The Basics of Portable Exchange DI (PEDI)

Bill Koebel – Eastern Regional Sales Manager

ResinTech® Inc.
INNOVATIONS IN ION EXCHANGE

Topics for Discussion

- Basic Water Chemistry
- Types of Resin and Properties
- Ion Exchange Principles
- DI Applications

Basic Water Chemistry Parameters

- pH
- Conductivity
- Total Dissolved Solids (TDS)
- Cations
- Anions
- Total Organic Carbon (TOC)
- Microbiological Content
- Total Suspended Solids (TSS)

Definition of pH

- Measure of H+ concentration in water
- Meter ranges from 0 – 14
- 0 to < 7 is Acidic, 7 Neutral, > 7 to 14 Basic
- HCl is an Acid
- NaOH is an Base

Definition of Conductivity and TDS

- Conductivity is a measure of electrical conductance in solution
- Relative to TDS
- Measured as uMhos and uS/cm
- Inverse is resistivity, measured in MegOhms
- TDS is comprised of cations and anions dissolved in solution
- Conductivity * 0.5 to 0.6 =ppm TDS as $CaCO_3$
- pH can effect conductivity

Definition of Terms

- PPM (mg/l)
  - Parts Per Million (milligrams per liter)
  - A measure of the concentration of ions as defined by their weight.
- Grains
  - A very small unit of weight, originally equal to a "grain" of wheat. Grains are used to describe the capacity of ion exchange resins used for water softening.
- "as $CaCO_3$"
  - "As Calcium Carbonate equivalents."
  - A convenient way of describing concentrations based on the number of ionic charges rather than the weight of the ions.

Definition of Ions

- Cations
  - Positively charged ions dissolved in solution
- Anions
  - Negatively charged ions dissolved in solution
- Law of Electroneutrality
  - In any solution the number of cations equals the number of anions

Common Cations

- Iron (Fe^{++})
- Calcium (Ca^{++})
- Magnesium (Mg^{++})
- Sodium (Na^{+})
- Potassium (K^{+})
- Hydrogen (H^{+})

Notes about Calcium

- Calcium easily precipitates from solution under various conditions
- High temperatures – $CaCO_3$
- High pH or high CO_3^{-2} content – $CaCO_3$
- High Sulfate content – $CaSO_4$

Common Anions

- Sulfate (SO_4^{-2})
- Nitrate (NO_3^-)
- Chloride (Cl^-)
- Bicarbonate (HCO_3^-)
- Hydroxide (OH^-)

Weakly Ionized Anions

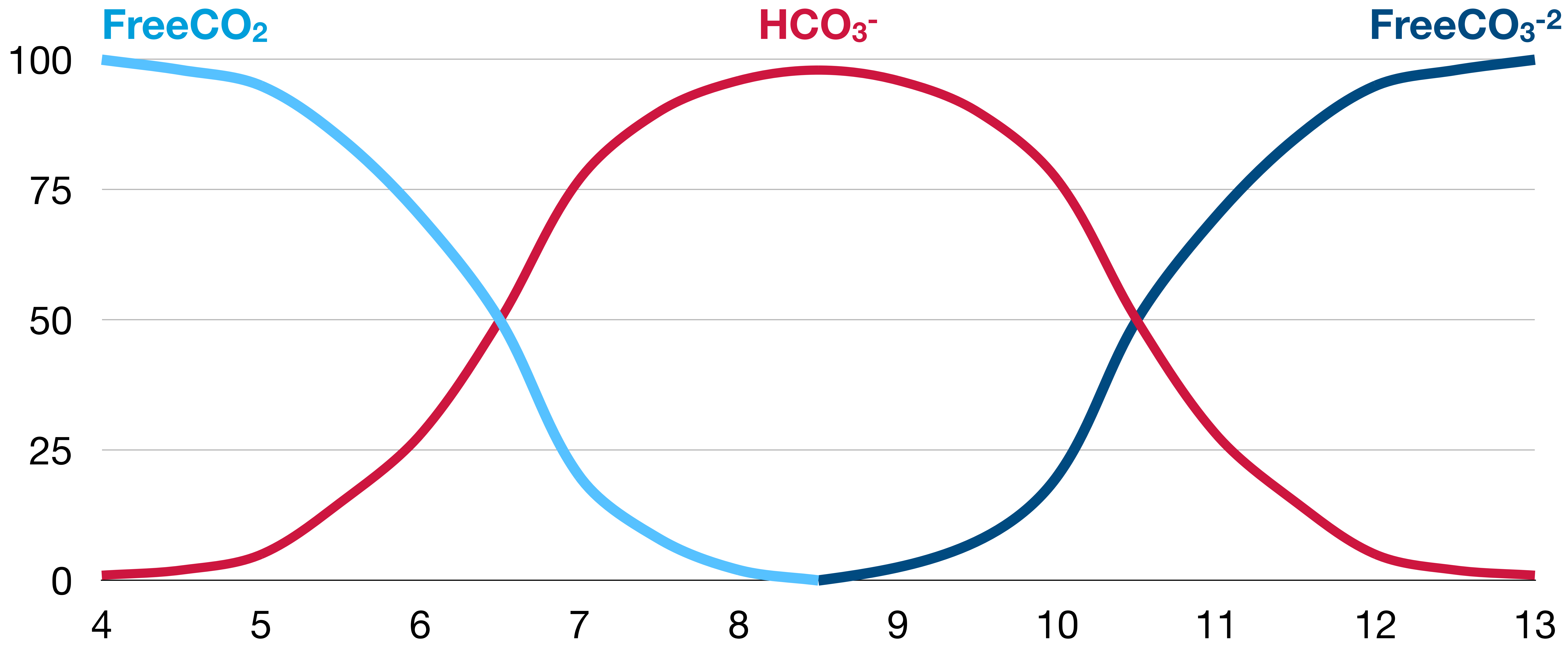
- Carbon Dioxide (CO_2)
- Silica (SiO_2)
- Natural Organic Matter (TOC)

Notes About Alkalinity

- CO2 + HCO3- + CO3-2 + OH-
- Percentage of which of species dependent on pH in water

Alkalinity vs. pH Relationship

- $CO_2 + HCO_3^- + CO_3^{-2} + OH^-$
- Percentage of which of species dependent on pH in water



Total Organic Carbon (TOC)

- In all water there are naturally occurring organics, specifically surface waters
- TOC or Organics behave as weakly ionized anions
- Organics partially removed by anion resin can foul the resin
- Fouled resins produce poor capacity and water quality after regeneration
- Resin can be treated to remove organics - Hot Brine/Caustic treatment utilized

RO vs. City Water

- City water
  - Contains all the parameters described
  - Organics will be present
- RO water
  - Primarily only contains Na+ and Cl-
  - Very clean, low organics
- Do not place City water resin after RO!
- Do not use post RO resin on city water
  - Resin will irreversibly be contaminated

Types of Ion Exchange Resins

- Cation Resins
- Strong and Weak Acid
- Anion Resins
- Strong and Weak Base
- Mixed Bed Resins
- Selective Resins & Zeolites

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 Strong Base Anion Resins

- ResinTech SBG1 and SBG1P*
  - Strong base anion, Type 1
  - Chloride or hydroxide form
  - Higher selectivity
- ResinTech SBG2
  - Strong base anion, Type 2
  - Chloride or hydroxide form
  - High regeneration efficiency
  - Lower water quality

Differences of SBA Resin - T1 vs. T2

Type 1

- Better thermal stability
- Better chemical stability
- Longer life potential
- Regenerable at higher temperatures
- Shorter rinses
- Lower TOC Throw
- Lower Silica Leakage
- Higher Selectivity

Type 2

- Higher operating capacity
- Higher regen efficiency
- Improved organic fouling resistance

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 and Ultra
  - Grades reference initial levels of TOC throw

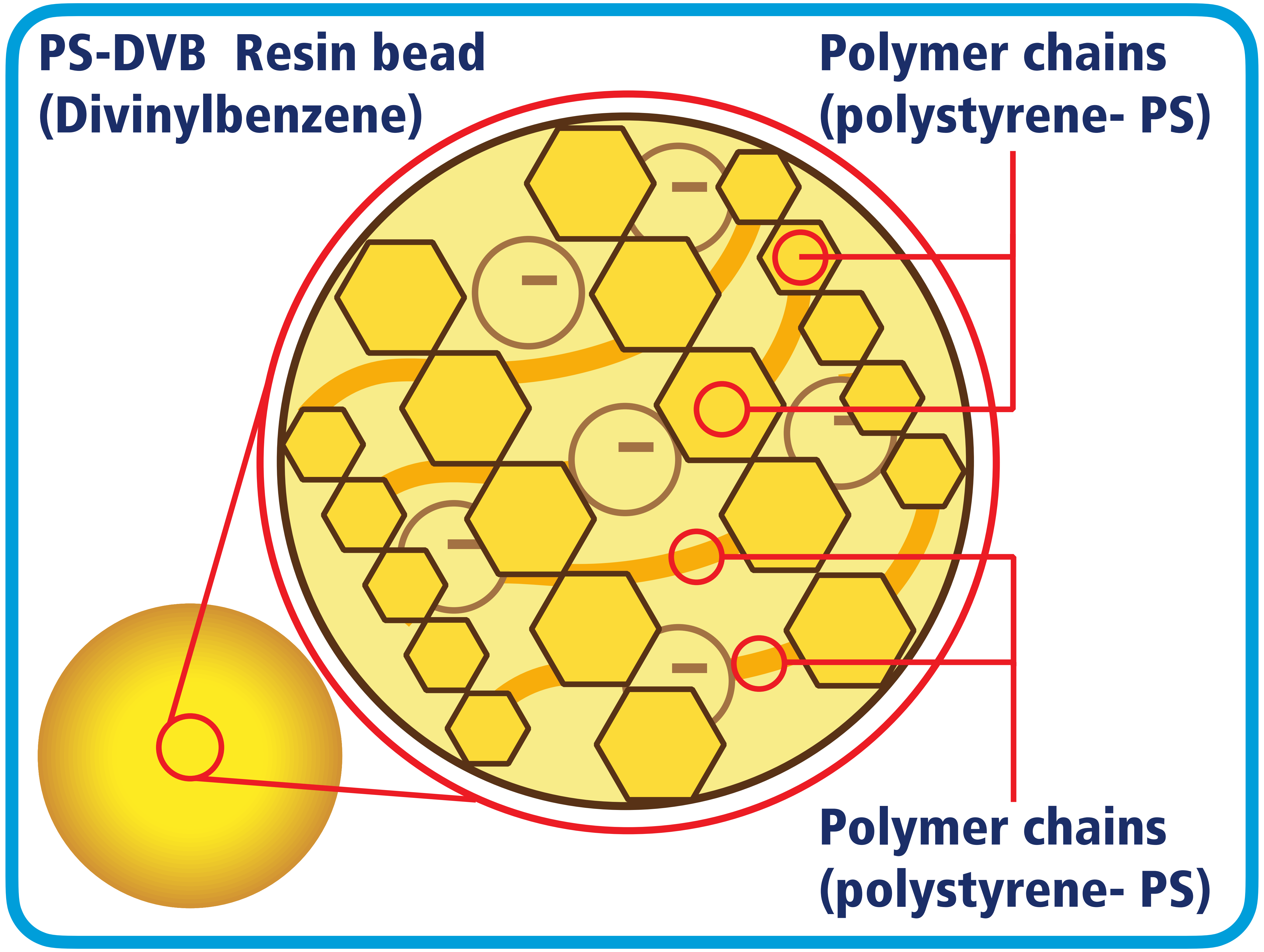
Ion Exchange Theory

- Solid acidic or basic plastic spheres that act as ionic sponges.
- Exchange ions of low selectivity for ions of higher selectivity.
- Exchange of undesirable ions for more desirable ions
- Exchange ions of high concentration for ions of low concentration
- Regeneration- reversing the reaction or reversing selectivity

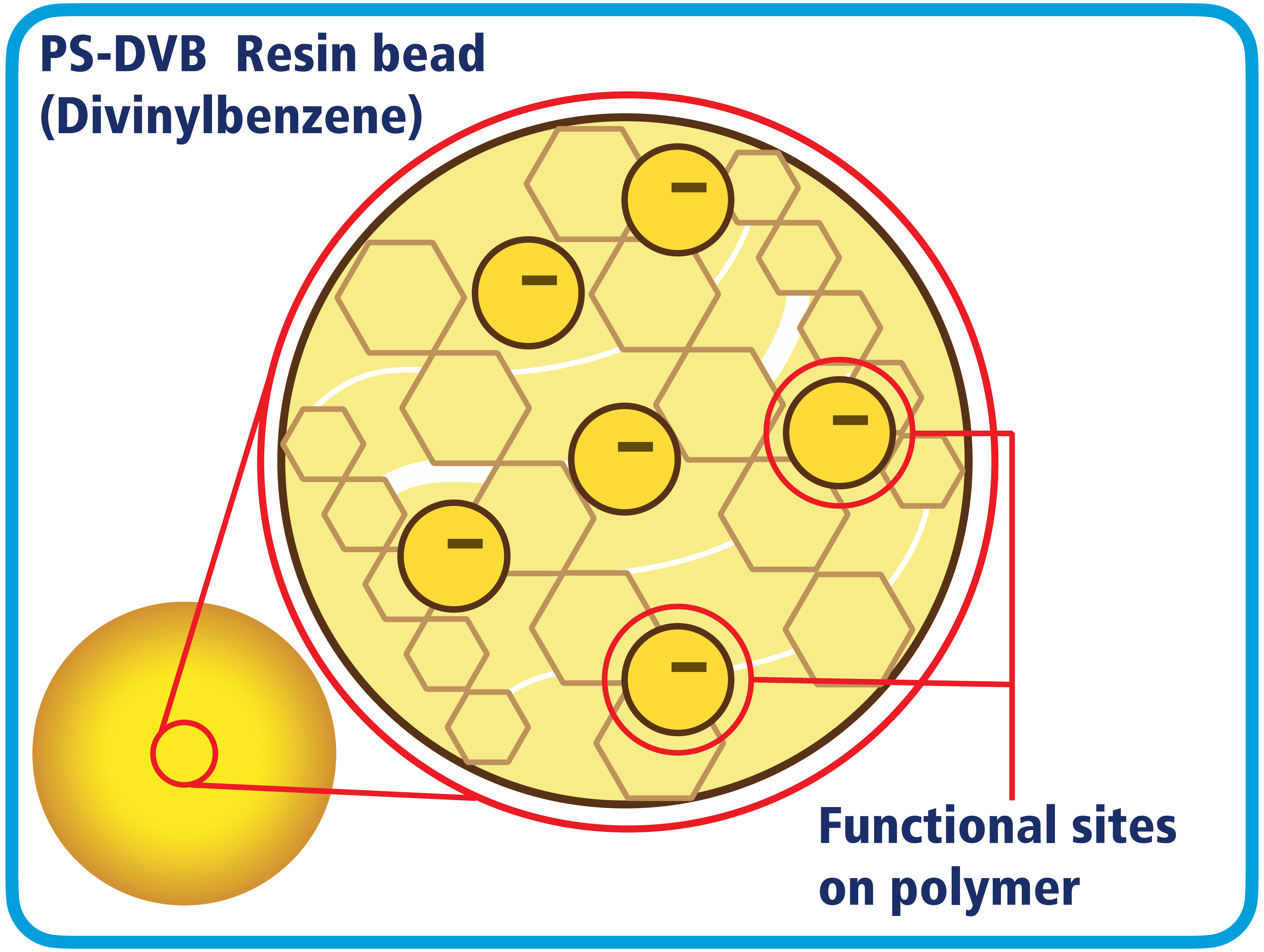
Selectivity

- The attraction, of one ion over another, to an ion exchange resin
- Function of ion charge, size and concentration
- For SACs and SBAs:
    - Bigger the ion, higher the charge, the more selective the ion becomes i.e. $-3 > -2 > -1$ and $+3 > +2 > +1$

