Complex Water Treatment Problem Solving

By Jim Baker

AmeriWater Suez

What are some of the water problems you have had?

- Microbiological
- Reverse Osmosis
- Portable ROs
- Carbon Filters
- Pumps
- High pH water
- Concentrate Mixing

What we will cover:

1) Microbiological
2) Reverse Osmosis
3) Portable ROs
4) Pretreatment
5) Cartridge Filters
6) Concentrate Mixers & loops
7) DI, UV, Blend Valves, Pumps, etc.

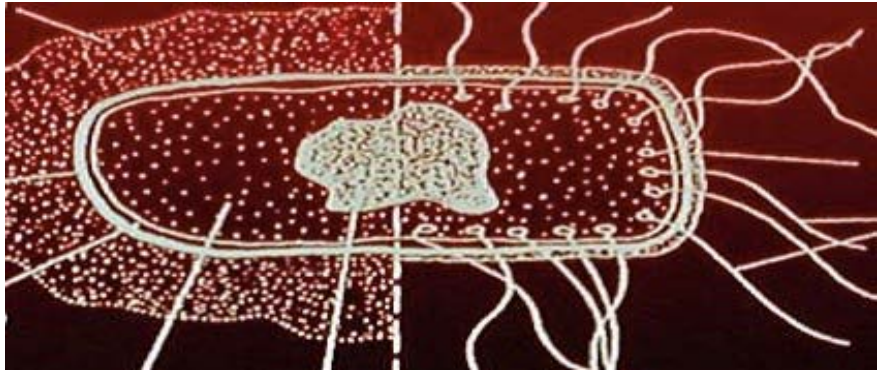

Microbiological

Chronic Micro-inflammation, challenges the patients' immune systems.

What we want to produce is Ultra-Pure water to make dialysate.

The cause of micro-imflamation: When bacteria are killed byproducts are released.

- Endotoxin
- RNA
- DNA
- Metabolites



What is Ultra-Pure water?

Ultra Pure Water?

Each “industry” must define what ultra pure water should be for it’s application.

Dialysis will have to define it for dialysis.

Dialysis has defined Ultra Pure Dialysate.

The main ingredient in dialysate is water (over 90%)

Therefore Ultra Pure Water should have the same standard as Ultra Pure Dialysate.

AAMI/ISO standards

- **AAMI/ISO 23500 replaces AAMI RD52**
  - Bacteria
    - < 100 CFU w. 50 CFU Action limit
  - Endotoxin
    - Water < 0.25 EU w. 0.125 EU Action limit
    - Dialysate < 0.50 EU w. 0.25 EU Action limit
- **Ultra Pure Dialysate and Water**
  - Bacteria < 0.1 CFU/ml
  - Endotoxin < 0.03 EU

Ultra Pure

	Dialysate	Water
Endotoxin	< 0.03 EU	< 0.03 EU
Bacteria	< 0.1 CFU/mL*	< 0.1 CFU/mL*

* The same as < 1.0 CFU/10 mL

New AAMI standards will cause...

Three possible strategies to control microbiological levels:

- Heat disinfection of water and bicarb loops
- Ozone disinfection of water distribution, bicarb systems and bicarb loops
- Final barrier filters at POU for water, bicarb, and dialysate
- Heat Disinfection of Central ROs
- Heat Disinfection of Portable ROs

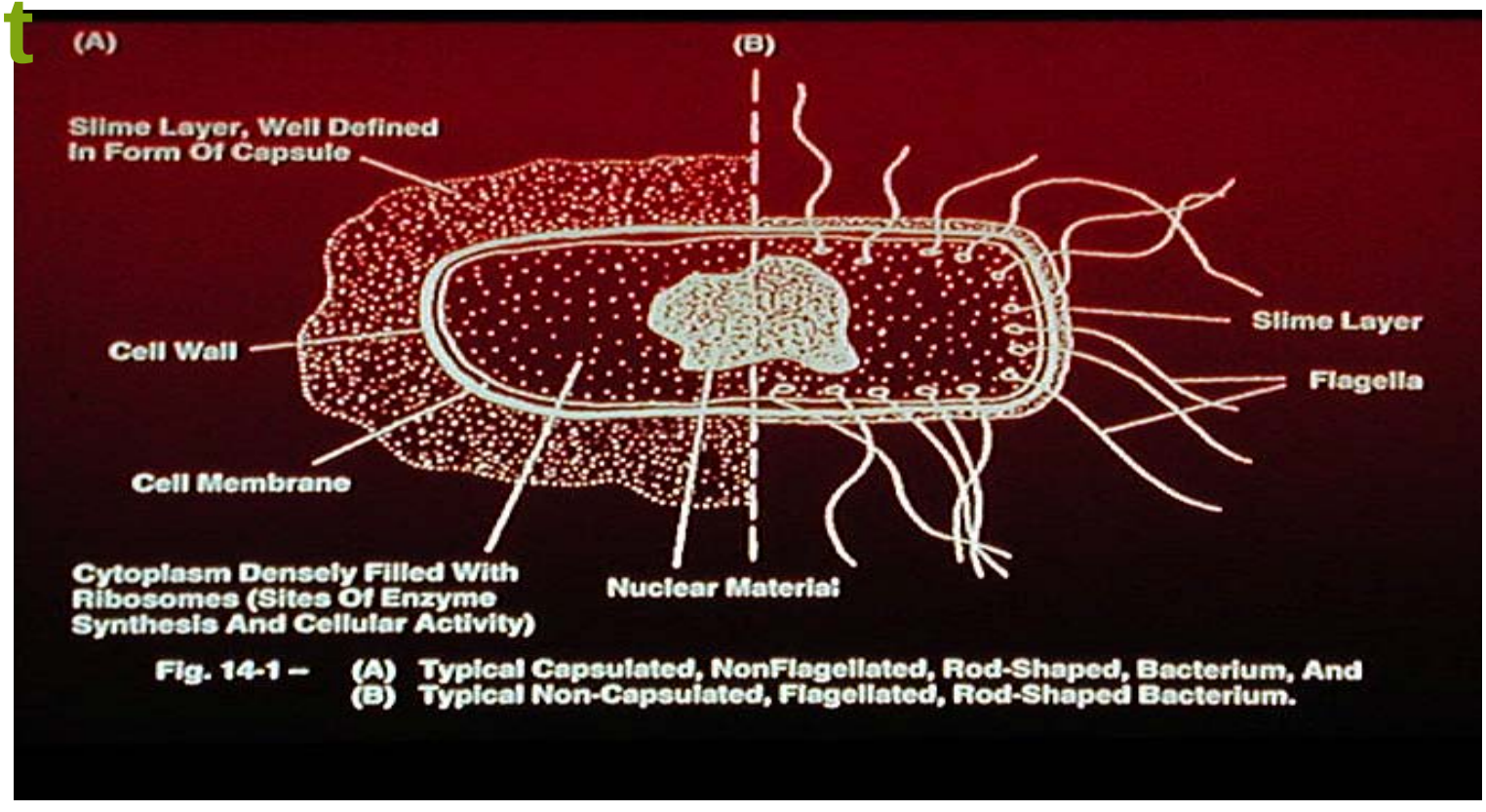
Remember!

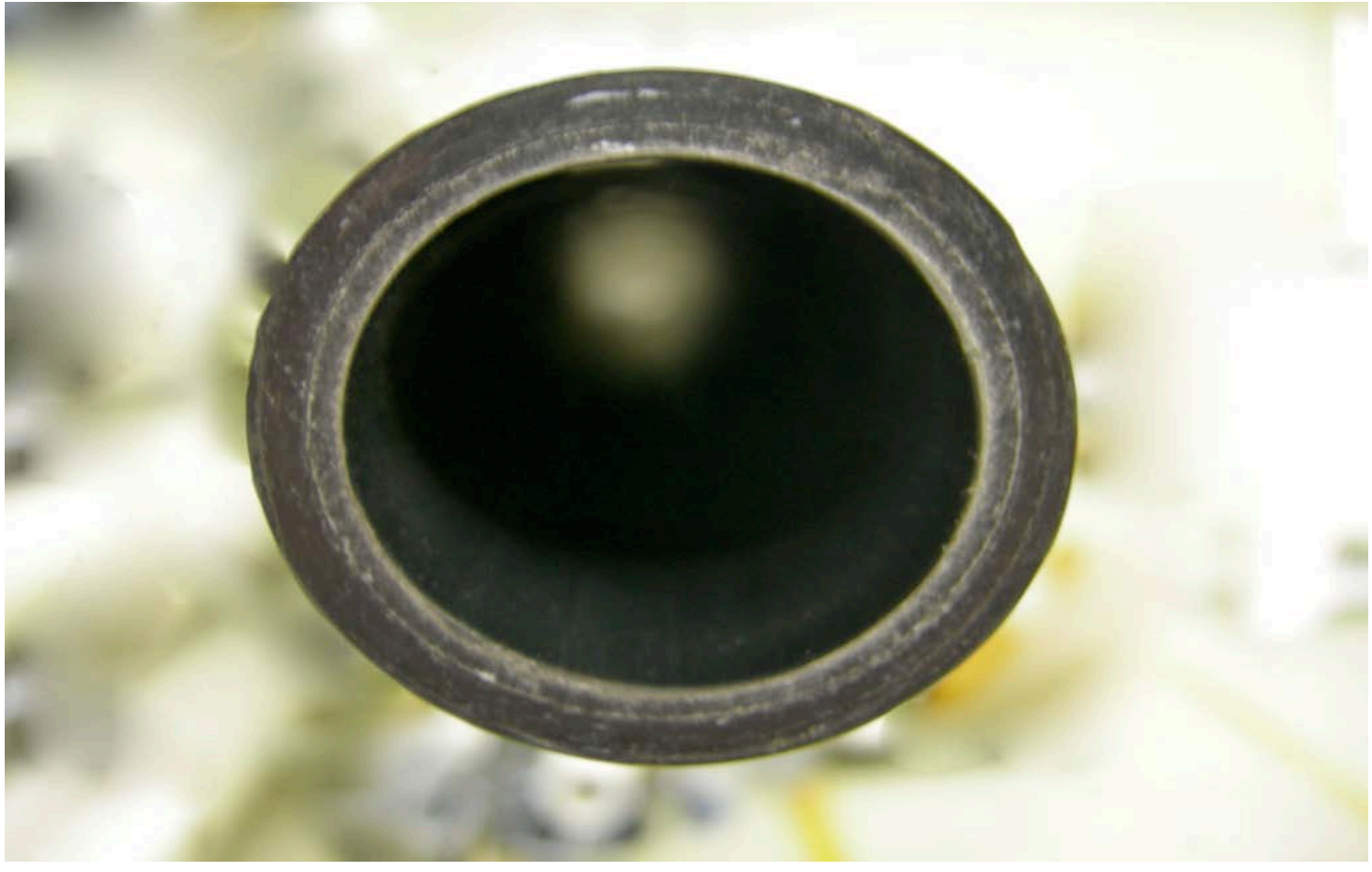
Heat, Chlorine, Ozone and PAA all kill bacteria that are present and create Endotoxin and other by-products.

This will require an Endotoxin Retentive Filter in water systems using these disinfectants.

