

Water Treatment



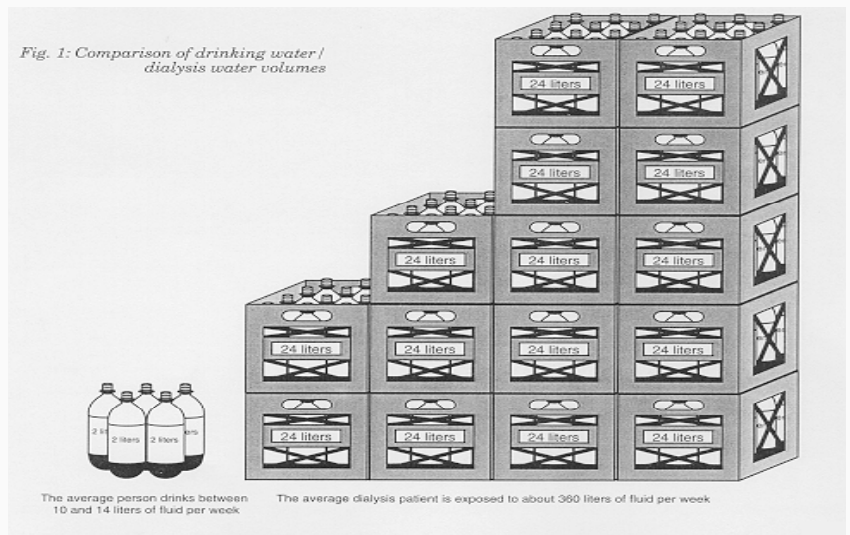


Objectives

- Understand the components of the water treatment system
- Understand the importance of providing safe, treated water during dialysis

Water Treatment

- Patient safety
 - Very large exposure volume
 - Little or no renal excretion
 - Dialyzer membrane is sole barrier





Water Treatment Processes

- Pre-treatment
 - Before the RO
- Purification
 - Removes organic, inorganic and bacterial contaminants
- Distribution



Water Treatment System

- Monitoring

Continuous

- Temperature
- % rejection, TDS
- Pressures and flow rates

Periodic

- Chlorine/chloramine (before each shift **or every 4 hours if there is no set shift schedule**)
- Hardness (end of day)
- Cultures and endotoxins (monthly)
- Water analysis (annually)