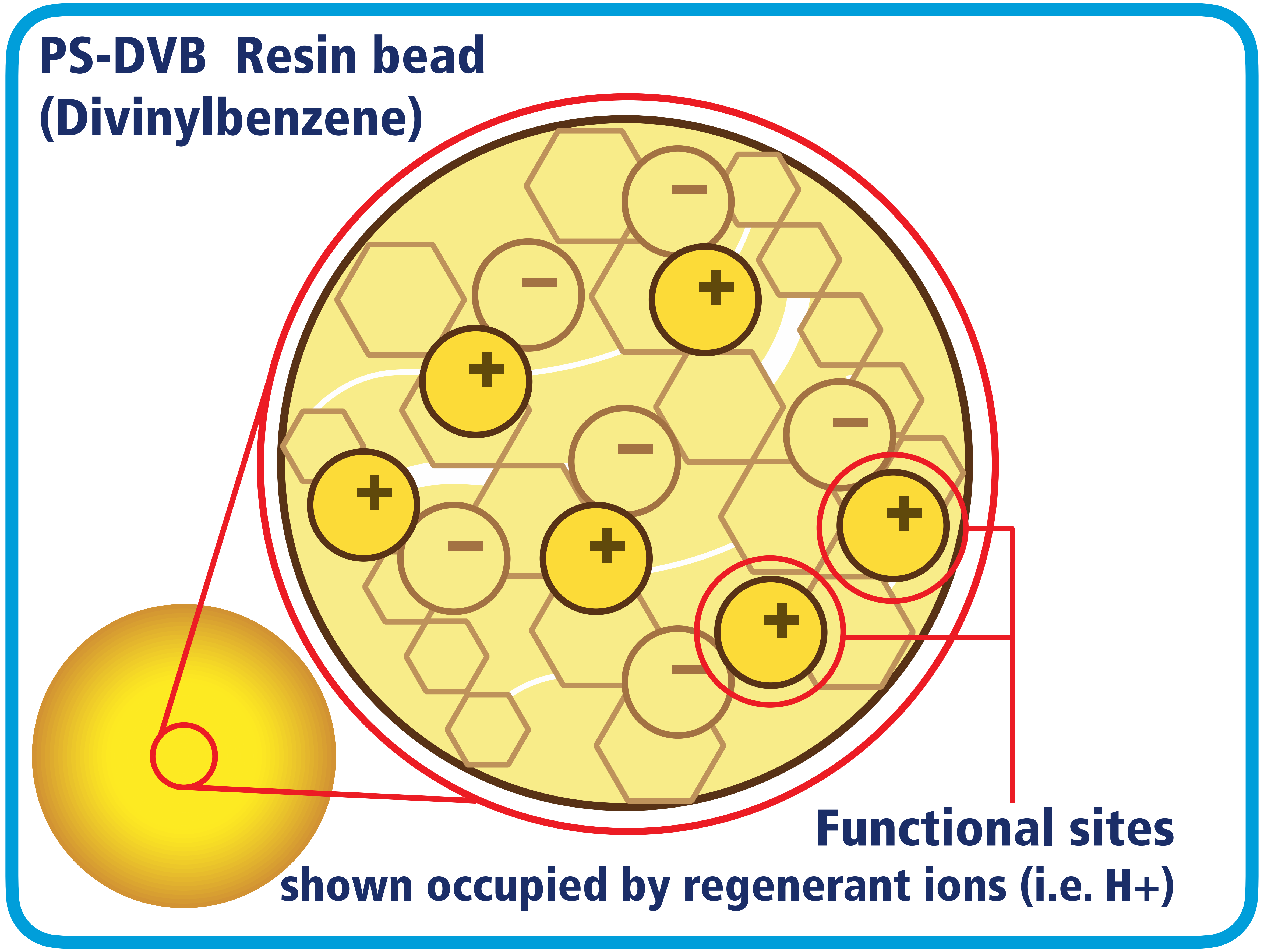
Inside the Resin Bead



Inside the Resin Bead

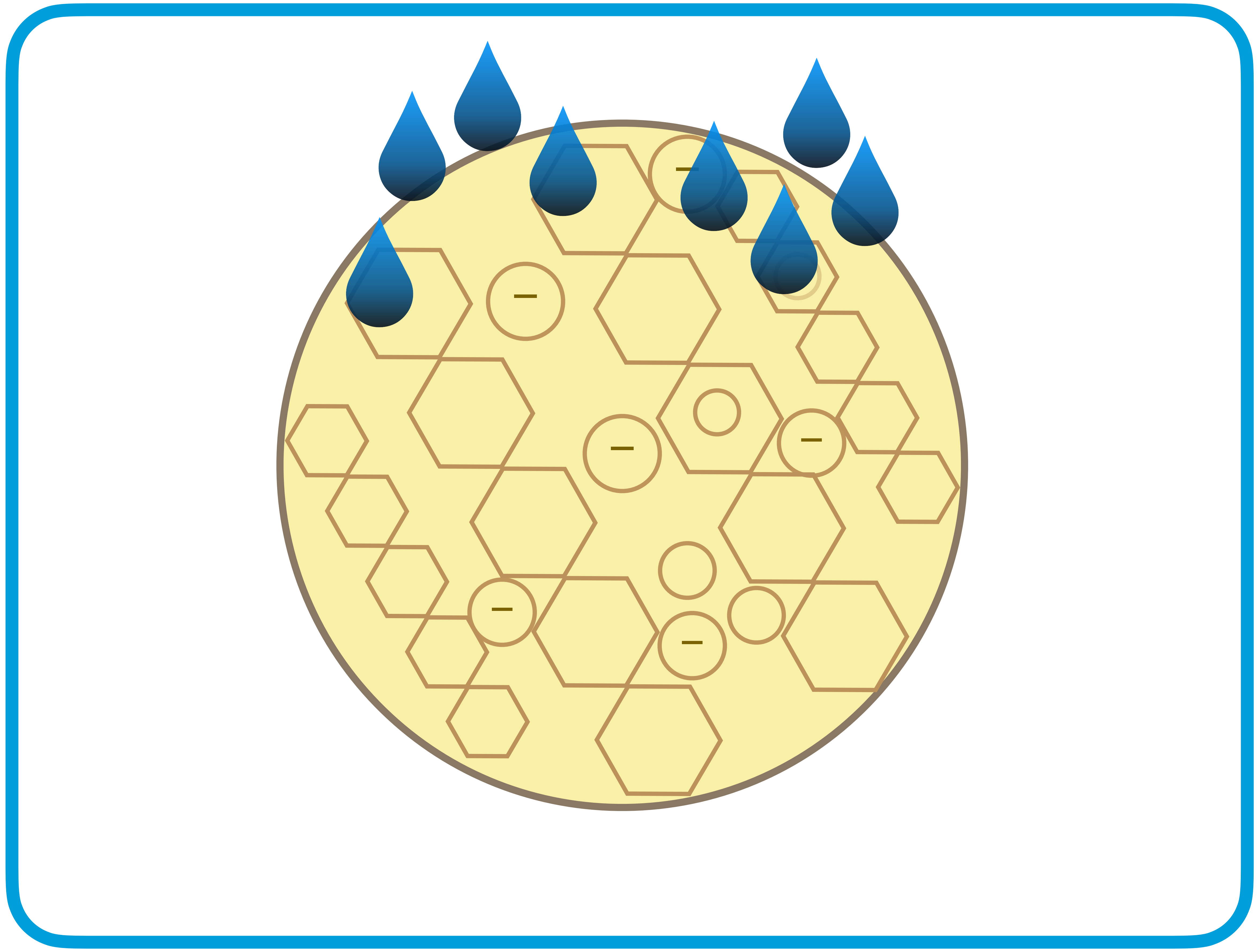


Inside the Resin Bead



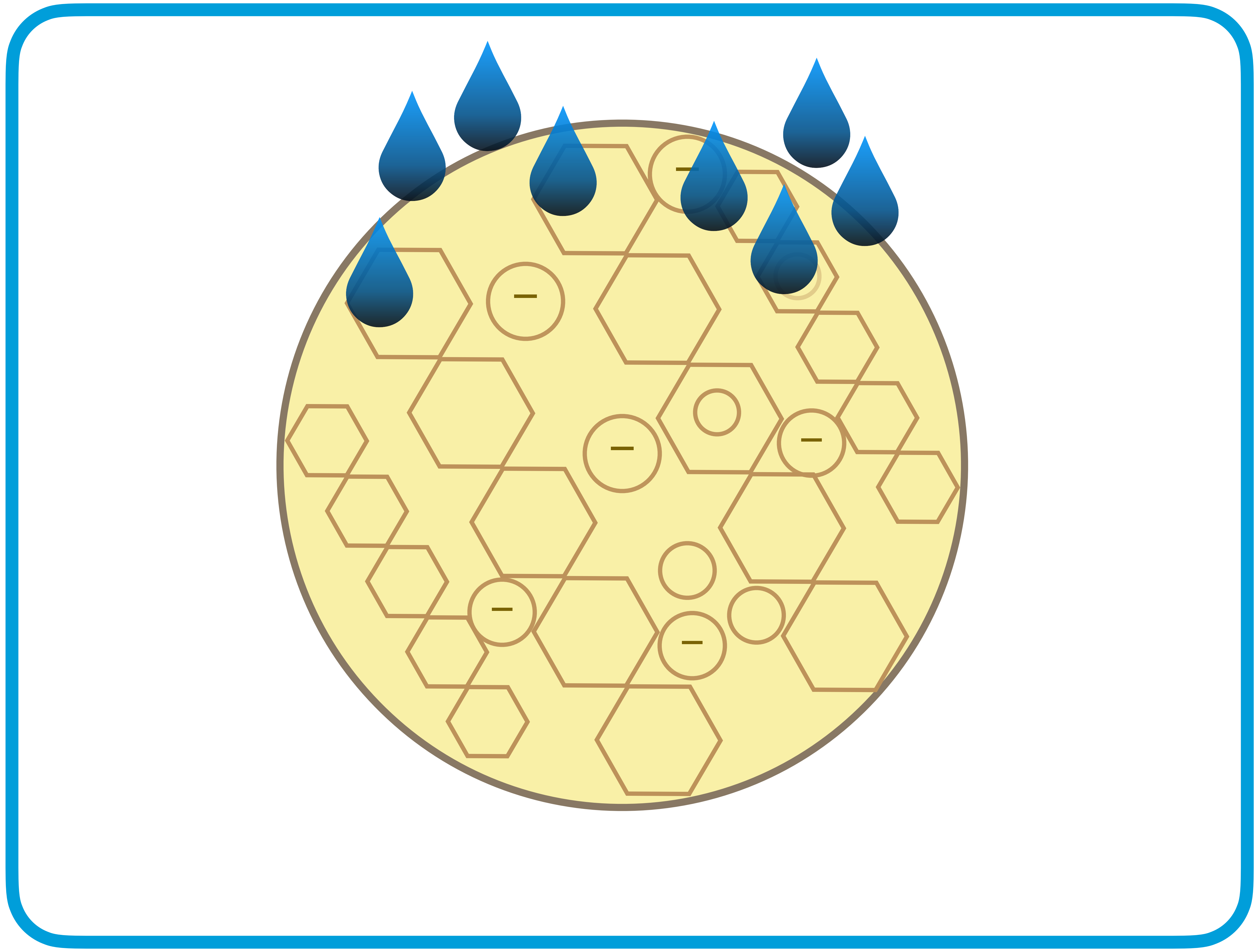
The Resin Bead in Action

Water contacts resin beads. Beads are 50% water.



