVERSE OSMOSIS

Examples of such filtration devices include:

- *cartridge filters*
- *bag filters*
- *sand filters*
- *and multimedia filters.*

Macrofiltration separation capabilities are generally limited to undissolved particles greater than 1 micron.

For the removal of small particles and dissolved salts, crossflow membrane filtration is used.

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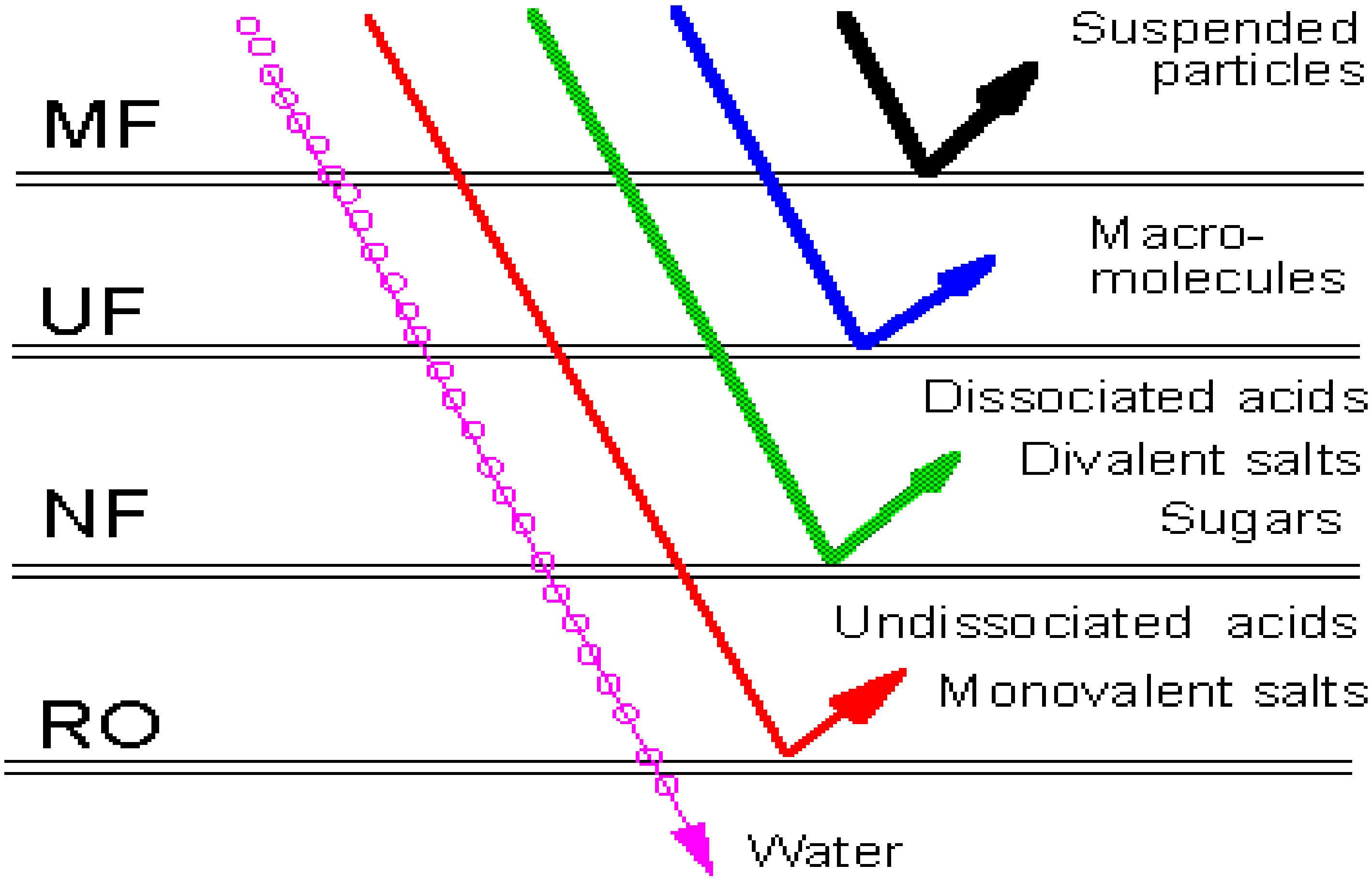
The various filtration technologies which currently exist can be categorized on the basis of the size of particles removed from a feed stream:



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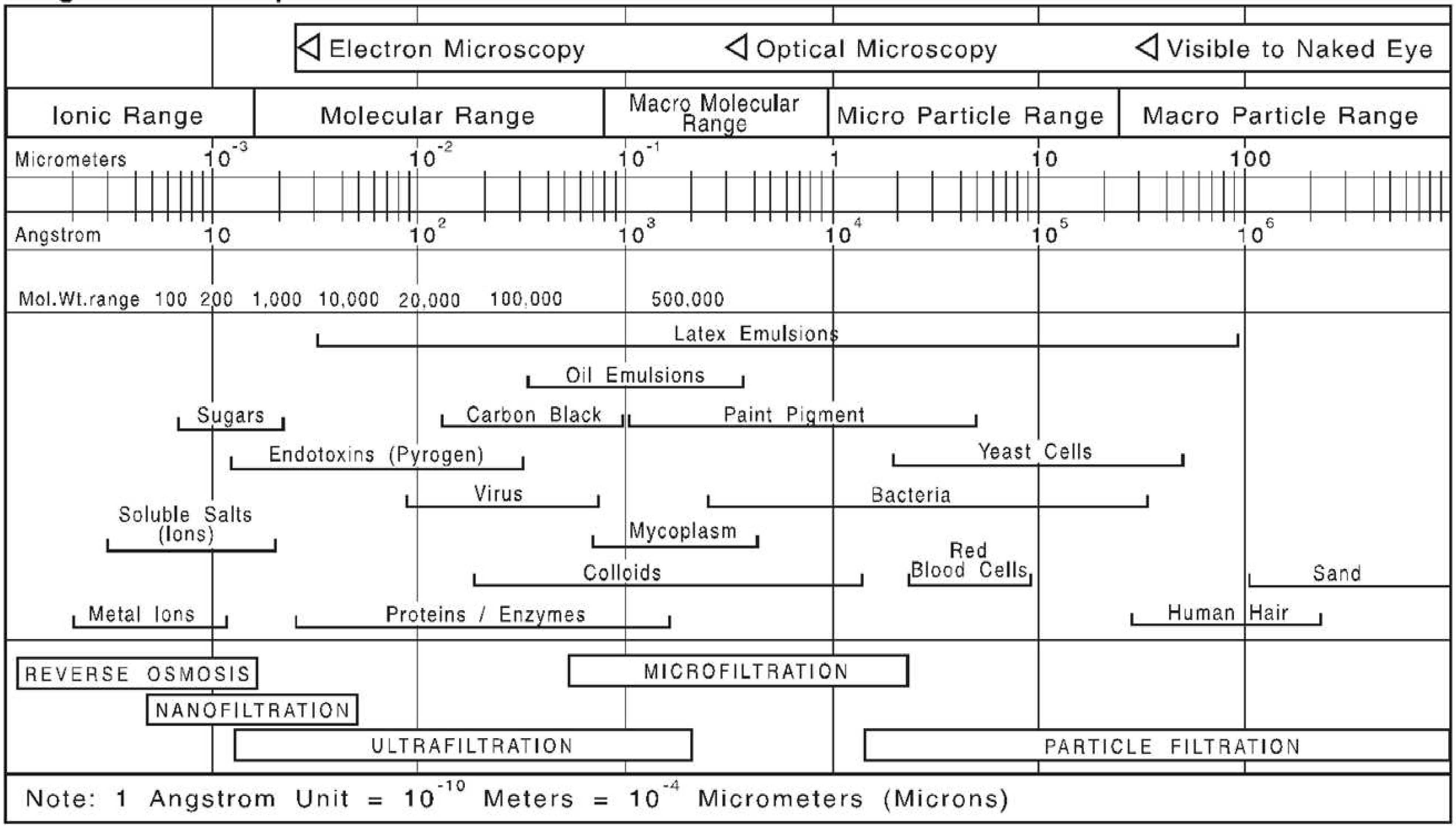
Ranges of filtration processes



