DEIONIZATION PROCESS

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RESINTECH INC.
INNOVATIONS IN ION EXCHANGE

What is Deionization?

A process of removing ionized salts from water.

Definitions

- **Cations** – Positively charged ions dissolved in solution
- **Anions** – Negatively charged ions dissolved in solution

Common Cations

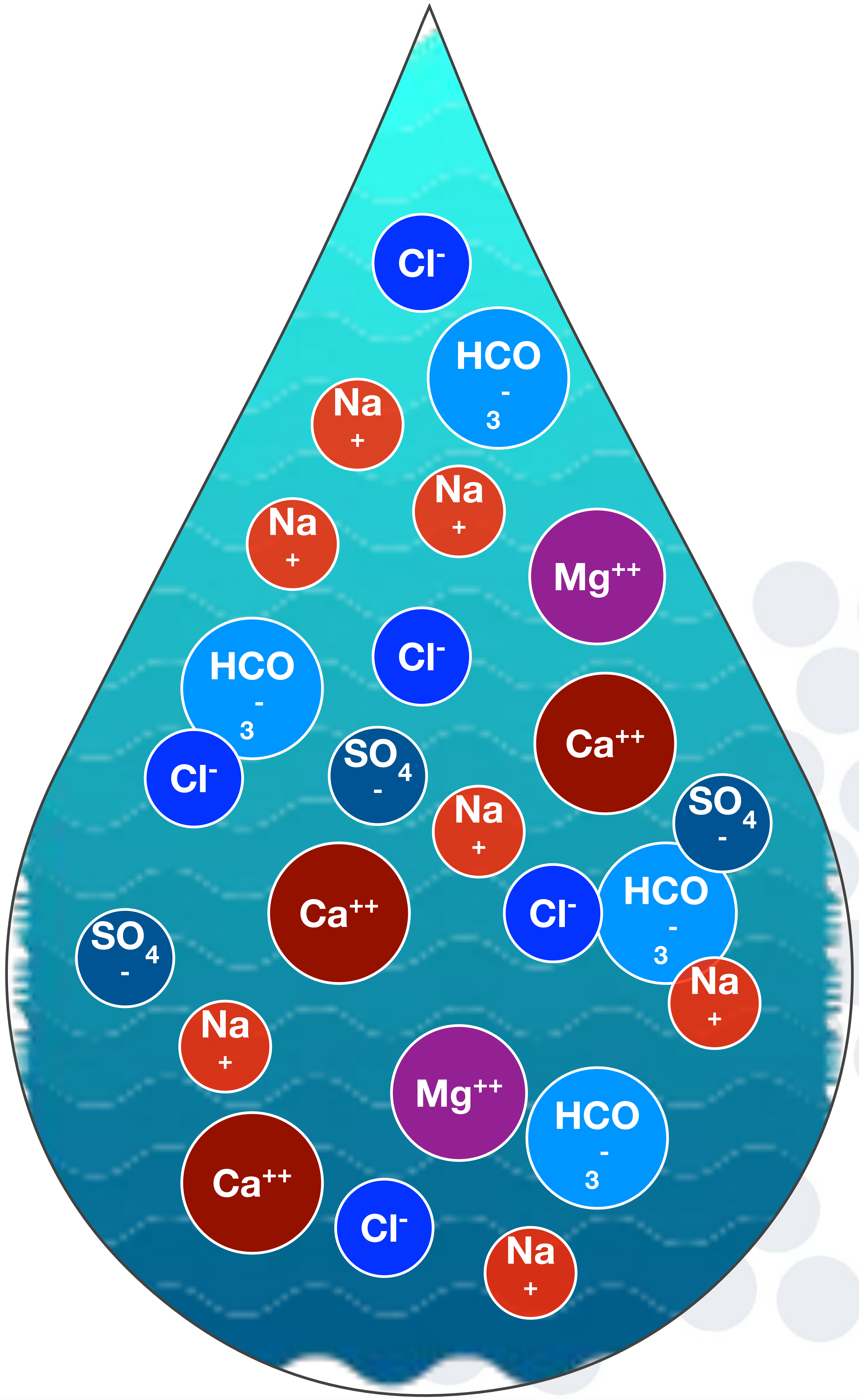
- Calcium (Ca^{++})
- Magnesium (Mg^{++})
- Sodium (Na^{+})

Common Anions

- Sulfate (SO_4^{--})
- Chloride (Cl^-)
- Bicarbonate (HCO_3^-)
- Silica (SiO_2^-)

Ion Exchange

The function of an ion exchange system is to remove dissolved ions present in water.



Two Common Types of IX Systems

Softeners versus Demineralizers

"Softeners" remove

- Calcium
- Magnesium

"Demineralizers" remove

- Calcium, magnesium, sodium
- Sulfate, chloride, alkalinity, silica

Deionization versus Distillation

Deionization

- Removes contaminants from water
- Lower operating cost
- Lower capital cost

Distillation

- Removes water from contaminants
- Higher operating cost
- Higher capital cost

What is TDS (Total Dissolved solids)?

- TDS comprise inorganic salts principally Ca, Mg, K, Na, HCO_3, Cl, SO_4 and some small amounts of organics dissolved in water.

- TDS is measured in mg/lit or ppm (parts per million)

Total Organic Carbon (TOC)

- Typical surface waters contain naturally occurring organics
- Certain types of TOC/Organics behave as weakly ionized anions
  - Tannic, Hummic, and Fulvic Acids
- Organics can be partially removed by anion resin and can foul over time
- Fouled resins produce poor capacity and water quality after regeneration
- Resin can be treated to remove organics
  - Hot Brine/Caustic treatment utilized

What is conductivity and Resistivity?

- The ions (cationic, anionic) carry electrical charge and can move through water, which allows water to conduct an electrical current.

- The measure of the ability of water to carry electrical current is called “electrical conductivity”

Resistivity = 1 / conductivity

Conductivity and Resistivity

Conductivity	Resistivity
0.055 µS	18.2 MΩ
0.1 µS	10 MΩ
1 µS	1 MΩ

Types of Ion Exchange Resins

Cation Resins

Strong & Weak Acid

Anion Resins

Strong & Weak Base

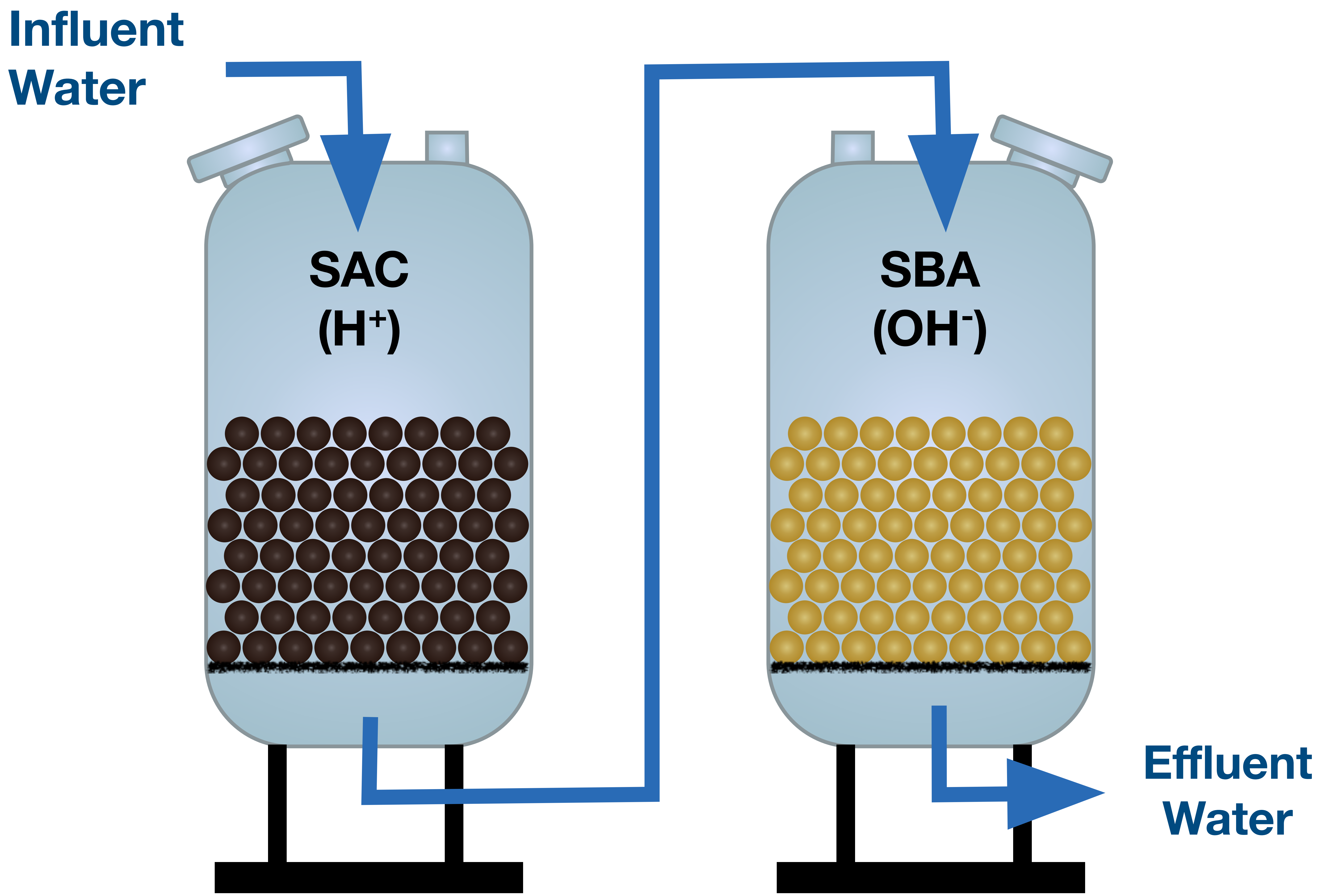
Mixed Bed Resins

Demineralization

- Exchange of dissolved ions for equal parts H^+ and OH^- ions to create water
- Cations exchange for equal parts of H^+ ions
- Anions exchange for equal parts of OH^- ions
- $H^+ + OH^- = H_2O$