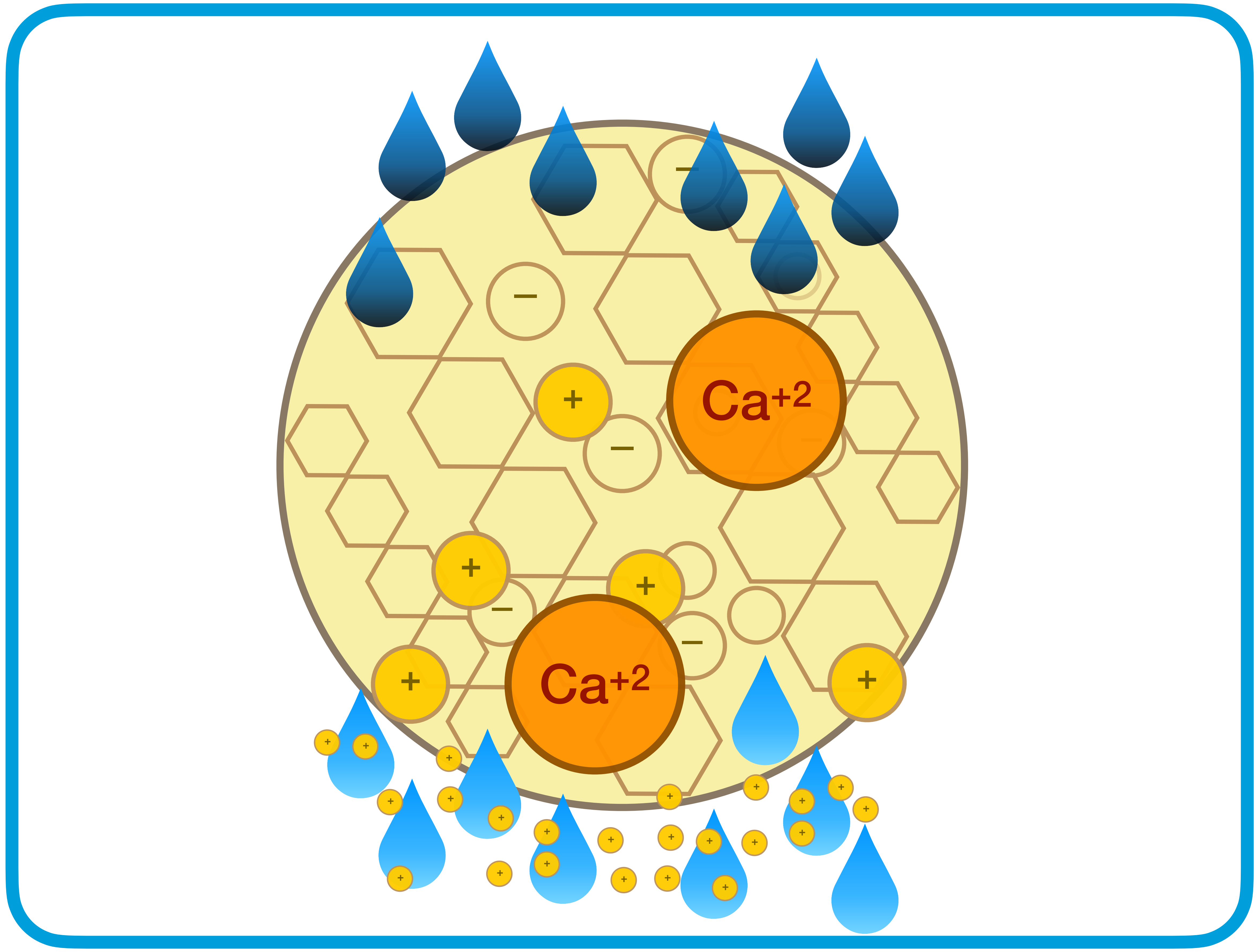
The Resin Bead in Action

Water containing unwanted ion, in contact with water inside beads, allows ions to diffuse in/out of beads.



The Resin Bead in Action

Hydrogen ions are exchanged and exit producing improved water.



Common Cations

- Iron (Fe^{++})
- Calcium (Ca^{++})
- Magnesium (Mg^{++})
- Sodium (Na^{+})
- Potassium (K^{+})
- Hydrogen (H^{+})

Common Anions

- Sulfate (SO_4^{-2})
- Nitrate (NO_3^-)
- Chloride (Cl^-)
- Bicarbonate (HCO_3^-)
- Hydroxide (OH^-)

Ion Exchange Applications

- Softening
- Demineralization
- Dealkalization
- Nitrate removal
- Condensate polishing
- Pollution control
- Metals Removal

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
- $H^+ + OH^- = H_2O$

Types of Systems

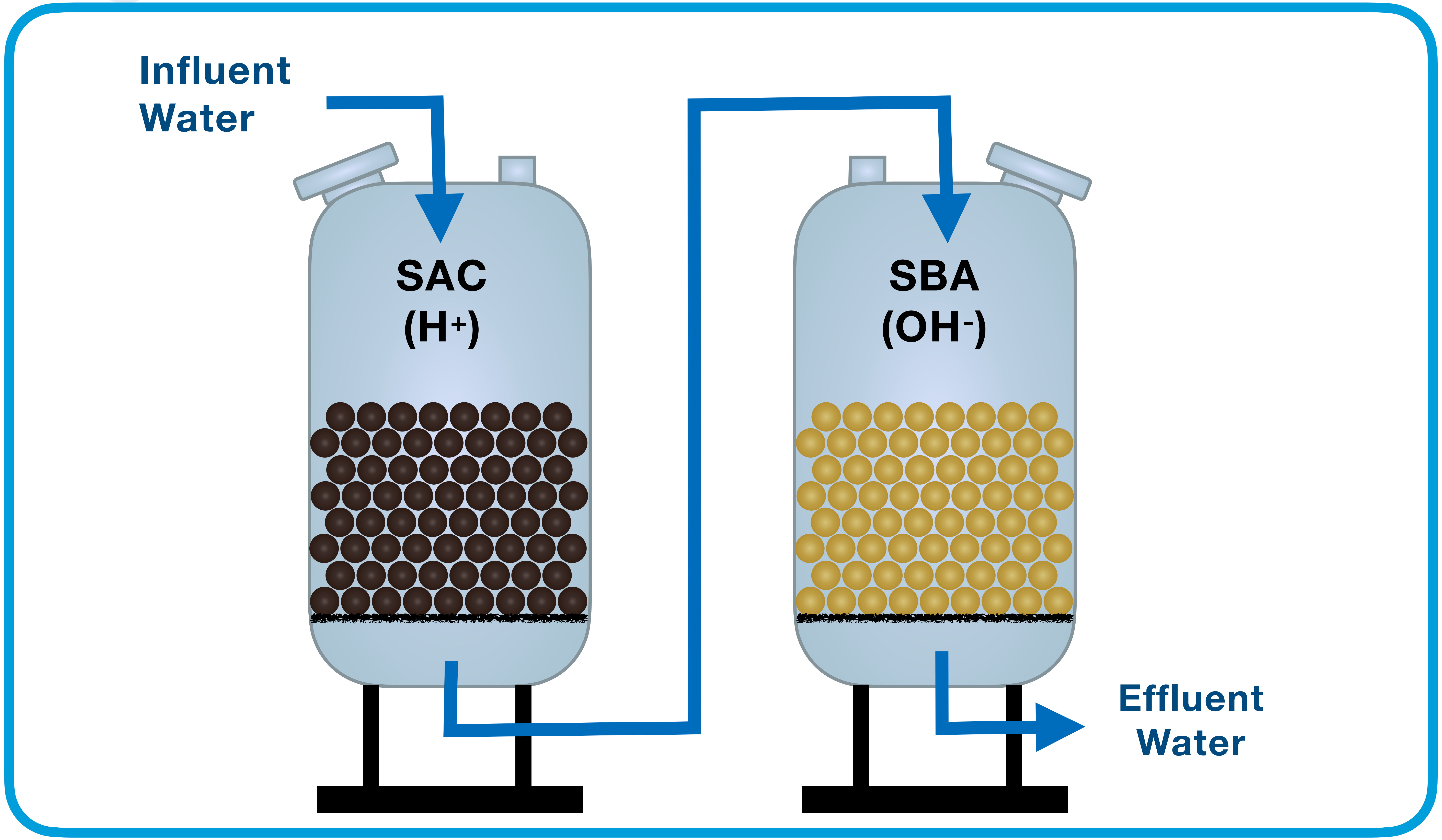
- Two Bed Demineralizers
- Mixed Bed Demineralizers
- Basic Capacity Calculation

Two Bed Demineralizers

- Typically, Strong Acid Cation (SAC) Resin and Strong Base Anion (SBA) resins in series
- Cation regenerated with acid (H+)
- Anion regenerated with caustic (OH-)