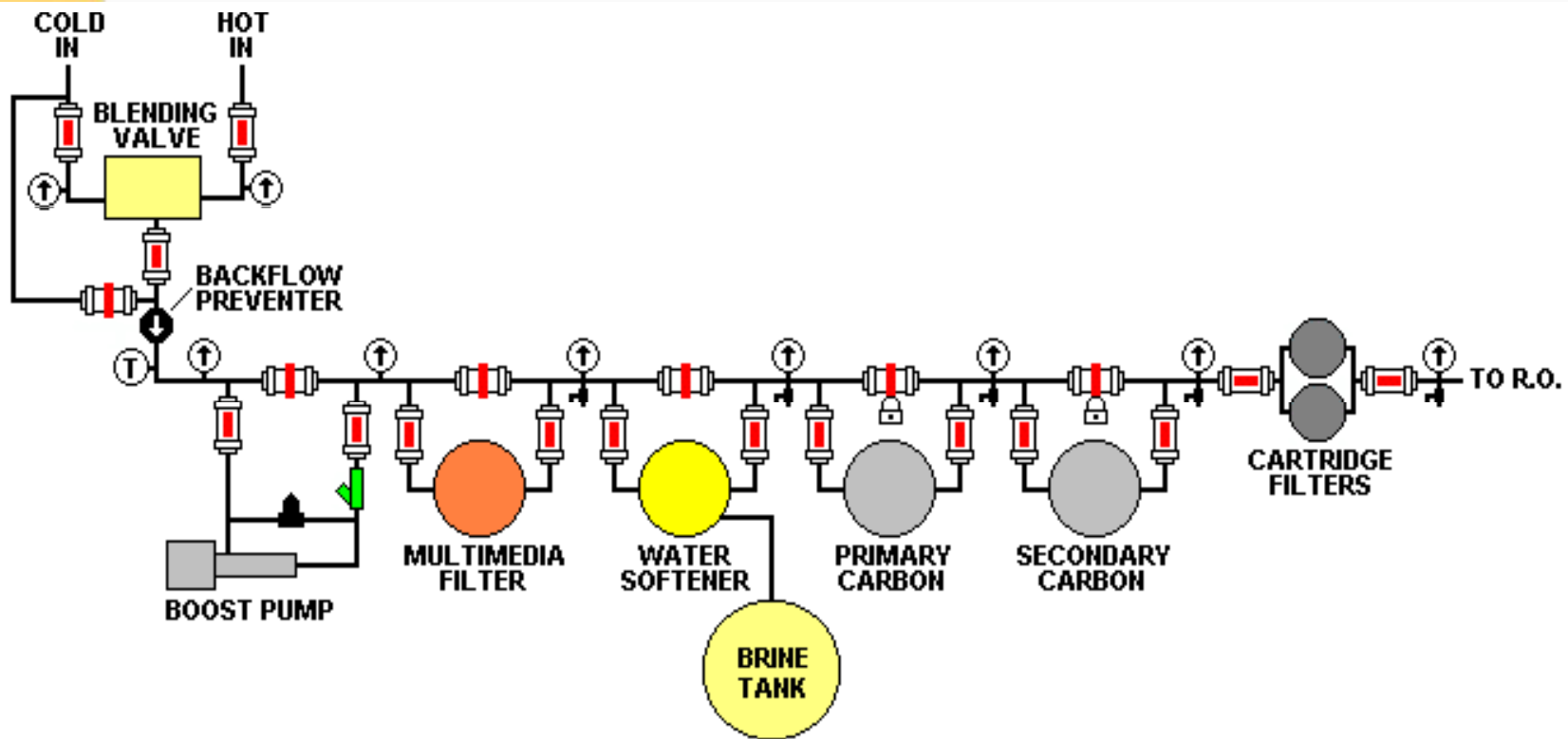
Water Supply

- Municipalities not only remove contaminants, they add chemicals to the water supply

- Aluminum
- Chlorine
- Chloramines

This dictates the type of pre treatment we install pre RO

Typical Pre Treatment System



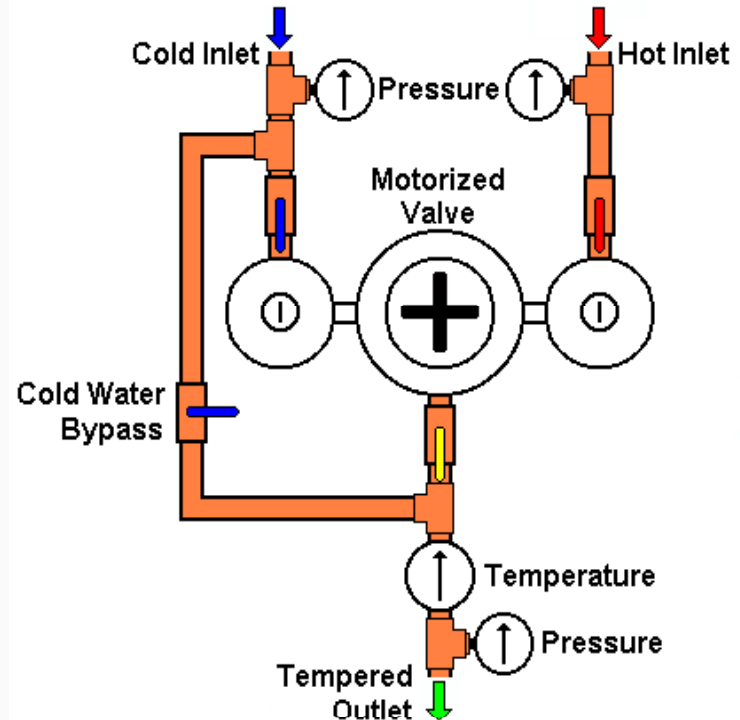


Components Of A Typical Dialysis Water Treatment System

- Backflow Preventor
- Required by water municipalities
- Prevents disinfectants from backing up into the city water supply
- Prevents pretreated water from backing up into the city water supply

