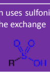
AWT Training Seminars

WATER SOFTENING
RESIN TECHNOLOGY
FILTRATION

Bruce Ketrick - Guardian CSC

ASSOCIATION OF WATER TECHNOLOGIES

Types of Resin

RESIN TYPES	Strong Acid/ Strong Cation	Weak Acid/ Weak Cation	Strong Base/ Strong Anion	Weak Base/ Weak Anion
Application	**Water Softener Deionization/ Demineralization**	**Cation removal in Deionization/ Demineralization**	**Dealkalizers Deionization/ Demineralization**	**Anion removal in Deionization/ Demineralization**
Function	Due to its ability to convert neutral salts into their corresponding acids, this resin is called strong acid resin.	Weak Acid or Weak Cation resin is used for removing the cations associated with alkalinity (Ca, Mg and Na).	Two types of strong base resin. The principle difference is that Type I has greater chemical stability and Type II has greater regeneration capacity.	Weak base resin has higher regeneration efficiency than strong base resin. A mixture of weak and strong base resin is required for silica removal.
Regeneration	Normal regeneration is with NaCl In the hydrogen cycle (using acid for regeneration instead of salt), virtually all of the raw water cations can be removed.	Resin is regenerated in the hydrogen cycle with acid. Weak cation resin will regenerate more efficiently than the strong cation resin.	When regenerated with salt, they will remove up to 90% of the anions (alkalinity) in water.	This resin is regenerated with NaOH
Exchange Group	This resin uses sulfonic acid as the exchange group. 	This resin uses the carboxylic group (-COOH) as the exchange group. 	This resin uses quaternary ammonium as the functionality group.	This resin uses primary (R-NH2), secondary (R-NRH) and tertiary (R-NR2) amines for exchange

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Resin Selectivity

Relative Affinity of Select Ions Removal with Ionic Resins			
Strong Acid Cationic		Strong Base Anionic	
Ra^{+2}	13.0	CrO_4^{2-}	100.0
Ba^{+2}	5.8	SeO_4^{2-}	17.0
Pb^{+2}	5.0	SO_4^{2-}	9.1
Sr^{+2}	4.8	$HAsO_4^{2-}$	4.5
Cu^{+2}	2.6	HSO_4^{-}	4.1
Ca^{+2}	1.9	NO_3^{-}	3.2
Zn^{+2}	1.8	Br^{-}	2.3
Fe^{+2}	1.7	SeO_3^{2-}	1.3
Mg^{+2}	1.67	HSO_3^{2-}	1.2
K^{+}	1.67	NO^{2-}	1.1
Mn^{+2}	1.6	Cl^{-}	1.0
NH_4^{+}	1.3	HCO_3^{-}	0.27
Na^{+}	1.0	OH^{-}	0.10
H^{+}	0.67	F^{-}	0.07

SAC & SBA Resins

- The ability for resin to attract ions favors large highly charged ions.
- Removal of zinc or copper from a water prefers the initial removal of calcium to allow the SAC resin to remove the other metals
- For Nitrate removal, where Sulfates are significant, SBA resin must be regenerated early, or the sulfates will act as a regenerant and cause a sudden severe discharge of the Nitrates off of the resin.

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WATER SOFTENERS

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Water Softener Resin

- STRONG ACID OR STRONG CATIONIC RESIN IS THE TYPE OF RESIN USED IN WATER SOFTENERS

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Terms

- "as CaCO3"
  - "As Calcium Carbonate equivalents"
  - A convenient way to describe the concentration of an ion in the water based on the number of charges rather than the weight of the ions.
- DVB (cross link)
  - Divinylbenzene
  - The chemical used to strengthen resin beads
  - Increased DVB will increase the physical strength of the resin bead and the resistance of the resin bead to oxidation
- PPM (mg/l)
  - Parts per million (milligrams per liter)
  - A measure of the concentration of ions as defined by their weight.
- Grains
  - Unit of weight originally equal to a grain of wheat. Grains are used to describe the capacity of ion exchange resins used in water softening
- Resin
  - Common name for the strongly acidic polystyrene copolymer that is used for softening water

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Mathematical Relationships

- PPM to GPG (grains per gallon)
  - 17.1 ppm (as $CaCO_3$) equals 1 GPG
- PPM (mg/l) to PPM (as $CaCO_3$)
  - Calcium (as Ca) X 2.50 = Ca (as $CaCO_3$)
  - Magnesium (as Mg) X 4.18 = Mg (as $CaCO_3$)

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Helpful Conversions

- 7.48 Gallons = 1.0 Cubic Foot
- 7000 Grains = 1.0 Pound
- Approximately 40% = Voids in Resin Bed
- 2.5 lbs./gallon = Conc.. Of Saturated Brine
- 0.9 lbs./gallon = Conc.. Of 10% Brine

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Process Limitations For Resin

- Flow Limitations
  - 0.5 - 10 gpm/cubic foot
  - 4 - 6 gpm/ cubic foot for boiler quality soft water
  - 2-20 gpm/ square foot (based on surface area of resin bed)
- Bed Limitations
  - 2- 8 feet of bed depth
  - Max. 25 psi pressure drop across the resin bed
- Inlet Contaminants (limits for best life)
  - 0.3 ppm free chlorine
  - 1.0 ppm of turbidity
  - 1.0 ppm of iron

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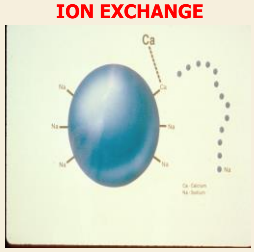
HOW IS WATER SOFTENED ?