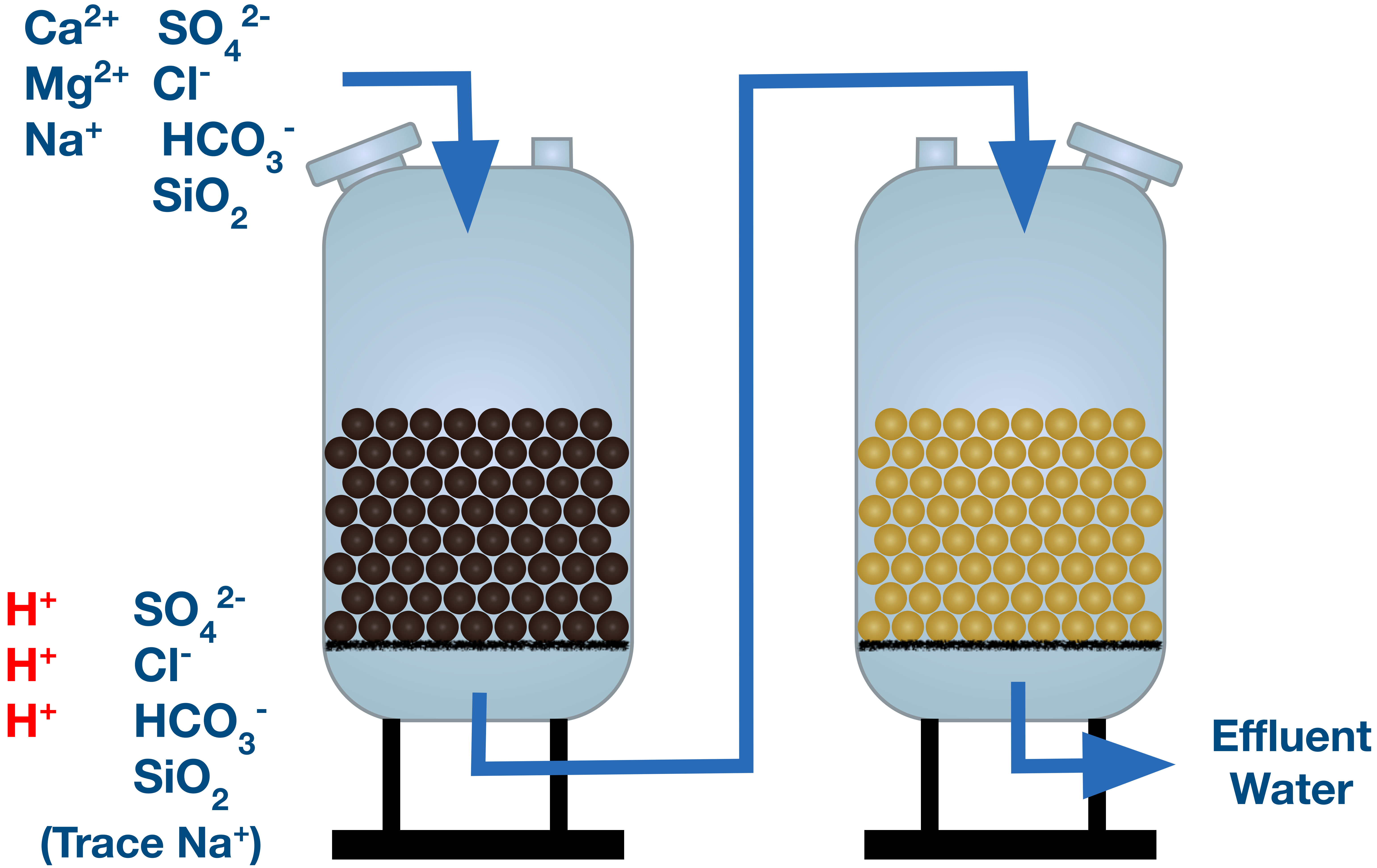
Two Bed Demineralizer

Strong Base

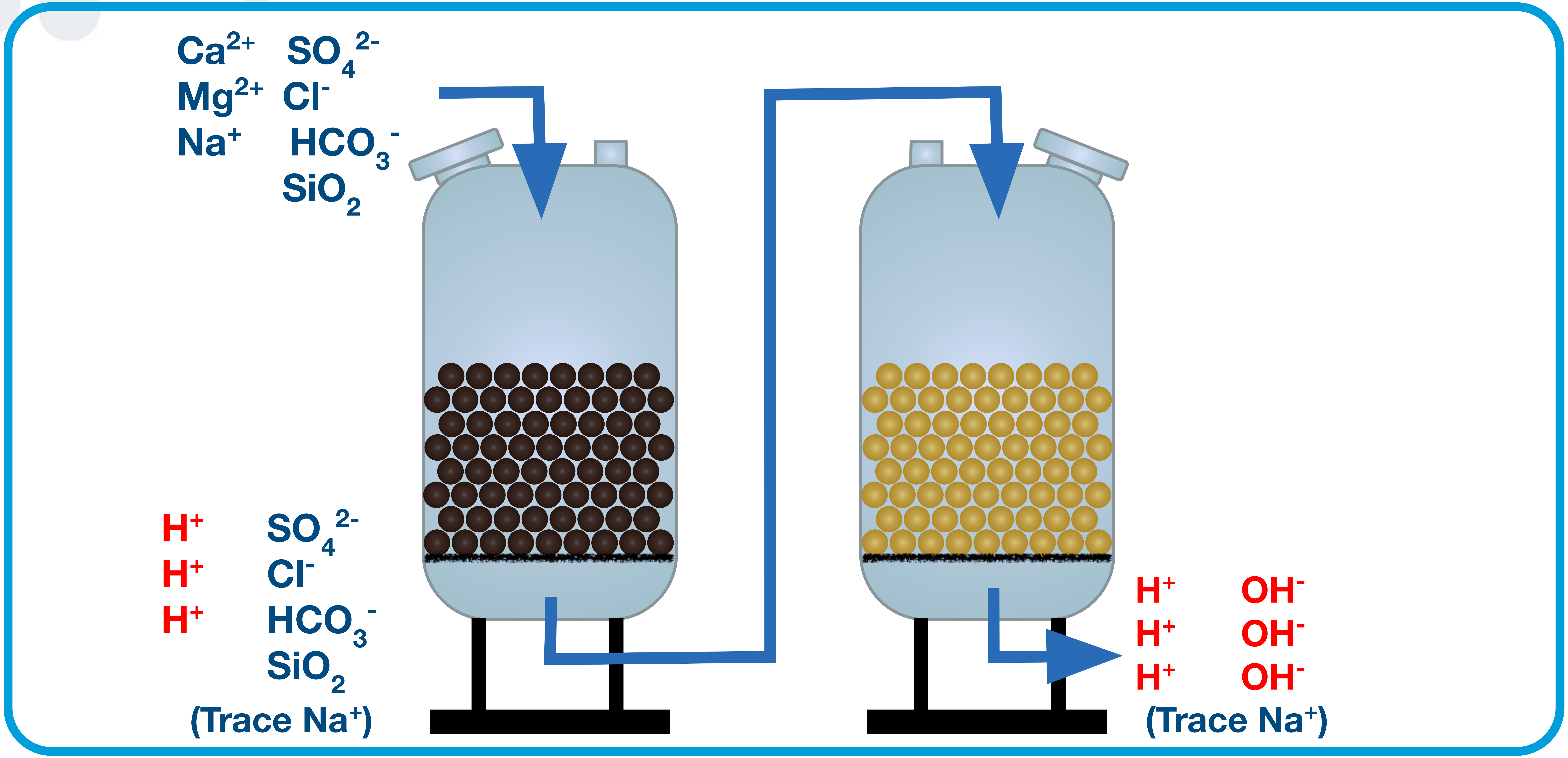


Two Bed Demineralizer

Strong Base