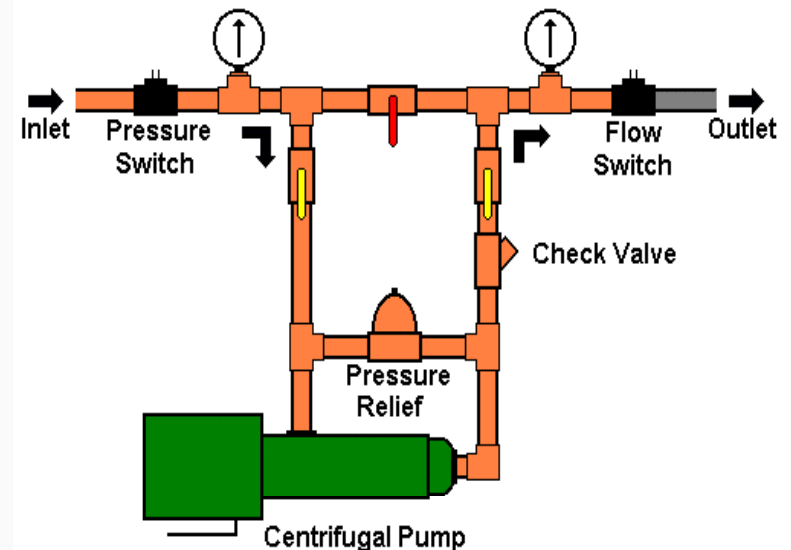
Blending Valve

- Allows the RO membrane to function at the most efficient temperature range
- Mixes hot and cold water at desired RO temperature
- 70-80°F



Booster Pump

- The booster pump increases the pressure in the pre treatment pipes to avoid shut off of the RO due to low pressure
- The municipal water service often can not deliver enough pressure to prevent the RO from shutting down due to low pressure



Water Treatment System

COMPONENT

- Sediment filter
(Multimedia Filter)