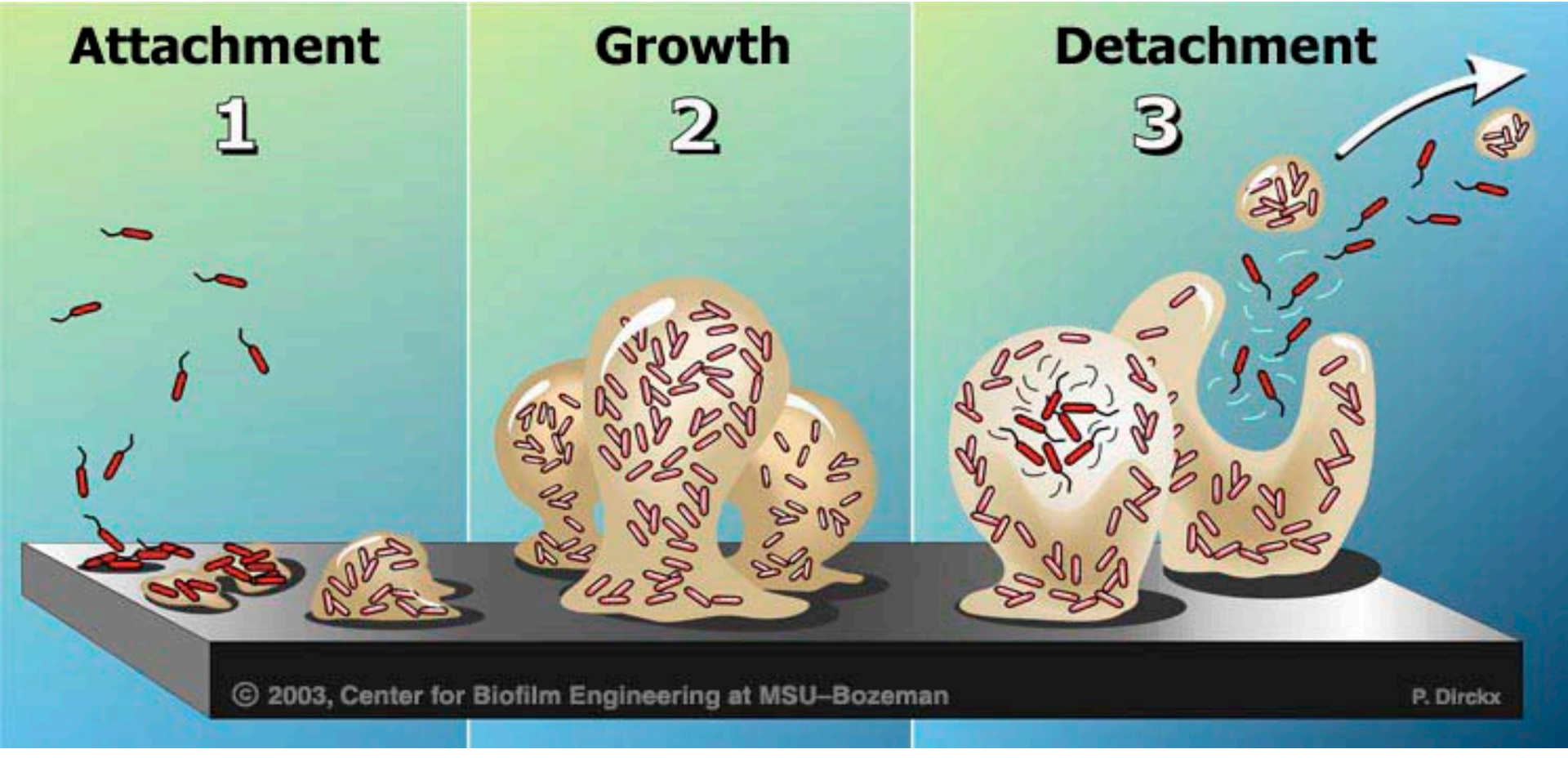

Biofilm
battle

Bacteria develops biofilm to protect it





Biofilm Cycle

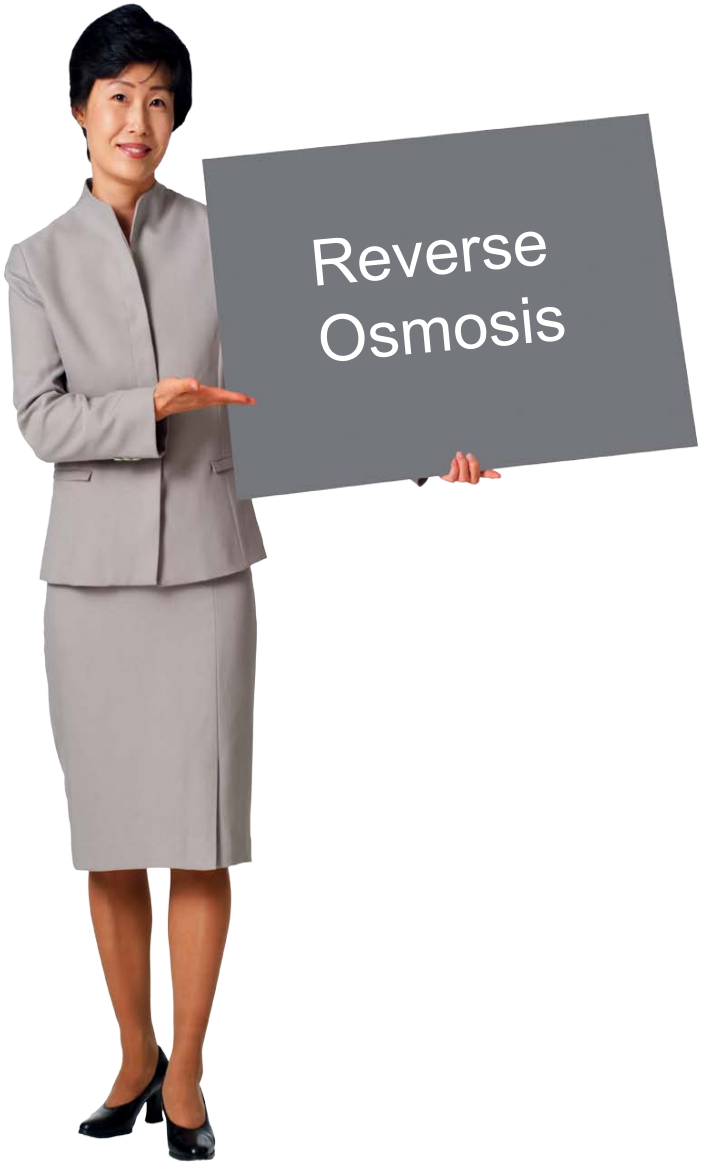


It’s Simple!

This will make monthly disinfection obsolete

At least weekly disinfection will be necessary

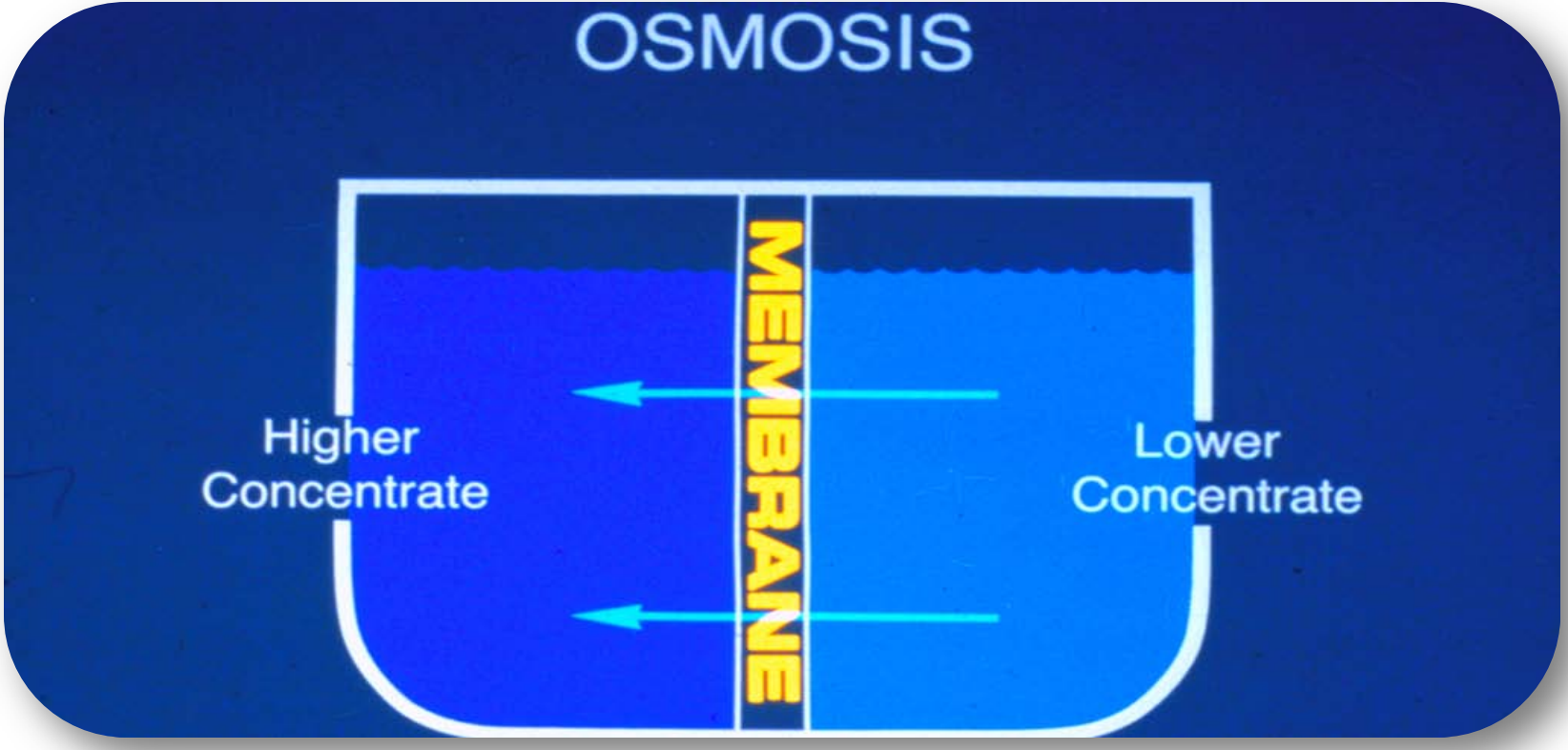
The major source of bacteria and bacteria byproducts in your water treatment system is the Reverse Osmosis Machine.


Reverse
Osmosis

Reverse Osmosis Problems

1. Reduced product water flow
2. Too much product water flow
3. Increase in product water conductivity
4. High ΔP across the RO membranes
5. High bacteria cultures in product water
6. High endotoxin levels in product water
7. Low RO pump pressure

What is Osmosis?