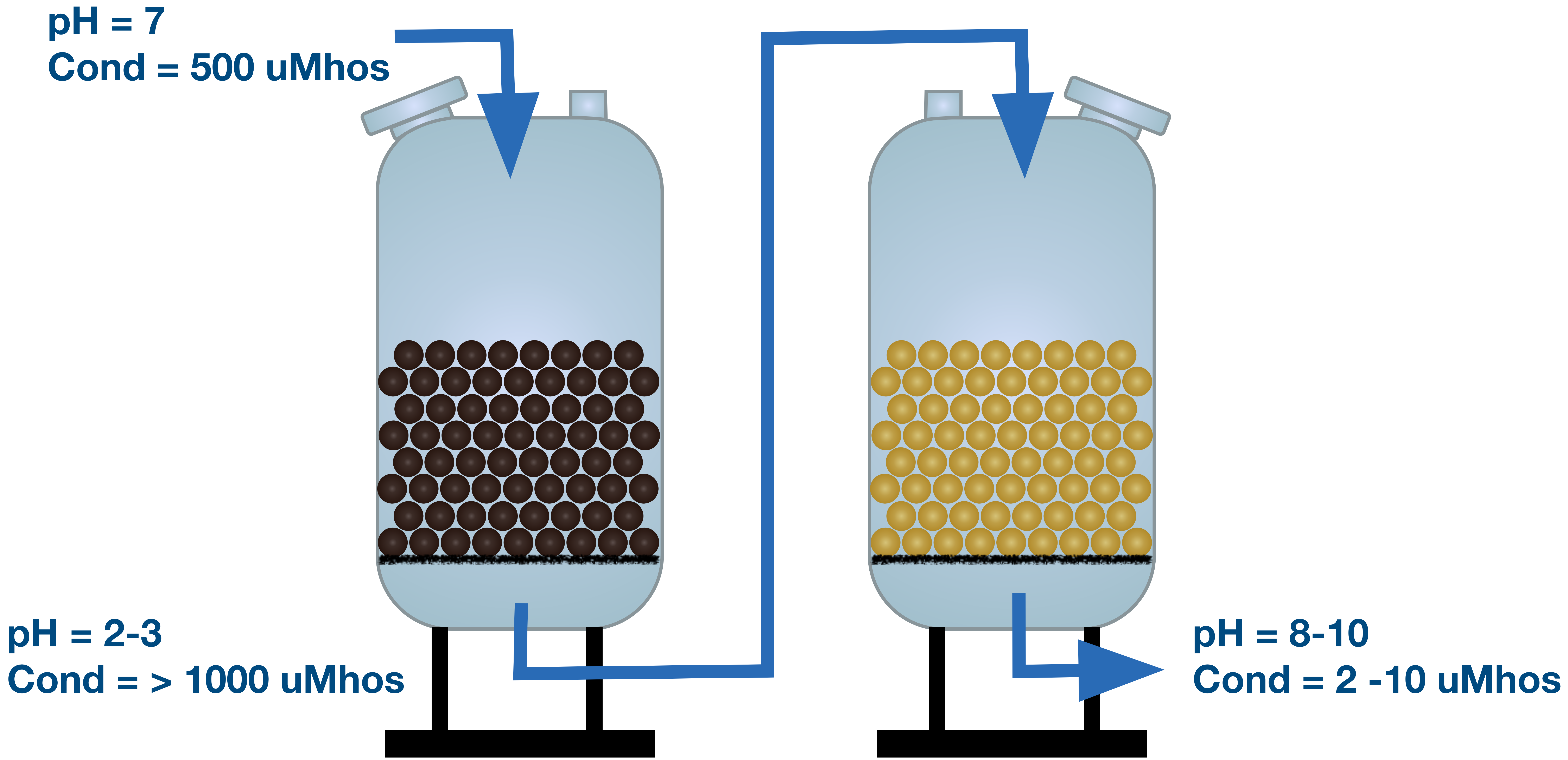


Two Bed Demineralizer



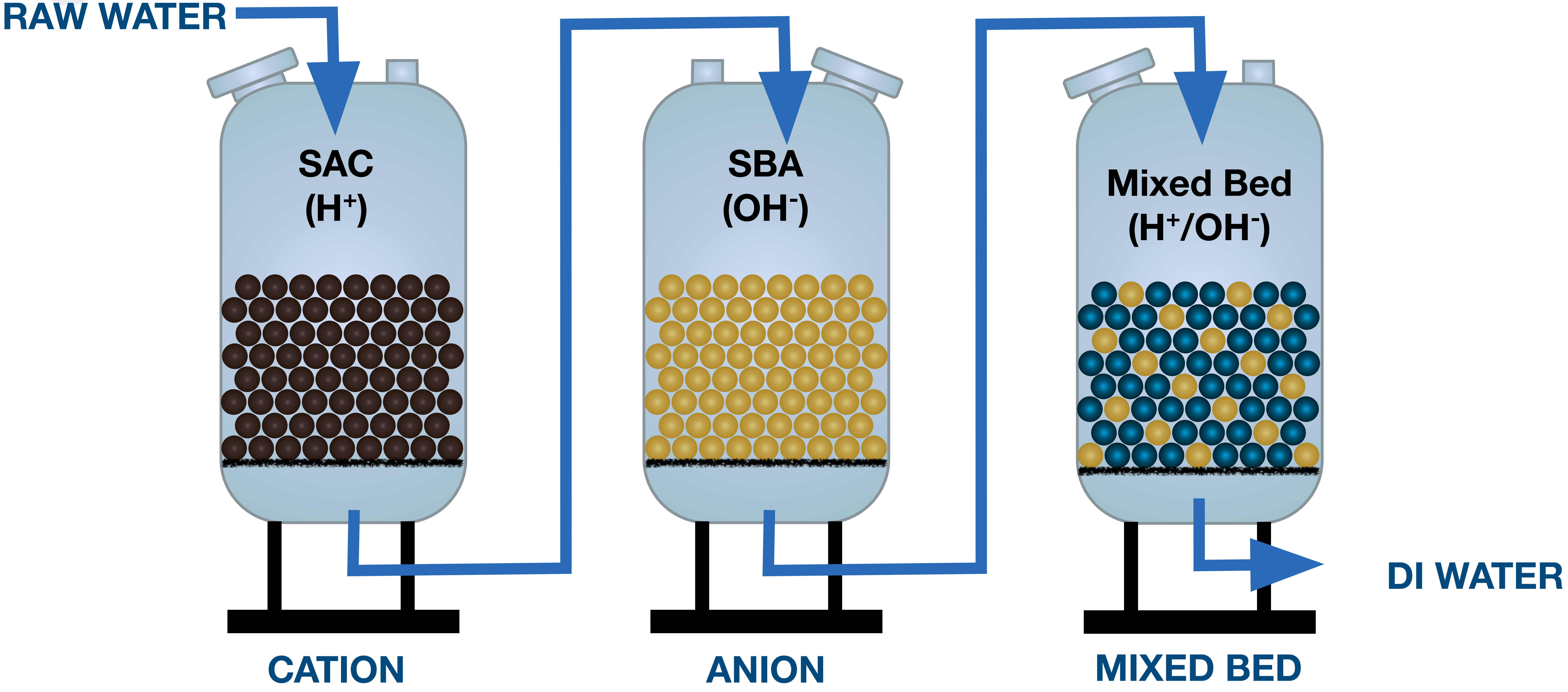
Two Bed Demineralizer

Strong Base

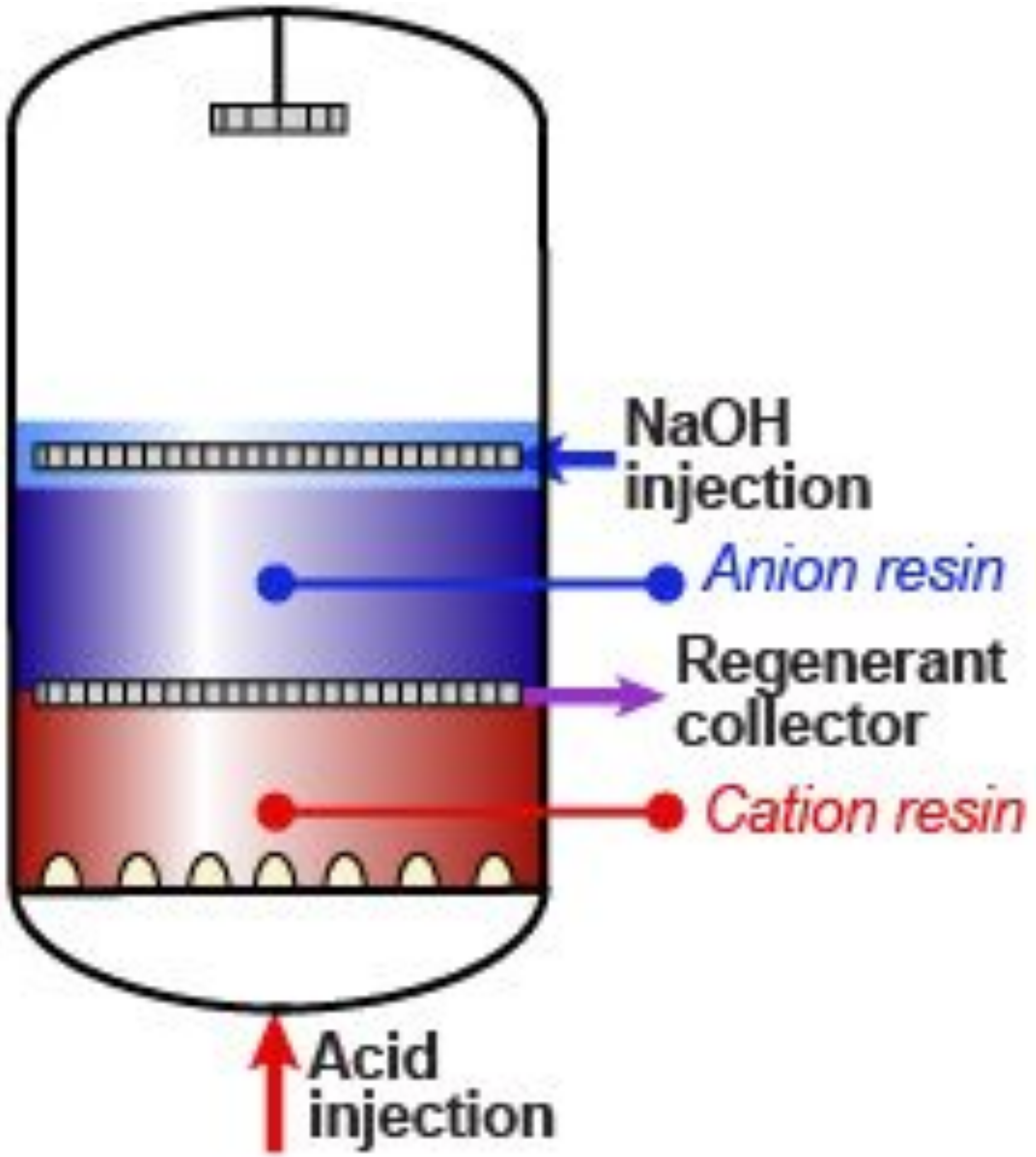