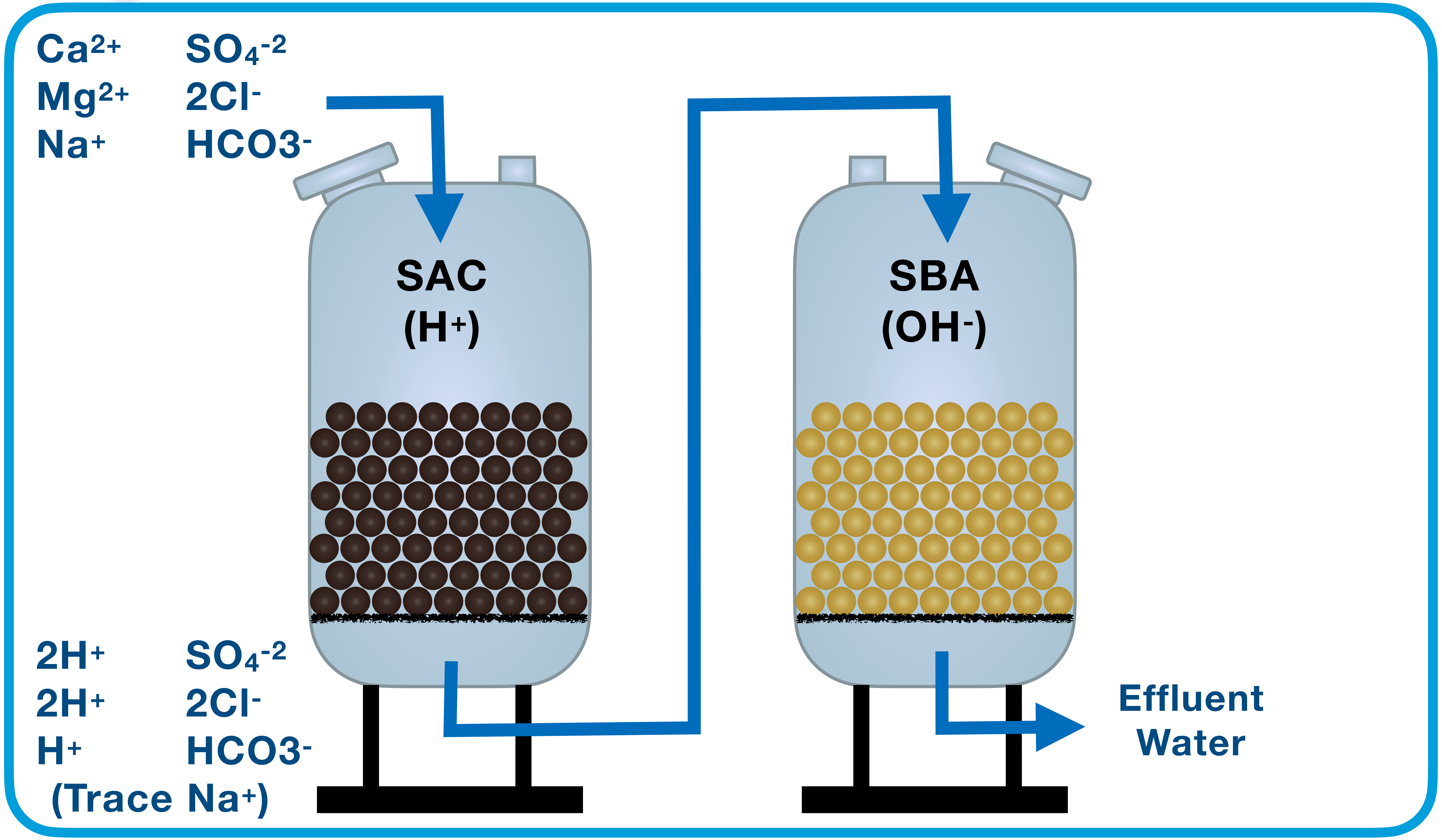
Two Bed Demineralizer

Strong Base

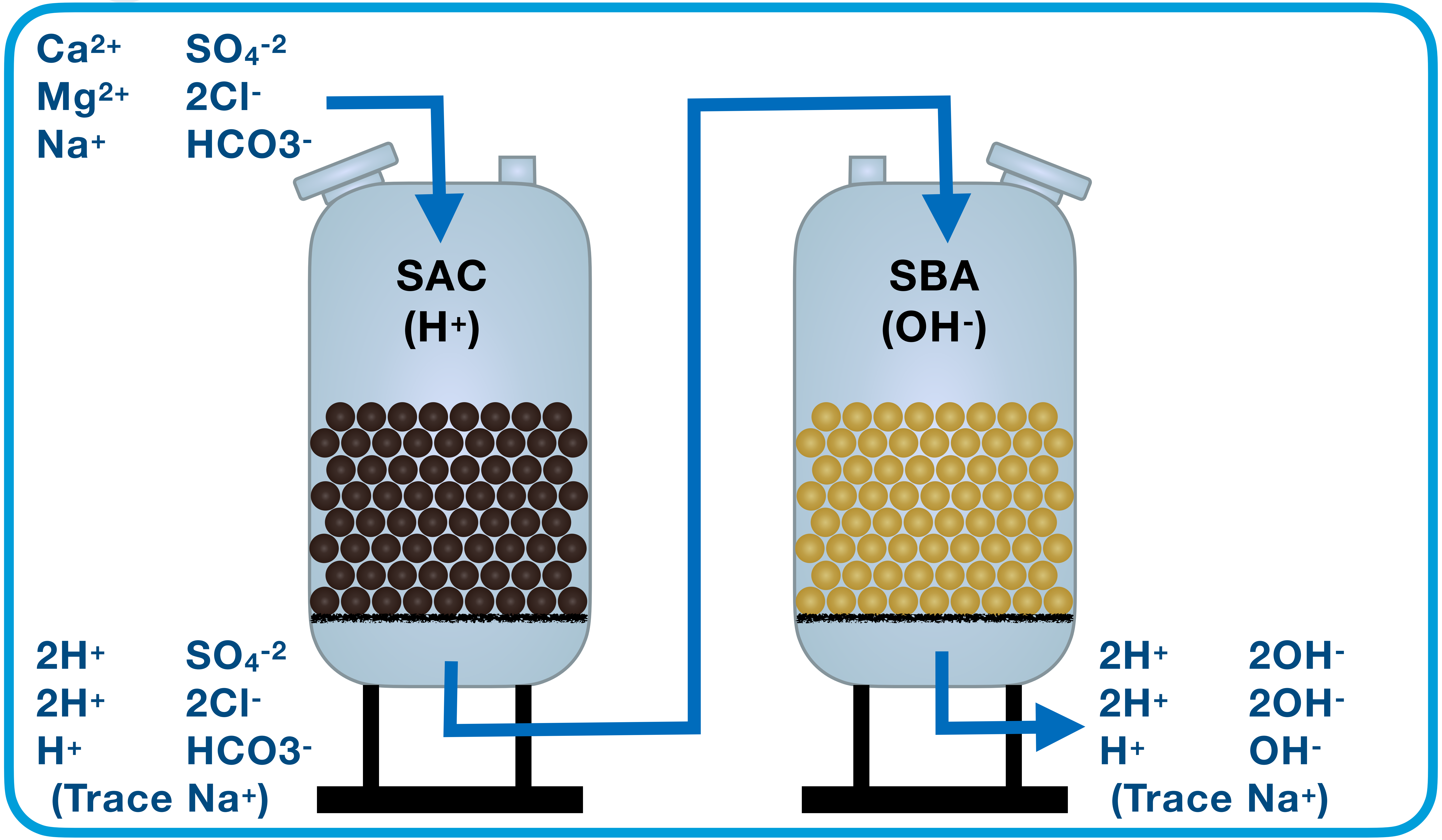


Two Bed Demineralizer

Strong Base



Two Bed Demineralizer



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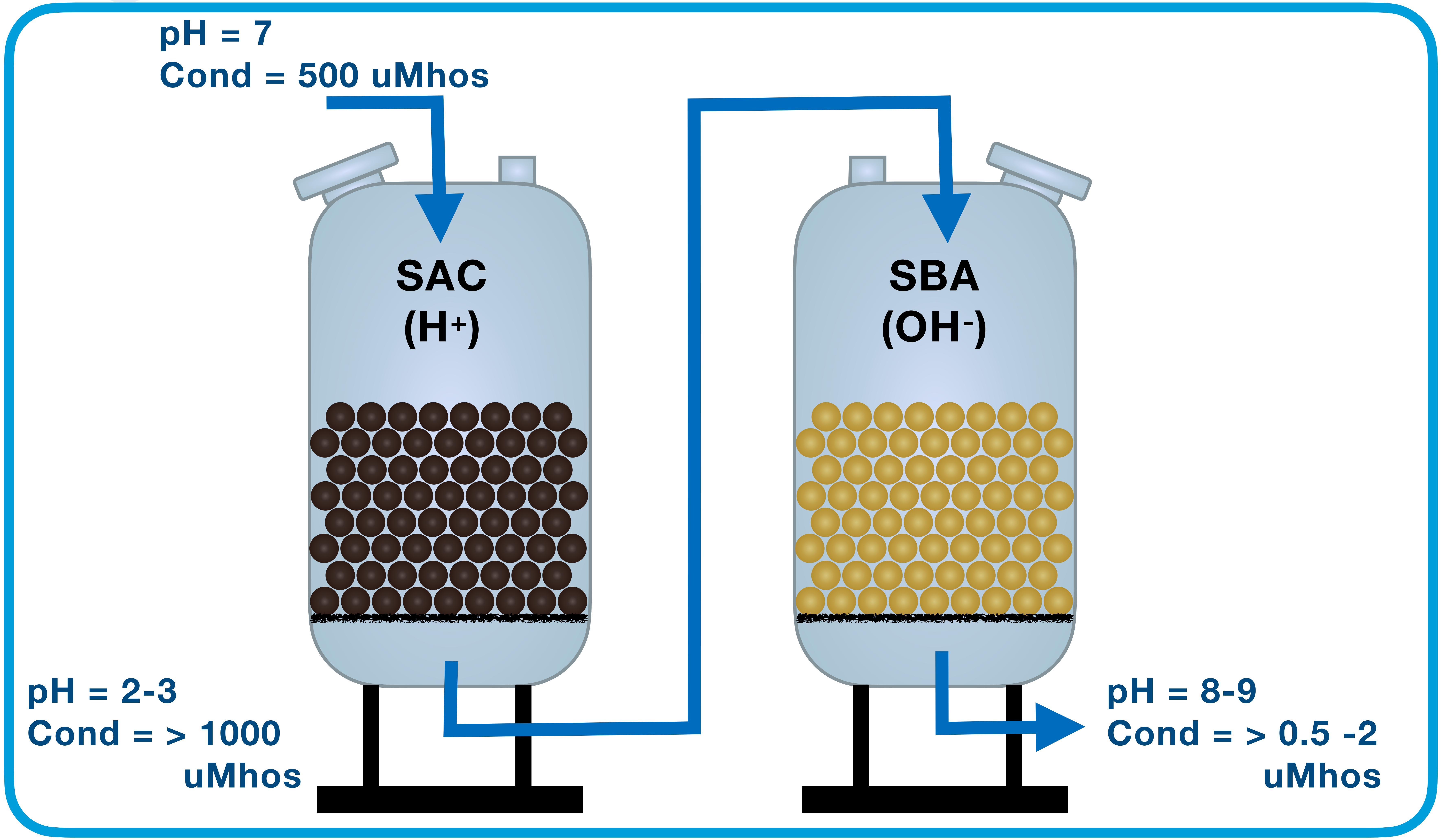
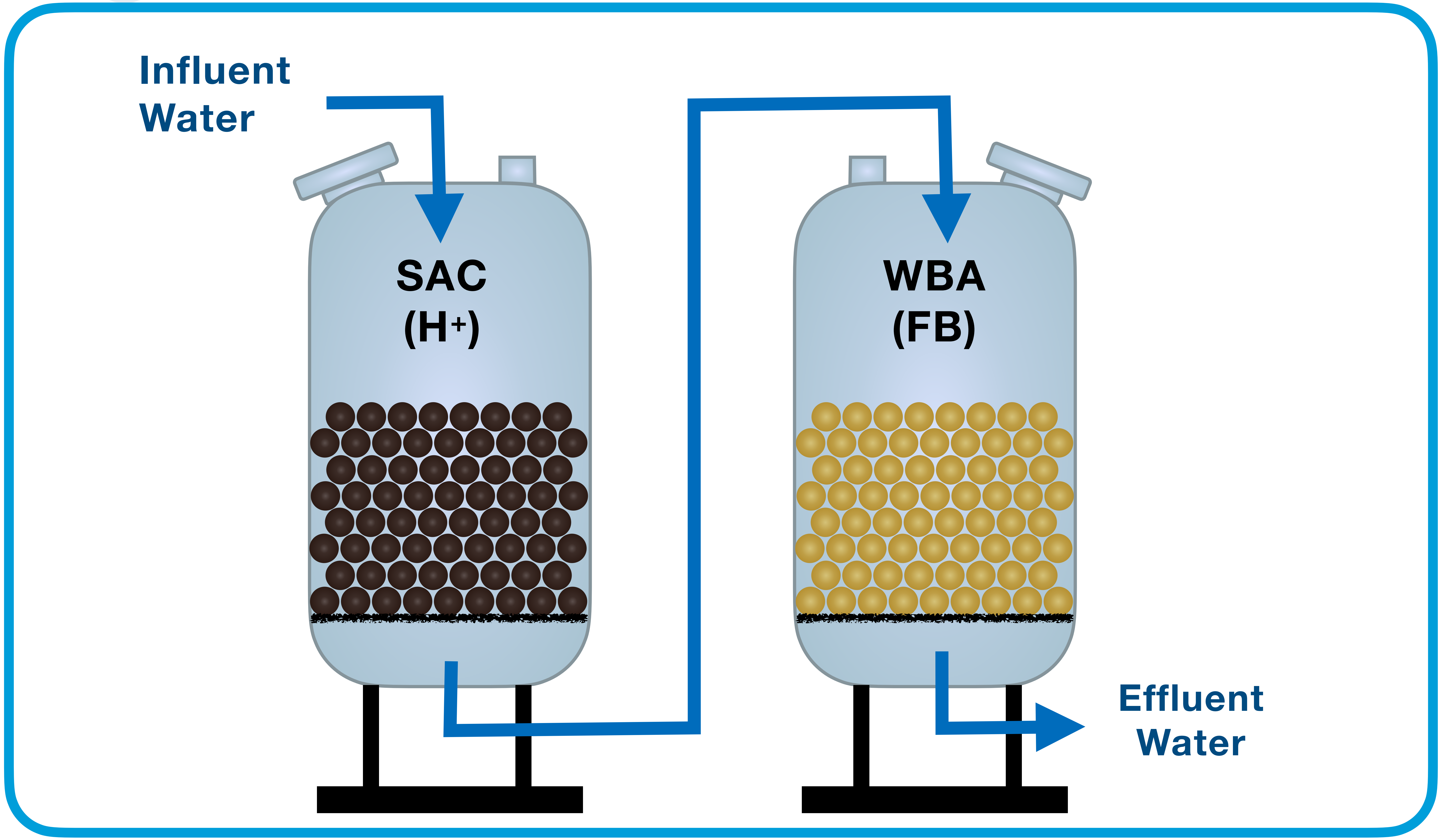


Two Bed Demineralizer

Weak Base



Two Bed Demineralizer

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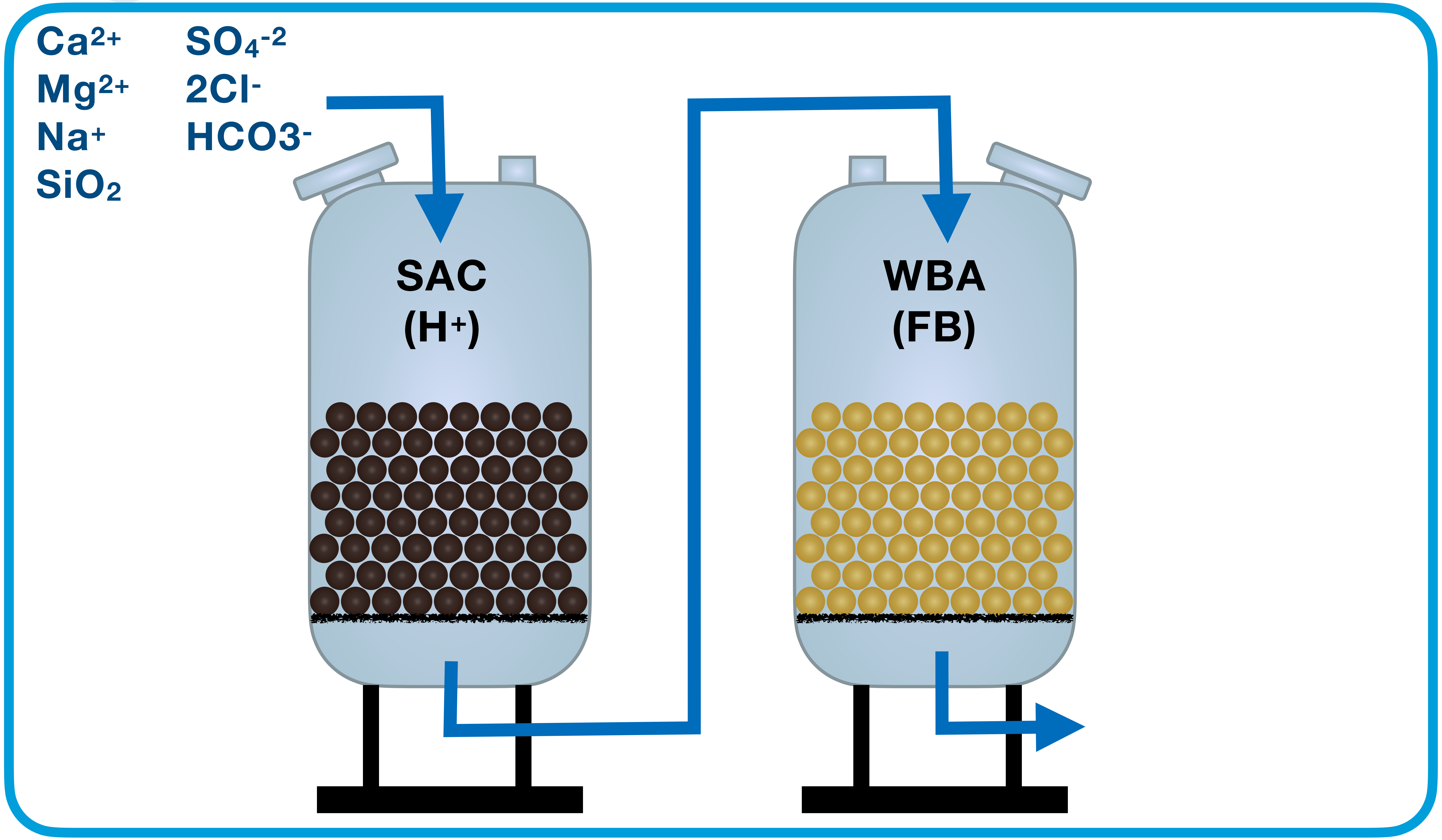
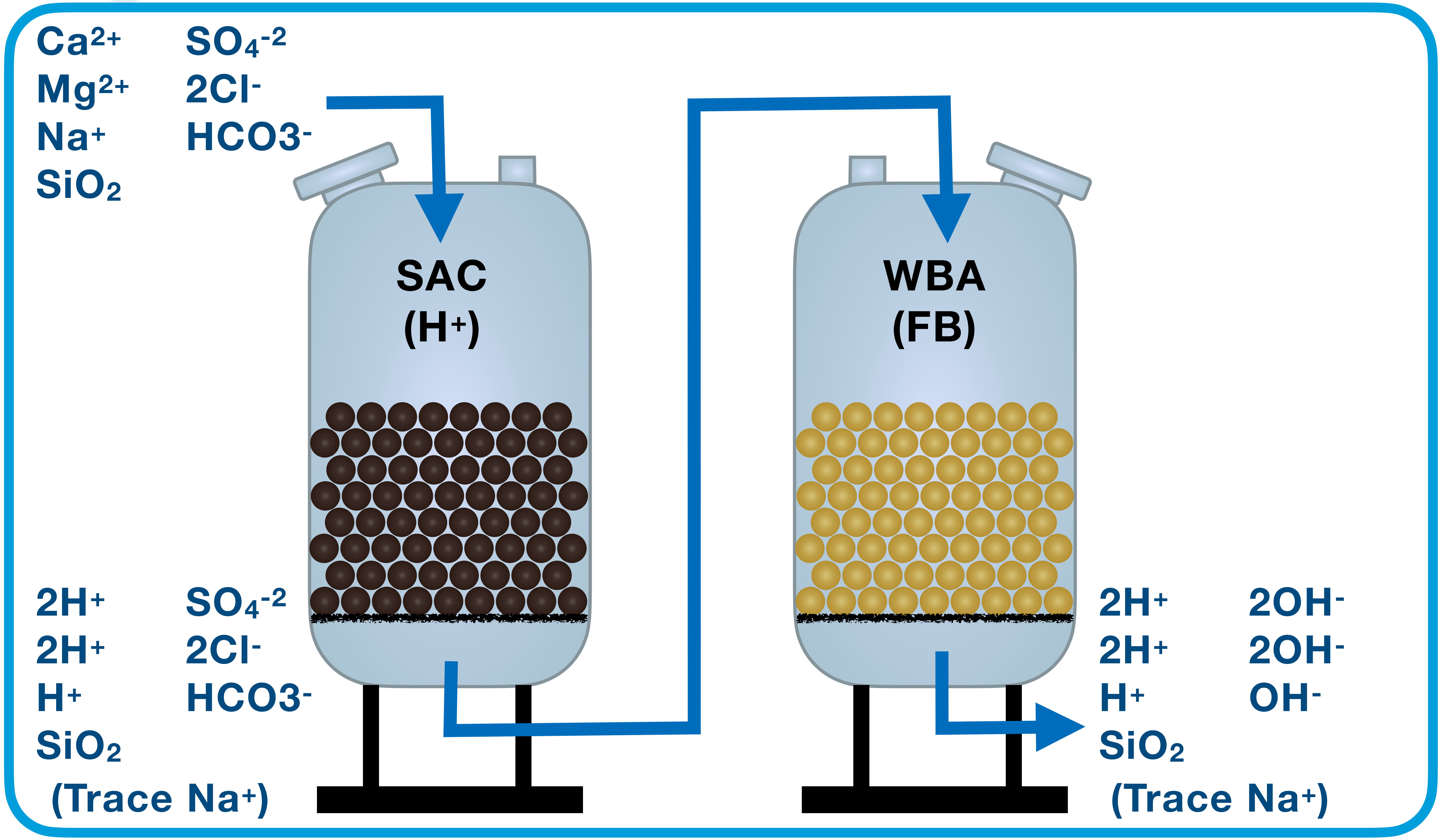