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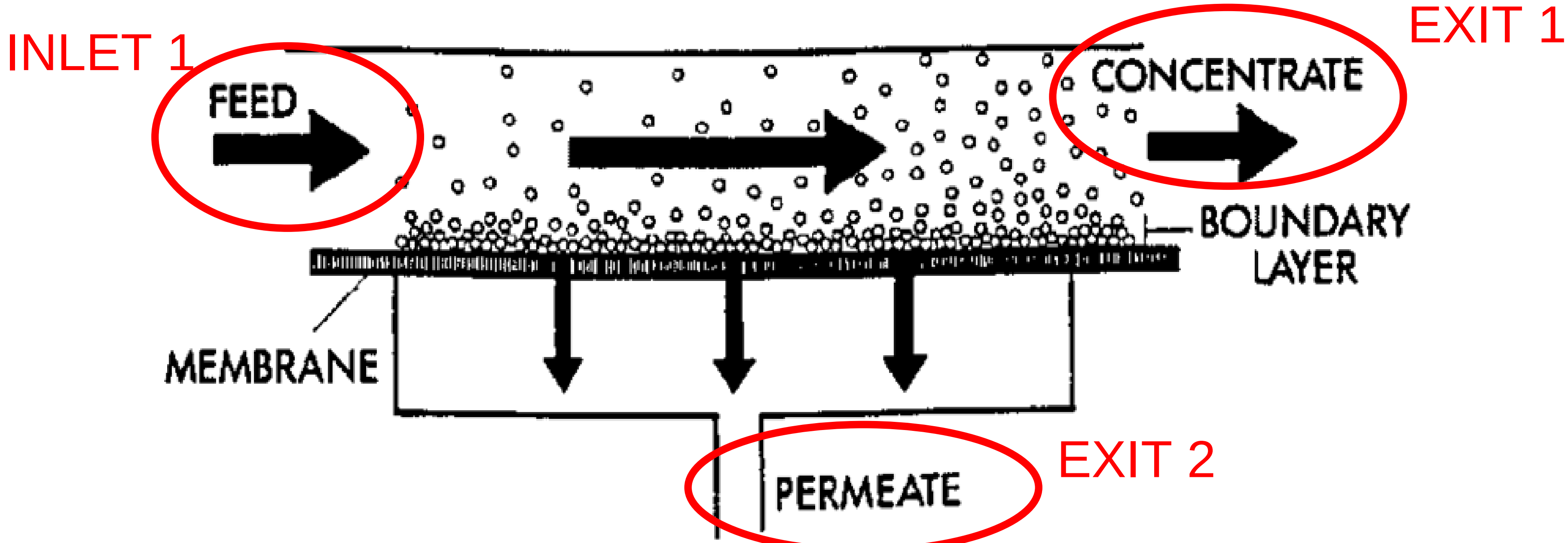
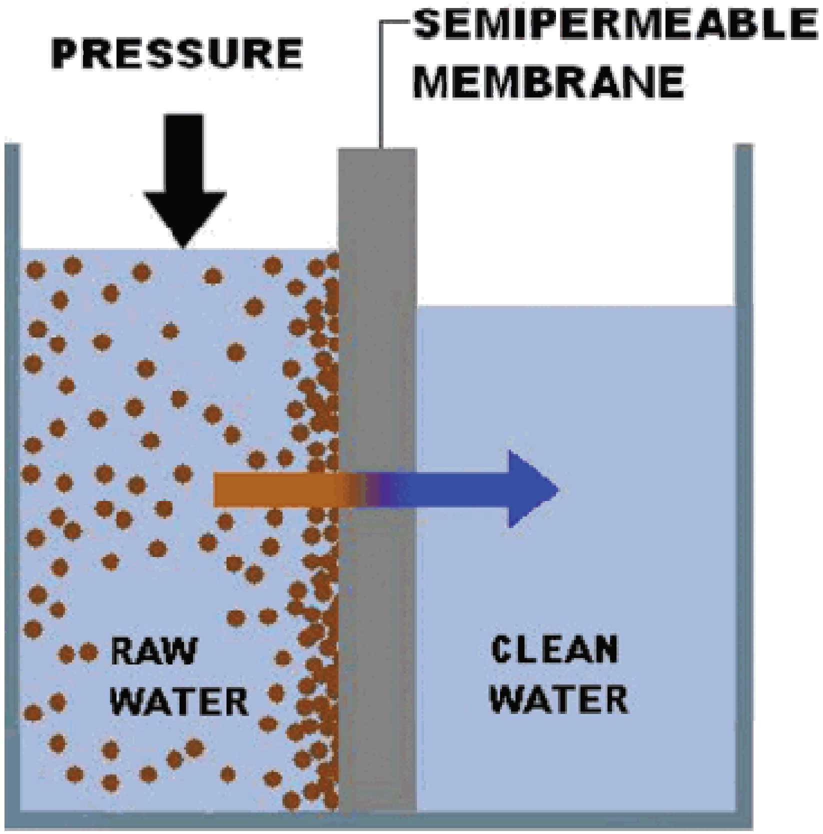
Crossflow membrane filtration uses a pressurized feed stream which flows parallel to the membrane surface:



A portion of this stream passes through the membrane, leaving behind the rejected particles that are swept away by the continuous flow of the concentrate stream.