Typical DM Plant scheme

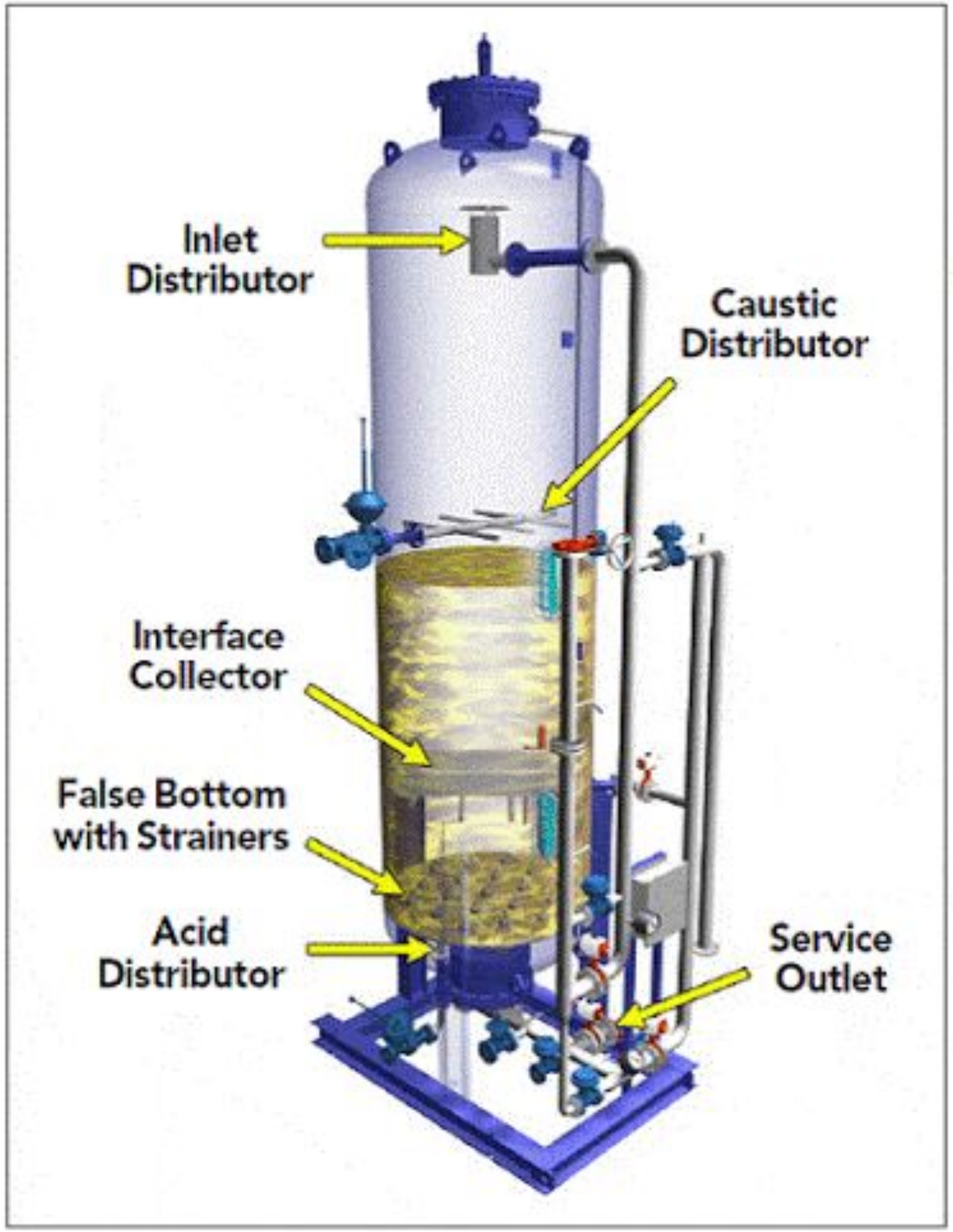
SAC-H followed by SBA-OH followed by Mixed Bed as polisher



Mixed Bed Resin Bed



How Mixed bed resin vessel looks?