ION EXCHANGE

- Hard Water is a combination of Calcium Carbonate ($CaCO_3$) and Magnesium Carbonate ($MgCO_3$) (It is also in the bicarbonate form (HCO_3)
- As the hardness salts contact the resin bead, Calcium and Magnesium's higher charge (+2) forces the Sodium ion (Na+) with the lower charge off of the resin bead.
- The Sodium (Na+) then combines with the carbonate (CO_3) to form Sodium Carbonate (Na_2CO_3) which we consider soft water.



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Dual Softeners - Diaphragm Valve

- **Dual softeners use metal tank and a diaphragm valve.**
- **Timer actuates the regeneration sequence.**
- **Regeneration uses an internal stator that directs water in and out of tubing.**
- **This tubing is connected to diaphragm valves.**

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Dual Tank Softener System

•Dual tank softener system used a Fleck valve and fiberglass tank.
•The system is controlled with a PLC controller.
•Each tank has it’s own brine tank and water meter.
•This allows the system to operate in series or staged.

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Dual Tank Single Valve Softener

Disadvantage: unit size is 10 cubic feet or less. You can not put the two tanks in series when higher flow is required.

Advantage: It only uses one valve. Uses soft water for regeneration, improving regeneration quality.

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Water Softener Operation

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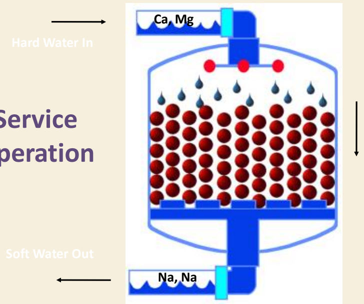
Service Operation



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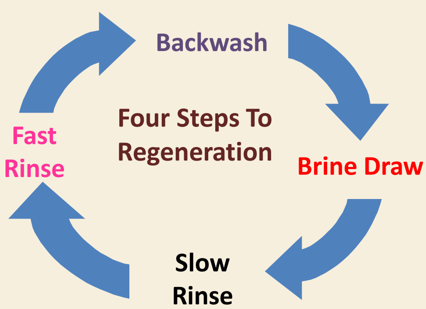

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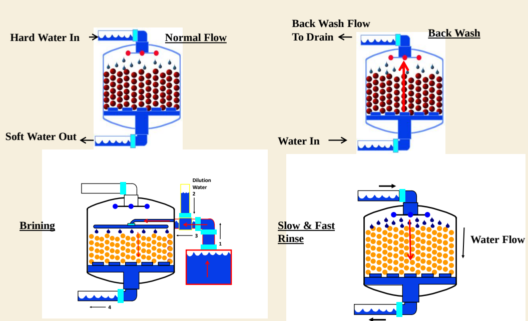
Softener Cycles



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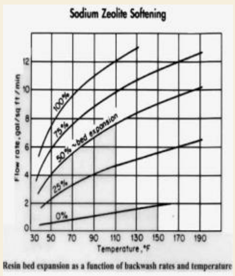
Resin Bed Expansion



The rule of thumb: water softener resin depth is 2/3 of the vessel volume.

Allows a 50% expansion of the resin bed during back wash.

Actual bed expansion is dependent on the water temperature and the flow rate of the water.

@ 4 gallon/ft²/min., 50ºF bulk water temperature, you would have 50% bed expansion

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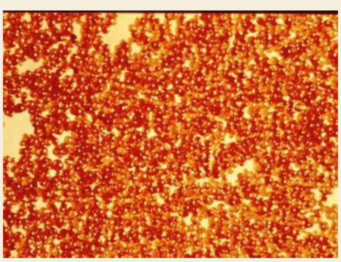
Resin Beads



Resin beads as they would be seen under a magnifying glass

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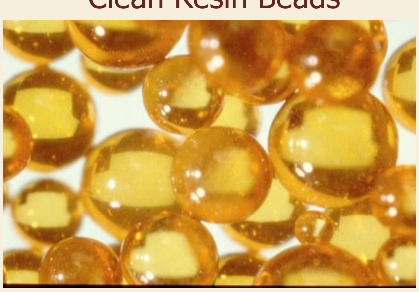
Clean Resin Beads



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Irregular Sized And Broken Beads - Chlorine Resistant

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Resin Bead Internals

Resin appears to be hard plastic spheres.

In reality, the resin is actually like a ball of yarn.

The ion exchange occurs at the sites on the internal of the resin bead.

Fouling will restrict passage of water through the internal of the resin bead, this reduces exchange and as such, capacity.

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Water Softener Operation Trouble Shooting

- Is Service Flow Satisfactory?
  - Poor flow distribution may result from high or low flow rates, check the gpm flow per cubic foot of resin.
- Is Complex Phosphate Present?
  - Complex phosphate will cause hardness leakage and will not be detected by standard hardness test.
- Is Water Softener In Standby For Any Length Of Time?
  - Standby allows the hardness salts on the resin to migrate. Rinse with twice the vessel volume through the water softener before putting it on-line.
- Was Resin Found In The Drain?
  - Resin loss due to colder water being more viscous.
  - Wear of the fixed rate orifice valve on the drain line.