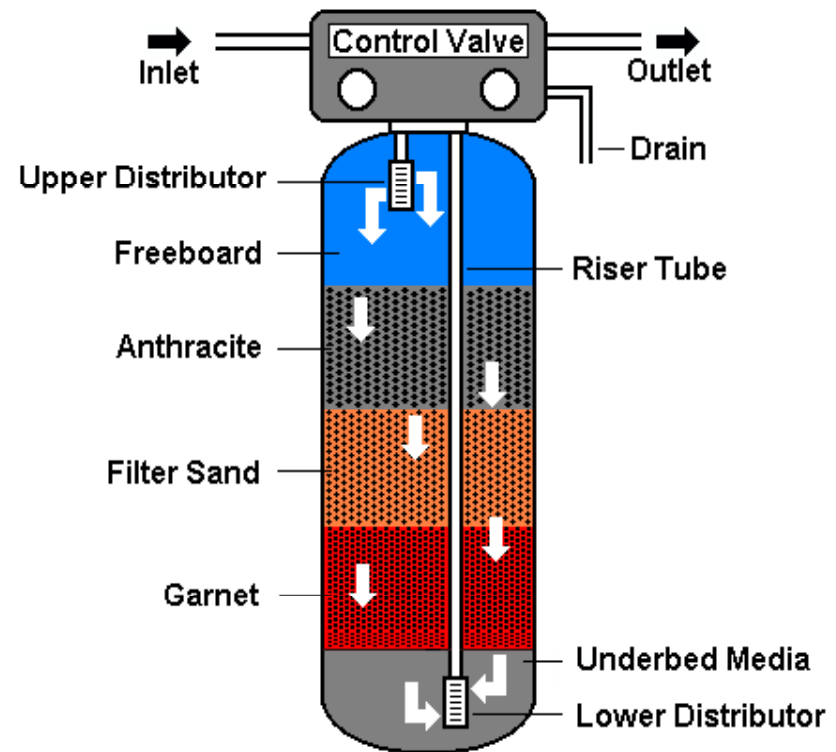
FUNCTION

- Removes
Dissolved
Solids



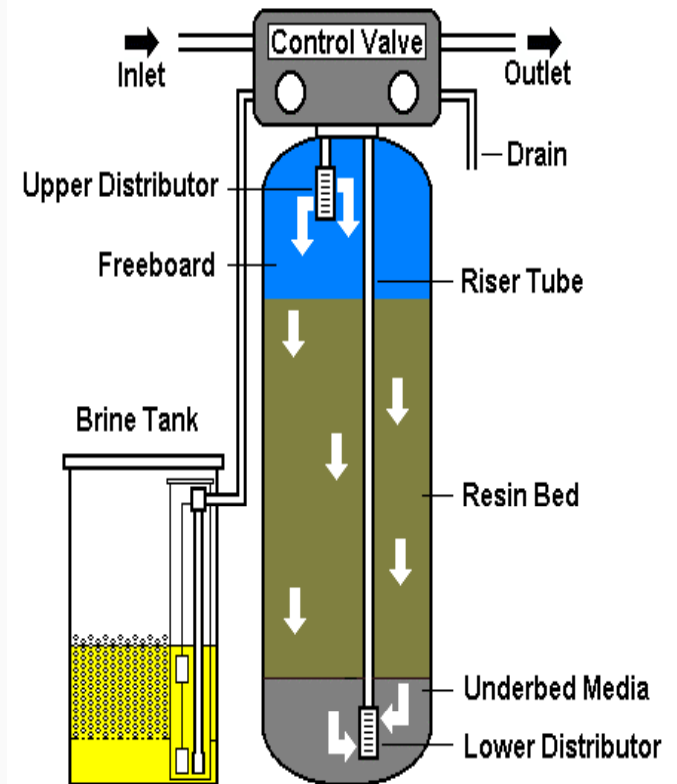
Sediment Filter

- Purpose is to remove suspended material from the “feed” water
- In opaque canister
- Pre and Post filter gauge should read <15psi



Water Softeners

- Primarily for RO protection
- Remove “hardness” ions (calcium & magnesium) and add sodium
- Sized for at least 1 day’s operation
- Regenerate with pellet salt
- Regeneration must NOT occur during dialysis as this would cause very high Na^+ levels in the water