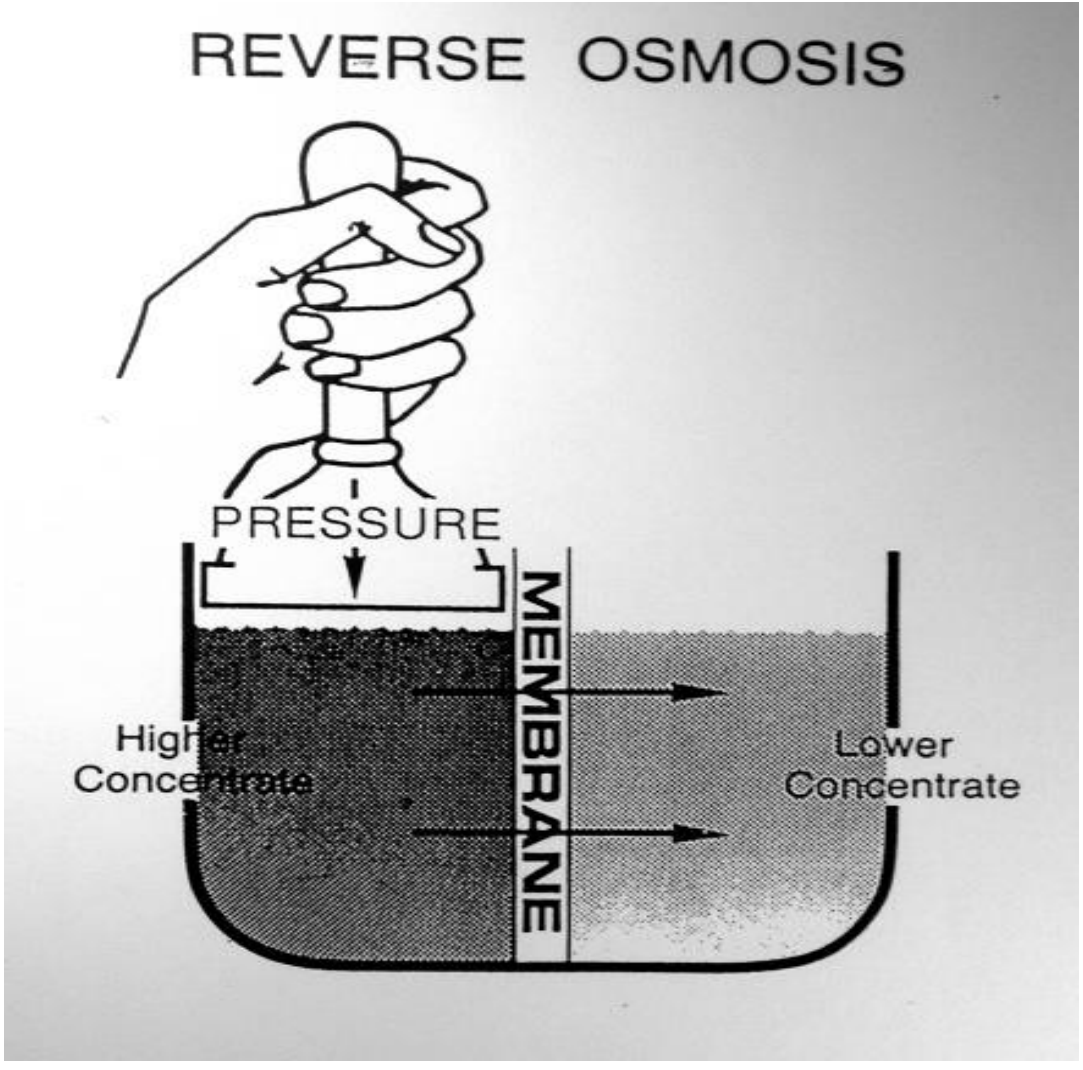
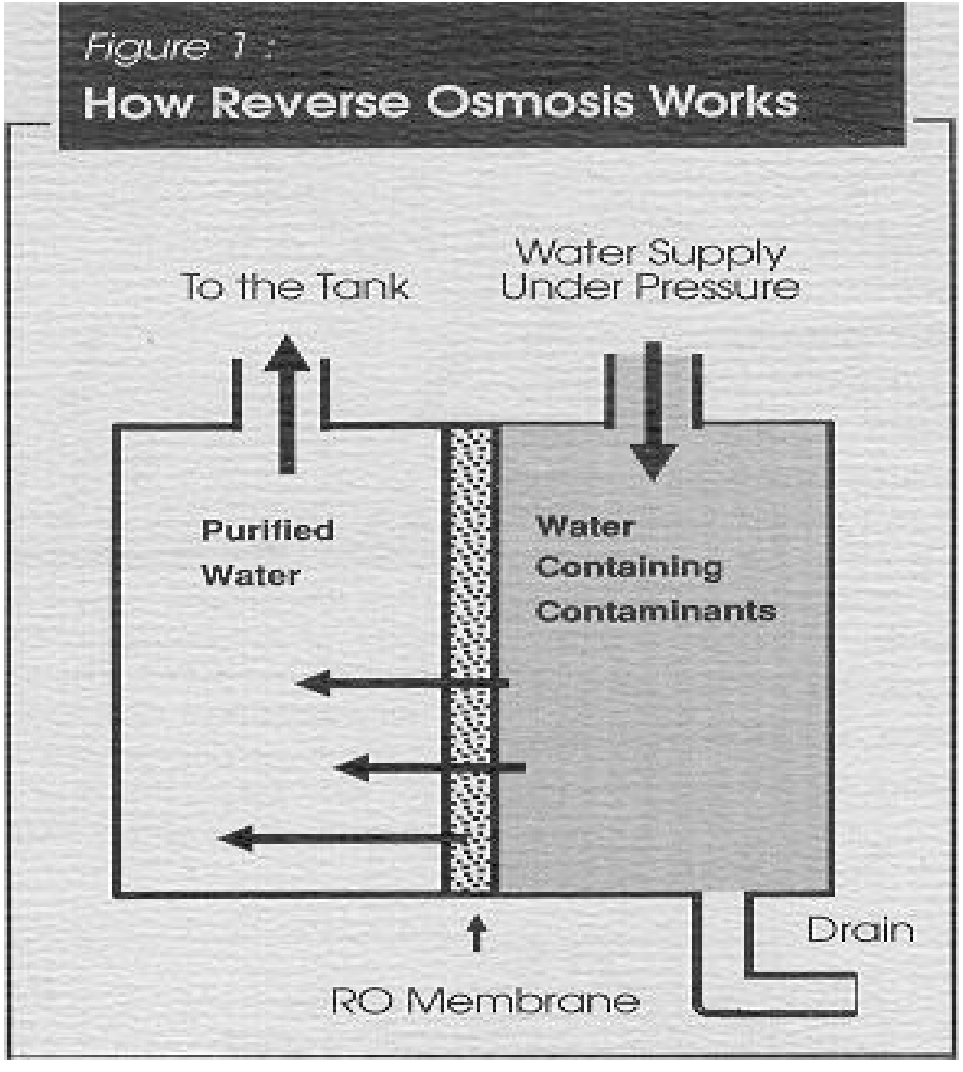
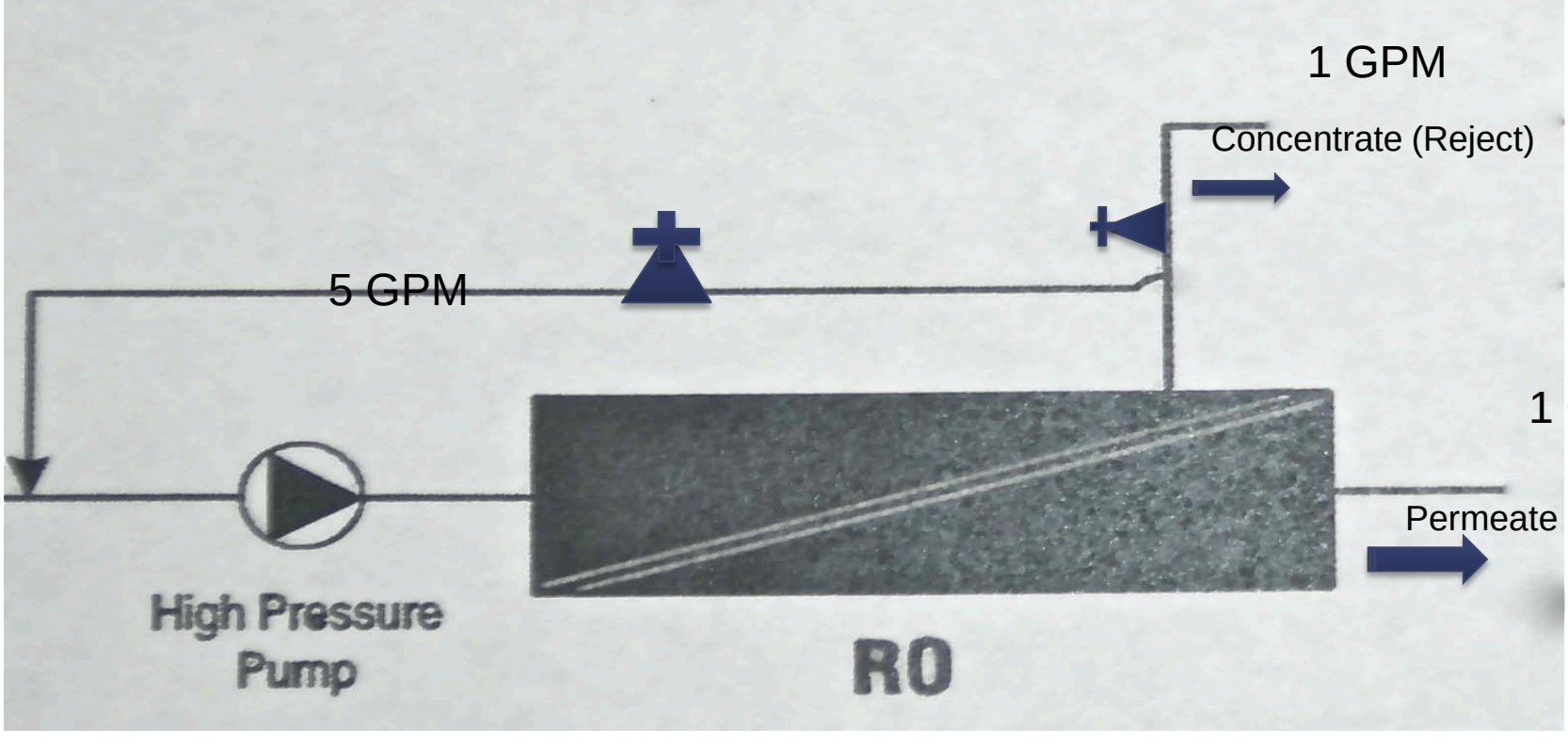

REVERSE OSMOSIS
PRESSURE
MEMBRANE
Higher Concentrate
Lower Concentrate

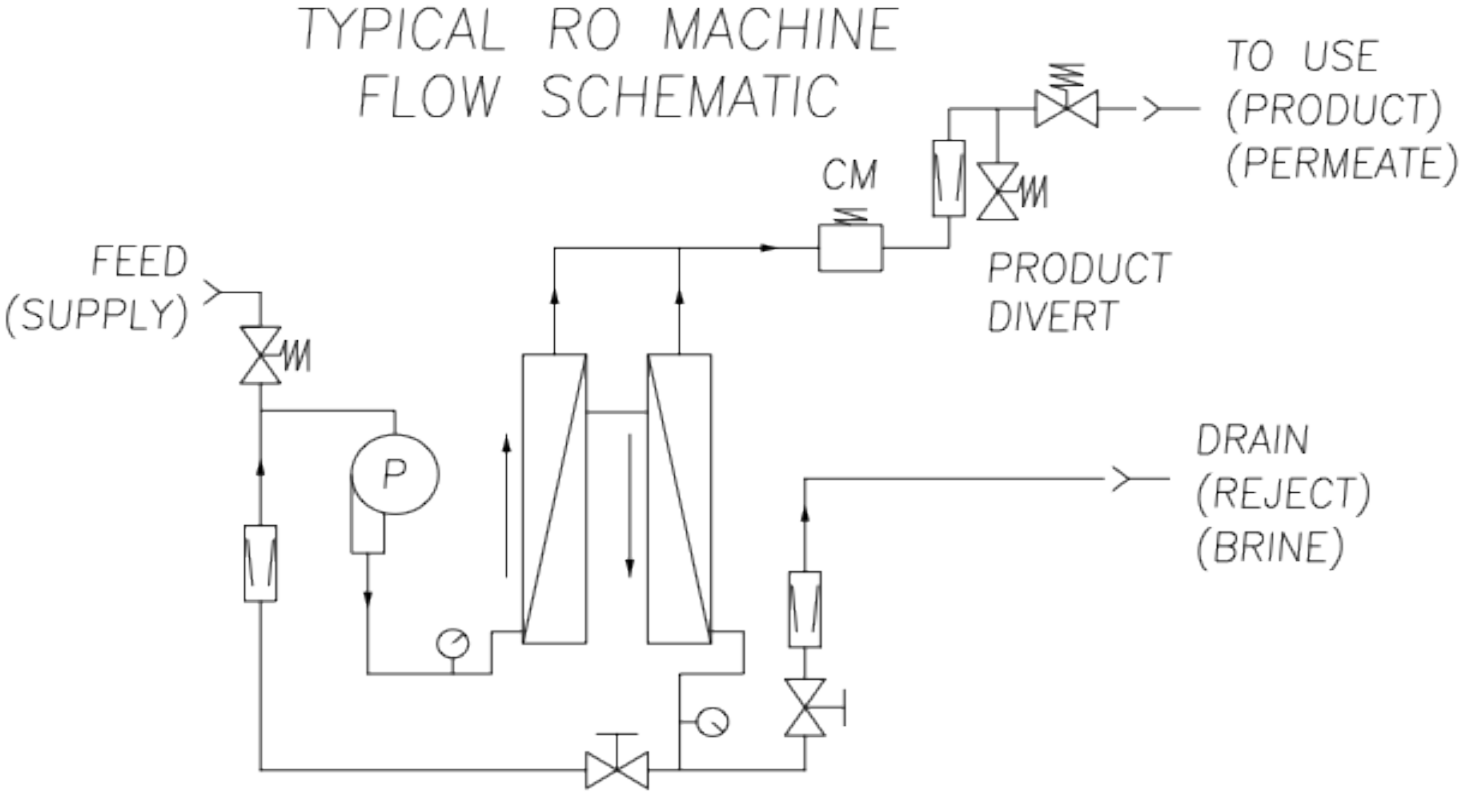
Figure 1 :

How Reverse Osmosis Works



RO membrane with recirculation to meet specs

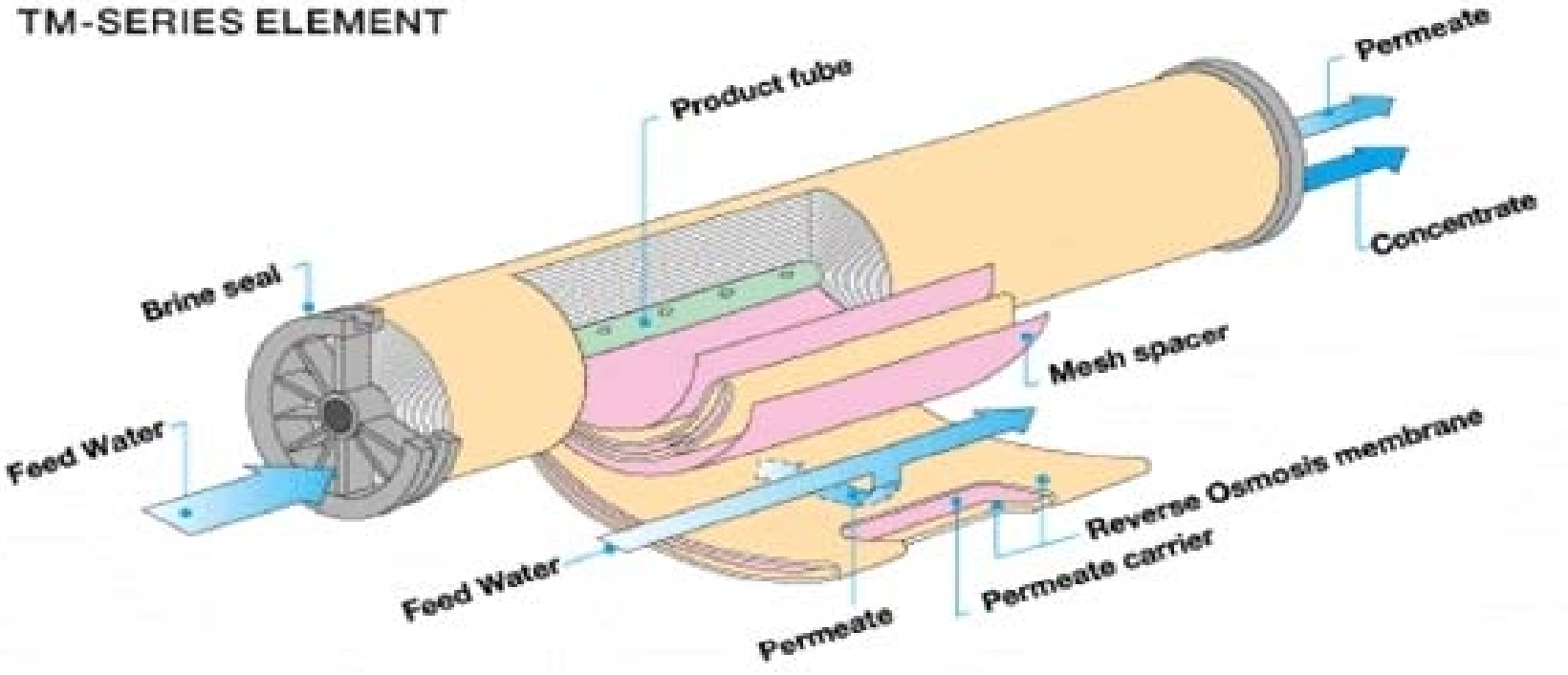



TYPICAL RO MACHINE
FLOW SCHEMATIC
TO USE
(PRODUCT)
(PERMEATE)
CM
PRODUCT
DIVERT
FEED
(SUPPLY)
P
DRAIN
(REJECT)
(BRINE)