DESALINIZATION VIA REVERSE OSMOSIS

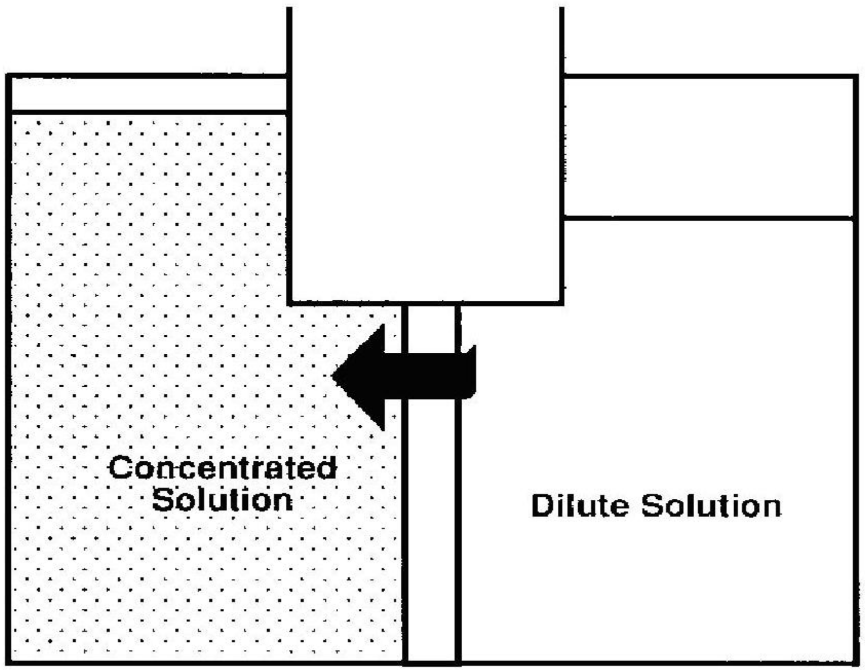
The phenomenon of osmosis occurs when pure water flows from a dilute saline solution through a membrane into a higher concentrated saline solution.



A semi-permeable membrane is placed between two compartments.
“Semi-permeable” means that the membrane is permeable to some species, and not permeable to others.
Assume that this membrane is permeable to water, but not to salt.

DESALINIZATION VIA REVERSE OSMOSIS

As a fundamental rule of nature, this system will try to reach equilibrium:

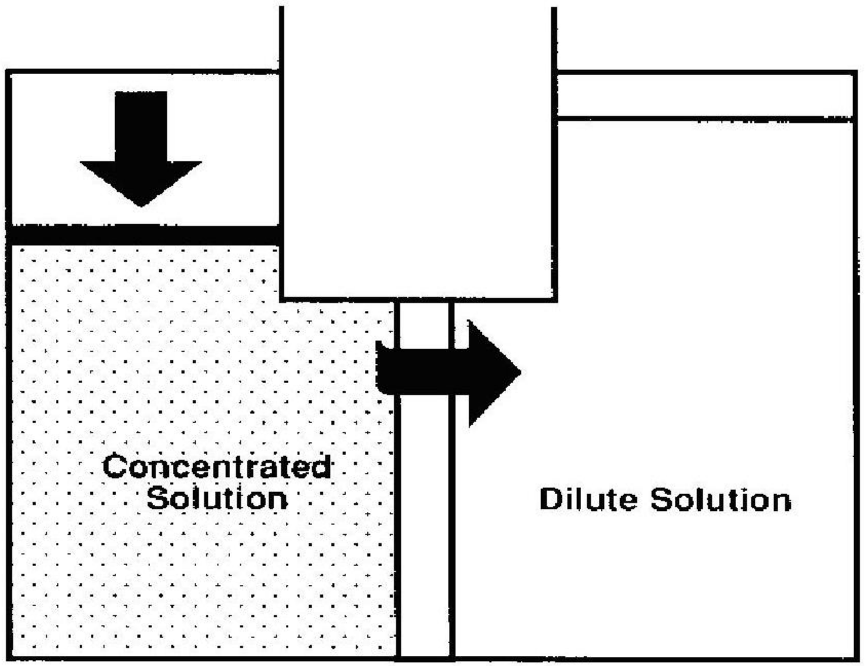


So it will try to reach the same concentration on both sides of the membrane. The only possible way to reach equilibrium is for water to pass from the pure water compartment to the salt-containing compartment, to dilute the salt solution.

DESALINIZATION VIA REVERSE OSMOSIS

As a fundamental rule of nature, this system will try to reach equilibrium:

So it will try to reach the same concentration on both sides of the membrane. The only possible way to reach equilibrium is for water to pass from the pure water compartment to the salt-containing compartment, to dilute the salt solution.



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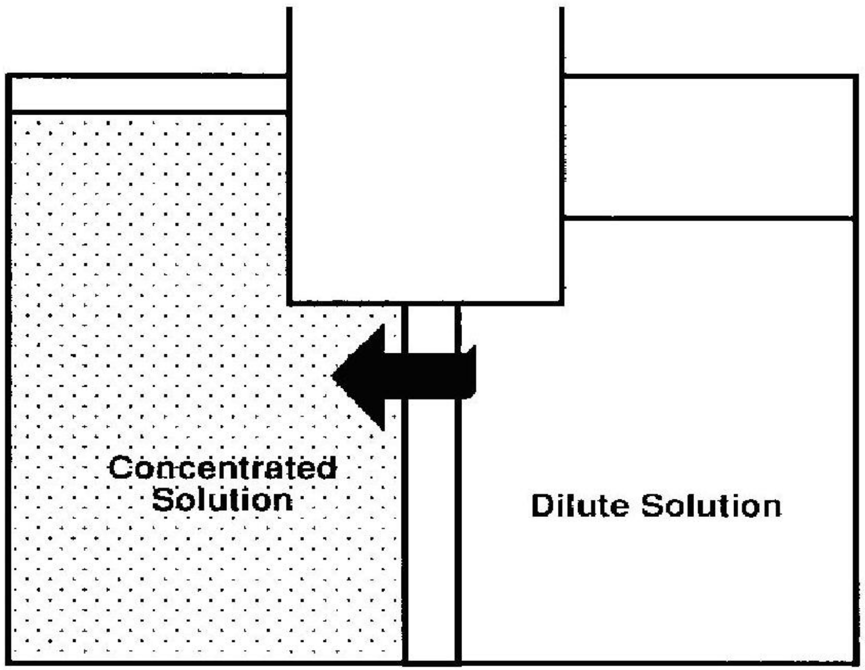
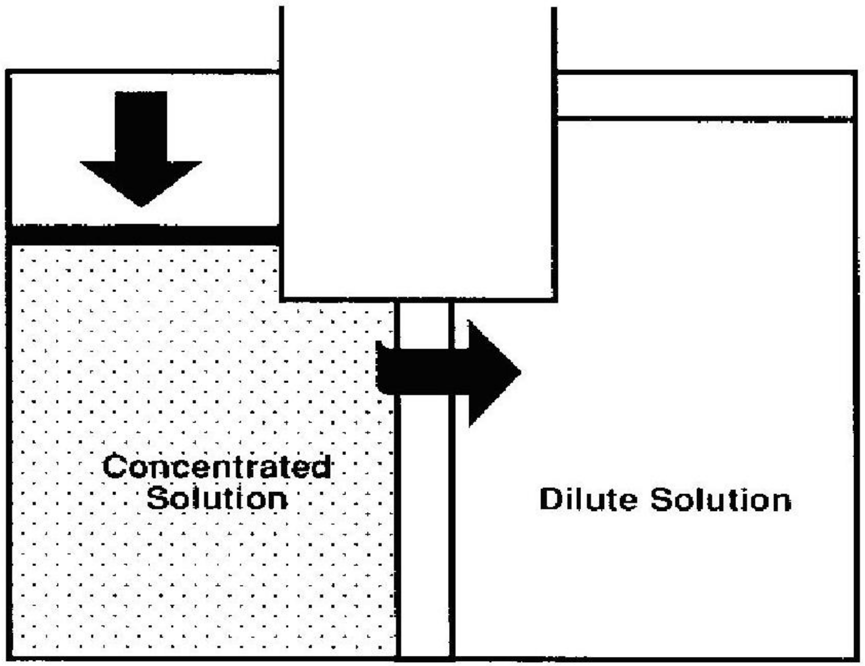


Osmosis

Water diffuses through a semi-permeable membrane toward region of higher concentration to equalize solution strength. Ultimate height difference between columns is “osmotic” pressure.