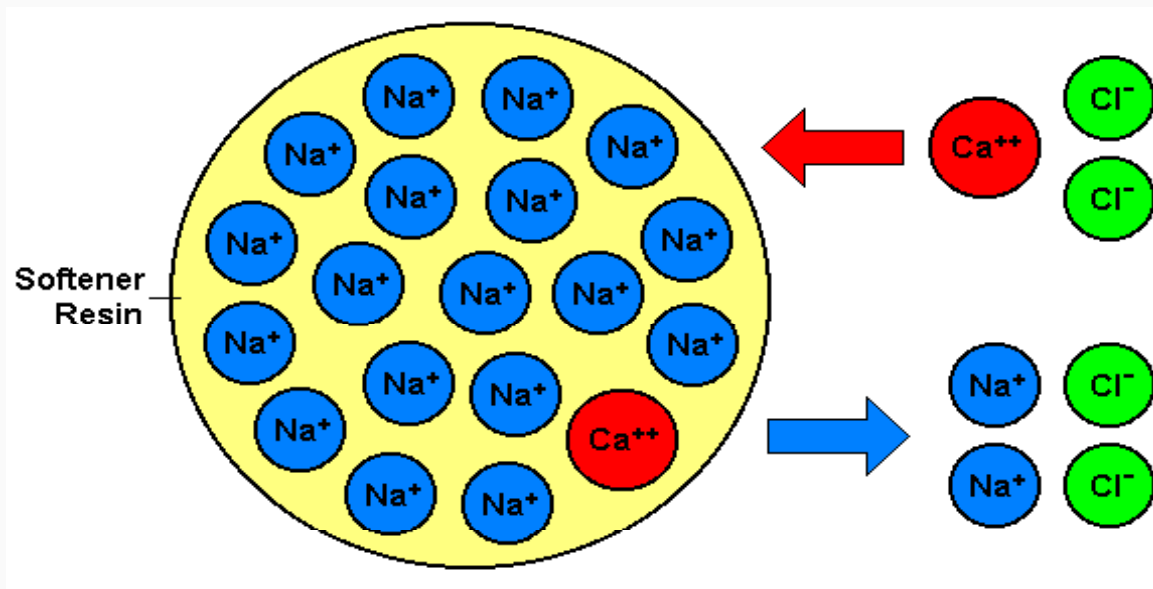


Water Softener



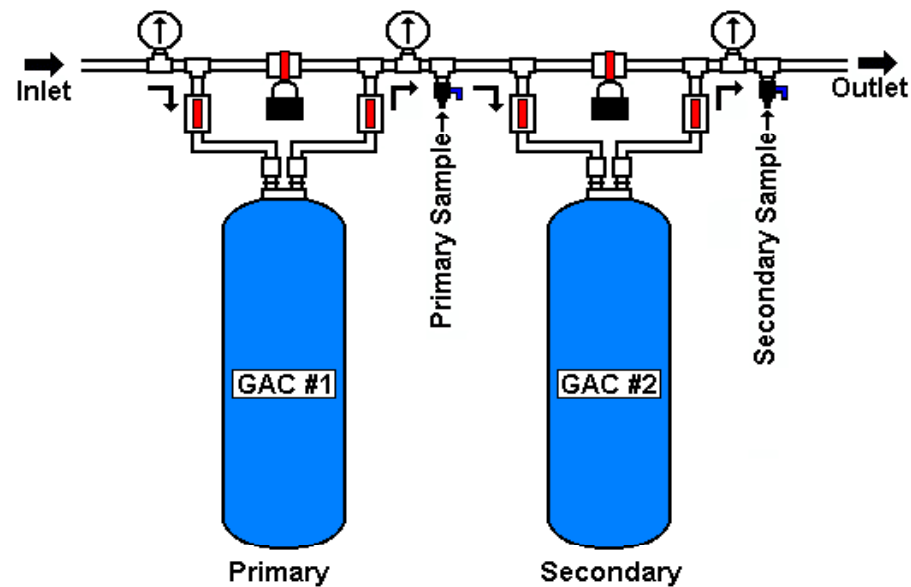
- Regenerable
- Timers checked daily
- Hardness Test daily

Ion Exchange Softening



Carbon Filters

- Essential for free chlorine and chloramine removal



Carbon Tanks – At Least 2

- Chloramines and chlorine added to prevent bacteria growth
- Can cause hemolysis
- SOB, chest pain, arrhythmias, death at chloramines levels of .25ppm





Carbon Tanks

- Contain granular activated carbon
- Absorbs chlorine like magnet
- Timer – backwash tanks
- Timer read and recorded daily
- Total chlorine checked prior to each patient shift or every 4 hours if there is no set schedule and recorded