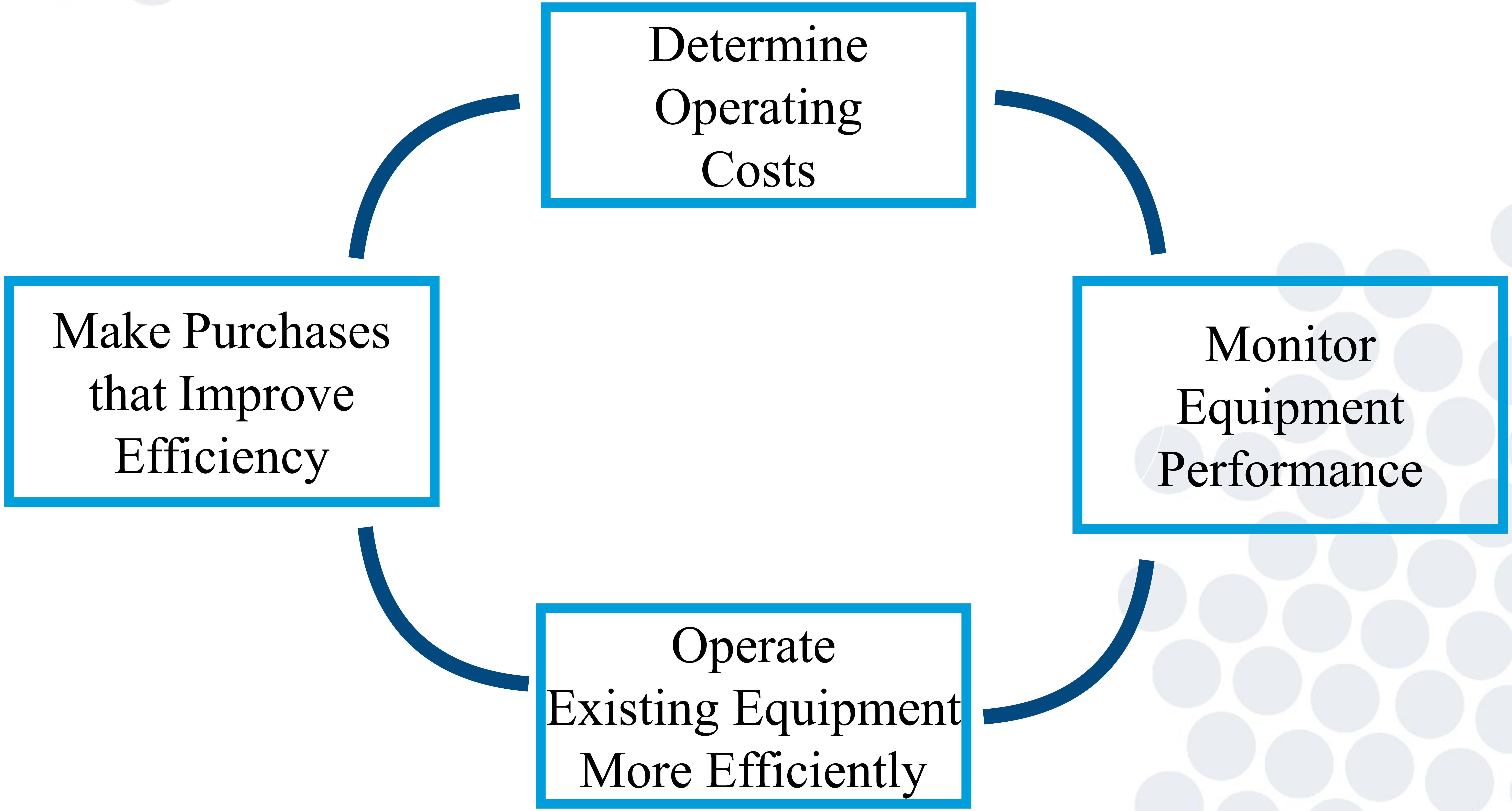


Keeping the DI Plant Running Efficiently

Ever find yourself in this situation?

- Short runs
- Low quality water
- High chemical consumption

Cycle of Improving Efficiency



Feedwater Quality

Raw water analysis

- pH
- Conductivity
- Total alkalinity
- Ammonia
- Potassium
- Sodium
- Hardness
- Turbidity

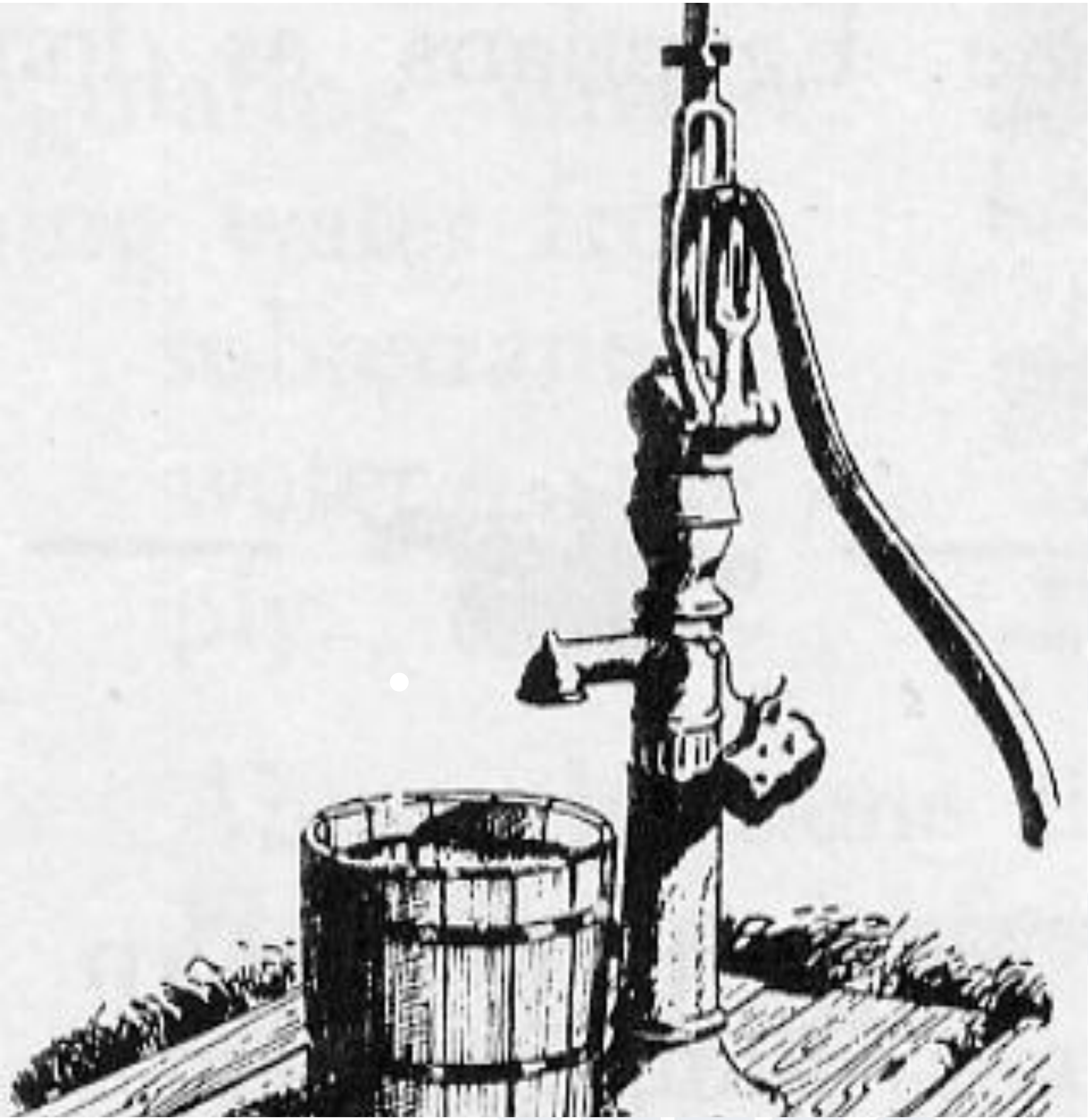
What do we need to know?

- **Customer Expectations**
  - Conductivity/Resistivity desired
  - Silica and/or TOC specification
  - Any other special requirements
- **What water will you be treating?**
  - Tap, Well, RO source(s)
  - Understand feed chemistry
    - pH, TDS, carbon dioxide and silica impacts
- **System set-up and operation**
  - Service exchange, in-place, etc.

Operating Costs

Feedwater quality

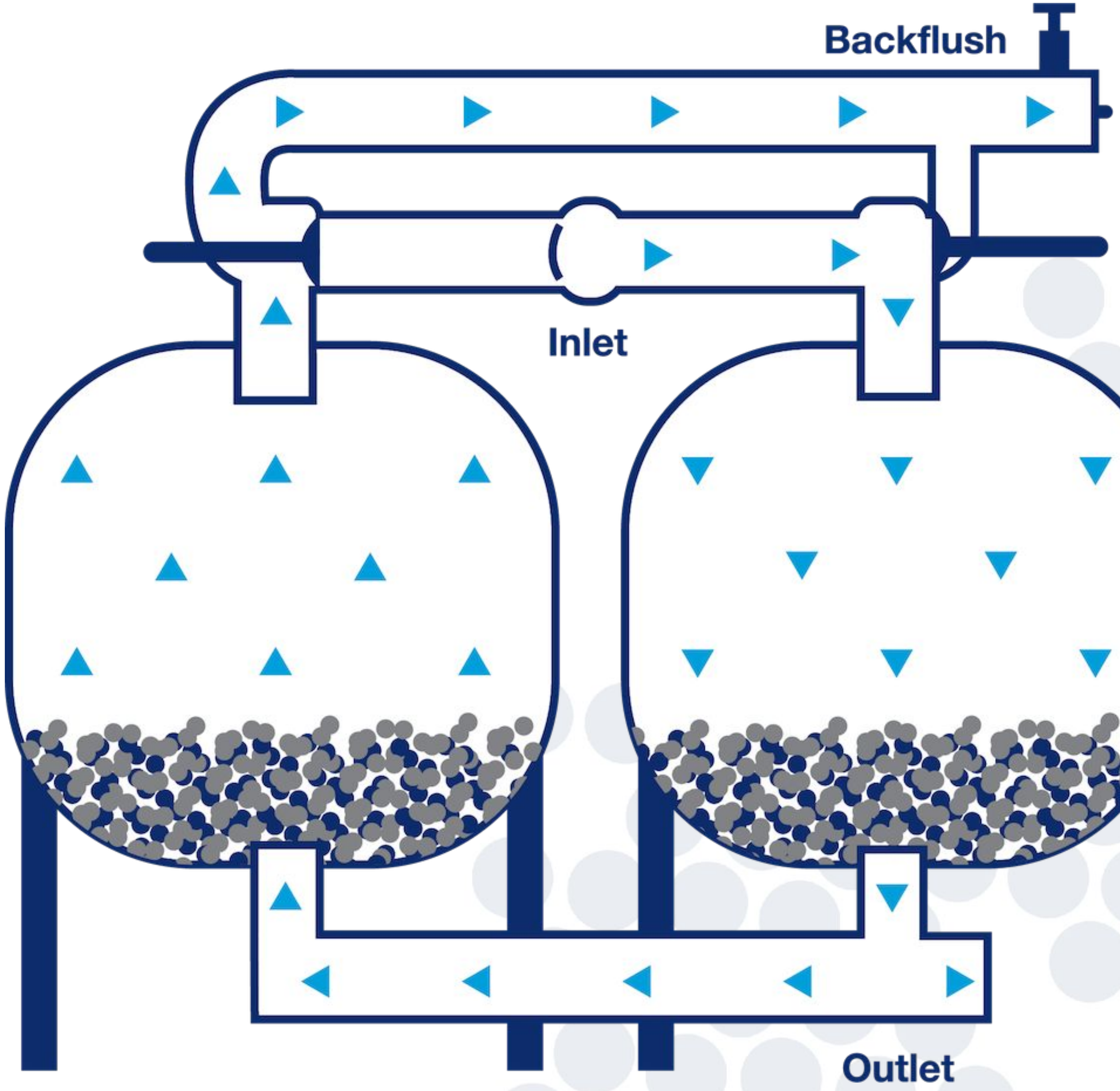
- How old is plant?
- Seasonal variances
- More than one source
  - Cost per gallon