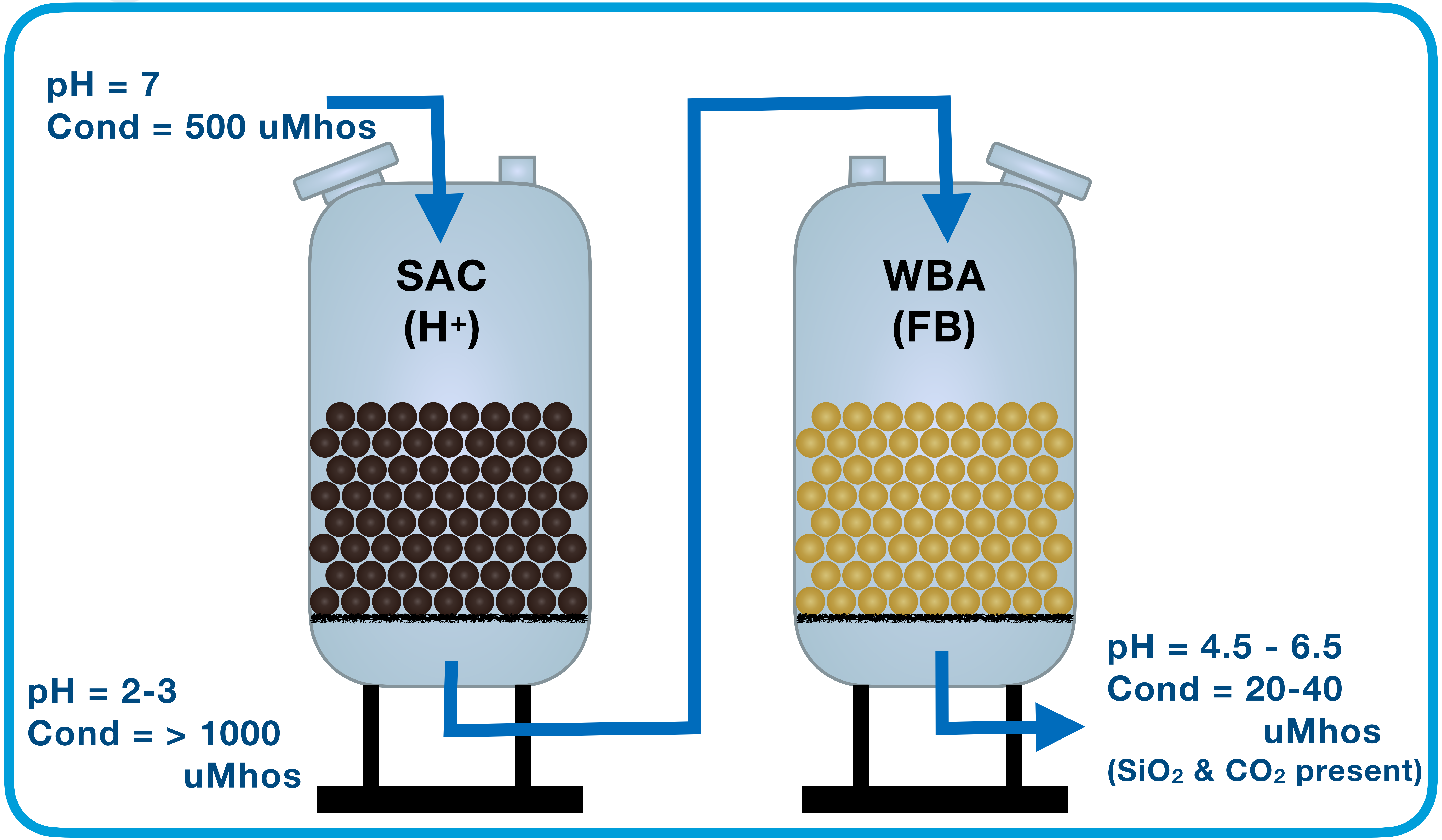
Two Bed Demineralizer

Weak Base



Two Bed Demineralizer

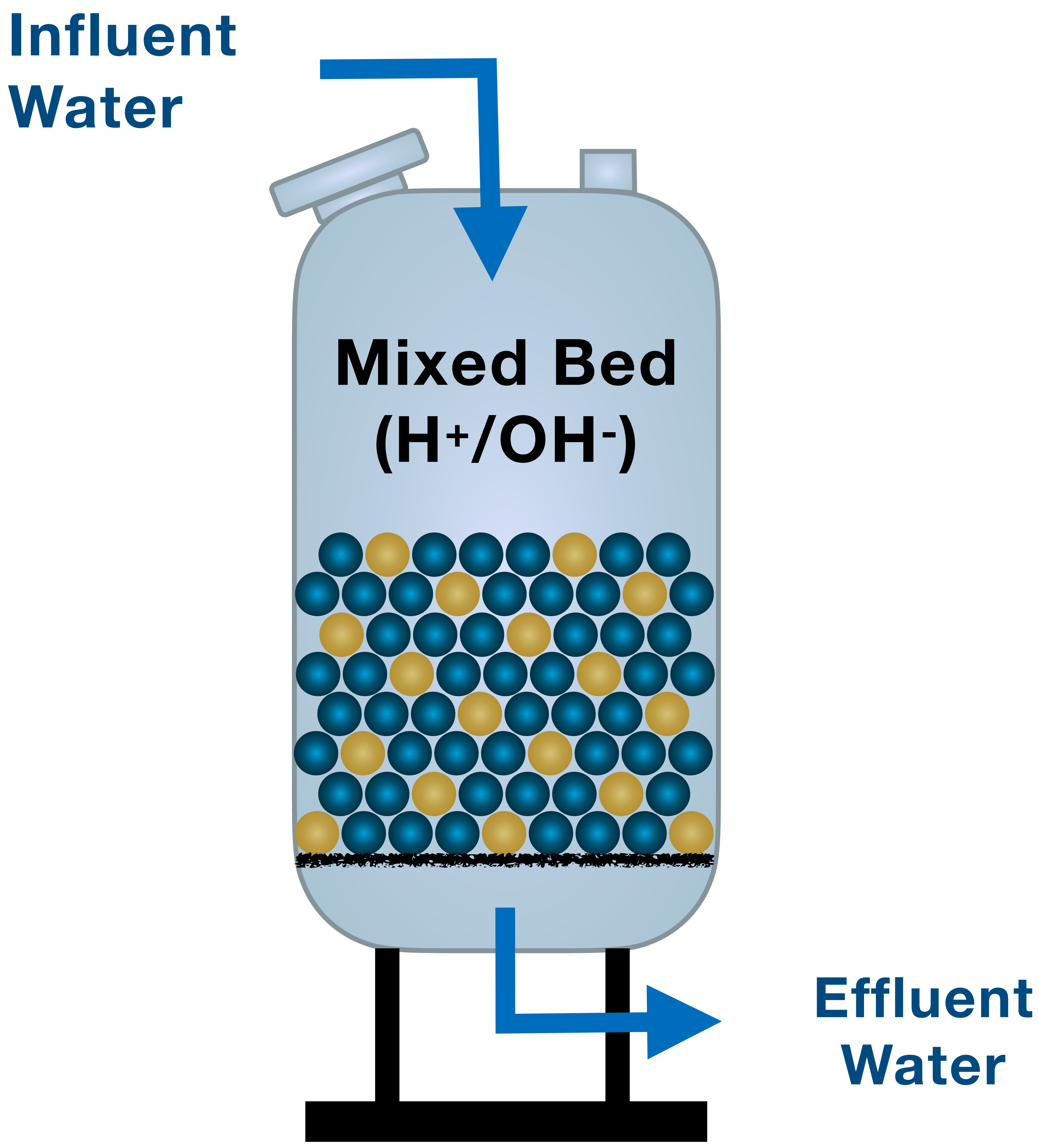
Weak Base



Mixed Bed Demineralizers

- Exchanges all Cations and Anions for equal parts of H^+ and OH^-
- Cation and Anion resins mixed in the same vessel
- Mixture typically 40% SAC and 60% SBA
  - Yields a 1:1 Ratio of H^+ to OH^- ions
- “Infinite Two Beds”

Mixed Bed Demineralizer



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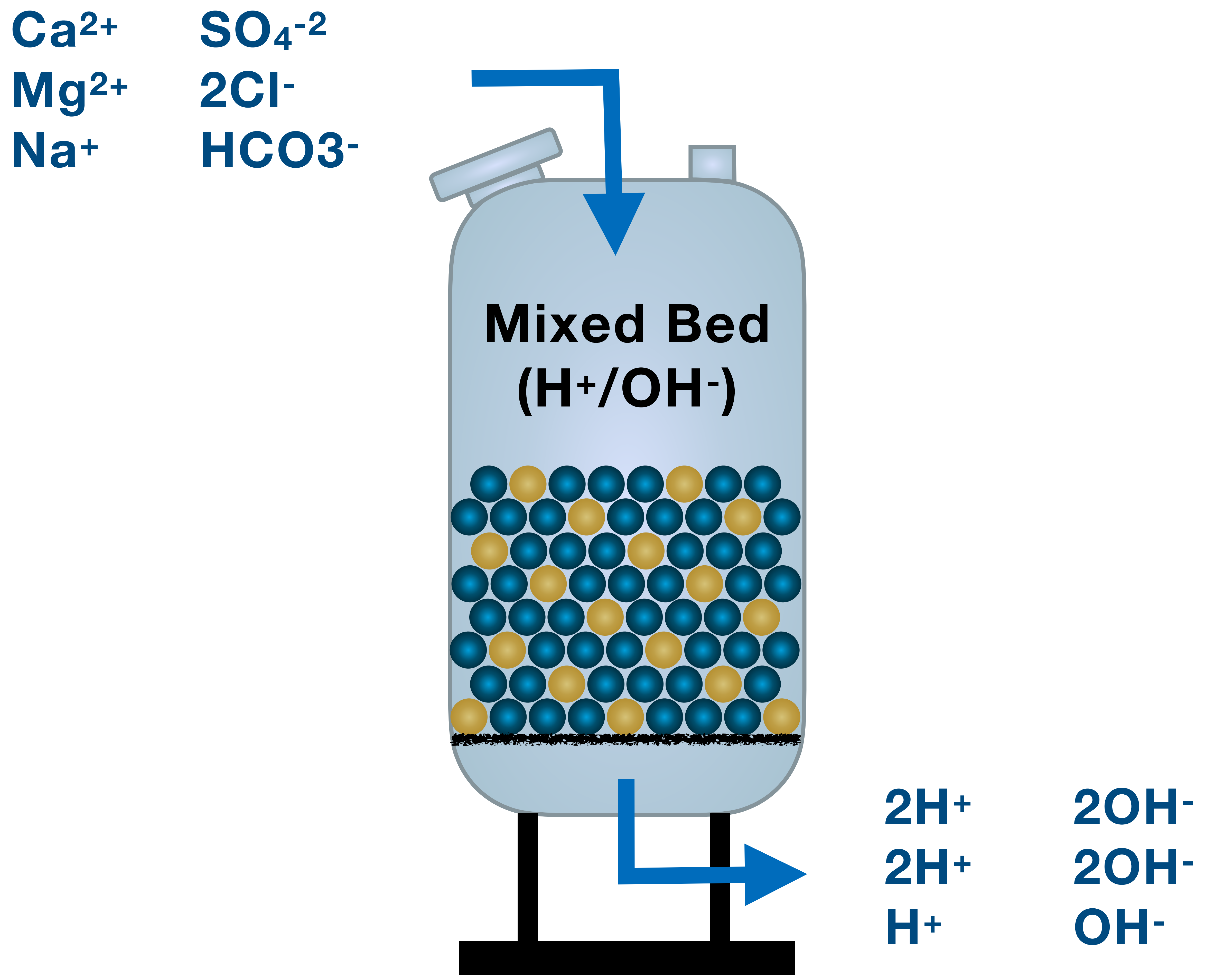
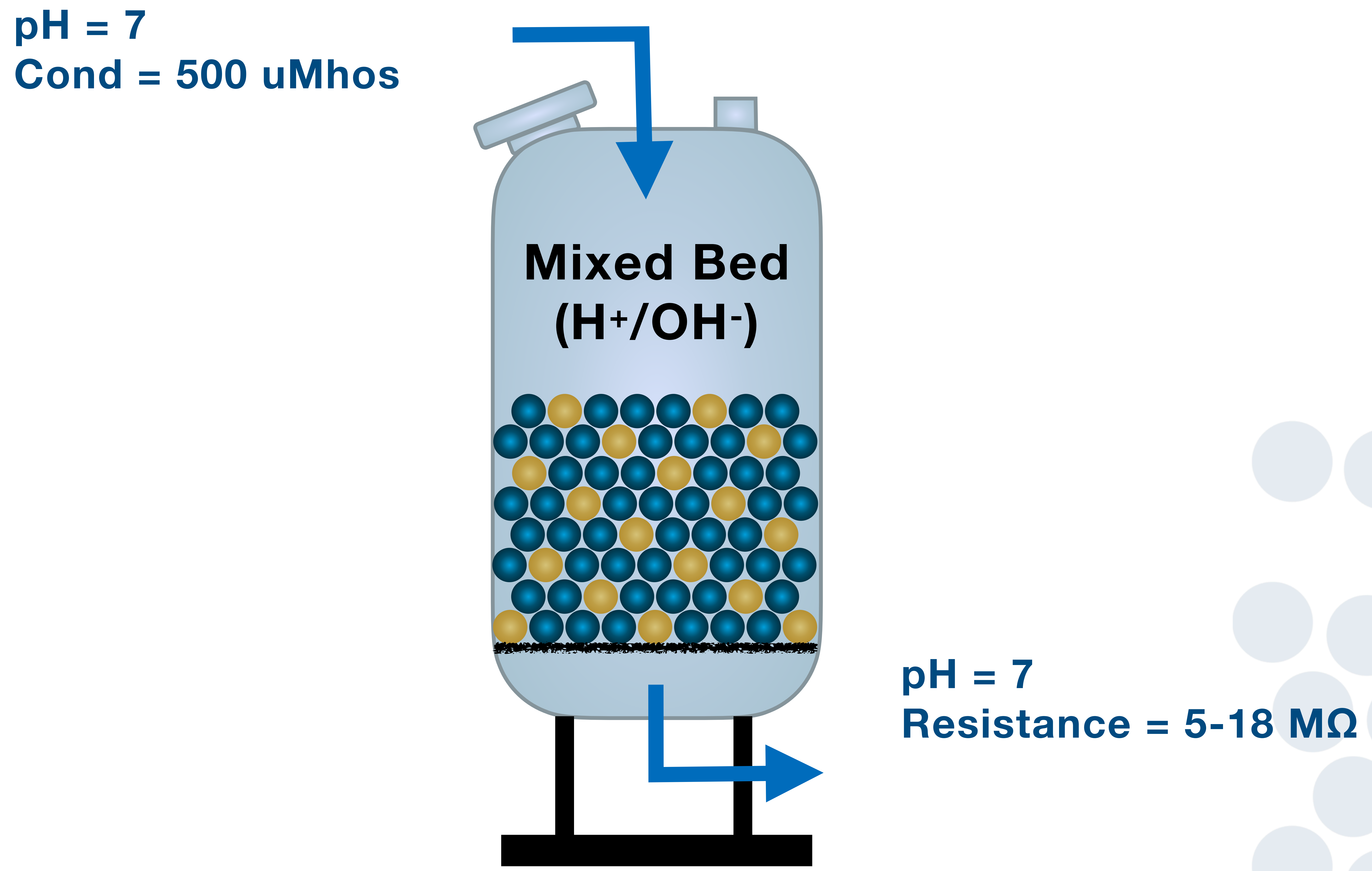