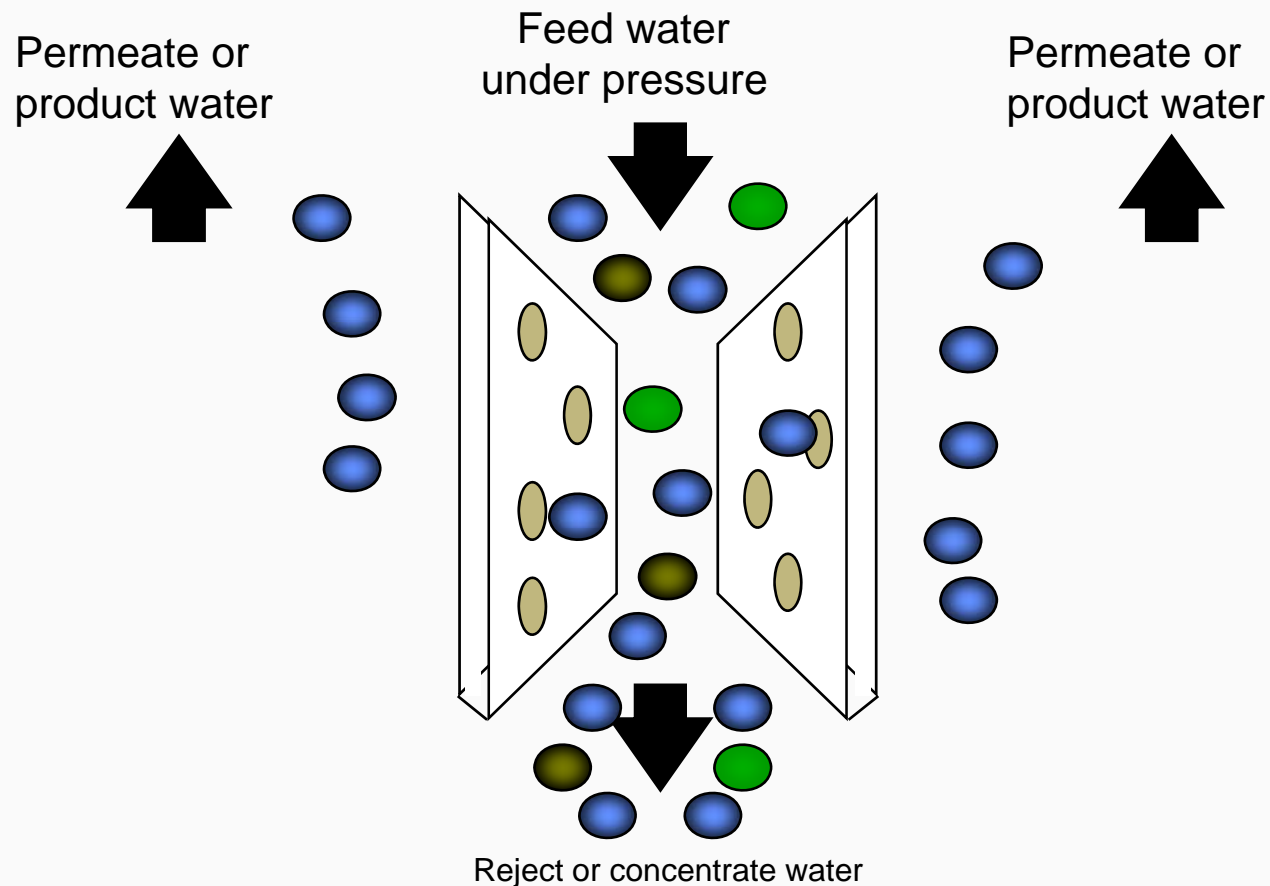


Paired Carbon Tanks

- Chlorine test – obtained following the first tank or tanks
- Maximum allowable limit is 0.1mg/L or ppm for total chloramine
- If + for chlorine post first tank, test the second tank
- Second tank >0.1 mg/L or ppm stop dialysis until new carbon obtained

Water Treatment System

- Reverse Osmosis
- Removes Bacteria, Ions, Dissolved Organics



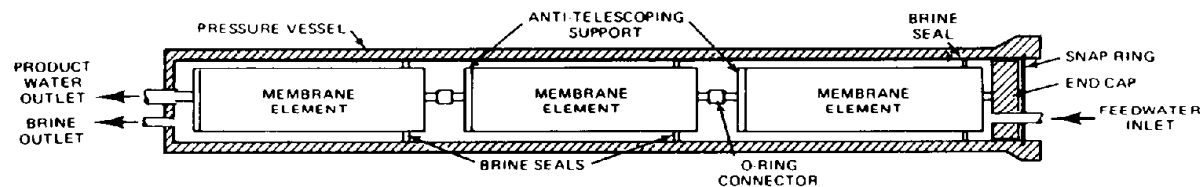
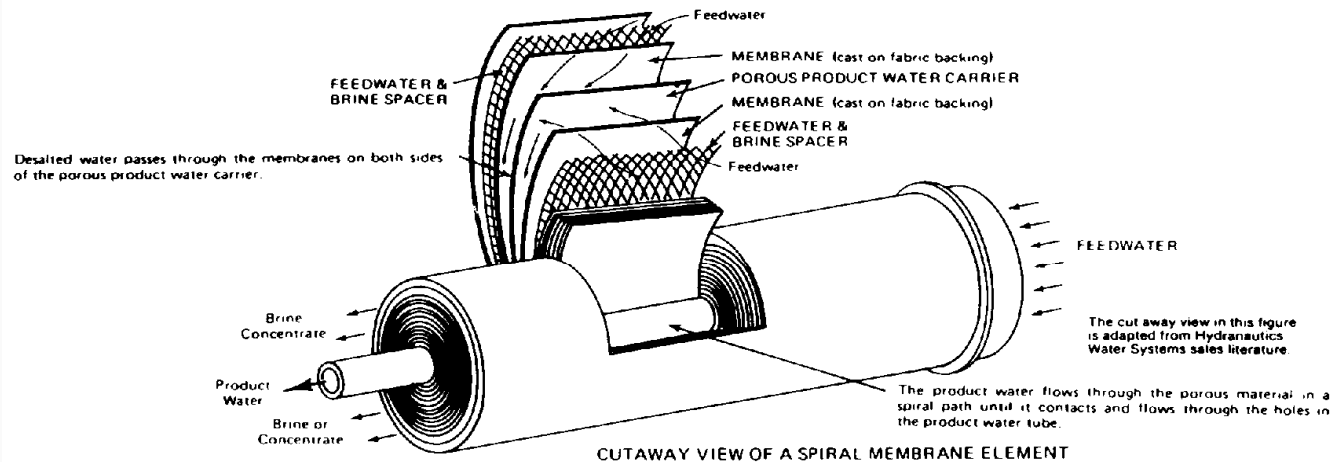