Operating Costs

Backwash, regeneration & rinse water

- Source
- Quality
  - DI water for regen
  - Hidden costs
- Recycle



Operating Costs

Regeneration Frequency

- Endpoint
- Timer

Operating Costs

Chemicals

Acid

- Sulfuric or hydrochloric
- Tech grade

Caustic

- Should be high grade
- Specifications

Operating Costs

Regeneration waste treatment & discharge

- Compliance
- Minimization
- Recycle

Operating Costs

Power for pumps

- Minimize pressure loss through resin beds

Operating Costs

Labor

- Training
- Certification

Make Purchases that Improve Efficiency

Resin

Current operating conditions

Chemicals

Cheaper not always better

Replacement parts

Upgrades available?

Factors Affecting Resin Performance

- **Oxidation**
  - Chlorine
  - Temperature
- **Loss of capacity**
- **Fouling**
  - Organic
  - Oil
- **Loss of resin**
  - Backwash loss

Monitoring Performance

Demineralizers

- Feedwater conductivity
- Effluent conductivity
- Differential pressure
- Run length, gallons
- Working capacity v. theoretical
- Amount of regenerant used
- Rinse water, gallons
- Silica

Monitoring Performance

Demineralizers

Deionization Applications

1. Spot free rinsing – Car wash/ window cleaning
2. Aquarium Industry
3. Pharmaceutical - UPW
4. Industrial boilers
5. Beverage Industry - UPW
6. Power Generation - UPW
7. Laboratories - UPW
8. Vehicle battery
9. Semiconductor Industry - UPW

Spot Free Rinsing

Vehicle cleaning and window cleaning

Water spots are caused by residual minerals and salt contained in the water. These salts remain after the water dries or evaporates. Using ‘demineralized’ water for washing allow the items to dry spot-free.

Aquarium Industry

American Marine Life Dealers Association (AMDA) Guidelines

Important parameters

- PH – 6.8 to 7.8
- Ammonia - < 0.02 ppm
- Nitrates- < 10 ppm
- Alkalanity
- Phosphates- <0.5 ppm

Laboratory Applications

1. HPLC
2. GC/MS
3. Life science, cell culture
4. DNA Sequencing/PCR (Polymerase chain reaction)
5. Electrophoresis

ASTM Standards for Laboratory Reagent Water

	Type I	Type II	Type III	Type IV
Electrical Conductivity Max. (µS/cm @ 25°C)	0.056	1.0	0.25	5.0
Electrical Resistivity Min. (MΩ-cm @ 25°C)	18.0	1.0	4.0	0.2
pH @ 25ºC	-	-	-	5.0 - 8.0
TOC max. (µg/L)	50	50	200	No limit
Sodium max (µg/L)	1	5	10	50
Silica max. (µg/L)	3	3	500	No limit
Chloride max. (µg/L)	1	5	10	50

ASTM: American Society for Testing and Materials

Which Type water do you need?

GENERAL APPLICATIONS

TYPE III

- Glassware rinsing
- Humidifiers autoclaves
- Environmental chambers
- Hot/cold baths

STANDARD APPLICATIONS

TYPE II

- Buffers
- pH solutions
- Media preparation
- Chemistry analyzers
- Reconstitution
- Instrument Feed

CRITICAL APPLICATIONS

TYPE I

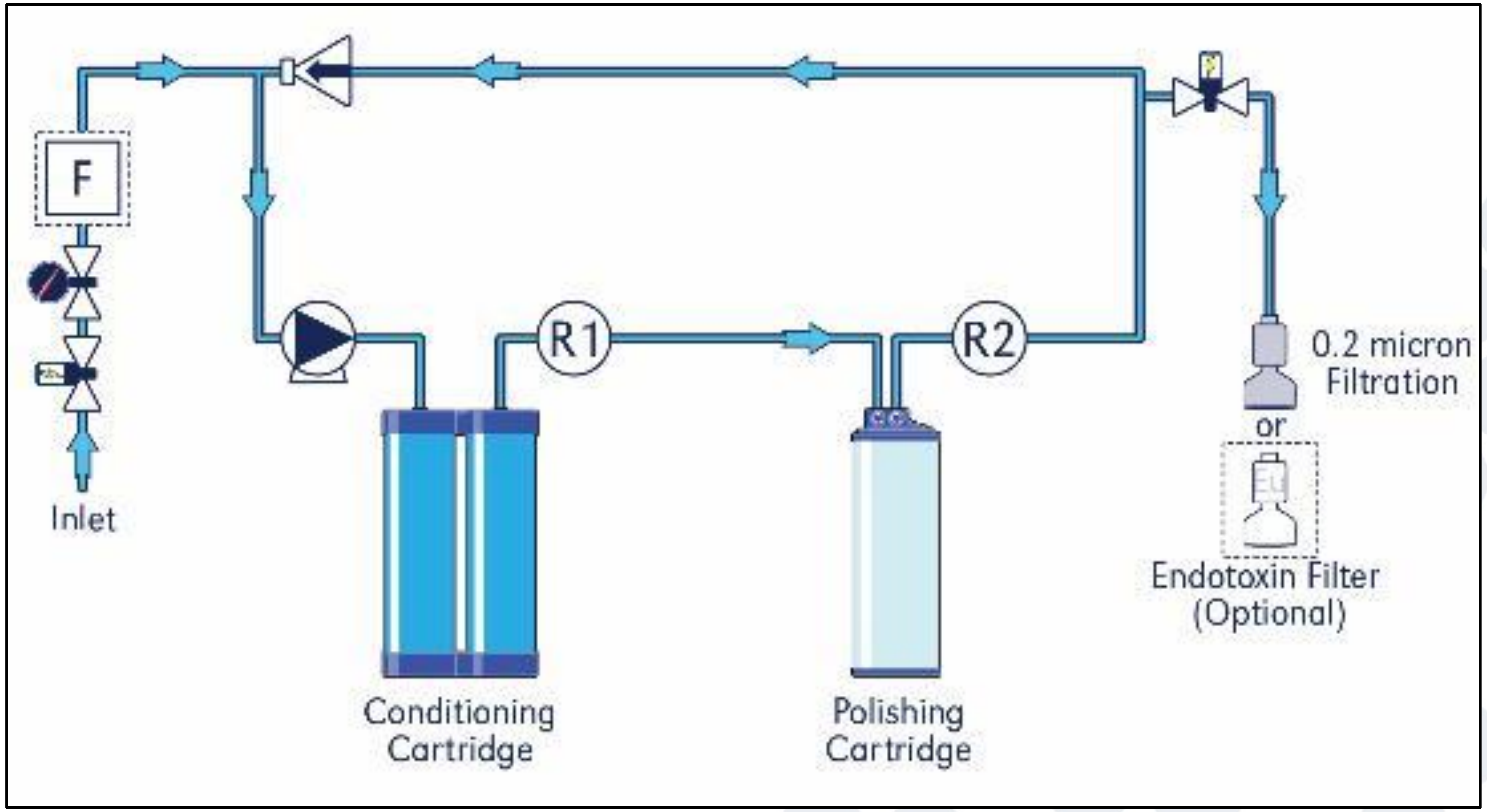
- HPLC, GC, AA, ICP-MS
- Buffers
- Cell culture
- IVDF
- Molecular biology reagents

“Pure” PPM ⟷ **”Ultrapure”** PPB

Achieving Type I Water (Review)

Basic Requirements

- Mixed Bed Deionization
- Recirculation
- Resistivity Monitoring
- Sub-micron Filtration