Mixed Bed Demineralizer



Quick Reference Chart

Resistivity (Ohms)	Conductivity (uMhos)
10K	100
50K	20
500K	2
1 Meg	1
2 Meg	0.5
5 Meg	0.2
10 Meg	0.1
15 Meg	0.0667
18 Meg	0.0556

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

Capacity Calculations

- Capacity dependent upon efficiency of regeneration
- The Law of Diminishing returns
  - 8 Lbs per Cuft of Acid (HCl) and Caustic (NaOH)
- Virgin resin capacity much higher than plant regenerated resin

Questions?

THANK YOU

Bill Koebel

Eastern Regional Sales Mgr

p. 412-716-7921

e. wkoebel@resintech.com

RESINTECH® INC.

INNOVATIONS IN ION EXCHANGE

Advanced Portable Exchange DI (PEDI)

Bill Koebel – Eastern Regional Sales Manager

ResinTech Inc.

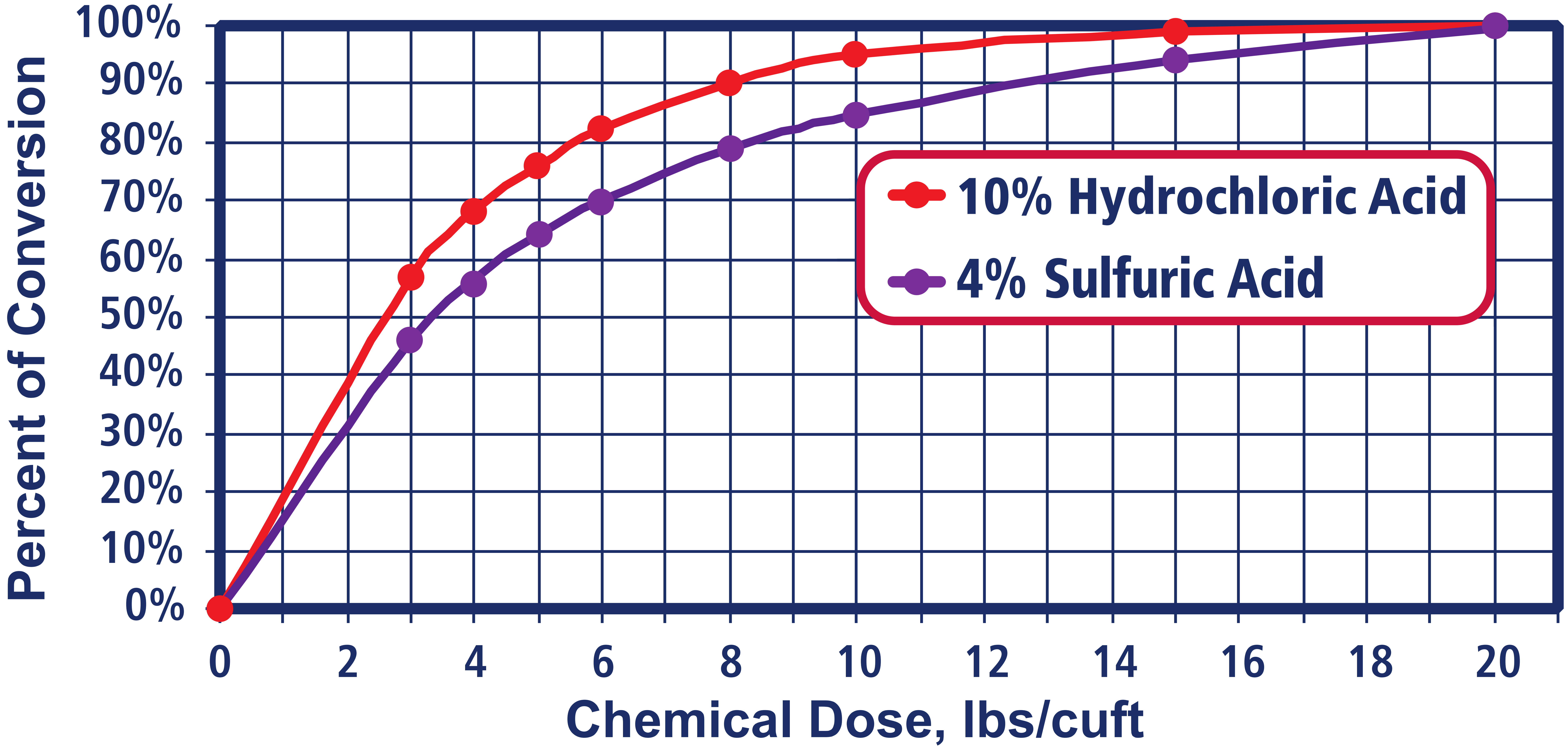
INNOVATIONS IN ION EXCHANGE

Topics for Discussion

- Resin Regeneration Efficiency
- Troubleshooting
- Mixed Bed Regeneration
- Good Housekeeping

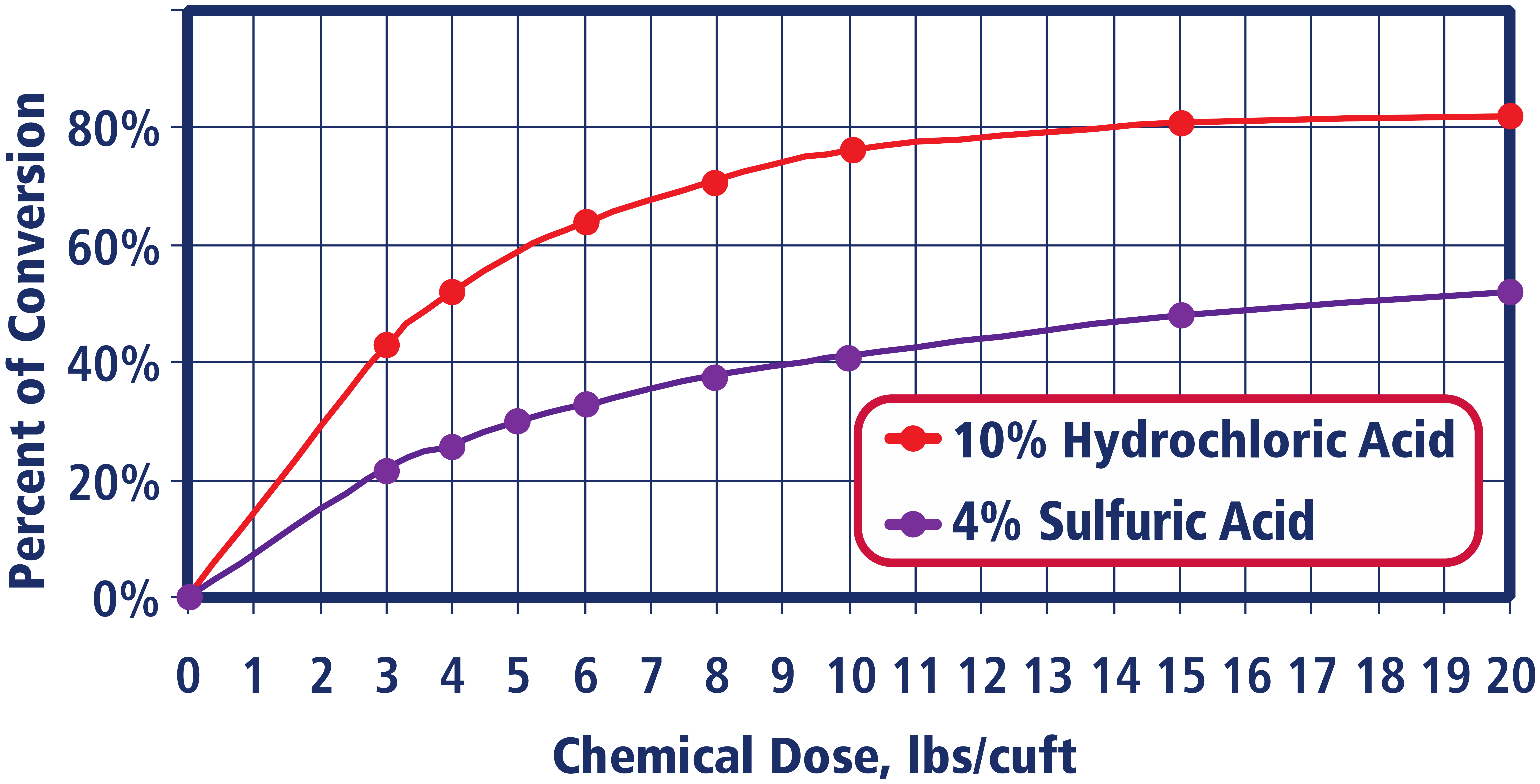
Regeneration of CG8 (BI)

from Sodium form to Hydrogen Form



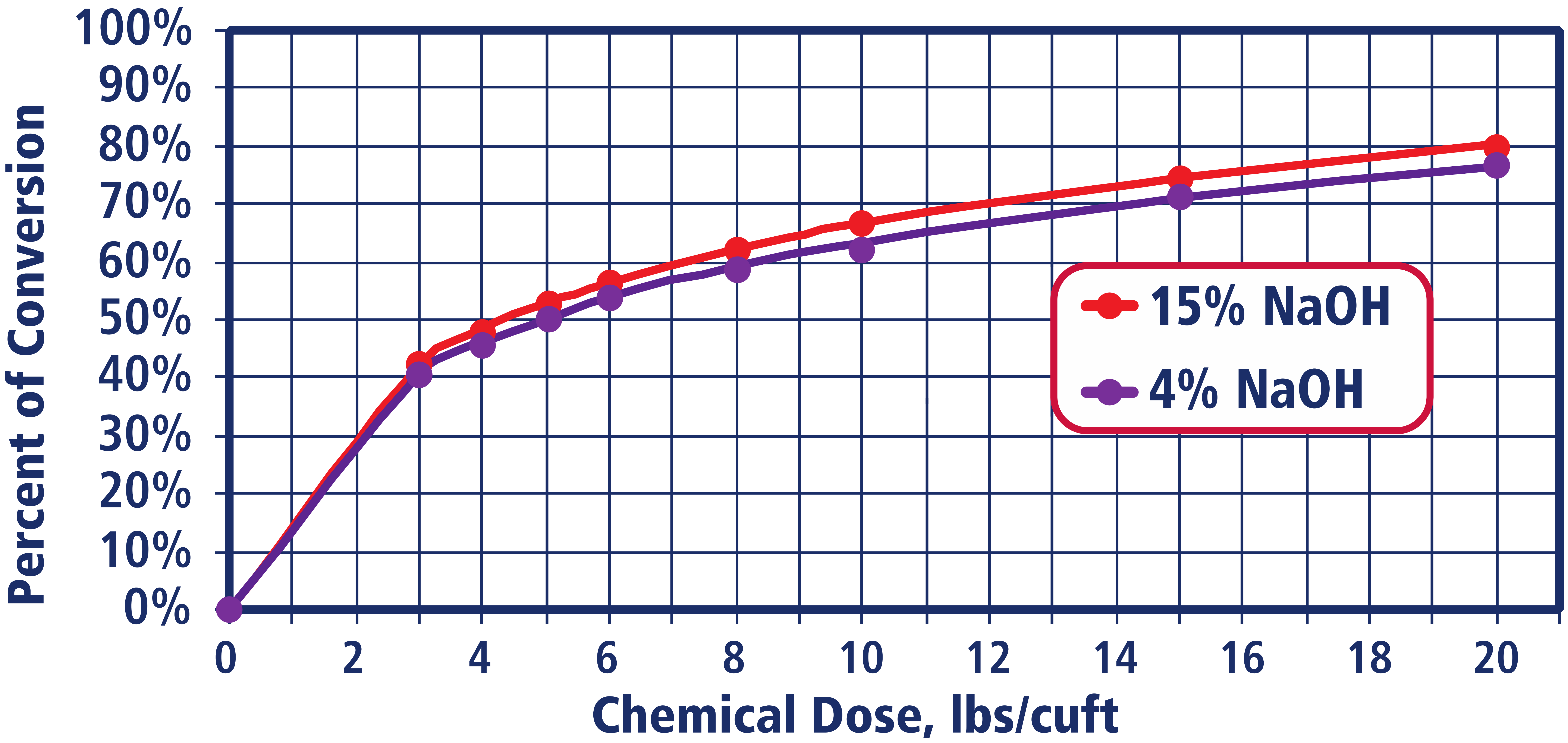
Regeneration of CG8 (BI)