Reverse Osmosis

Applied pressure in excess of osmotic pressure reverses water flow direction. Hence the term “reverse osmosis”.

DESALINIZATION VIA REVERSE OSMOSIS

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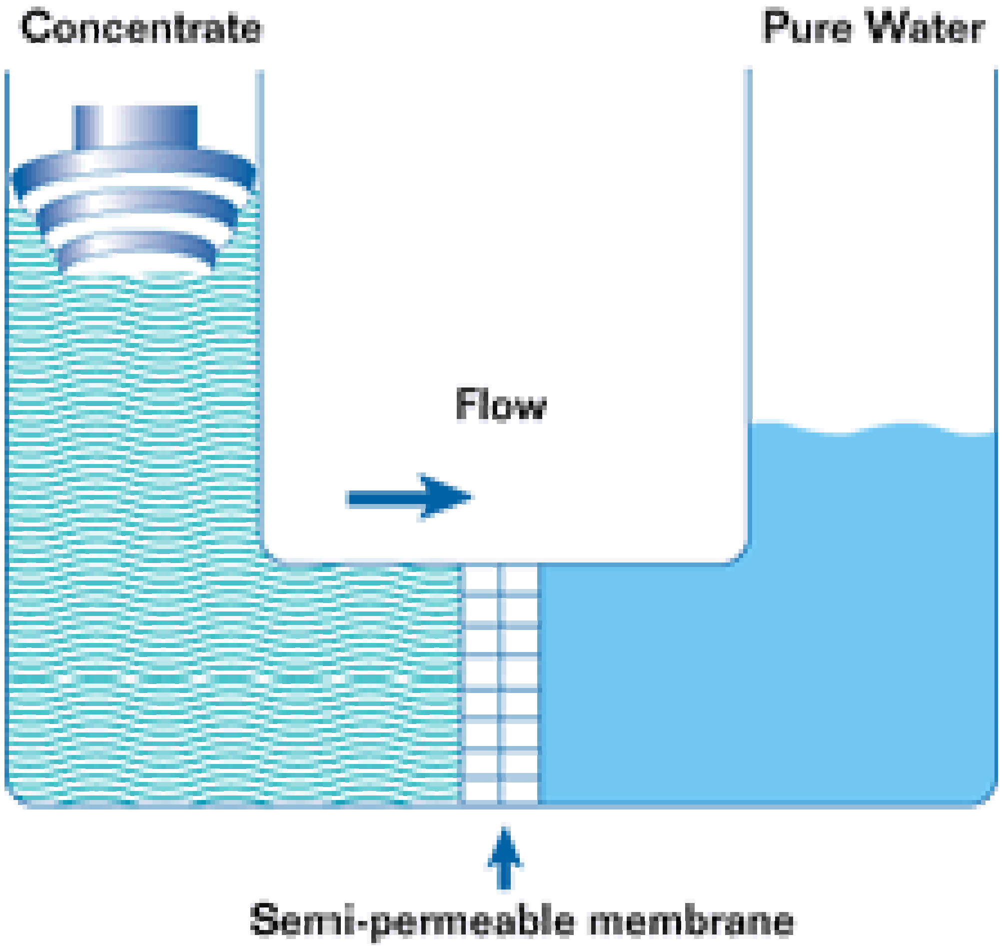
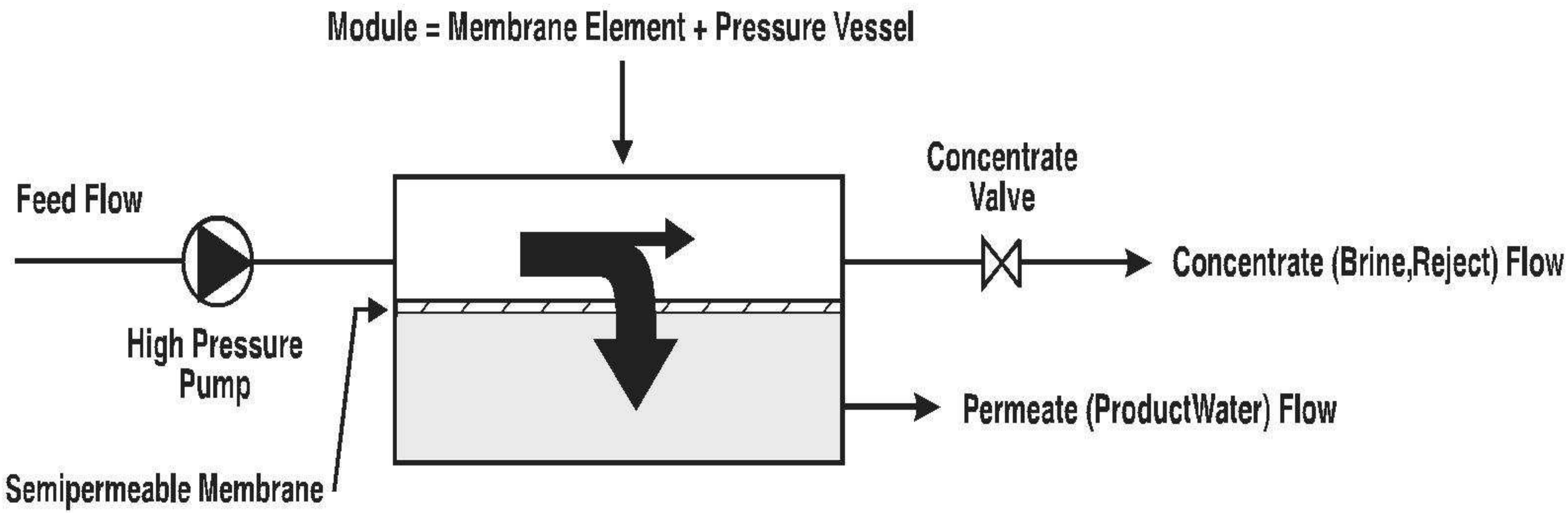