RO % recovery and effect on Concentrate quality (250 uS feed)

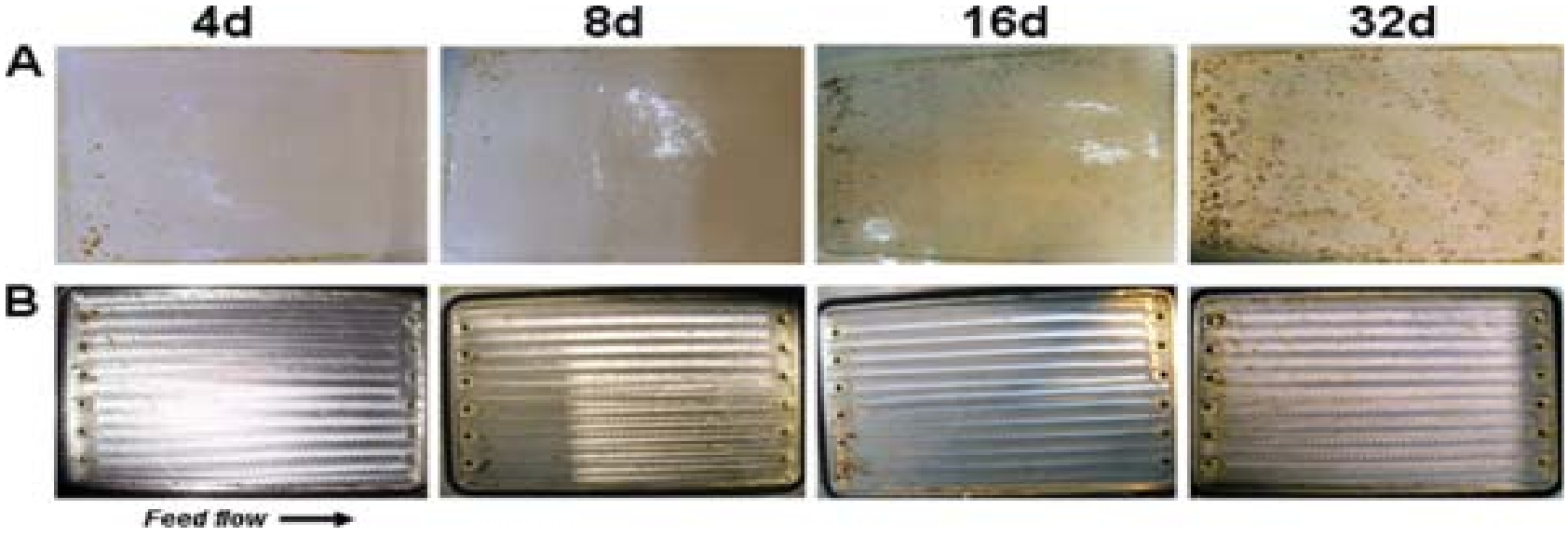
- **50% = 2x feed conductivity(500 uS)**
- **66% = 3x feed conductivity(750 uS)**
- **75% = 4x feed conductivity(1000 uS)**

RO Membrane


TM-SERIES ELEMENT
Product tube
Permeate
Concentrate
Brine seal
Mesh spacer
Feed Water
Reverse Osmosis membrane
Feed Water
Permeate carrier
Permeate

Membrane Problems

- Calcium Carbonate Scaling: happens on the last membrane or end of the membrane
- Chemical Attack: chlorine, oxidizers
- Fouling: bacteria, biofilm, silt, clay, rust
  - Velocity is necessary
  - Happens on the front end of the membrane



RO Membrane and Spacer Biofouling

A = RO membrane

B = Membrane spacer

d = Days

Reverse Osmosis Problems

1. Too much product water flow
2. Reduced product water flow
3. Increase in product water conductivity
4. High bacteria cultures in product water
5. High endotoxin levels in product water
6. Low RO pump pressure
7. High ΔP across the RO membranes

Direct Feed creates special problems

Program flush when not in use

Disinfect Monthly (RO and loop)

Use smallest diameter pipe for loop

Return product (loop flow) to RO feed, use pressure regulator on feed from the pretreatment

Plan for bulk (peak) uses

Direct feed loop disinfection:

Either use a CIP including the loop and the RO or a device to add PAA to loop.


Portable
ROs

Portable Systems Create Special

Bacteria and Endotoxin

Problems.

Down Time = Bugs

- Bacteria and endotoxin proliferation (caused by inadequate carbon replacement and lack of use)
- If biofilm develops in a portable RO you may have to disinfect it daily for a week or more
- Or bio scrub and replace the membranes

Portable RO Systems Maintenance

Disinfect at least Weekly

Flush before treatment – Flush after use

Operate-”flush” daily or

“Pack” with a bacteriostatic solution

Replace carbon regularly

RO Disinfection

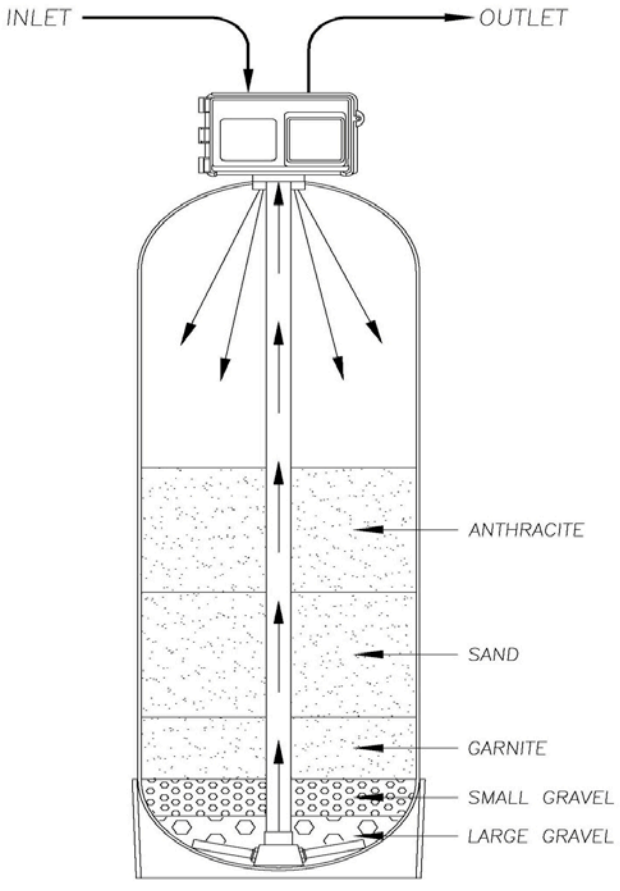
Flushing and operation flow for 1 to 2 hours after disinfection is necessary to remove endotoxin.

Ultra Filter as final barrier filter on Portable RO

- Media Filters
- Carbon Filters
- Softeners
- Dealkalizers
- Organic Scavengers

Dialysis pretreatment

Inside Multi-Media



AAMI/CoC on BW Filters

Fitted with inlet and outlet pressure gauges

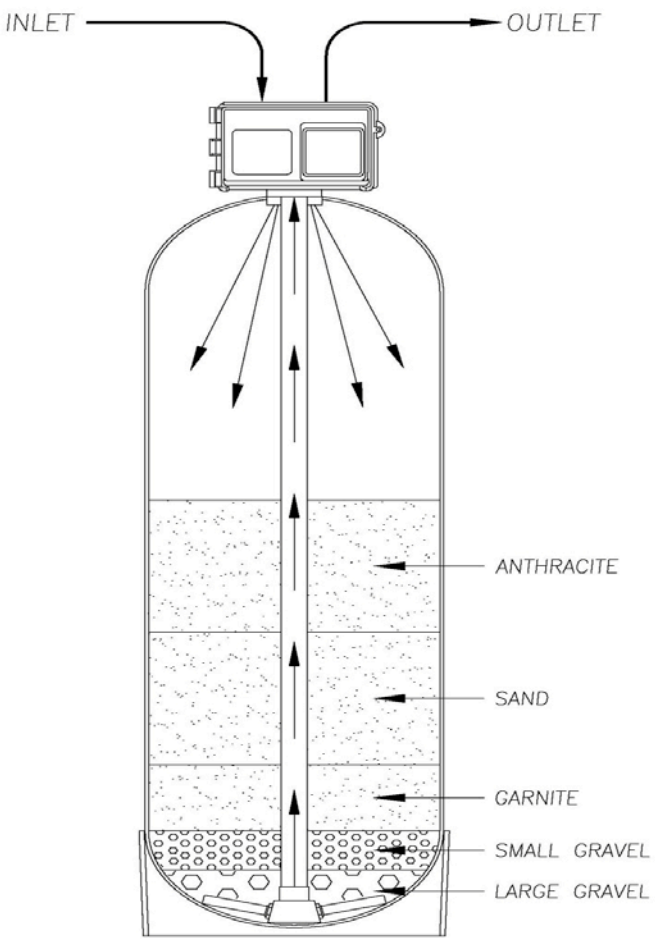
RO lockout

Verification of Timer time of day (LOG daily)

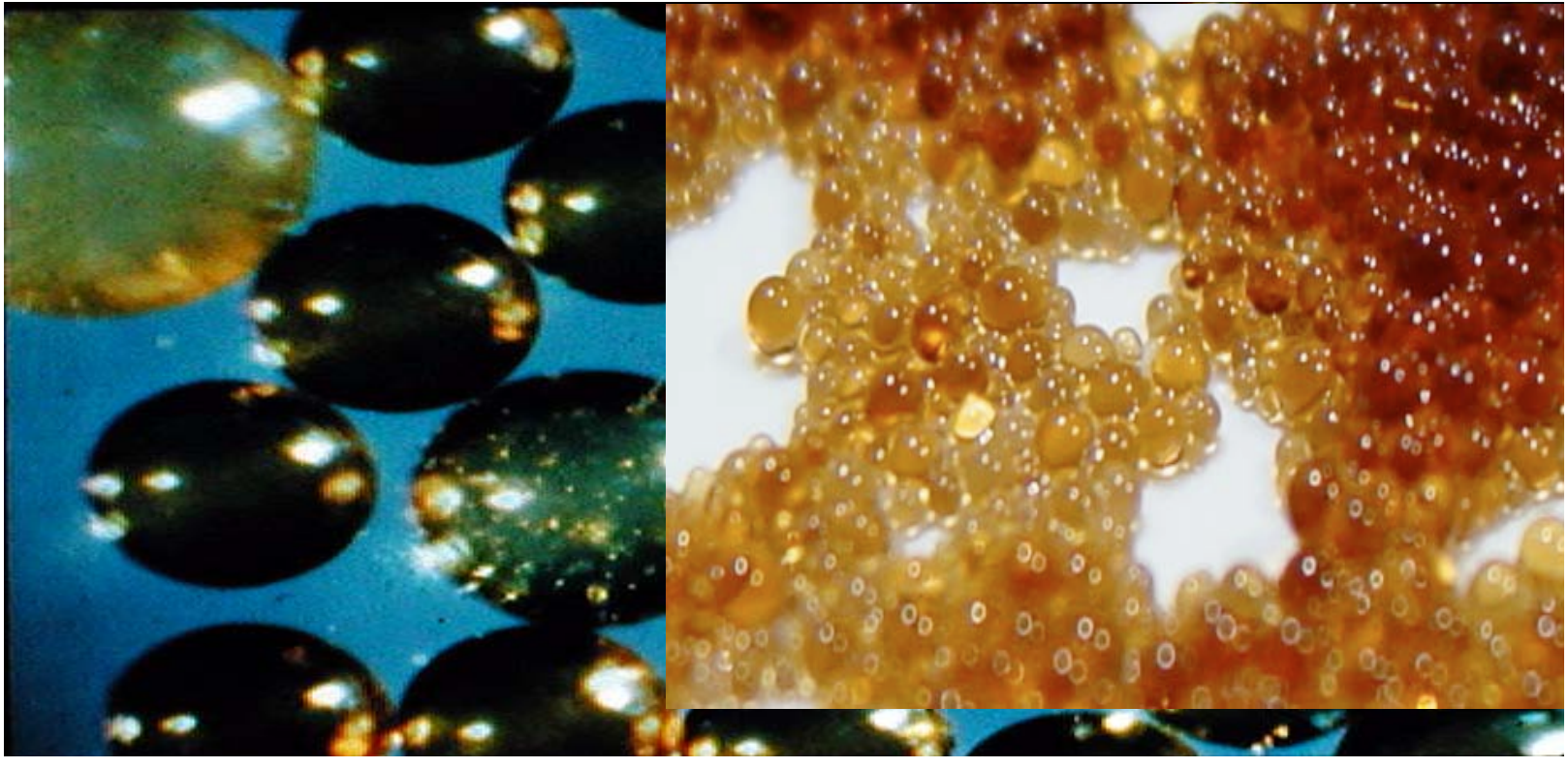
Monitor pressure drop ΔP (LOG daily)

System filter problems (all types)