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Water Softener Operation Trouble Shooting

- Is The Slow Rinse Time Too Short?
  - Slow rinse is a continuation of the brining cycle that allows additional contact time for the brine and the lower levels of the resin bed. Too short of a time will cause shortening of the run.
- Is The Fast Rinse Time Too Short?
  - If the fast rinse time is too short, brine will remain in the water softener.
  - This causes brine to be released into the feed water.
  - Brine is both corrosive and it has very high conductivity. This means that you will introduce high conductivity into the boiler causing the operator to blow down excessively.

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Resin Trouble Shooting

- **OsmoticShock** - Excess sodium concentration on bead.
- Thermal Shock- Temperature changes on the resin bead.
- **Iron, Aluminum & Copper** - These ions bind to the bead and do not easily come off with regeneration. Clean resin with sequestering agent.
- **Calcium Sulfate** - Fouling occurs on the anion train of a dealkalizer or DI system. Caused by hardness leakage from softener
- **Oil Fouling**: Oil coats the resin bead, preventing ion exchange
- **Oxidation**: Oxidation of resin causes resin failure. Chlorine contact breaks down the resin bead. Replace resin and use carbon filter.
- **Mechanical Strain**: Flow rate, water velocity and pressures can affect the exchange capacity of the resin bead. Maintain 4-6 gpm per cubic foot of resin flow.

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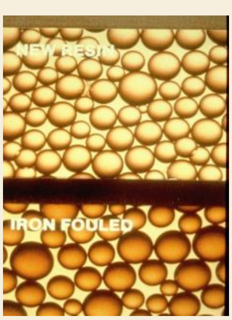
Iron Fouling Of Resin



Iron has three positive charges. As such, it will tend to bind to the resin, and remain on the resin after regeneration.

Eventually, the resin looses capacity due to the fouling of reactive sites that are now covered with iron.

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Resin Cleaners

- **There are a number of different types of resin cleaners. The three basic formulas are:**
- **10% HEDP - Good General Cleaner**
  - ***1 quart/10 cubic feet of resin as a maintenance dosage***
  - ***1 gallon for every 10 cubic feet of resin for off-line clean up***
- **Sodium Bisulfite - Inexpensive, Watch For Fumes**
  - ***1 lb./10 cubic feet of resin for maintenance***
  - ***1 lb./2.5 cubic feet for off-line cleaning.***
  - ***Be careful where iron is the main contaminant, as this can form with heavy iron to bind up the resin bed.***
- ***10*% Citric Acid/ 20% HEDP - Most Effective General Cleaner**
  - ***0.3-0.6 gal/10 cubic feet of resin for maintenance***
  - ***0.3-0.6 gal/ cubic foot of resin for off-line cleaning***

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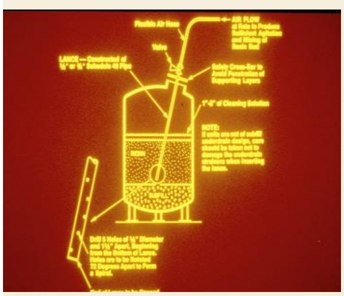
Off- Line Resin Cleaning



To clean resin off-line;

1. Remove head or hand hole at the top of the tank.

2. Insert a air lance to the gravel layer in the tank.

3. Add resin cleaner

4. Agitate the resin GENTLY with air.

5. Allow 1-4 hours of contact time.

6. Remove air lance and seal softener tank.

7. Put unit into back wash to remove cleaner and debris.

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Elution Study

- What is an elution study?
  - It is a graph of the salt percentage in a water softener effluent during the regeneration cycle
- How do you do an elution study?
  - Every 5 minutes from the start of the brine eduction into the water softener, tank a sample of the water softener effluent and check the salt percentage with a salometer.
- What does it show?
  - Evaluates the regeneration cycle
  - Shows salt eduction inefficiencies.
- What does it miss?
  - Can't predict resin fouling or loss of resin capacity.

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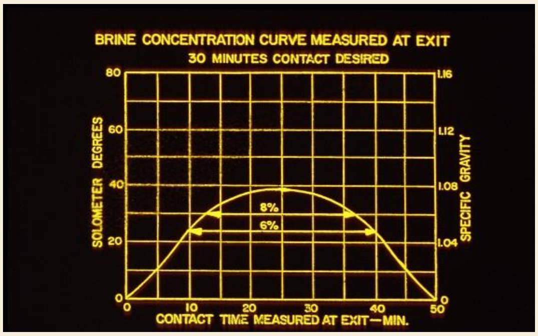

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WATER SOFTENER SIZING

- Flow Rate = 90 gpm
- Total Hardness = 86 ppm
- Grains/gallon = ppm TH/17.1
  - 86/17.1 = 5 grains per gallon
  - Using 28 Kgr/cu ft, 28,000/5 = 5,600 gallons per cubic foot of resin per regeneration
- 90 gpm X 1440 min/day = 129,600 gpd
- 129,600 gpd/5,600g/cu ft = 23.24 cubic feet of resin per day

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COMPARE FLOW RATE

- Softener sized @ 23.14 ft³
  - 23.14 ft³ / day resin requirement
  - 90 gpm flow rate
- @ 4 - 6 gpm per cubic foot of resin flow rate requirement, you can flow 120 - 180 gpm over this amount of resin.
- Minimum flow for this type of resin is 1-2 gpm per cubic foot of resin or 30 - 60 gpm.
- Considering that it takes up to 8 hours for brine to saturate in the brine tank, what size unit should you use and is there a flow problem?