from Calcium form to Hydrogen Form



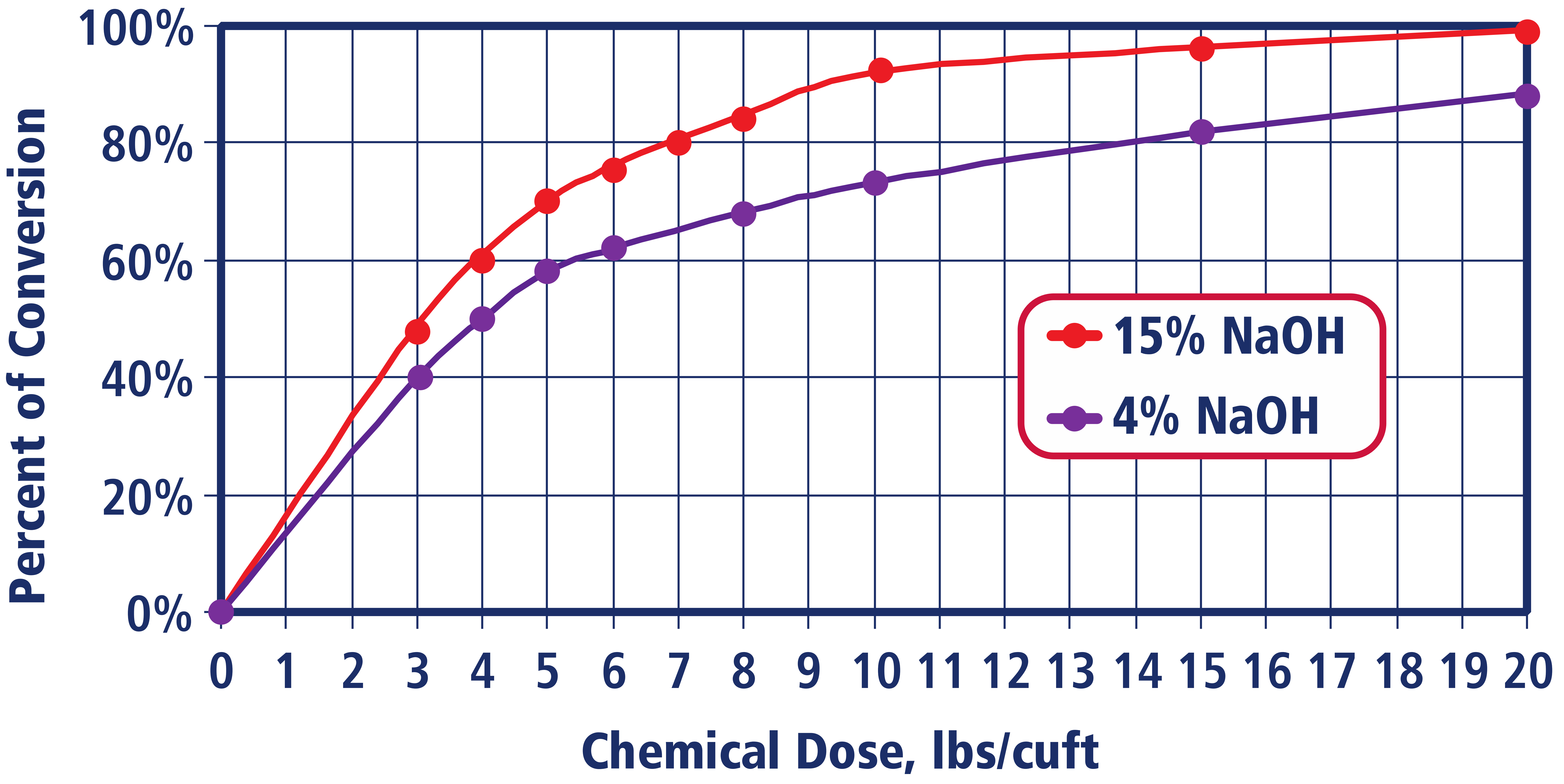
Regeneration of SBG1P

from Chloride form to Hydroxide Form



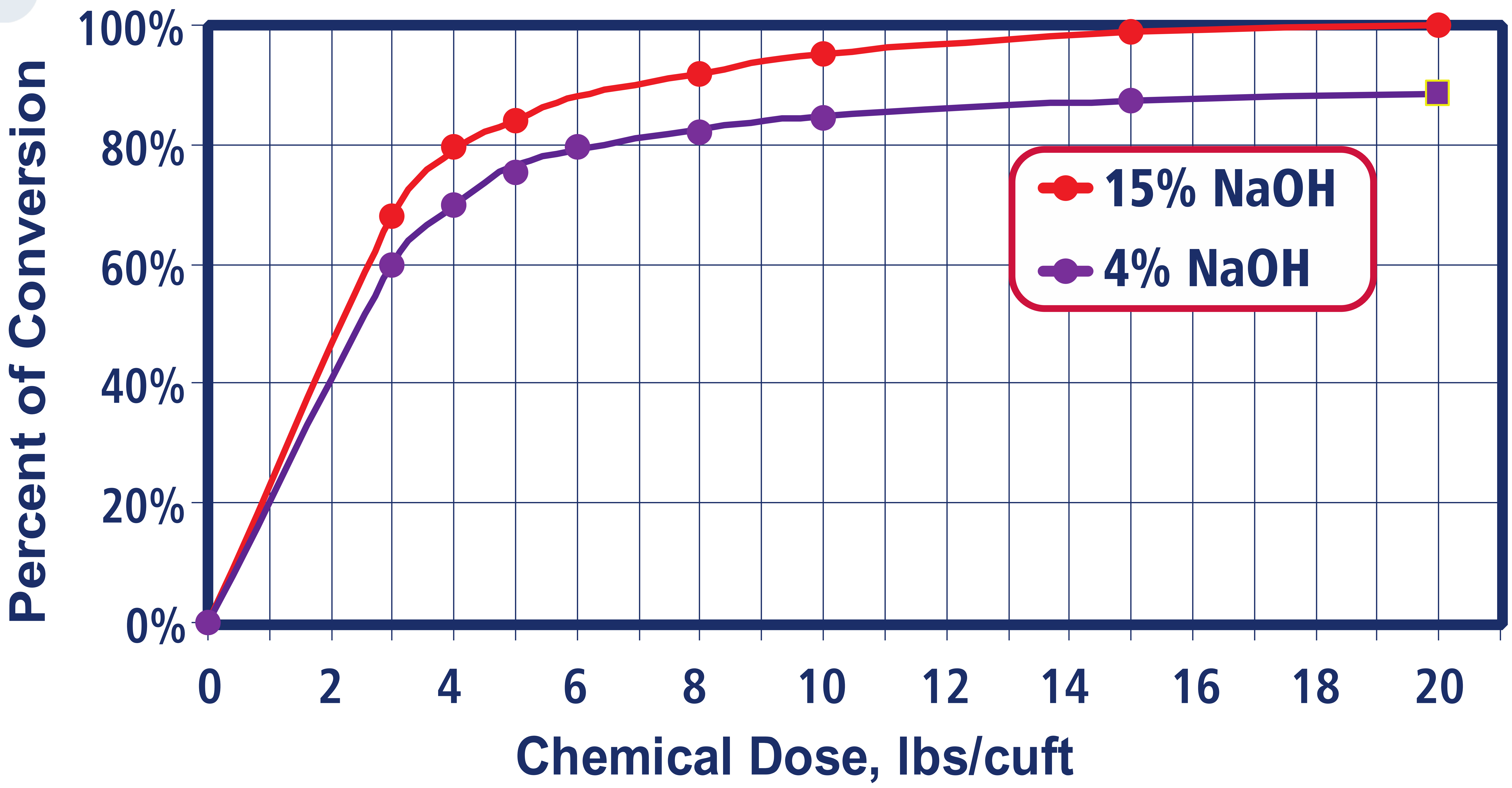
Regeneration of SBG1P

From Sulfate form to Hydroxide Form



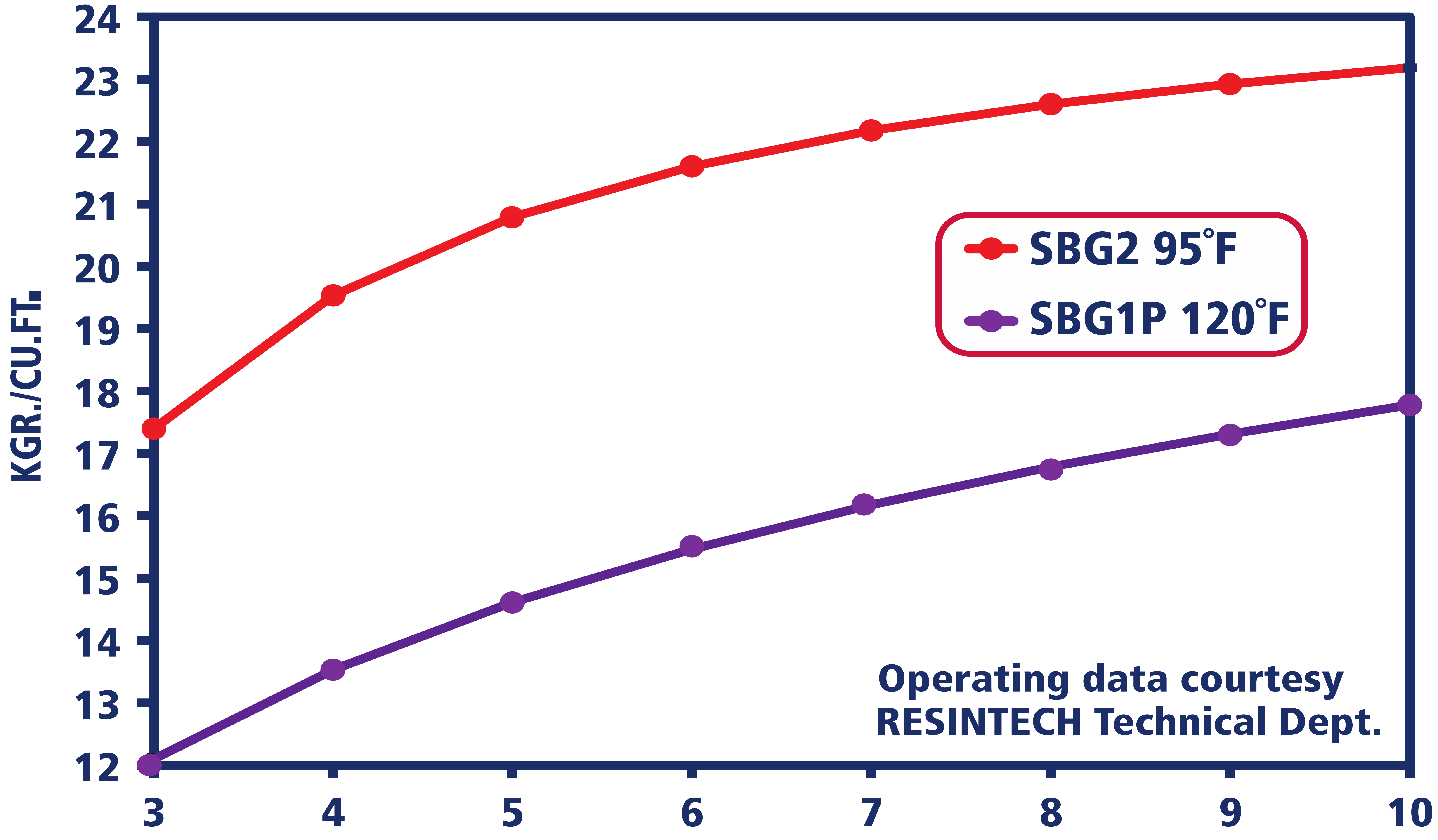
Regeneration of SBG1P

From Bicarbonate form to Hydroxide Form



Comparison of Operating Capacities

Type 1 vs. Type 2

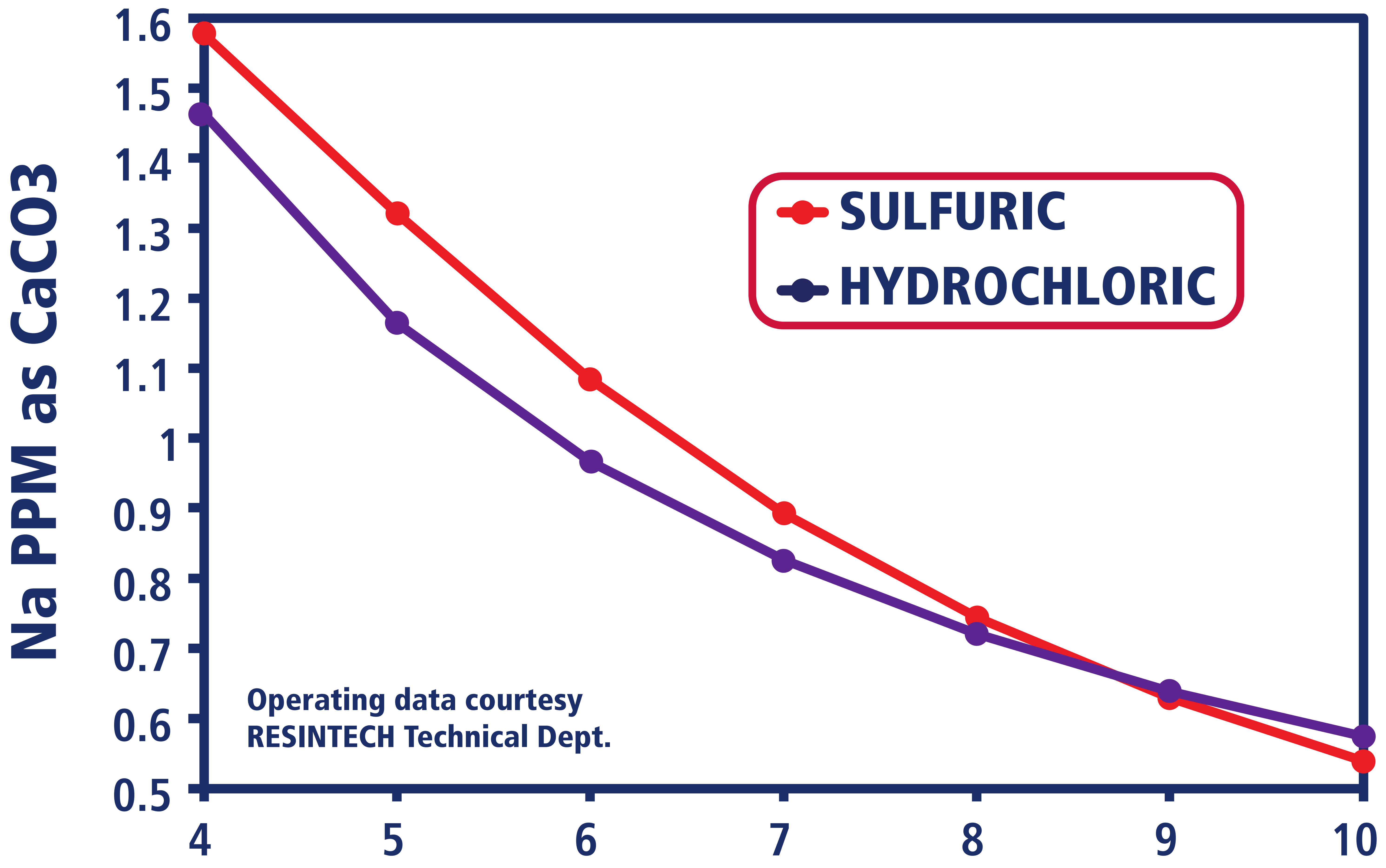


Effluent Water Quality

- Function of Selectivity and Leakage
  - Least strongly held ion first to come off
  - Na^+ for SAC
  - SiO_2 for SBA
- Regeneration Dose
  - Higher the dose, the lower the leakage