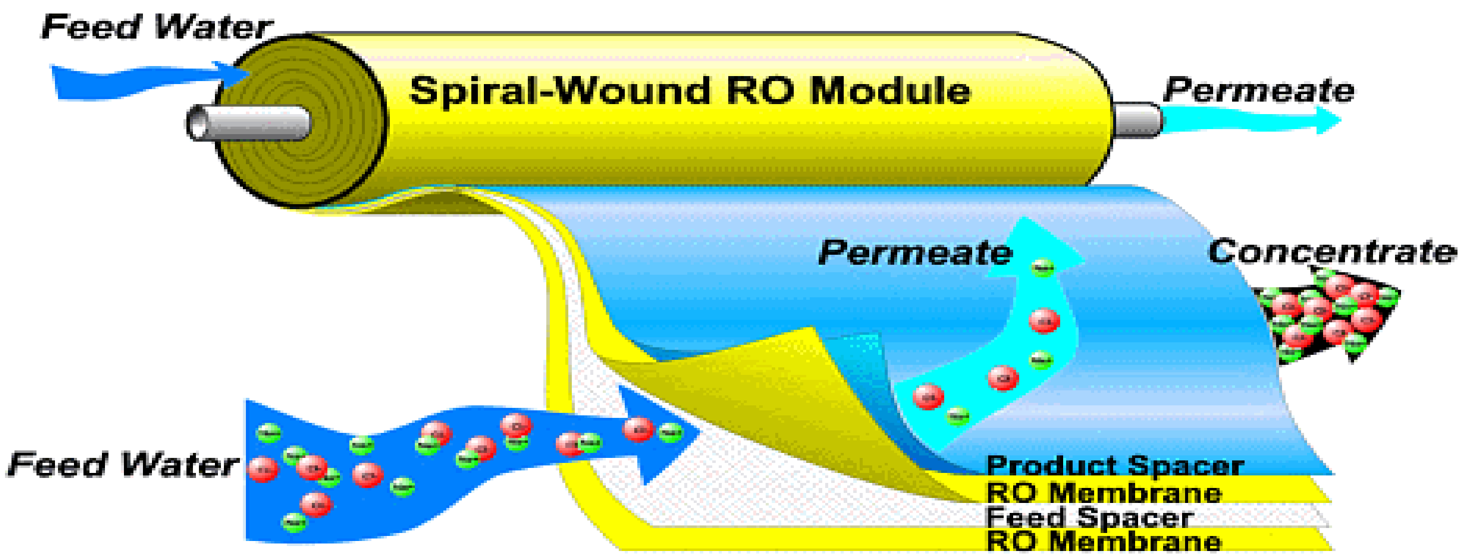
DESALINIZATION VIA REVERSE OSMOSIS

In practice, reverse osmosis is applied as a crossflow filtration process; the simplified process is shown in the figure below:



With a high pressure pump, feed water is continuously pumped at elevated pressure to the membrane system.

DESALINIZATION VIA REVERSE OSMOSIS



Within the membrane system, the feed water will be split into a low-saline and/or purified product, called permeate, and a high saline or concentrated brine, called concentrate or reject.
A flow regulating valve, called a concentrate valve, controls the percentage of feed water that is going to the concentrate stream and the permeate which will be obtained from the feed.

DESALINIZATION VIA REVERSE OSMOSIS

The key terms used in the reverse osmosis process are defined as follows:

- *Recovery*
- *Rejection*
- *Passage*
- *Permeate*
- *Flow*
- *Flux*

DESALINIZATION VIA REVERSE OSMOSIS

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- *Flow*
- *Flux*

the percentage of membrane system feed water emerging from the system as product water or “permeate”.

Membrane system design is based on expected feed water quality and recovery is defined through initial adjustment of valves on the concentrate stream.

Recovery is often fixed at the highest level that maximizes permeate flow while preventing precipitation of super-saturated salts within the membrane system.

DESALINIZATION VIA REVERSE OSMOSIS

The key terms used in the reverse osmosis process are defined as follows:

- *Recovery*
- ***Rejection***
- *Passage*
- *Permeate*
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- *Flux*

the percentage of solute concentration removed from system feed water by the membrane.

In reverse osmosis, a high rejection of total dissolved solids (TDS) is important.

DESALINIZATION VIA REVERSE OSMOSIS

The key terms used in the reverse osmosis process are defined as follows:

- *Recovery*
- *Rejection*
- ***Passage***
- *Permeate*
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the opposite of “rejection”, passage is the percentage of dissolved constituents (contaminants) in the feed water allowed to pass through the membrane.

DESALINIZATION VIA REVERSE OSMOSIS

The key terms used in the reverse osmosis process are defined as follows:

- *Recovery*
- *Rejection*
- *Passage*
- ***Permeate***
- *Flow*
- *Flux*

the purified product water produced by a membrane system.

DESALINIZATION VIA REVERSE OSMOSIS

The key terms used in the reverse osmosis process are defined as follows:

- *Recovery*
- *Rejection*
- *Passage*
- *Permeate*
- ***Flow***
- *Flux*

is the rate of feed water introduced to the membrane element or membrane system, usually measured in gallons per minute (gpm) or cubic meters per hour (m3/h).

Concentrate flow is the rate of flow of non-permeated feed water that exits the membrane element of system.

This concentrate contains most of the dissolved constituents originally carried into the element or into the system from the feed source.

It is usually measured in gallons per minute (gpm) or cubic meters per hour (m3/h).

DESALINIZATION VIA REVERSE OSMOSIS

The key terms used in the reverse osmosis process are defined as follows:

- *Recovery*
- *Rejection*
- *Passage*
- *Permeate*
- *Flow*
- ***Flux***

the rate of transported permeate per unit of membrane area, usually measured in gallons per square foot per day (gfd) or liters per square meter and hour (l/m2h).

Factors Affecting Reverse Osmosis Performance:

permeate flux and salt rejection are the key performance parameters of a reverse osmosis process. Under specific reference conditions, flux and rejection are intrinsic properties of membrane performance. The flux and rejection of a membrane system are mainly influenced by variable parameters including:

- *pressure*
- *temperature*
- *recovery*
- *feed water salt concentration*

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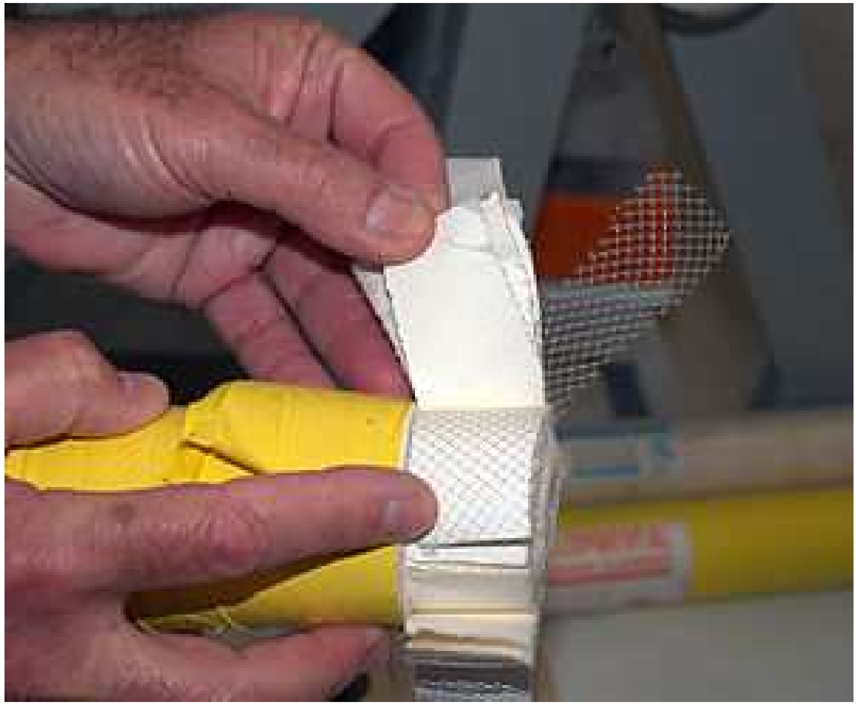
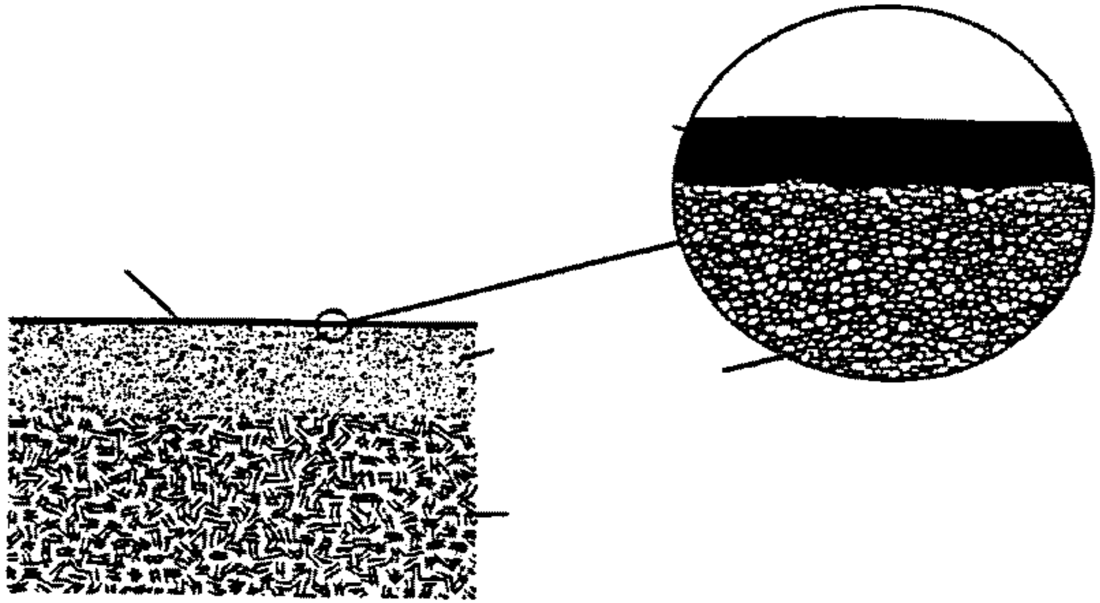
The most efficient RO membrane is a thin film composite membrane consisting of three layers, each one tailored to specific requirements.



The major structural support is provided by the non-woven web, which has been calendered to produce a hard, smooth surface free of loose fibers.

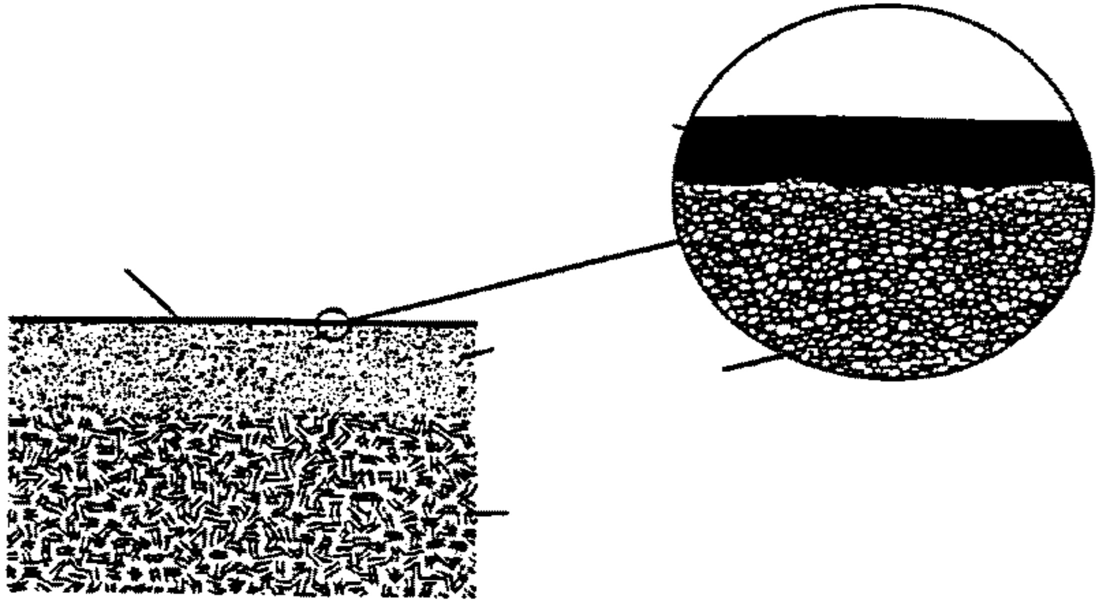
DESALINIZATION VIA REVERSE OSMOSIS



Since this web is too irregular and porous to provide a proper substrate for the salt barrier layer, a microporous layer of engineering plastic is cast onto the surface of the web.

The final coating is remarkable in that it has surface pores controlled to a diameter of approximately 150 Angstroms.