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Sizing With Brine Saturation

- Brine Concentration
  - Must be at least 8-10% NaCl
  - Concentrations over 14% are less effective
- Injection Time
  - Should be 30 minutes or longer
- **Warning**
  - Brine concentration is more important than injection time.
  - Brine conc. below 8% will cause serious loss of capacity & increase hardness leakage

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Dealkalyzer Resin

- STRONG BASE OR STRONG ANIONIC RESIN
- Selectivity of ions;
  - $SO_4^{2-} \leftarrow CrO_4^{2-} \leftarrow PO_4^{3-} \leftarrow HSO_4^{-} \leftarrow NO_3^{-} \leftarrow Br^{-} \leftarrow Cl^{-} \leftarrow HCO_3^{-} \leftarrow F^{-} \leftarrow OH^{-}$
  - What do you notice?

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Dealkalizer

- A dealkalizer is used to remove alkalinity from the raw water.
- Regeneration is accomplished by either salt brine (NaCl) regeneration or Sodium Hydroxide (OH) regeneration.
- A Dealkalizer is **down stream** of a water softener.
  - It is important that the water softener yields quality soft water.
  - Calcium hardness contacting dealkalizer resin will cause the formation of calcium sulfate on, reducing performance.
- When using salt regeneration, add 5% NaOH by weight with the salt to the brine tank to improve resin efficiency

Water Softeners & Dealkalizer

- Cation "Hardness" removal.
- Without filtration, this would become the filter.
- Must be installed prior to dealkalizer to prevent Calcium Sulfate fouling

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Dealkalizer

Externals are the same. Major difference is the type of resin. Dealkalizer is usually 1 ½ to 2 times the physical size of the water softener

Salt regeneration can remove 90% of alkalinity. Caustic soda regeneration can remove 100% of alkalinity.

Use 5% by weight caustic to salt to improve performance

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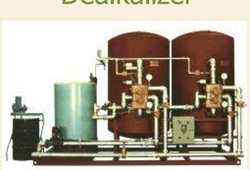
Chloride Cycle Dealkalizer



Use of salt for regeneration, with caustic pump to bring up effluent water pH.

The pH of the dealkalizer effluent will be below 7.0 and can be as low as 5.5 without caustic addition.

Substitution is the CHLORIDE ion for approximately 90% of Bicarbonate

$SO_4^{2-} \leftarrow CrO_4^{2-} \leftarrow PO_4^{3-} \leftarrow HSO_4^{-} \leftarrow NO_3^{-} \leftarrow Br^{-} \leftarrow Cl^{-} \leftarrow HCO_3^{-} \leftarrow F^{-} \leftarrow OH^{-}$

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Dealkalizer - Chloride Cycle

- Dealkalizer uses **strong base anion resin**
- Regenerates on the chloride cycle using salt and some caustic soda.
  - Removes up to 90% of the alkalinity
  - Uses 4-6 lbs of salt and 0.4-0.5 lbs of caustic soda to regenerate one cubic foot of resin.
  - Effluent will be acidic, so caustic must be injected into the effluent to prevent corrosion.
  - **Without caustic soda in brine, carbon dioxide will not be removed and capacity is reduced by one third.**
  - Softened water make up or severe fouling will occur.
  - Dramatically increases the chloride ion level in the discharge

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Dealkalization- Hydroxide Cycle

- Dealkalizers use ***strong base anion resin.***
- Caustic soda used for the regenerant.
  - This cycle will remove more anions than the chloride cycle
  - Caustic must be kept warm(over 60º F) or the caustic soda educator will foul.
  - Can remove silica. Silica is the indicator that the unit is exhausted. Silica breaks through, then sulfate ions.
  - Caustic will remove all of the carbon dioxide from the make up water.

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Dealkalizer - Tips

- Dealkalizers operate at boiler quality with a flow rate of 2-4 gpm
- When using sodium hydroxide (caustic soda) most if not all of the anions will be removed.
  - To determine when to regenerate this resin in the hydroxide cycle, run silica and sulfate tests on the effluent.
  - Silica will break through first, followed by sulfate.

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RESIN REFERENCE

KEEP IT FOR WHEN YOU NEED IT

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Conversion Factors For Calculation

- Is the water analysis expressed as the ion or as CaCO3?
- Ppm Ca X 2.5 = ppm CaCO3
- ppm Mg X 4.1 = ppm CaCO3

- 50 ppm Ca = 125 ppm Calcium as CaCO3
- 50 ppm Mg = 205 ppm Magnesium as CaCO3

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Properties Of Water Softening Resin

- Physical Properties
  - Size 0.3-1.2 mm (16-50 mesh)
  - Weight Approx.. 53 lbs./cu. ft.
  - Density Approx.. 1.28
  - Max Temp. Approx.. 250º F
- Chemical Properties
  - Capacity 30,000 grains/ cubic foot
  - % DVB Approx.. 8%
  - Type Strongly Acidic, Cationic
  - Matrix Sulfonated Styrene Divinylbenzene copolymer
  - Ionic Form Sodium (neutral salt)

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Properties Of Specialty Resins

- Fine Mesh
  - Usually 30 - 60 mesh
  - Used to get slightly higher operating capacity and brine efficiency
- Coarse Mesh
  - Usually 16 - 30 mesh
  - Used to get slightly higher flow rates through the resin bed
- 10% DVB
  - Higher crosslinked resin
  - Used to get longer life in waters that have high chlorine residuals

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Properties Of Specialty Resins

- Non Solvent Sulfonated Resin
  - Resin made without the use of solvent (usually propane dichloride)
  - Used where prerinsing of resin to remove traces of organic contaminants is not practical.
- High Purity Resins
  - Resin is hot water washed to remove traces of solvents and other impurities
  - Used where prerinsing of resin to remove traces of organic contaminants is not practical.