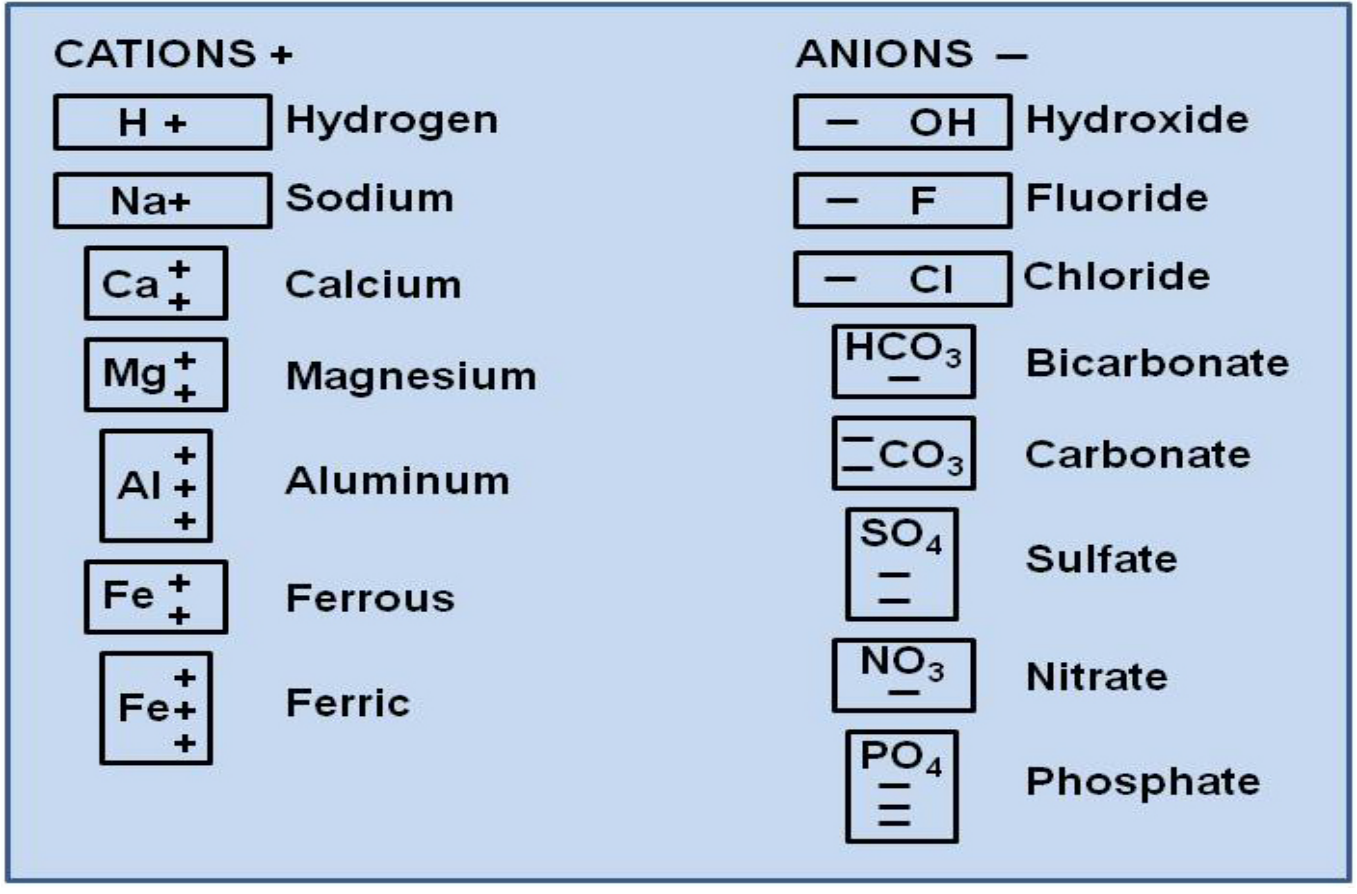
- Fine silt that passes through to the RO and fouls the membrane
- Undersized for system GPM
- High ΔP from inlet to outlet
- Sediment not being removed by the filter



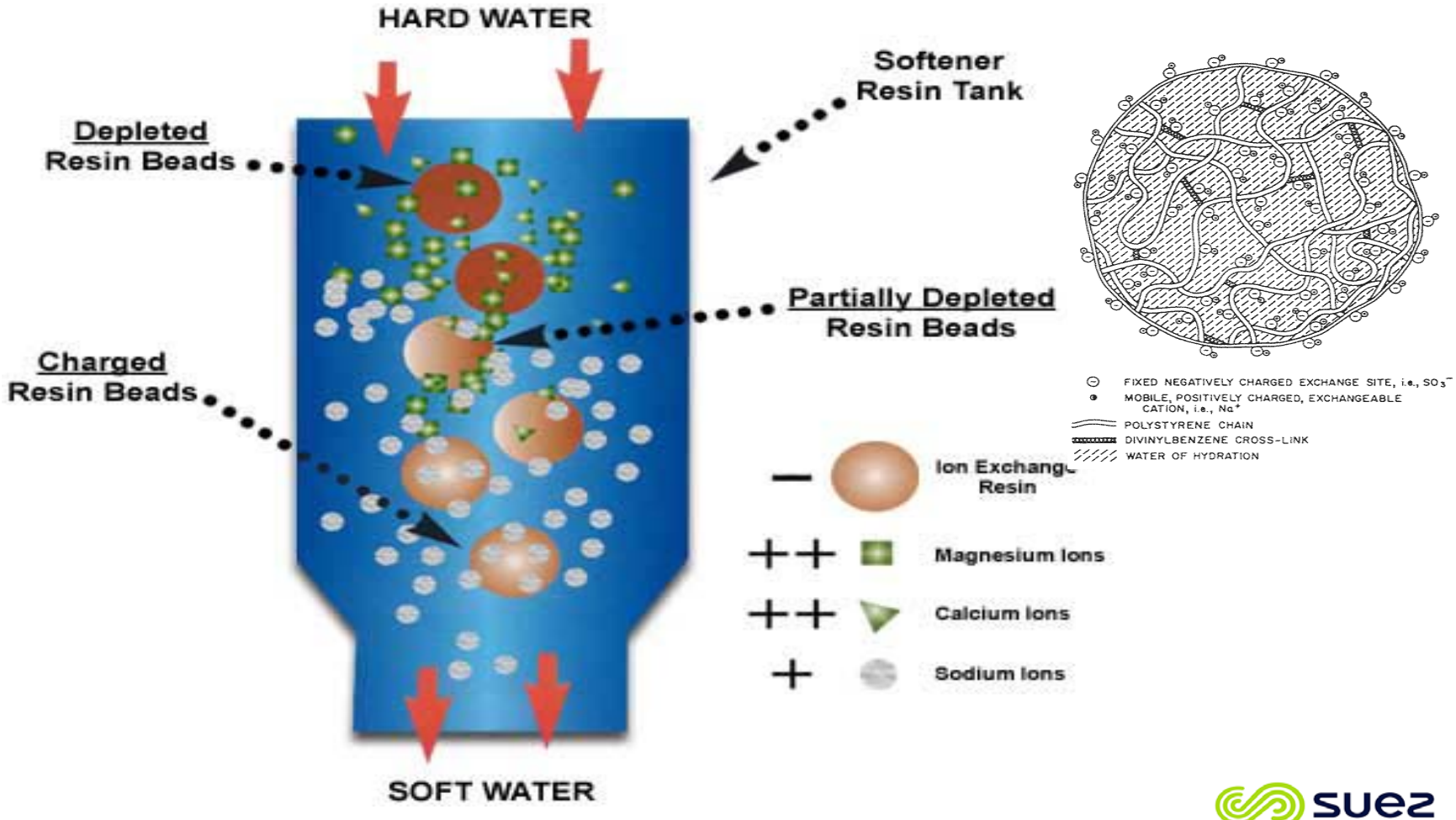
Water Softener Resin



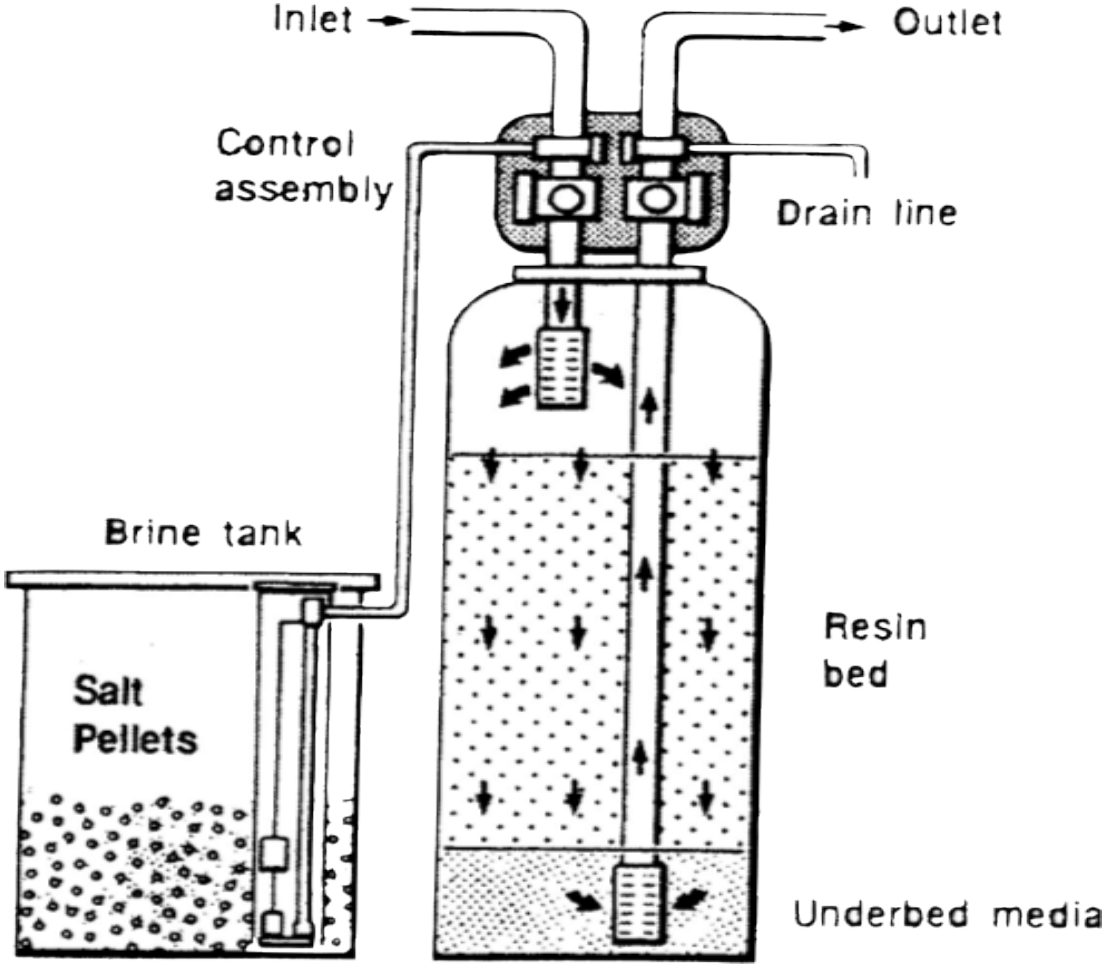
Sodium Cation Exchange is water softening