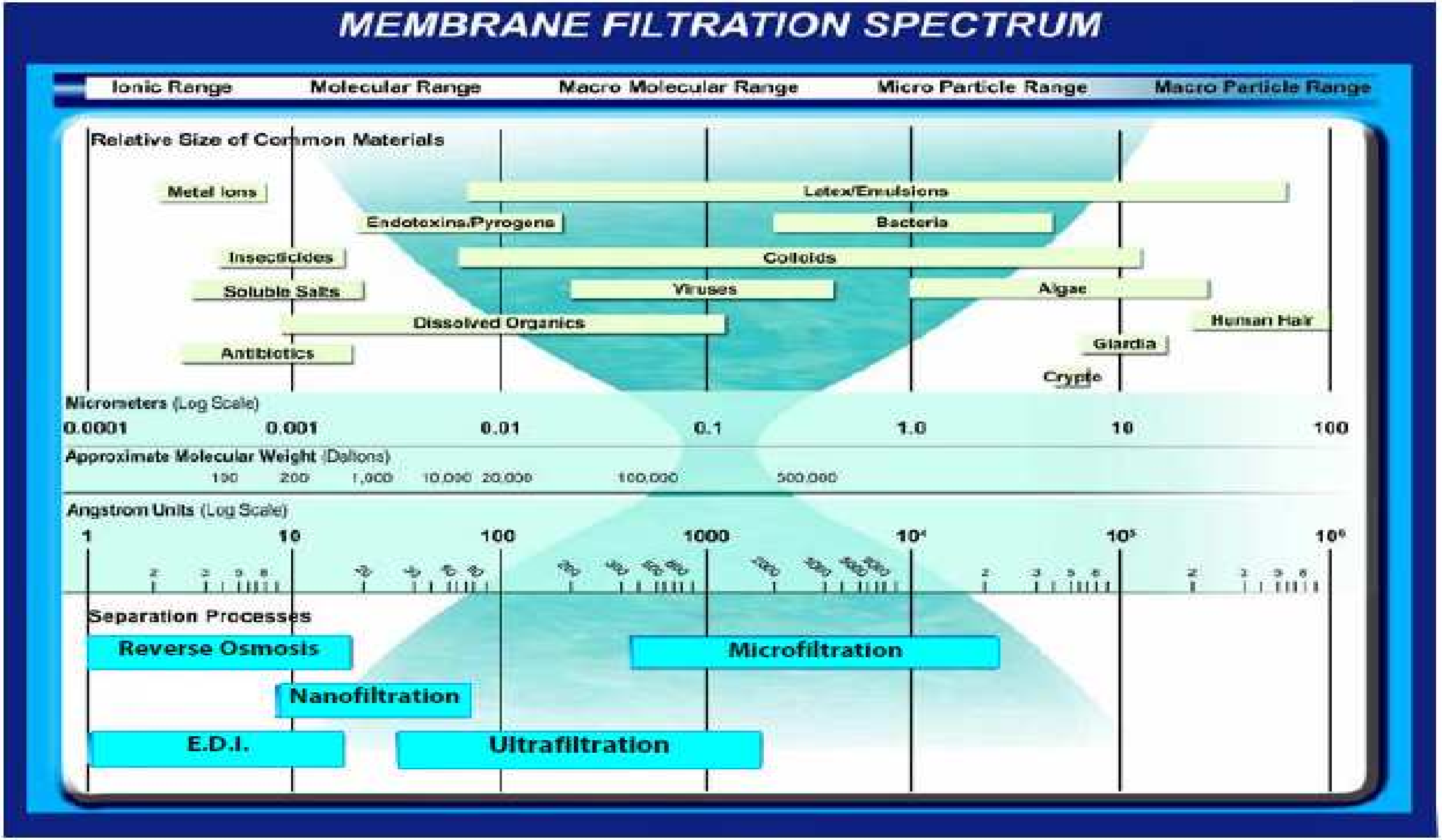
DESALINIZATION VIA REVERSE OSMOSIS



The barrier layer, about 2,000 Angstroms thick, can withstand high pressures because of the support provided by the final coating layer. The combination of the web and the final coating layer has been optimized for high water permeability at high pressure.
The barrier layer is relatively thick; making the membranes highly resistant to mechanical stresses and chemical degradation.

DESALINIZATION VIA REVERSE OSMOSIS

The difference is in the quality of the membranes:



DESALINIZATION VIA REVERSE OSMOSIS

The thin film composite membranes give excellent performance for a wide variety of applications:

- *seawater desalination*
- *brackish water purification*
- *chemical processing*
- *low pressure tap water use*
- *waste treatment*

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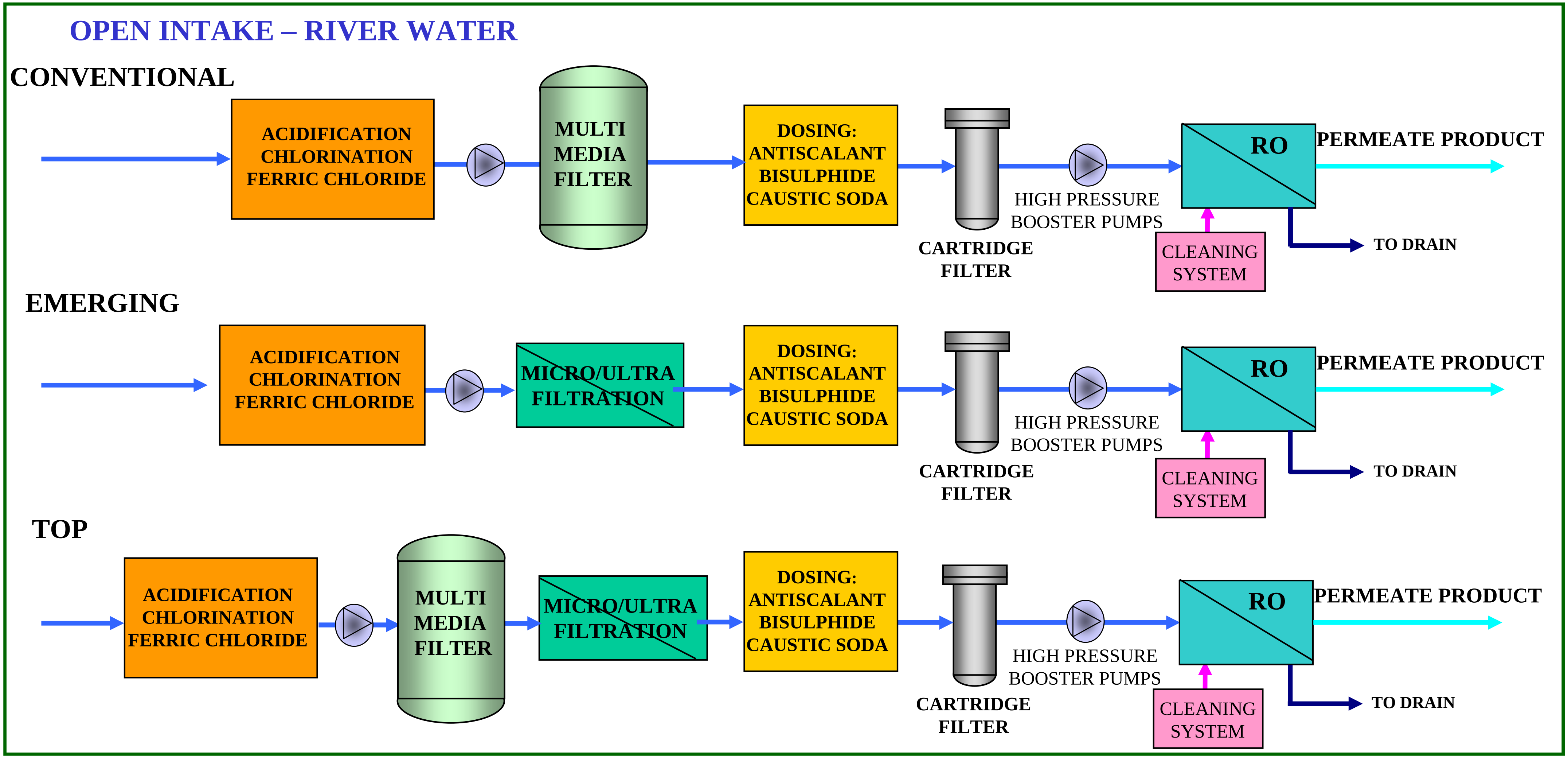
DESALINIZATION VIA REVERSE OSMOSIS