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Sodium Zeolite Minimum Design Parameters

	Cold	Hot
Service, gpm/sq ft	7-14	7-14
Backwash, gpm/sq ft	5-6	12
Brine, gpm/cu ft	0.75-1.0	0.75-1.0
Slow Rinse, gpm/cu ft	0.75-1.0	0.75-1.0
Fast Rinse, gpm/cu ft	1.5	1.5

Freeboard **75% minimum**

Expansion **50% minimum**

Regenerant Strength **10% minimum at Bed**

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Capacity & Leakage - Rules of Thumb

Salt Dosage Lbs/cu ft	Capacity Kgrns/cu ft	Leakage Ppm @ CaCO3
6 lbs	18.7	5-15 ppm
8 lbs	23.5	3-10 ppm
10 lbs	24.8	2-7 ppm
12 lbs	26.5	1-5 ppm
15 lbs	28.0	1 ppm

Capacity is based on 8% DVB with leakage based on 400 ppm to 1200 ppm (total cation) solutions

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Waste Stream Applications for Ionic Exchange

- SBA (Strong Base Anion)
  - Type 1 SBA - Macroporous SBA IX is used for organic scavenging of the water. Functional Group $CH_2N{+}CH_2CH_2OH$
    - Tannin selective SBA will remove tannins and color
    - Tannin selective macroporous SBA IX also removes color due to fulvic and humic acids.
  - SBA IX resin will also attract other anions, so test for potential interference from these anions to ensure organic removal.
  - Type 2 Strong Base Anion resin is less selective, so it is used for dealkalization. Functional Group $CH_2N{+}CH_3$
- WAC (Weak Acid Cation)
  - Highly selective for divalent cations at neutral to alkaline pH ranges
  - Used to remove copper and nickel from waste streams
- High capacity resins used in waste water will swell and shrink significantly, so keep this in mind when sizing equipment.
- Mixed Bed Rule of Thumb, mixing SAC and SBA resin for a mixed bed application should only be done where the calcium carbonate hardness is below 135 ppm or resin fouling will occur.

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EXTERNAL EQUIPMENT

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External Treatment

- External Treatment of water is the means by which the quality of the water is improved prior to chemical addition. This includes:
  - Clarification
  - Filtration
  - Water Softening
  - Dealkalization
  - Demineralizer
  - Feed Water

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Clarification

- **Primarily used to remove suspended solids from surface water, such as rivers, lakes and ponds.**
- **Mechanically or through chemical particle size improvement allows solids to settle out of the water.**

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What Is Filtration ?

- **Filtration is the mechanical removal of suspended solids from a fluid by means of a <u>pressurized flow</u> through a <u>permeable medium</u>. Amount and size of particles removed is based on the type of filtration media.**

TYPES OF FILTRATION
Aggregate: Media is a non-hydrous aluminum silicate.
Multi-Layered: Multiple layers of media, distinctively layered with the coarsest media on the top.
Sand: Sand media where filtration is done on the surface
Carbon: Activated carbon is used as the media, for removal of organics
Cartridge Filtration: Cartridge is designed to remove a specific size or type of particle
Cyclonic: Centrifugal force separates solids down to approx. 50 microns
Disk Filtration: Water percolates through disk entrapping solids

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Types of Solids

- **Undesirable**
  - Airborne dust and dirt
  - Erosive particles
  - Dirt (Soils, Muds, Clays, etc)
  - Sand
  - Corrosion Particles
  - Organic Material (Dead or Alive)

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Why Filtration ?

- **Remove solids suspended in water**
- **Keep valves from plugging up**
- **Prevent nozzles & distribution pans from plugging**
- **Prevent system plugging**
- **Prevent erosion of pipe and pumps**
- **Remove crystallization sites**
- **Remove surface for biological attachment**
- **Prevent under-deposit corrosion**
- **More efficient use of treatment chemicals**

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What is a "Micron"?

- **Micrometer is the correct term**
- **1 Micrometer (μm) = 10 -6 meter**
- **1 μm = 0.000039"**
- **Eye can see 40 μm**
- **Human hair is about 70 μm**
- **Grain of table salt is 100 μm**

Relative Micron Comparisons

- Beach Sand >150
- Granular Salt 100
- Pin Point 80
- Human Hair (DIA) 45-70
- White Blood Cell 25
- Plant Spores 15
- Red Blood Cell 8
- Fog Mist 5
- Tobacco Smoke .1
- Carbon Black .02-0.1
- Virus .008-.1
- Aqueous Salt <.002

Types of Separation in Microns

>1 Particle Filtration

08-1 Micro Filtration

007-.1 Ultra Filtration

.001-.009 Nano Filtration

<.002 Reverse Osmosis

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Classifications of Filtration