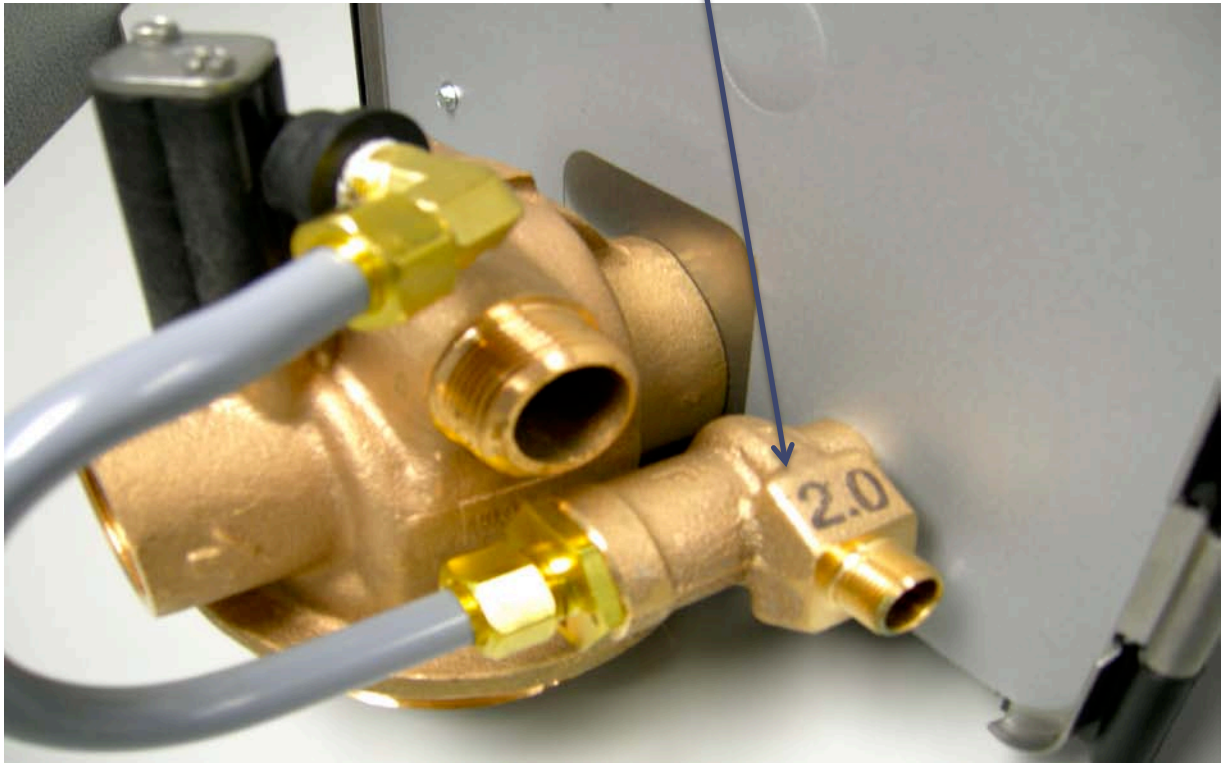
Water softening process



Inside Water Softener



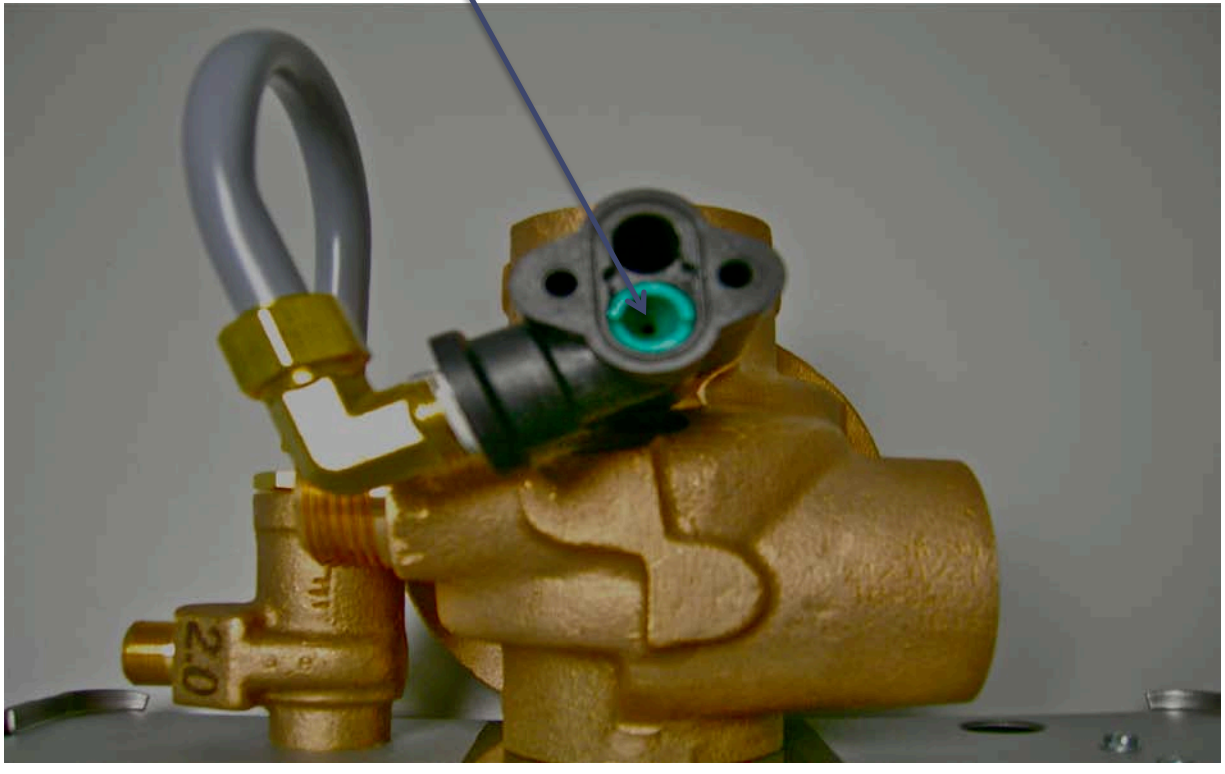
Brine Valve connects to the brine tank



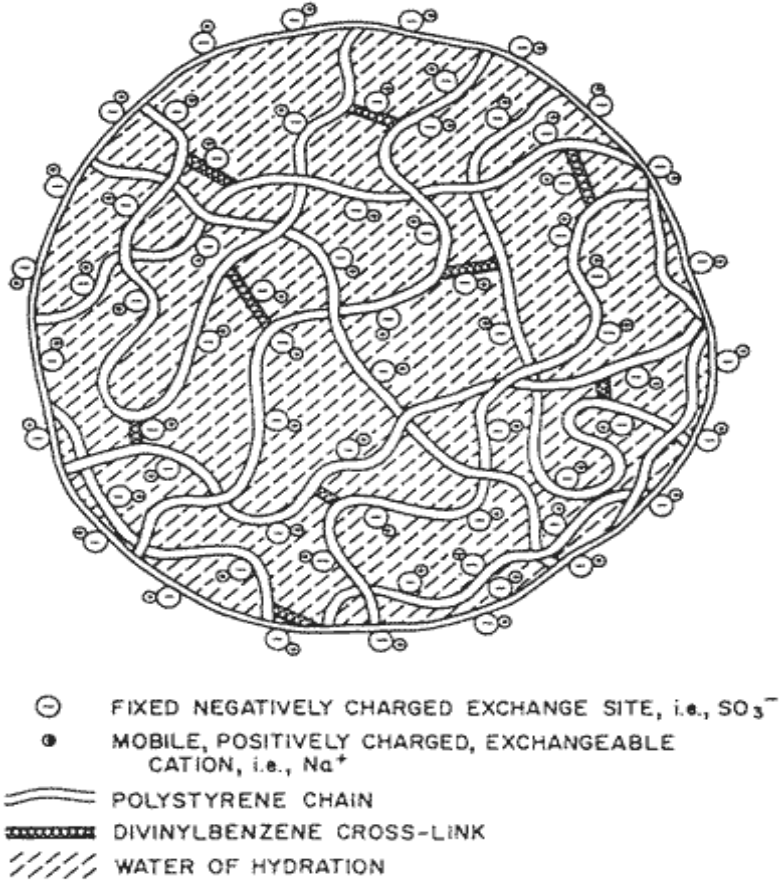
Brine tank air check valves

suez

Injector



Water softening cation ion exchange resin



Ion Exchange Resin Failure

Chlorine breakdown of crosslinking

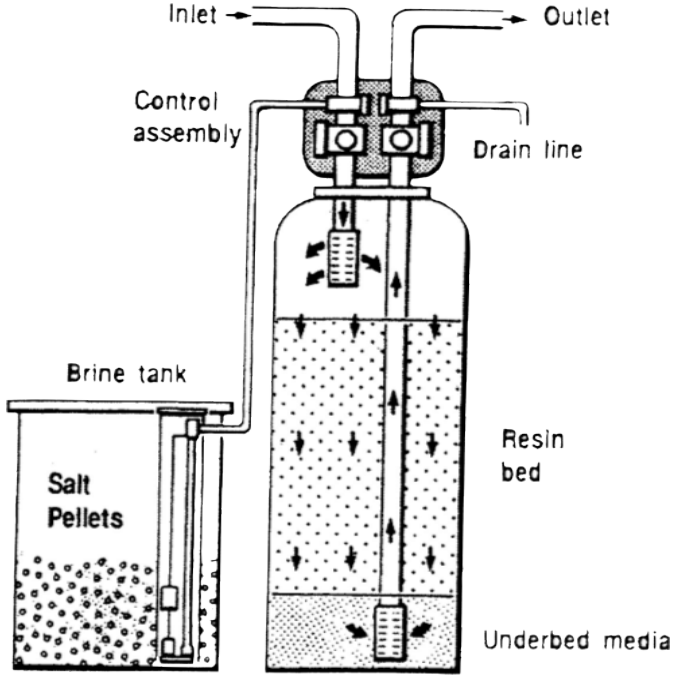
Number of cycles of regeneration

High pressure drop

Problems with the Water Softener

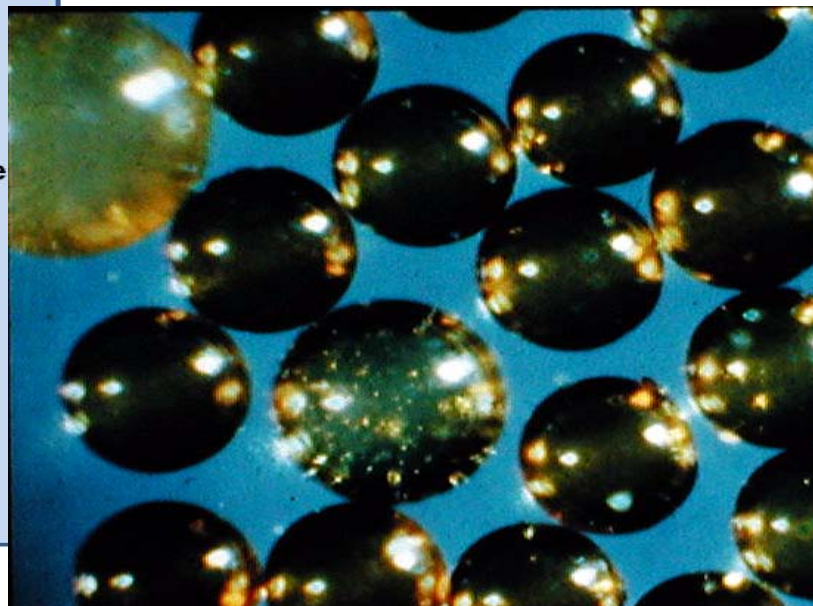
Hard water caused by:

- No salt in brine tank
- Low resin level
- Injector clogged
- Brine air check clogged
- BLFC clogged
- Not enough regenerations
- Brine tank overflowing
- Control set wrong
- Distributor “O” ring missing or damaged
- DLFC clogged or sized wrong



Anion Exchange:
Dealkalizer and Organic Scavengers

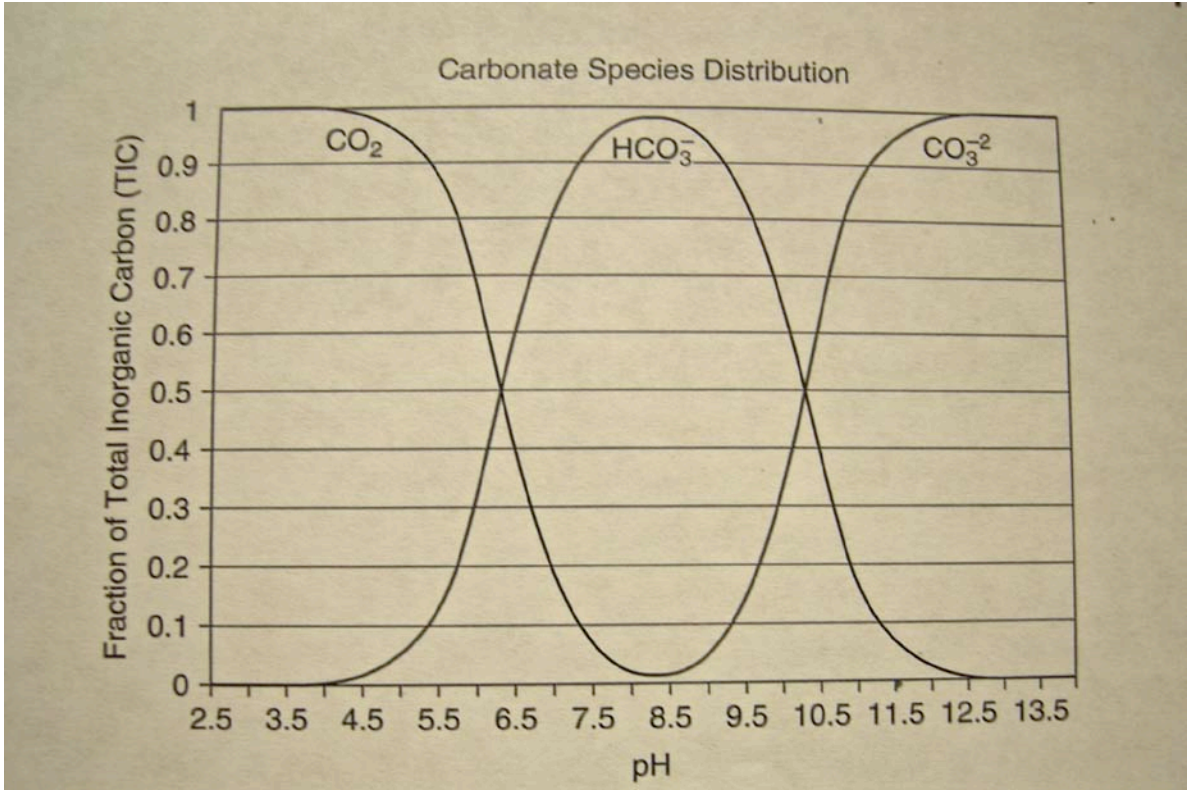
CATIONS +		ANIONS −	
H^+	Hydrogen	OH^-	Hydroxide
Na^+	Sodium	F^-	Fluoride
Ca^{++}	Calcium	Cl^-	Chloride
Mg^{++}	Magnesium	HCO_3^-	Bicarbonate
Al^{+++}	Aluminum	CO_3^{--}	Carbonate
Fe^{++}	Ferrous	SO_4^{--}	Sulfate
Fe^{+++}	Ferric	NO_3^-	Nitrate
		PO_4^{---}	Phosphate