Point-of-Use Systems

High Purity Water Systems

Cartridges

Pharmaceutical Industry

Water uses

- Raw material
- Ingredient and/or solvent in processing, formulation and manufacturing of pharmaceutical products, Active pharmaceutical ingredients (API) and analytical reagents.
- Cleaning Agent for rinsing vessels, equipments and packaging material/machines
- QC Lab and R&D Experiments

Ultrapure water (UPW) in Semiconductor Industry - 18.2 MΩ

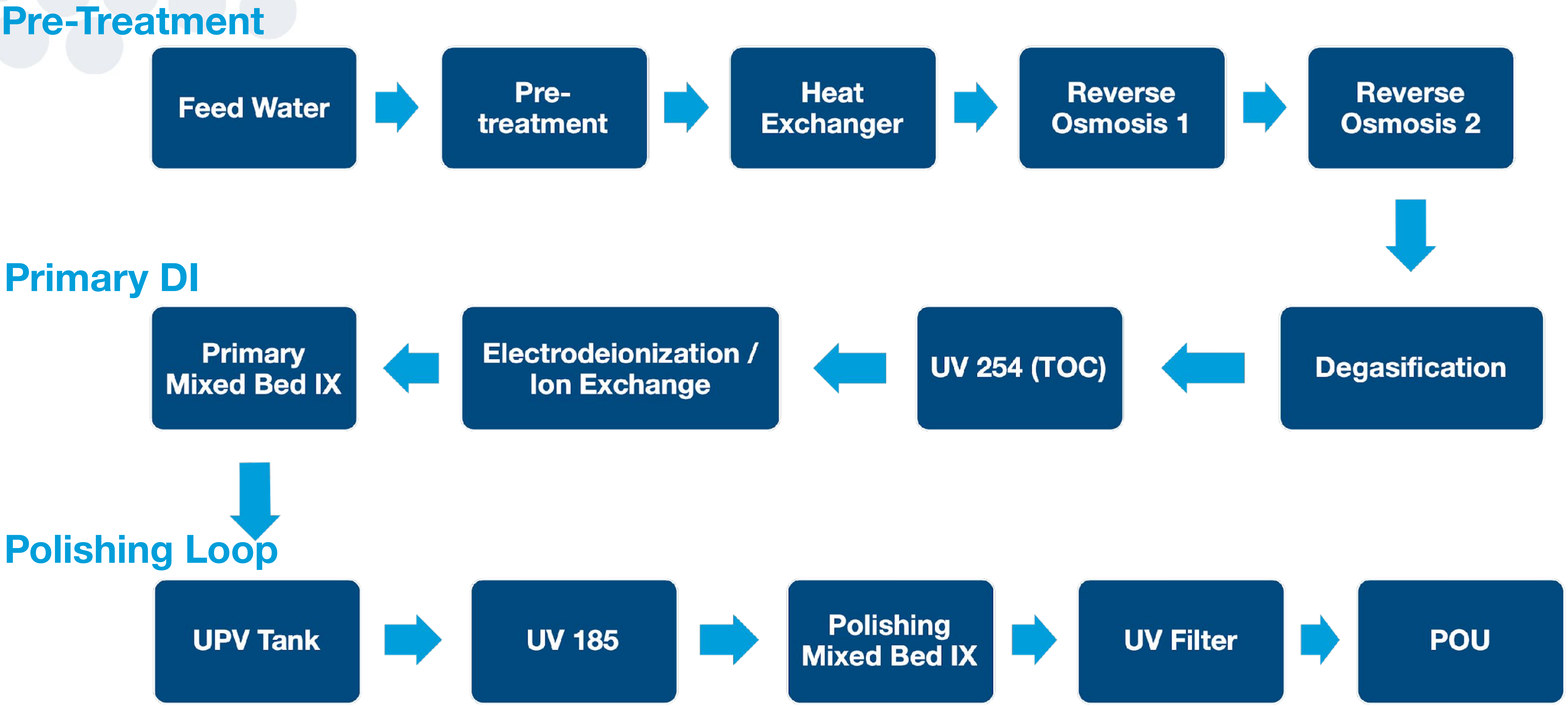
Three steps of treatment

1. **Pretreatment (Pure water)** - Removal of organics, chlorine, turbidity, suspended solids followed by deionization with RO/mixed bed resins

2. **Primary (further purification**)- UV for organic removal followed by mixed bed resin

3. **Polishing (UPW)** - UV followed by mixed bed resins as polisher

Ultrapure water in Semiconductor Industry

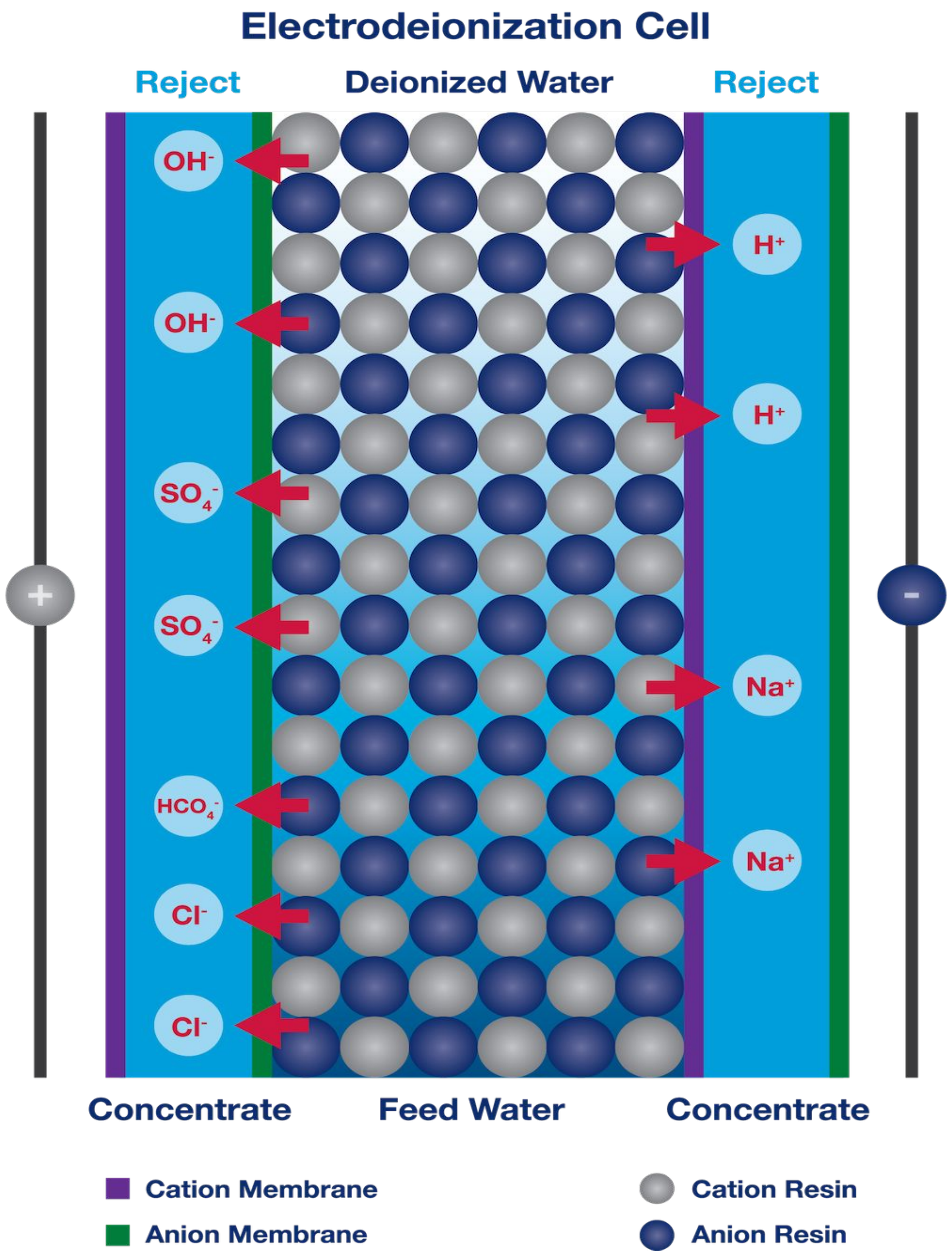


Electro-Deionization (EDI)

Used downstream of a reverse osmosis system, this technology combines electrodialysis and mixed bed ion exchange to produce high purity water.

Ions are split using a DC electric field and the cation and anion mitigate through a selective membrane to a compartment of mixed bed resins. Mixed bed resins are continually regenerated through this process.