Reverse Osmosis (RO)

- Primary device of water system
- Removes organic and inorganic contaminants
- Semi permeable membrane and pressure passes water through the membrane
- The volume of water produced depends on:
 - Transmembrane pressure
 - Surface area of the RO unit
 - Contaminants
 - Water temperature

RO Process

- Membrane – hollow fiber, spiral wound composed of cellulose acetate, polyamide, thin composite membrane





RO Process

- Osmosis – movement of fluid across a semi permeable membrane from a lower concentration of solutes to higher concentration of solutes



RO Terms

- Osmotic pressure – the force or pressure that results when two liquids having different solute concentrations, are separated by a semi-permeable membrane
- Reverse Osmosis – when pressure that exceeds the osmotic pressure is applied to the concentrated solution, water moves from the concentrated side to the less concentrated side

RO

- How do we monitor if the RO is delivering ultra pure water?
 - **Percent rejection** – measures the percent of total dissolved solids (TDS) in the **product** water compared to the **feed** water
 - Measured with a conductivity meter
 - % Rejection-
$$\frac{(\text{Feed TDS} - \text{Product TDS}) \times 100}{\text{TDS Feed Water}}$$



R.O. VOCABULARY REVIEW

- **Total dissolved solids (TDS)** is the sum of all ions, organic matter, and inorganic matter remaining in the product water
- **Percent Rejection or Rejection Rate** is a measure of the R.O. membrane's ability to remove salt contaminants

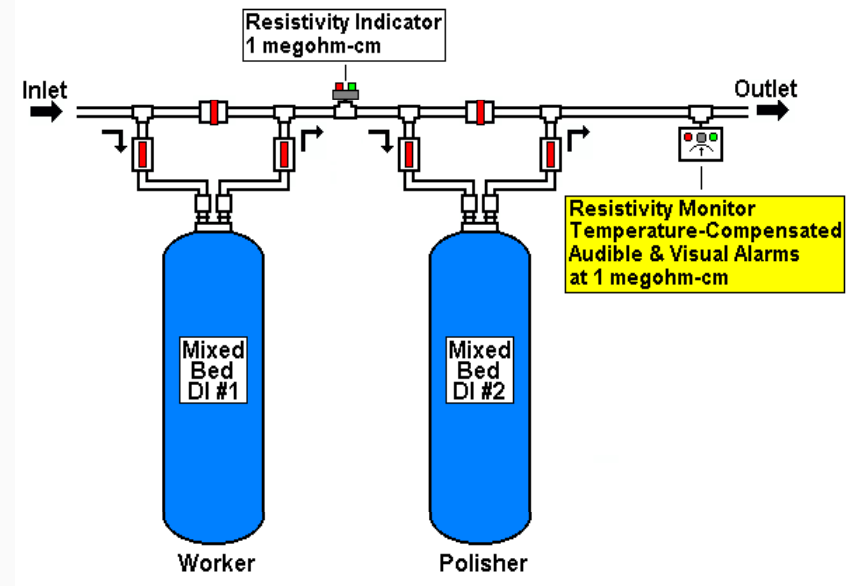
Deionization (DI) Tanks

- Exchange unwanted ions for hydrogen ions (H^+) and hydroxyl ions (OH^-) by use of electrically-charged resin beads.
- The hydrogen ions and hydroxyl ions combine to make water



Deionization (DI) Tanks

- Placed post RO to remove chemicals
- Backup for water purification
- “Polish” the RO
- DO NOT REMOVE MICROBIAL CONTAMINANTS