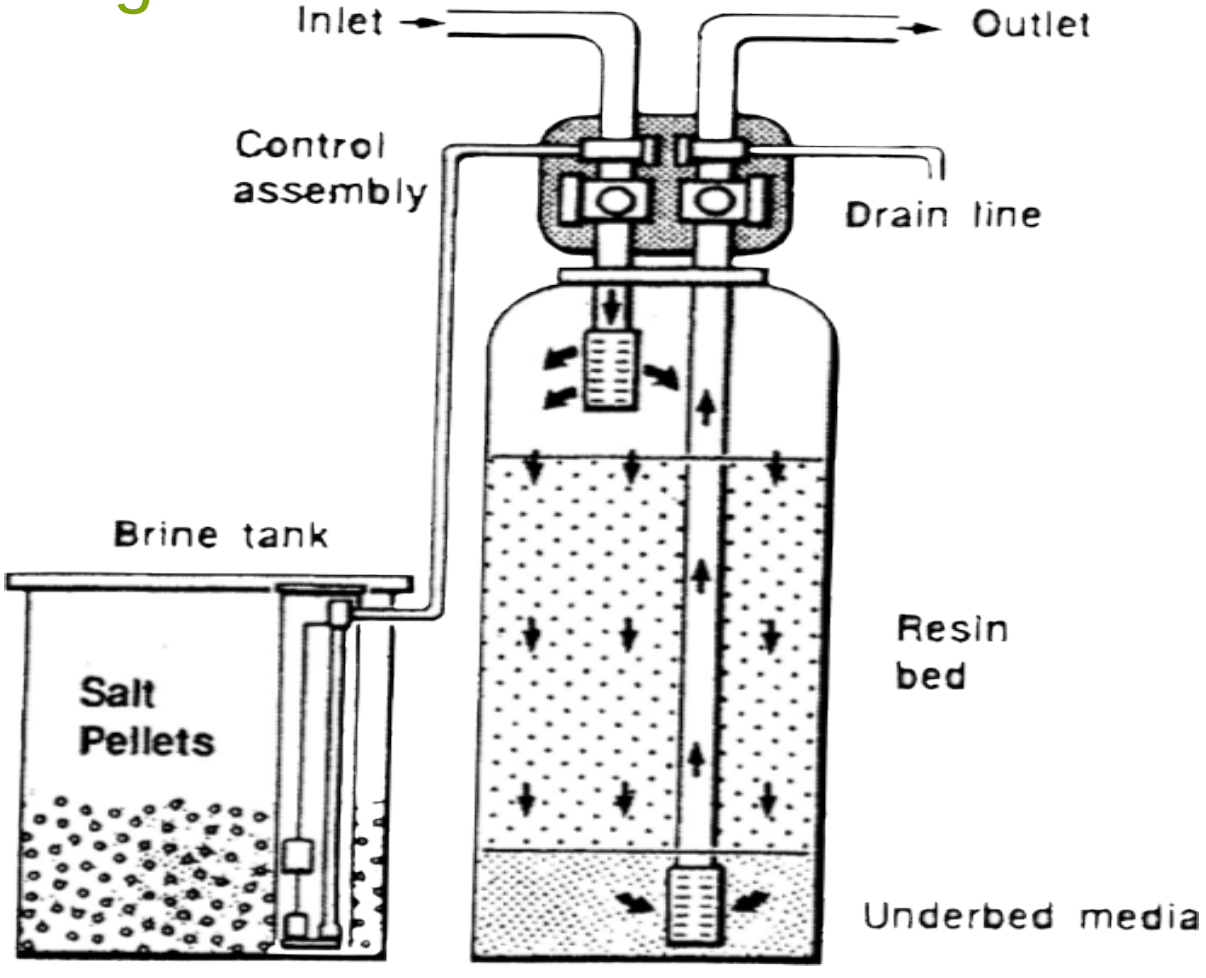
Dealkalizer

Must follow a Water Softener and pretreat the Carbon beds

Dealkalizer Operation



Anion resin in dealkalizer or oganic scavanger



Dealkalizer Operation

• Service Flow Rate	3 GPM per cubic foot resin
• Regenerant level	5 lbs. NaCl per cubic foot
• Regenerant Flow Rate	0.5 GPM/cu.ft. resin
• Regen contact time	> 60 minutes
• Pretreatment	Water Softener

Organic Scavanger
(for removal of humus and tannin)

- Service Flow Rate — 2 GPM per cubic foot resin
- Regenerant level* — 10 lbs NaCl per cubic foot resin
- Regenerant Flow Rate — 0.1 GPM/cu.ft. resin
- Regenerant contact time — > 90 minutes
- Pretreatment — None required

*Resin removal performance after regeneration is 50-70%

*Resin is replaced every 2 to 3 years

Antiscalant Feed

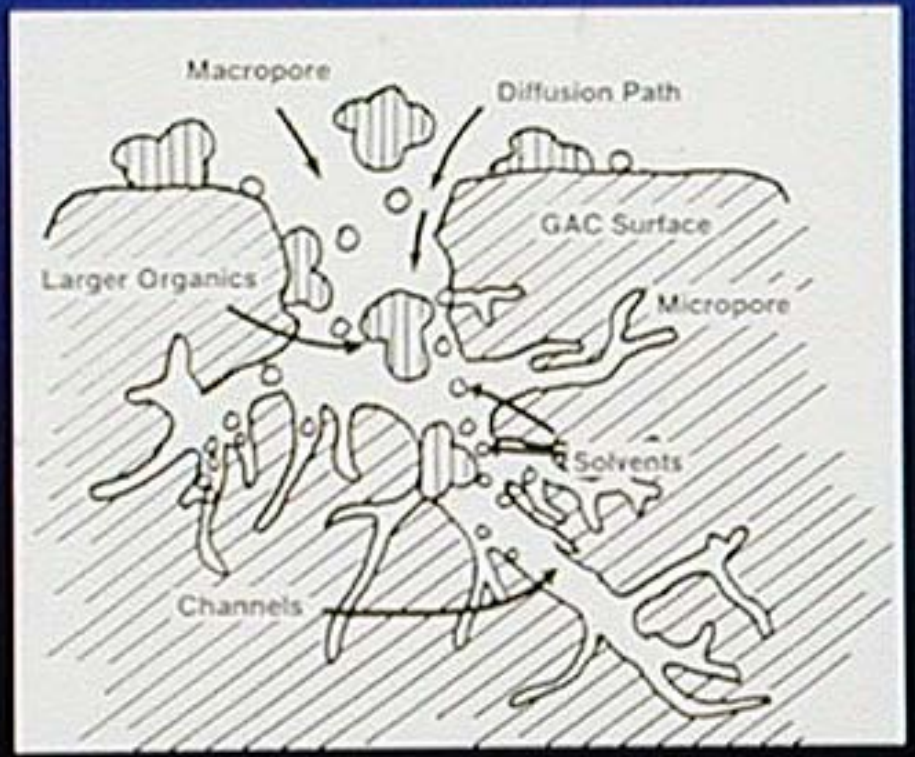
- Chemical is injected before the RO.

- The chemical ties up the calcium and magnesium which prevents the hardness scaling of the membranes and sends it down the drain.

- It is used instead of a water softener, on portable ROs, in installations with floor weight restrictions and where water softeners are banned.

Carbon Filters

Inside the Carbon Granule



Carbon (AAMI/CoC)

- If you can’t rotate tanks all tanks must have the carbon replaced.
- Multiple beds in a worker/polisher arrangement can be used with a sample port between the sets.
- Carbon must be replaced within 72 hours on exhaustion. Monitor polisher every hour and log with the time on the LOG.

EBCT

Empty Bed Contact Time:

RO feed flow* x 10 ÷ 7.48 = total cubic feet of carbon in all tanks

* RO feed flow = reject GPM + product GPM

Supplementing Carbon

Additions that can help carbon in high pH water:

1. pH adjustment using mineral acid
2. Sodium metabisulfite injection
3. Dealkalizer pretreatment
4. UV toc reduction 185nm light

Catalytic/Adsorptive Carbon

In Chloramine Removal:

- Reduces contact time
- Extends bed life
- Decreases equipment size requirements
- Reduces maintenance costs
- Same pH effects as standard carbon

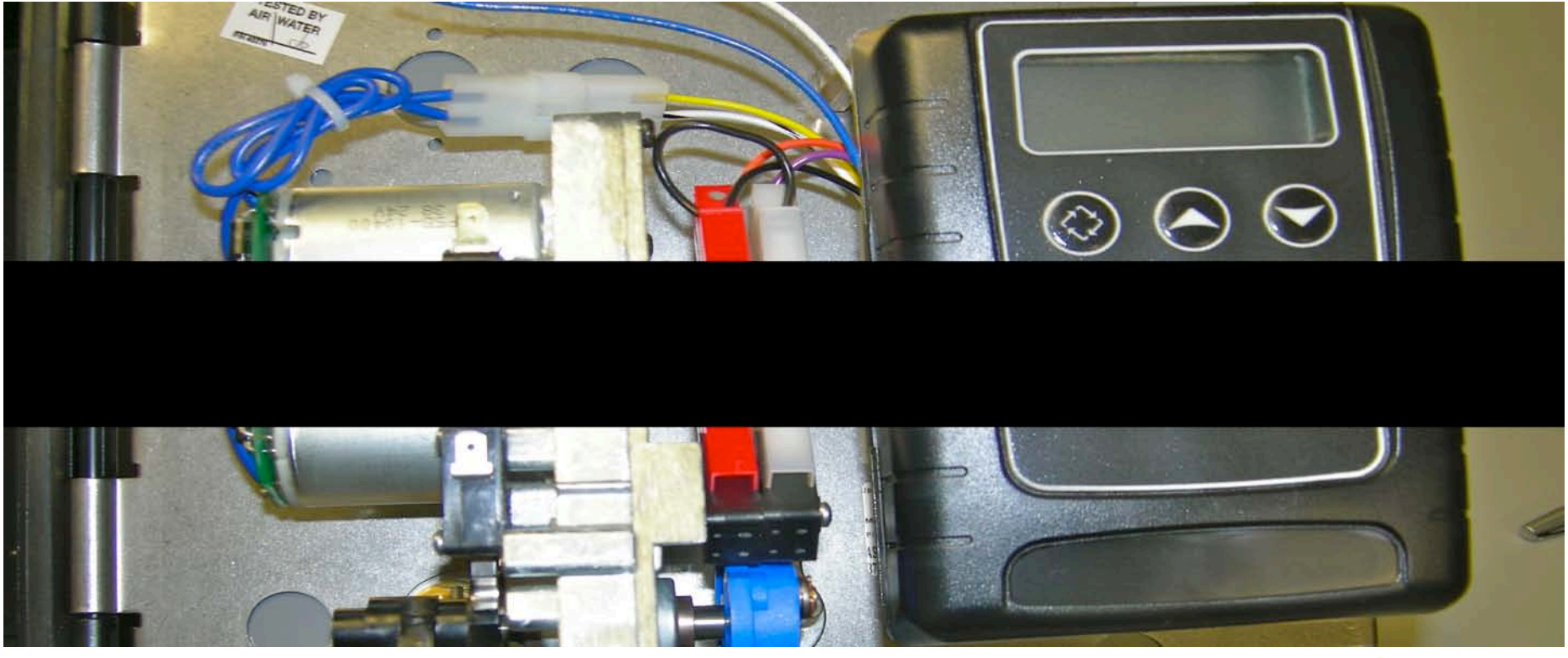
Carbon Maintenance

- **Monitor total chlorine before every patient shift or at least every four hours.**
- **Monitor bacteria cultures after carbon beds periodically**
- **Monitor RO pre-filter for carbon fines.**
- **Soak GAC for 24 hours before replacement.**
- **Disinfect tanks at carbon replacement.**
- **Replace carbon at 12 to 18 months and within 72 hours of breakthrough.**

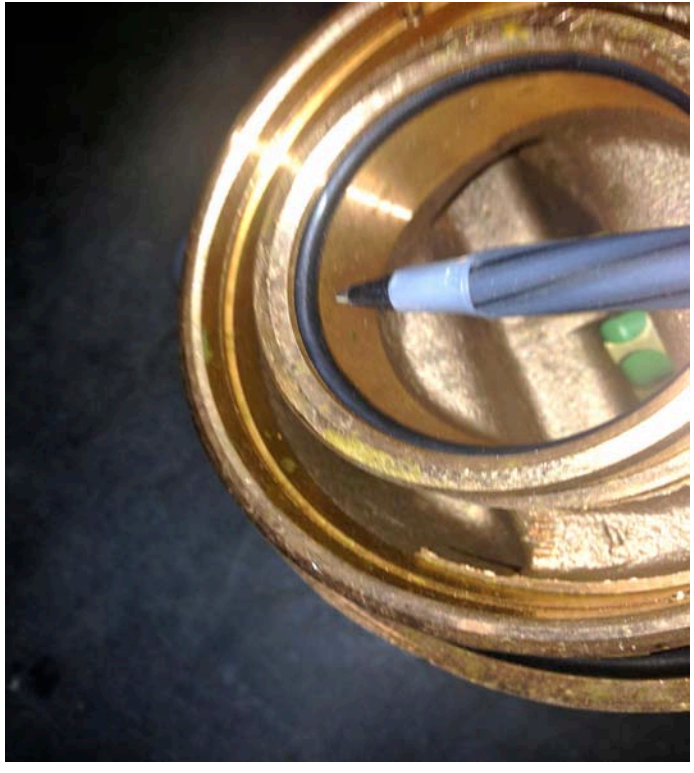
Carbon Filter Problems

1. High total chlorine test after worker and polisher
2. High bacteria levels after the carbon beds
3. Carbon fines reduce flow through RO pre-filter
4. High total chlorine at start-up
5. High total chlorine after replacing the carbon