Electro-Deionization (EDI)



Condensate polishing in power plants

- Once through steam Generators (OTSG)
- Critical and supercritical steam Generators
- Nuclear-fueled boiling water Reactors (BWR)
- Pressurized water Reactors (PWR)

Condensate polishing - Contd

- In a typical power plant steam condensate loop, steam is passed through a series of turbines, expending most of its energy
- Steam is condensed by a Heat Exchanger system and returned to boiler where it is converted back to steam

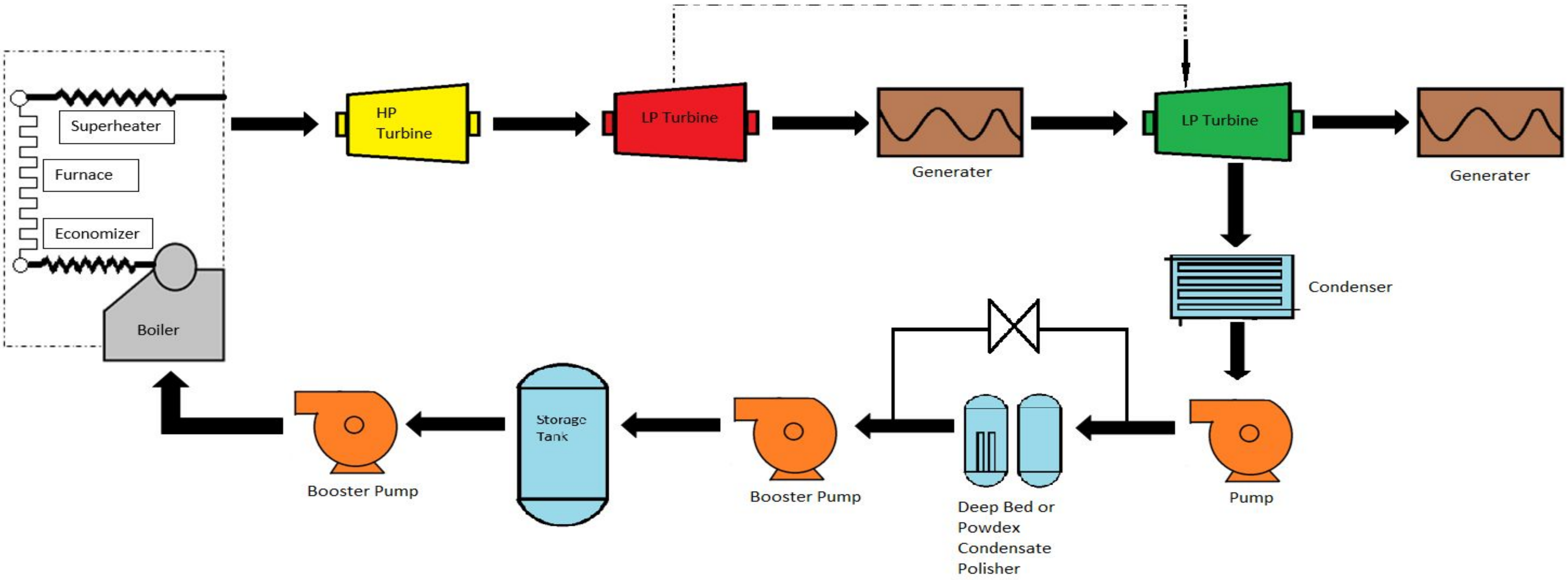
Why condensate polishing?

- To save on operating cost
- To recover energy
- Impurities from vacuum-induced leaks
- Prevent corrosion
- Careless repair work

Two approaches to condensate polishing

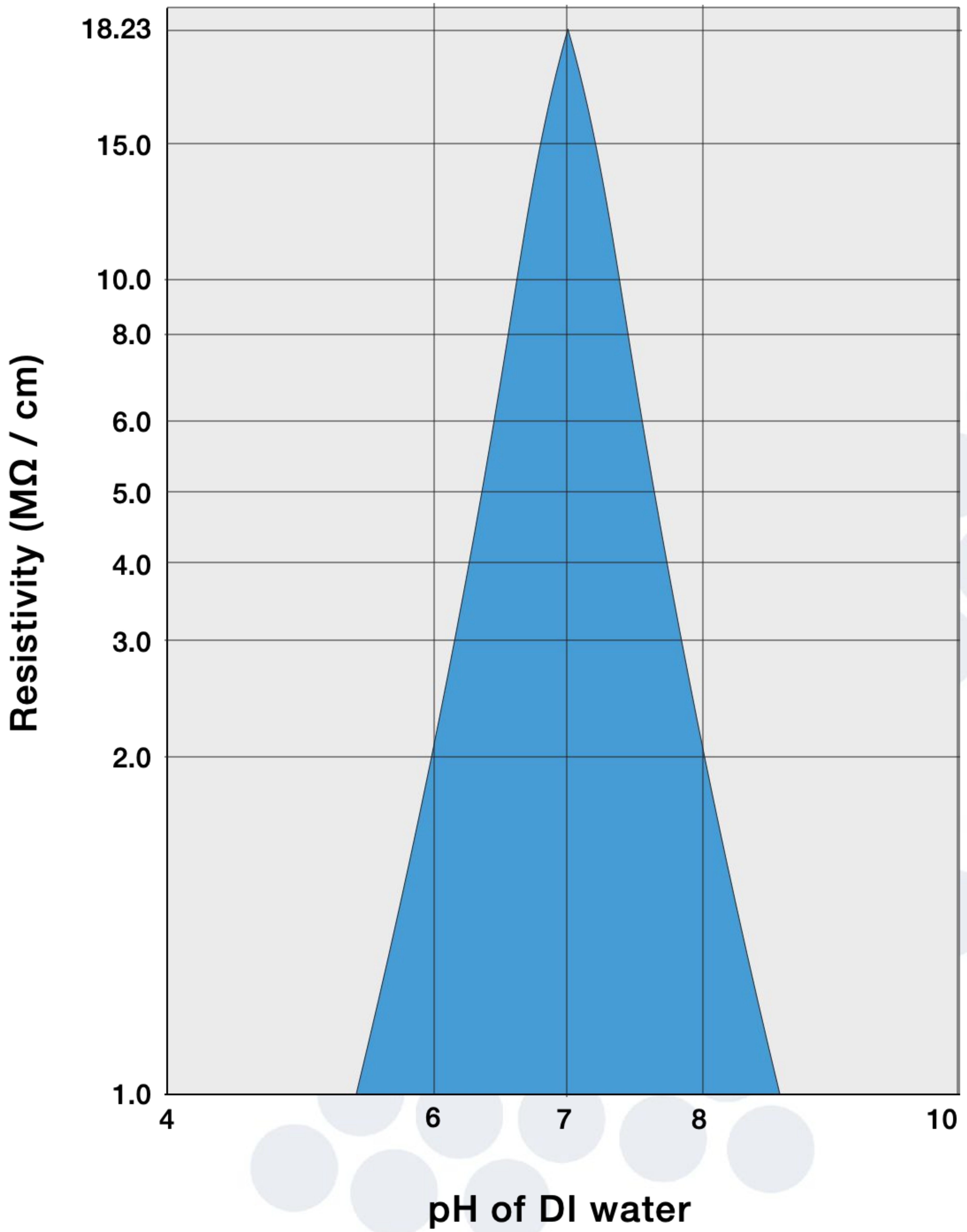
- Deep bed polishing – Bead type Ion exchange resins
- Powdered Ion exchange resins presented as a pre-coat media on a filter element

Condensate polishing Flow diagram



pH of High Purity DI Water

- Higher the resistivity, more neutral pH
- Conventional measurements aren't valid
  - No background buffer
  - CO_2 dissolves from atmosphere
- Usually not in specs
- Specialized inline equipment required
  - KCl buffer



Capacity Calculations

Rules of Thumb

Resin Type	Virgin (Grains / Cuft)	Regenerated (Grains / Cuft)
SAC (H^+)	38,000	30,000
SBA (OH^-)	30,000	15,000
Mixed Bed (H^+/OH^-)	13,000	8,000

ResinTech Products: Strong Acid Cation Resins

- **ResinTech CG8-BI***
  - 8% crosslinked, industrial quality
    - sodium or hydrogen form
    - light or dark color (BI)
- **ResinTech CG10**
  - 10% crosslinked
  - More resistant to oxidation
- **ResinTech SACMP**
  - Macroporous resin, physically toughest

ResinTech Products Mixed Bed Resins

- **ResinTech MBD-15*/MBD-10**
  - High regenerable capacity
  - Easy separation
  - High capacity
  - Good for high temp applications
- **Multiple grades available**
  - NG, SC, LTOC, Ultra & Nano
  - Grades reference initial levels of TOC throw
  - Soon to come non-solvent cation resin

ResinTech Products: Anion Resins

- **ResinTech SBG1 and SBG1P***
    - Strong base anion, Type 1
    - Chloride or hydroxide form
    - Higher selectivity
- **ResinTech WBMP**
    - Weak Base, macroporous
    - Free Base Form
    - High regeneration efficiency
    - Lower water quality

THANK YOU

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