Type	Size Range	Examples
Screening	> 2000 μm	Panning for gold, removing rocks
Coarse Filtration	75 – 2000	Sand
Fine Filtration	1.5 – 75	Flour, yeast, silt, precipitant salts
Ultrafine	0.1 – 1.5	Tobacco smoke, Bacteria
Ultrafiltration	0.002 – 0.1	Viruses
Hyperfiltration	0.0001 – 0.002	Molecules, ions

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Wire Mesh to Micron Size

1 Micron (1x10-6 meters = 4x10-5 inches =(0.00004 inches))

MESH	MICRON
10	2000
20	842
25	707
30	595
35	500
40	420
45	354
50	297
60	250

MESH	MICRON
70	210
80	177
100	149
120	125
140	105
150	95
170	88
200	74
250	61

MESH	MICRON
270	53
325	44
400	37
500	25
200 x600	20
165 x 800	10
200x1400	5
325x2300	2

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Filter Requirements

- **Porous medium – Porosity allows liquid to pass through the medium.**
- **Pressure Difference across medium**
  - Gravity
  - Vacuum
  - Positive pressure source
- **Differential Pressure (ΔP) = (Pressure Upstream – Pressure Downstream)**

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Filtration Assembly

- **All Filters will consist of at least two components**
  - Housing
    - Retains the fluid
    - Positions the medium
    - Provides fluid pathway through medium
  - Filter Medium
    - Permeable
    - Porous
    - Selected based on size and type of solid to be removed.

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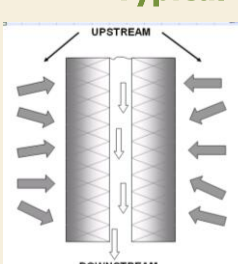
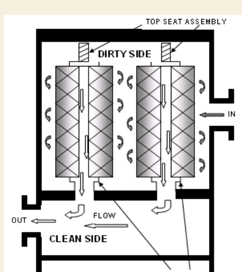
Typical Filter



Filter Media



Filter Assembly

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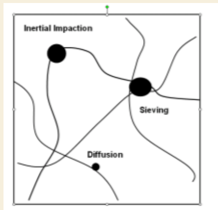
Particle Capture Mechanisms

Filtration is based on the various ways in which a particle can come into contact with the filter medium surface.



INERTIAL IMPACTION; or Interception occurs when the particle is so large that the straight line inertia of a particle prevents it from adjusting it's path to the flow of the filter media and is intercepted or captured on the media surface.

SIEVING; is where a particle is so close to a media, that the particle impacts on the media and the water flows around it. This usually due to gravity and is also sedimentation

DIFFUSION; random Brownian motion of particles, causes them to depart from the stream line so that they randomly collide with the filter media.

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Rating Filters

- **Dirt Holding Capacity**
  - The weight of contaminant fed to the filter during a test to reach a predefined terminal ΔP.
- **Efficiency**
  - The ability of the medium to remove particles from the fluid system.

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Rating Filters

- **Absolute Rating**
  - A rating factor that expresses near 100% removal of a specific micron size particle on a single pass through the filter media.
- **Nominal Rating**
  - An arbitrary rating that expresses the removal of a specific micron size particle at various efficiencies.

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Filter Selection Factors

- Amount of Contaminant
- Flow Rate
- Nature of Contaminant
- Degree of Filtration
- Temperature
- Compatibility
- Viscosity
- System Pressure
- Initial ΔP

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Filter Housings (Cartridge Style)

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Filter Cartridges

- **Stringwound**
  - Polypropylene Media
  - Tin Cores
  - Nominal Rating
  - 80% Efficient
  - Max Temperature: 200°F
  - Available
    - 3" to 40" Lengths
    - 0.5 – 300 Microns
- **Resin Bonded Cartridges**
  - Bonded Fiberglass Media
  - Industrial Non-Water Applications
- **Pleated**
  - Polyester Media
  - CPVC Cores
  - High Temp Caps
  - Absolute Rating
  - 99.98% Efficient (0.35 – 100 micron)
  - 6 sq ft Media Per 10" Length
  - Max Temperature: 200°F
- **Thermally Bonded Cartridges**
  - Polypropylene Melt Blown Media
  - 95% Efficient
  - Meets FDA Title CFR21 Requirements. ANSI/NSF 42 Certified For Potable Water

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Filter Bags

- Materials of Construction; Polypropylene or Polyester Felt
- Sizing; #1 (7" X 16.5") , #2 (7" X 32")
- Particle Removal; 1 – 800 micron
  - Most common particle sizing is 5, 10, 25, 50, 100 micron
- Bags can be washed so they are reusable.
  - Bag filter does not back wash, so it must be removed based on pressure drop.
- Inexpensive compared to other filter systems
- High maintenance to maintain clean bags.

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Aggregate Filtration

- Uses non-hydrous aluminum silicate media
- Media has irregular grains which make it very effective for collecting suspended matter.
- Filters over the entire length of the bed, so unit takes small foot print.
- Light media, so it will handle large load with low backwash rate.
- Removes down to 10 micron effectively and 5 micron as it begins to foul

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Multi-Layered Filters

- For removal of heavy sediment and suspended solids.
- Contains a multi - layered bed of distinct layers.
- Coarsest media is at the top with the finest media on the bottom of the unit.
- Because of the reverse grading, collection of suspended solids will not form in a layer but rather collects throughout the bed.
- Will filter at higher flow rates than aggregate or sand.
- Will hold substantially more sediment than aggregate or sand before pressure drop or backwash is required.