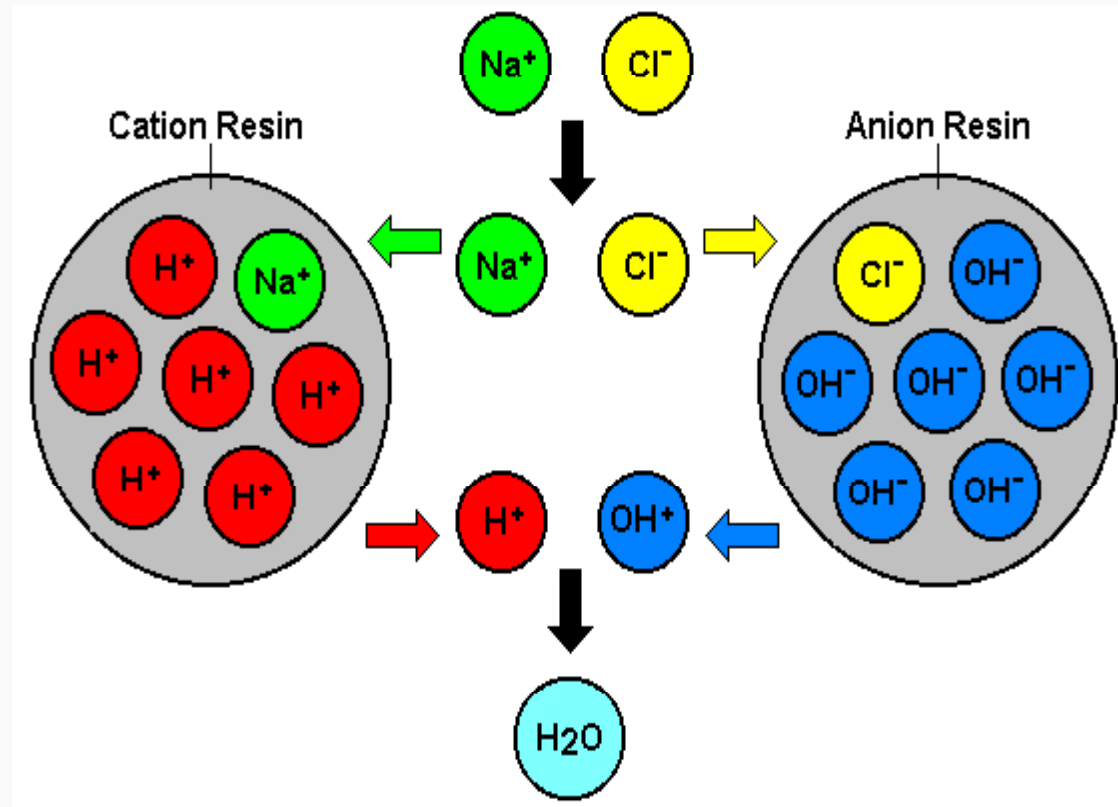




DI Tanks

- Work on principle of ion exchange
- Cation resin - Hydrogen
 - H^+ ion and attracts +charged molecules
- Anion resin – Hydroxyl
 - OH^- ion and attracts – charged molecules
- The release of H^+ and OH^- = water
- Measured water resistivity with Resistivity Monitor => 1.0megohm/cm

The Ion Exchange Process





Deionization (DI) Tanks

- DI tanks must be only medical grade tanks for dialysis patients
- DI tanks can become exhausted
- DI tanks can become easily contaminated with bacteria, so ultra filtration must be present downstream of the DI tanks
- DI tanks are used only as temporary replacement for RO or to augment RO function



DI Monitoring

- On-line resistivity monitoring
 - Minimum resistivity is 1 megohm/cm at 25°C
 - Final monitor must have audible/visual alarms
- Off-line monitoring
 - Laboratory analyses for AAMI contaminants
 - Bacterial & endotoxin analyses (post UF)



Pyrogen Filter Ultrafilter

- Placed at the end of the water system prior to treatment area
- Provide pure water
- Capable of removing all viruses, bacteria, and most endotoxin
- Monitored by pressure gauges (delta (Δ) pressure), daily and documented
- <30 but >2 psi



Microbial And Bacterial Control

- Primarily Gram negative bacteria
 - Grow in water rapidly
 - Thrive on the nutrients or organics in purified water
- Cell walls contain endotoxin
- Endotoxin is released when there is breakdown of the bacterial cell wall



Endotoxin

- If water contains bacteria, endotoxin can be released during disinfection
- Cannot be destroyed by Peracetic Acid because endotoxin is not a living organism
- Can only be removed by an ultra filter

Bacterial and Endotoxin Cultures – AAMI Standards

| <u>Source</u> | <u>Standard</u> | <u>Action Level</u> |
|---------------|-----------------|---------------------|
| • Water | 200 cfu/ml | 50 cfu/ml |
| • Dialysate | 200 cfu/ml | 50 cfu/ml |
| • Endotoxin | ≤ 2 EU/ml | 1 EU/ml |



Chemical Analysis

- New water system complete analysis performed
- Equipment installed based on analysis results
- Monitored annually
 - Municipalities may change their procedures based on seasonal needs



QUESTIONS?