Typical flow diagram



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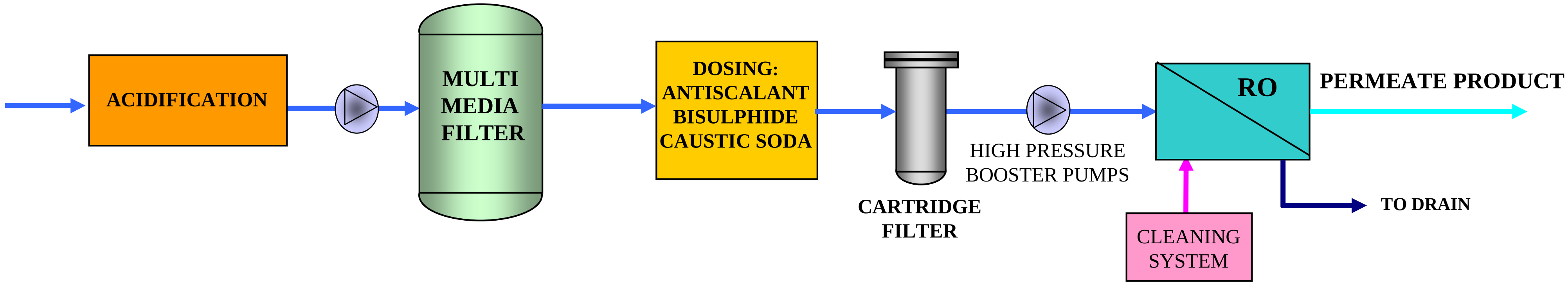
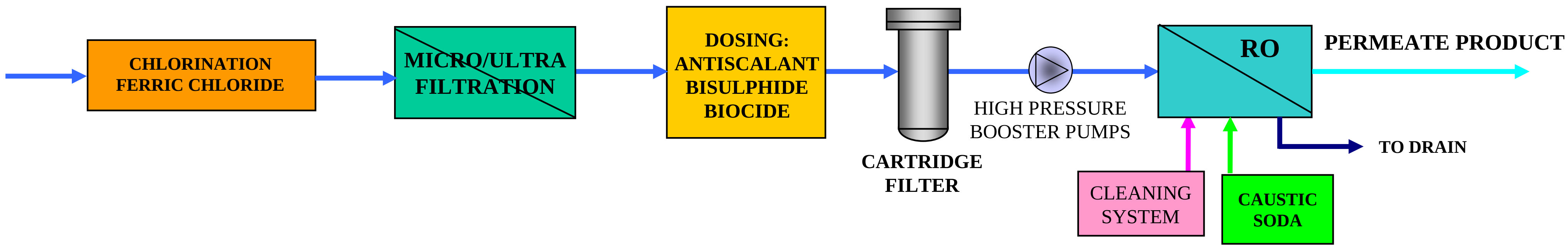
DESALINIZATION VIA REVERSE OSMOSIS

Typical flow diagram

BEACHWELL – WELL WATER

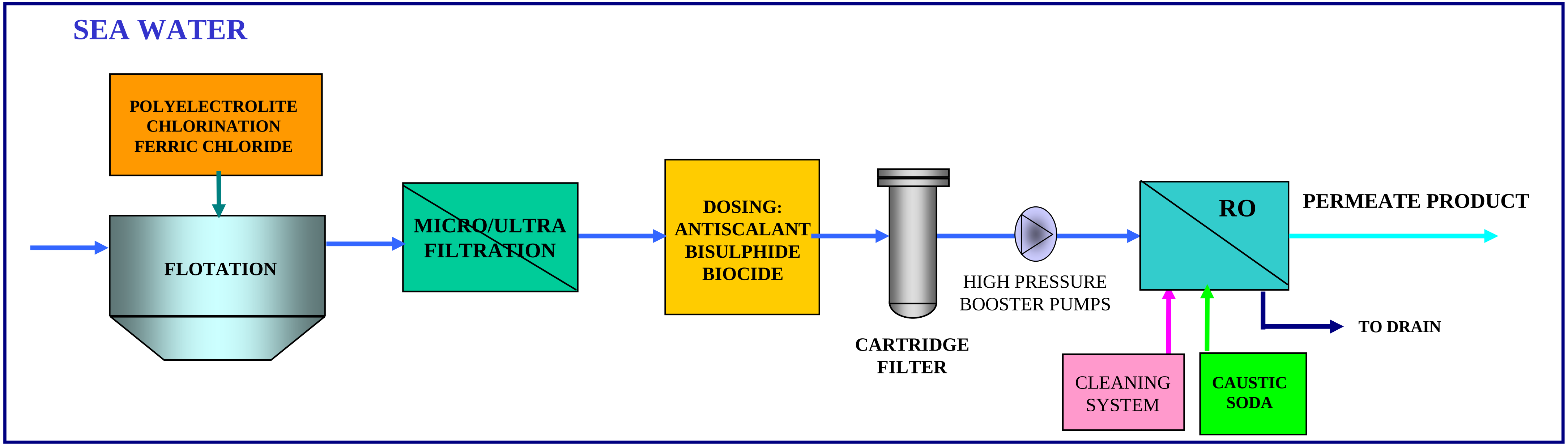


BRACKISH WATER



DESALINIZATION VIA REVERSE OSMOSIS

Typical flow diagram



DESALINIZATION VIA REVERSE OSMOSIS

This membrane exhibits excellent performance in terms of:

- *flux*
- *salt and organics rejection*
- *microbiological resistance*

This elements must stand operation in a pH range of 2 to 11, be resistant to compaction and suitable for temperatures up to 45℃. They must guarantee stable performance over several years, even under harsh operating conditions.

The membrane shows some resistance to short-term attack by chlorine (hypochlorite).

DESALINIZATION VIA REVERSE OSMOSIS

The free chlorine tolerance of the most effective membrane is < 0.1 ppm. Continuous exposure, however, may damage the membrane and should be avoided.

Under certain conditions, the presence of free chlorine and other oxidizing agents will cause premature membrane failure so it is recommended to remove residual free chlorine by pretreatment prior to membrane exposure.

DESALINIZATION VIA REVERSE OSMOSIS

The parameters which characterize the performance of a membrane are:

- *the water permeability*
- *the solute permeability.*

The ideal reverse osmosis membrane has a very high water permeability and a zero salt permeability.

DESALINIZATION VIA REVERSE OSMOSIS

As a general rule, membranes with a high water permeability (low feed pressure) also have a higher salt permeability compared to membranes with lower water permeability.

The permeability of solutes decreases (the rejection increases) with an increase in:

- *degree of dissociation*
- *ionic charge*
- *molecular weight*
- *non polarity*
- *degree of hydration*
- *degree of molecular branching*

weak acids, for example lactic acid, are rejected much better at higher pH when the dissociation is high

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- *degree of dissociation*
- *ionic charge* → e.g. divalent ions are better rejected than monovalent ions
- *molecular weight*
- *non polarity*
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higher molecular weight species are better rejected

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- *ionic charge*
- *molecular weight*
- *non polarity* → less polar substances are rejected better
- *degree of hydration*
- *degree of molecular branching*

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- *ionic charge*
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- *degree of hydration*
- *degree of molecular branching*

highly hydrated species, e.g. chloride, are better rejected than less hydrated ones, e.g. nitrate

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The permeability of solutes decreases (the rejection increases) with an increase in:

- *degree of dissociation*
- *ionic charge*
- *molecular weight*
- *non polarity*
- *degree of hydration*
- *degree of molecular branching* → e.g. iso-propanol is better rejected than n-propanol.

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Thank you !

STATE OF THE ART TECHNOLOGIES FOR WATER PURIFICATION SYSTEM