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Sand Filter

- Uses sand as the media
- Grade of sand determines the filter micron size
- Filters over the top of the bed and not through the length of the bed. This means that the unit must be short and wide.
- Sand should be replaced every 5 years
- Requires large foot print
- Easily fouled with organics

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Carbon Filtration

- For the removal of:
  - Chlorine
  - Sediment
  - Organics - Phenols, pesticides, surfactants, etc.
- Removes odors as moldy, musty or woody odors
- Organics can be removed from bed by steaming media
- Is a good growth media for bacteria
- Carbon filtration is placed after the media filter and before the water softener. This filter should always be in front of an ***RO system***.

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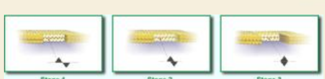
DISC FILTER



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DISC FILTRATION

- Disc Water Filtration Systems operate using grooved discs
- Thin, polypropylene discs are diagonally grooved on both sides to a specific micron size.
  - A series of these discs are then stacked and compressed on a spine.
  - When stacked, the groove on top runs opposite to the groove below, creating a filtration element with a statistically significant series of valleys and traps for solids.
  - The stack is enclosed in a corrosion and pressure resistant housing.
- During the filtration process, the filtration discs are tightly compressed together by the spring's power and the differential pressure, thus providing high filtration efficiency.
  - Filtration occurs while water is percolating from the peripheral end to the core of the element.
  - Depending on the micron rating, there are from 18 (in 400 micron discs) to32 (in 20 micron discs) stopping points in each track, thus creating the unique in-depth filtration.

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DISC FILTRATION

- **Color Code**; Disc Filtration manufacturer's tend to color code the filter discs to indicate the micron sizing of the filter.
- **FILTER SIZING**; Disc Filters are sized from 20 micron up to 400 micron (PEP is 20, 40, 55 ,70, 100, 130, 200, 400)
- **AUTOMATIC:** Automatic units backwash by spinning the discs while in reverse flow.
- The history of disc filtration has been primarily for agriculture where water pressure was used to operate and to backwash the filters.

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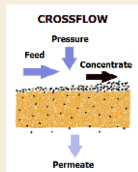
CYCLONIC FILTRATION

- Cyclonic separation occurs when the water entering the separator forces solids out of the water by centrifugal force.
- The unit has to operate within the specification flow rate and pressure drop across the unit.
- Shake up a volume of water to be separated and allow it to sit for 30 seconds. What does not settle out may not separate in the unit.
- Usually efficient for 50 micron or larger particles.

HYBRID – CYCLONIC/SAND

- Water enters the unit and the larger particles are removed by cyclonic separations.
- The water then passes over the sand media, which filters the remaining particles to 1 – 5 microns based on sand media used.
- Cyclonic action on the top of the unit causes a sweeping effect across the sand media, reducing the potential for blinding the filter and increasing holding capacity.



Demineralization – Pure Water

- A demineralizer (unless it is a mixed bed) is a two tank system.
- The ***strong acid cationic resin*** will have capacities of 15,000 to 30,000 grains per cubic foot based on the type of rein and the quality of the acid used.
- The ***strong base anionic resin*** will have capacities of 10,000 to 20,000 grains based on the resin type and the quality of the caustic soda used.
- ***Weak base resin*** is not used as it can not remove weakly ionizable substances as CO_2 and silica
- A water softener may precede the Cationic unit in high hardness to prevent sulfate loading on the Anionic resin, where there is high hardness and sulfuric is the regenerant

Demineralization First Process Tank In The Train

- Water demineralization process:
  - First Process Tank In the Demineralization Train - Cation
    - Water passes through a ***strong acid cation*** exchanger where the salts in the water are converted into their respective acids.
    - The first unit is regenerated with acid. 30% Hydrochloric acid is usually used.
    - This is a fuming acid, so the unit should be vented to prevent excessive corrosion in the building.
    - Sulfuric acid can also be used, however it can cause sulfate fouling.

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Demineralization Second Process Tank In The Train

- After the water has passed through the cation exchange tank, it passes through a ***strong base anion*** resin where the negative radicals of the acid are converted to hydroxyl ions.
- The result is a water containing only hydrogen (H+) and hydroxyl (OH-) ions - PURE WATER.
  - 50% Textile grade heated to minimum 60ºF caustic soda should be used.

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Demineralization – Carbon Dioxide

- Raw water alkalinity is converted to carbon dioxide in the strong acid cation vessel.
- When the alkalinity to total anion ratio is excessive, the load on the strong base anion resin can be significant.
- This loading is dramatically reduced in these cases with the installation of a degasifier prior to the strong base vessel.