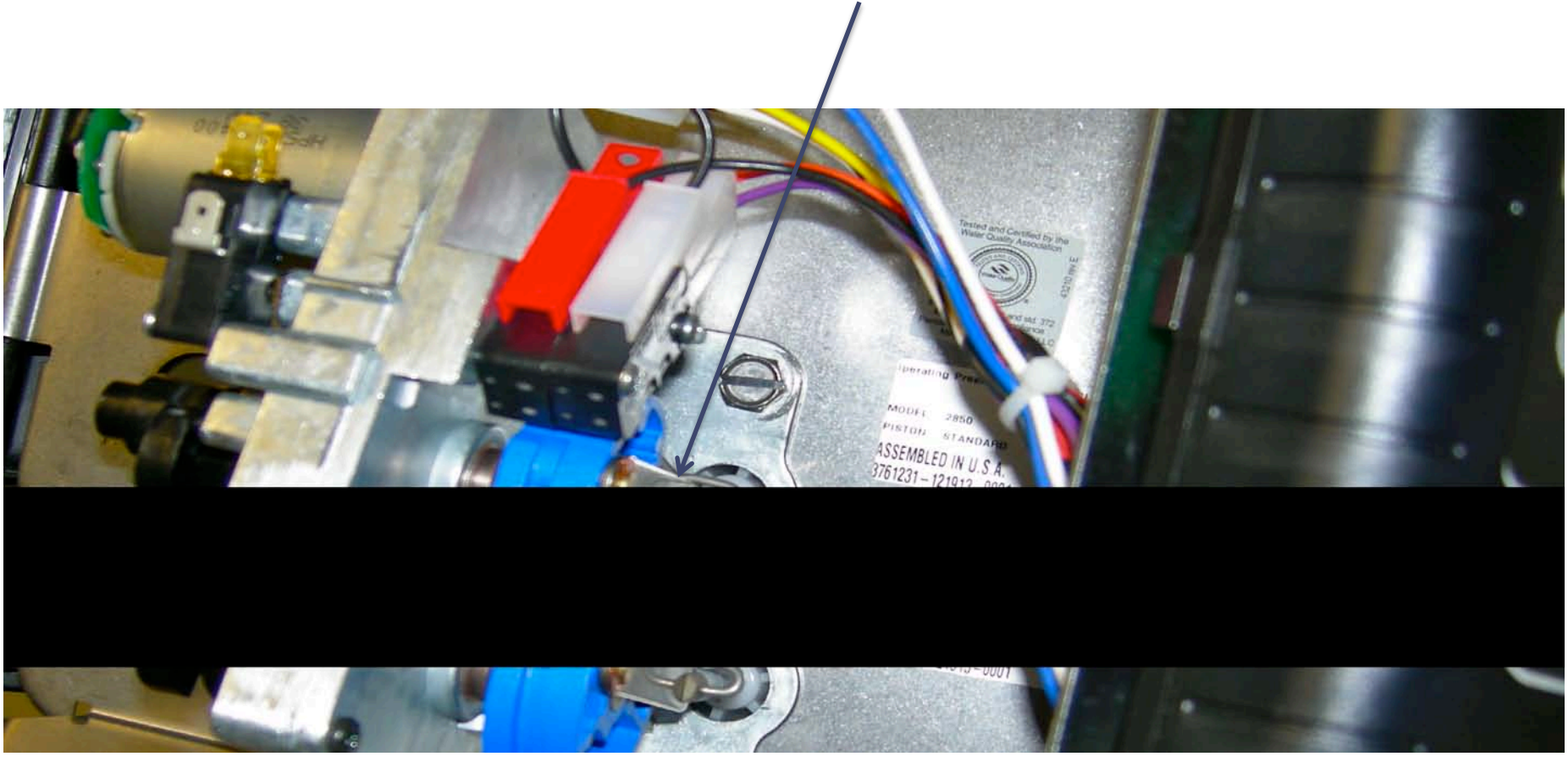
Valve must connect properly to the distributor and tank.



“O” Ring seal of Distributor to Valve



Piston driver and piston connection



Piston Assemblies

Flow Rate (50 psi inlet) - Valve Alone

Piston	Standard (P/N 61453 -10)	High Flow (P/N 61452-10)	Filter (P/N 61452-20)
Continuous (15 psi drop)	27.7	35.8	36.7
Peak (25 psi drop)	35.5	46	47.5
Cv (flow @ 1 psi drop)	7.1	9.2	9.5
Max. Backwash (25psi drop)	7.4	15.8	31.3

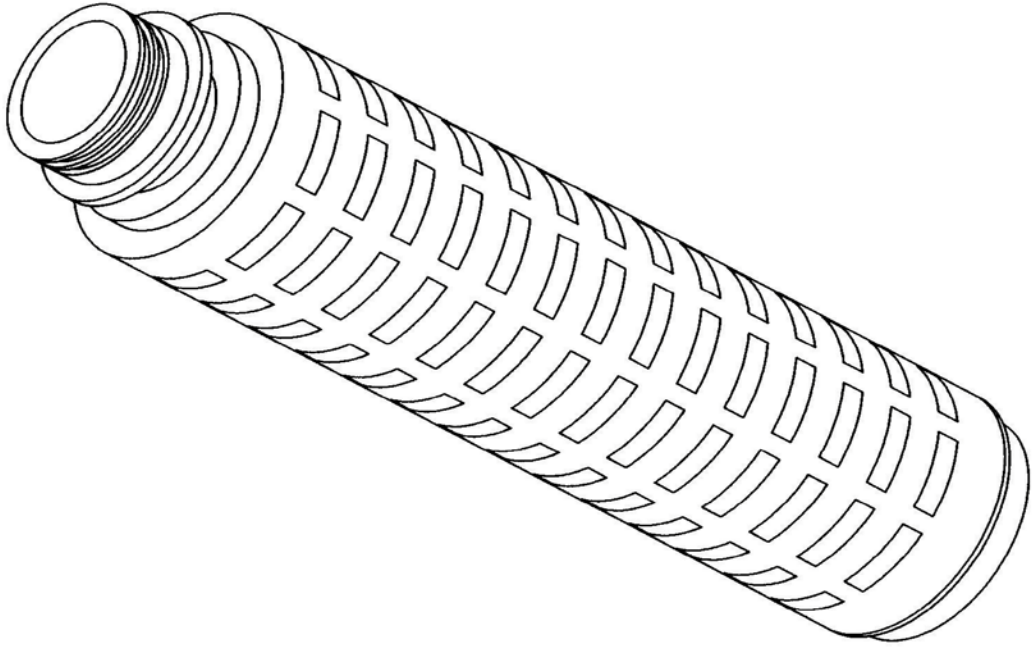
Cartridge Filters

Dual Open End Filter

1 to 25 micron

222 “O” Ring

0.05 to 1 micron



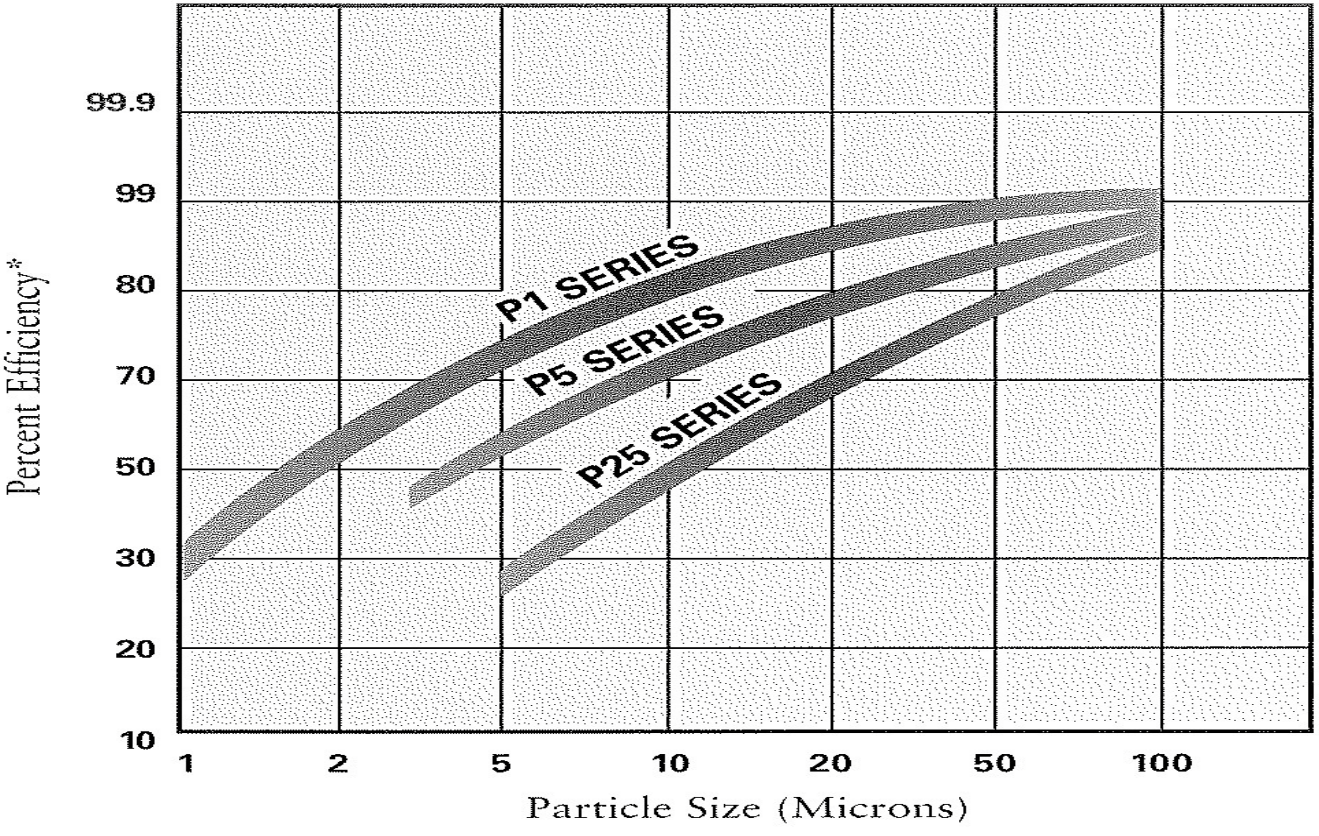
Cartridge Filter Rating

Absolute 99.9 to 100 %

Nominal 30 to 99%

- Generally a good nominal rated filter is about 70-80% efficient.

Cartridge Filter Efficiency Rating



RO Pre-Filter Problems

1. **Sediment in the RO membrane mesh concentrate chamber**
2. **Bacteria breakthrough of the RO membrane**
3. **Clogging of the RO membrane pores by fine silt**
4. **Low feed flow to the RO membranes**
5. **Low feed pressure to the RO membranes**


Concentrate Mixing & Loops

Bicarb Concentrate Mix & Distribution

Features to Think About

Separate mix and distribution tanks

Low level opening for powder addition

Polyethylene or PEX 1/2” OD loop tube for up to 30 stations

Keep recirculating the bicarb loop at night with RO water

Return loop to bottom of tank, will siphon w/o pump

Feed loop with 2 to 4 psig

Ability to increase loop pressure and flow during rinse out of bicarb and disinfectants

AAMI/CoC Bicarb Mixing Standards

- Mixing tanks should be drained and rinsed before mixing another batch.
- The concentrate should be used within the time specified by the manufacturer of the concentrate.
- Bicarb systems drained and rinsed at the end of the day
- Bicarbonate systems and jugs should be purged of bicarbonate concentrate before disinfection.
- Disinfect bicarb systems at least weekly
- Test the mixed solution with a conductivity meter or hydrometer and not for pH

AAMI/CMS Bicarb Mixing

- **If you are mixing bicarbonate and/or acid concentrates, you are the quality control person.**
- **Make sure:**
  - All components in the system(s) are compatible with the concentrates and disinfectants.
  - Purified water source that meets AAMI RD62:2001.
  - Suitable drain.
  - Ground fault protected electrical outlet.
  - Personal protective equipment as recommended by the manufacturer.
  - Mixing procedure documented and a log of each batch.
  - Test by using conductivity meter or a hydrometer. The use of pH is inappropriate.
  - Record and sign test results before transferring.

What should the conductivity of bicarb be?

The powder manufacturers may not tell you

Determine your own level by:

- Mixing a batch
- Send to your Dialysis Machine and check the reading
- Adjust the batch concentration until the Dialysis Machine is in specification
- Read the batch conductivity
- This is your set point for mixing future batches

Acid Concentrate Mixing

anuFlo® Concentrate Dissolution Unit has a 99 Gallon capacity

Spikes

- Acid concentrate additives
  - Usually an RN or Pharmacy mixes
  - make sure the “spike” is completely mixed
  - label container with final concentration, the date and time mixed, and the person mixing
  - log of mix in permanent record

DID WE ANSWER YOUR QUESTIONS?

Thank You!