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Microfiber Technology

- Fibers are 2nm X 250nm
- Crystal structure has positive, electrokinetic potential
- Nanofibers are mineral pseudoboehmite AlOOH
- Known to dissolve in stomach acid and in the blood
- A high surface area, electroadsorptive filter media

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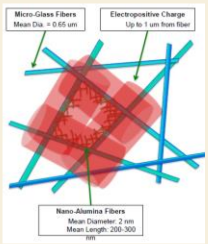
Microfiber Technology - Experimental



- Wet laid, non-woven depth filter media (~1 mm thick)
- Mean pore size < 2.0 microns
- Removes submicron particles through electroadsorption not captured by conventional mechanical filters
- Organic/microbial macromolecules (EPS/TEP)
- Biofouling precursors: organic acids, proteins, polysaccharides
- Virus and bacteria
- Used as pleated filter cartridges. Initial pressure drop < 0.1 bar (14.5 psi = 1 bar)

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Reverse Osmosis Microfiber Filtration

- Functions - electrochemistry taking out anionic and cationic particles.
  - Nanotechnology, microglass 2 nanometers - positive electro kinetic potential.
  - Nanofibers are pseudo bohemite AlO(OH), 2 micron and 10 micron
- Focus is on biofilm removal.
  - Protecting RO membranes from fouling by removing iron, SDI, polsaccharides, bug bodies and organic acids.
  - Removes TEP (Transparent Exopolymer Particles).
- Use pH 5-9
- Dissolves in stomach acid and in the environment into nontoxic byproducts
- High capacity for submicron contaminants.
- More efficient than UF membrane, when used to polish water before the RO and after the pre filter
- NSF/ANSI Standard 61 for Municipal Potable Water Contact.
- Using a two (2) layer configuration removed e. Coli from well water
  - 4 log reduction of Virus & Legionella with single layer paper
  - >99.99992% removal of Legionella with double layer paper

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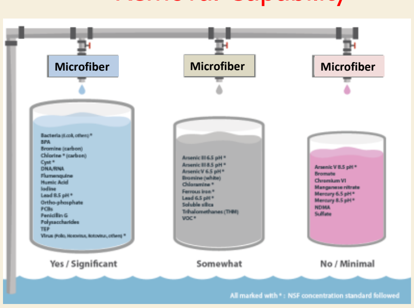
Removal Capability



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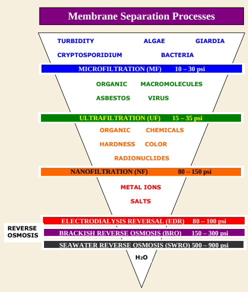
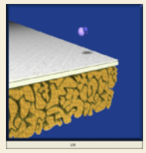
New World of Water





- Microfiltration
- Ultrafiltraion
- Nano Filtraion
- Reverse Osmosis

The future will see mechanical conditioning of the water to meet the requirements of the user rather than chemical modification of the impurities

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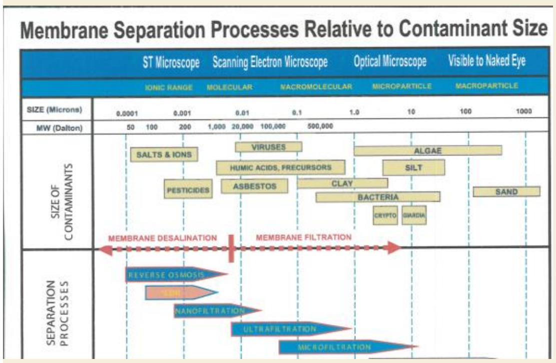

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Microfiltration

- **Microfiltration** is a membrane filtration process which removes contaminants from a fluid (liquid & gas) by passage through a microporous membrane. A typical microfiltration membrane pore size range is ≈ 0.1 to 10 microns (µm).
- Microfiltration is fundamentally different from reverse osmosis and nanofiltration in that both RO and Nano require pressure to function, Micro may use low pressure, but also may not require pressure.
- Operates at 10 – 30 psi, where pressure is required
- Removes; Turbidity, Algae, Bacteria, Giardia, Cryptosporidium

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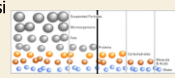
Ultrafiltration

- **Ultrafiltration** (**UF**) is a variety of membrane filtration in which hydrostatic pressure forces a liquid against a semipermeable membrane. Suspended solids and solutes of high molecular weight are retained, while water and low molecular weight solutes pass through the membrane.
- UF refers to a pressure driven membrane separation technique in which a membrane is employed to separate different components in a fluid mixture.
  - UF membranes have pore sizes less than 0.01 micron.
  - Separation occurs based on molecular size and chemical interactions between the membrane and fluid components that are in contact with the membrane.
- Operates at 15 – 35 psi, can run up to 150 psi
- Removes; Organics, Color, Chemicals, Hardness



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Nanofiltration

- Operates at 80 – 150 psi
- ≈ 0.001 – 0.05 Microns
- Nanofiltration removes divalent ions (Calcium and Magnesium)
  - Removal will be similar to RO efficiencies.
  - Removes metal ions and salts
- Calcium, Magnesium and other divalent ions can concentrate up in the reject to the level where scaling can occur, similar to the scaling potential found on RO membranes.
  - Antiscalants and/or crystal modifiers can be fed to prevent scaling
  - Filter membrane should be cleaned periodically to remove scales.
- Iron can be a significant foulant on the membranes and pretreatment to remove iron is recommended.

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Reverse Osmosis

- Osmosis is a natural process in which a dilute stream flows through a semi-permeable membrane into a more concentrated solution on the other side.
- Reverse Osmosis uses pressure to force water through a semi-permeable membrane yielding a dilute on one side of the membrane (Permeate) and a concentrate on the other side (Reject)

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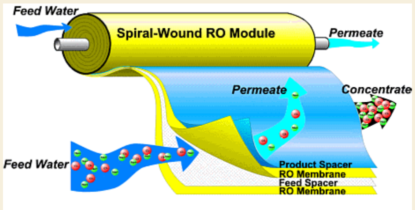
Roll Your Own



END FILTRATION TAKE A 10 MINUTE BREAK