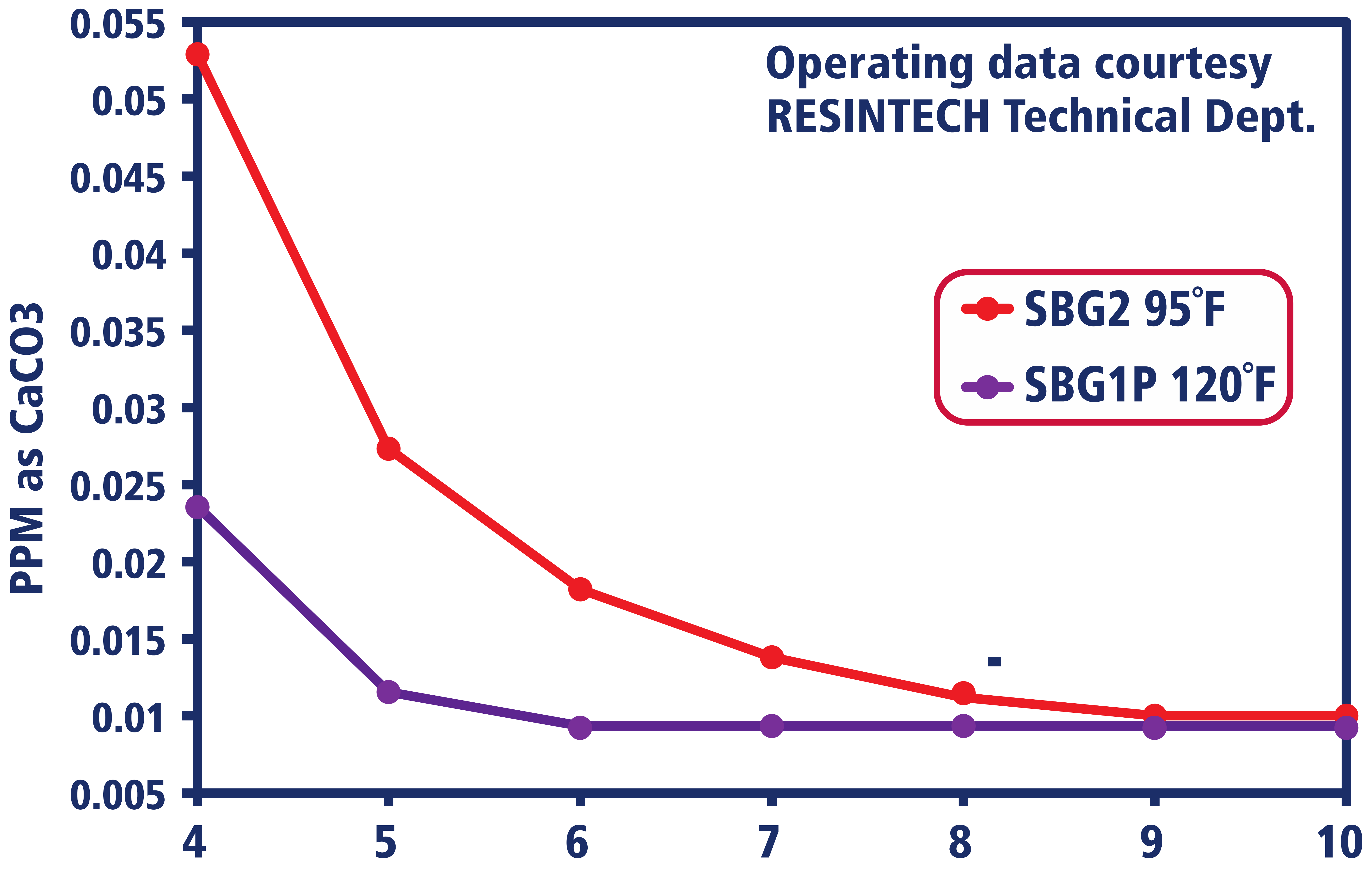
Comparison of Operating Capacities

Type 1 vs. Type 2



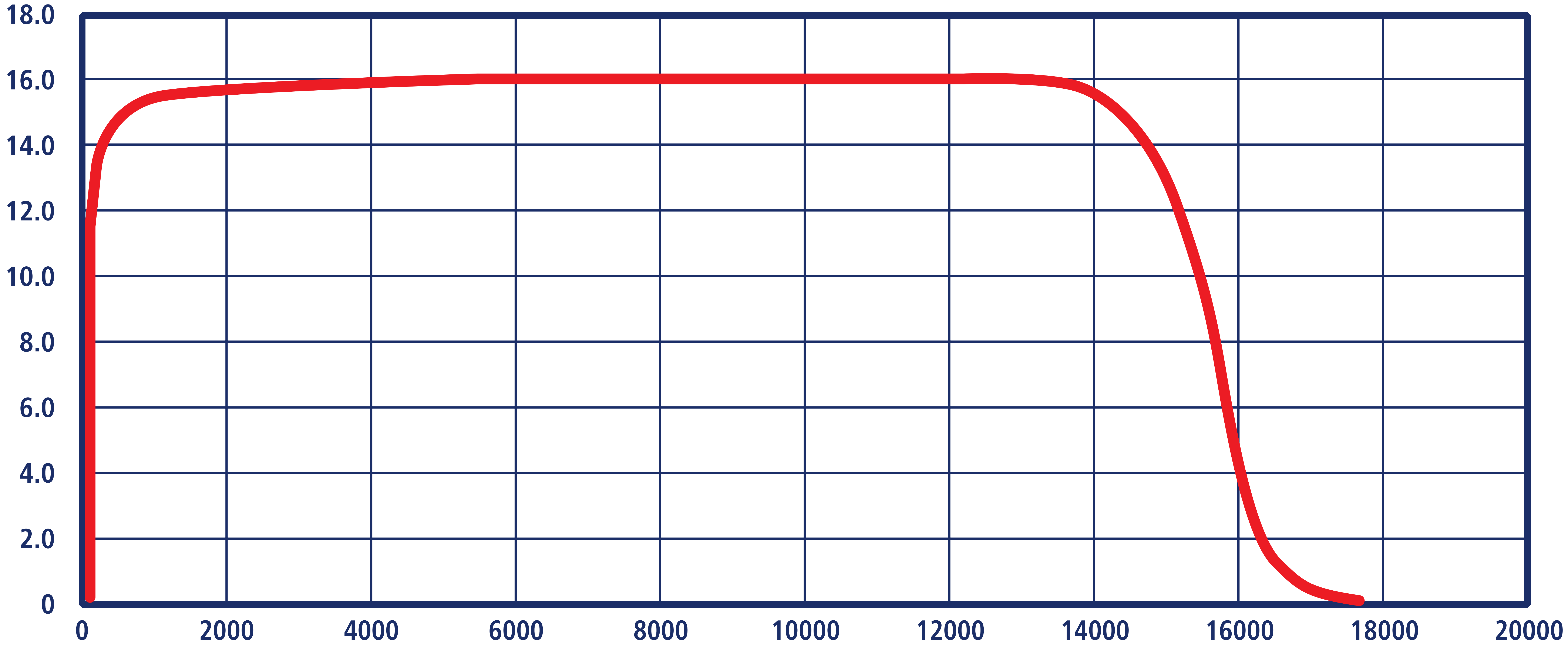
Regenerant & Leakage Comparison

ResinTech CG8 (BL)



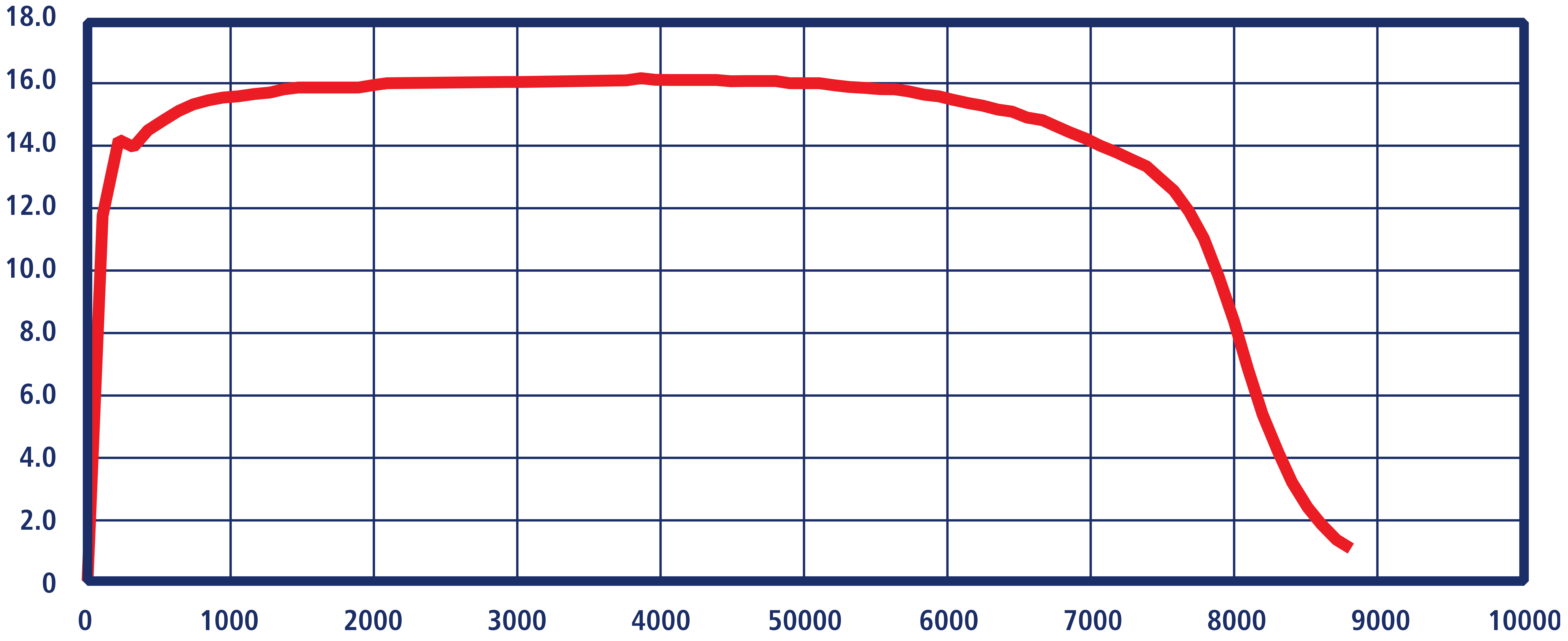
Typical Mixed Bed Exhaustion

(Virgin Resin)



Typical Mixed Bed Exhaustion

(Regenerated Resin)



Typical Mixed Bed Exhaustion

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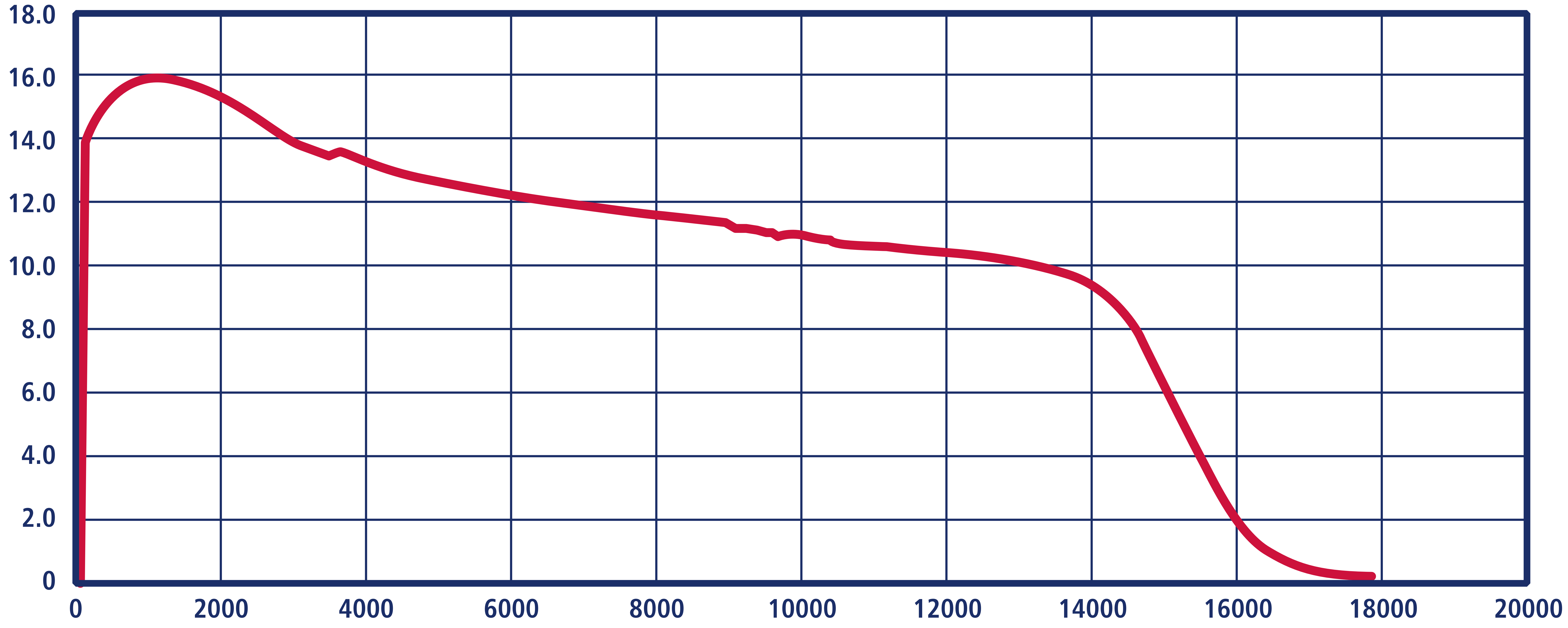


Troubleshooting

- Equipment
- Factors Affecting Resin Performance

Equipment Troubleshooting

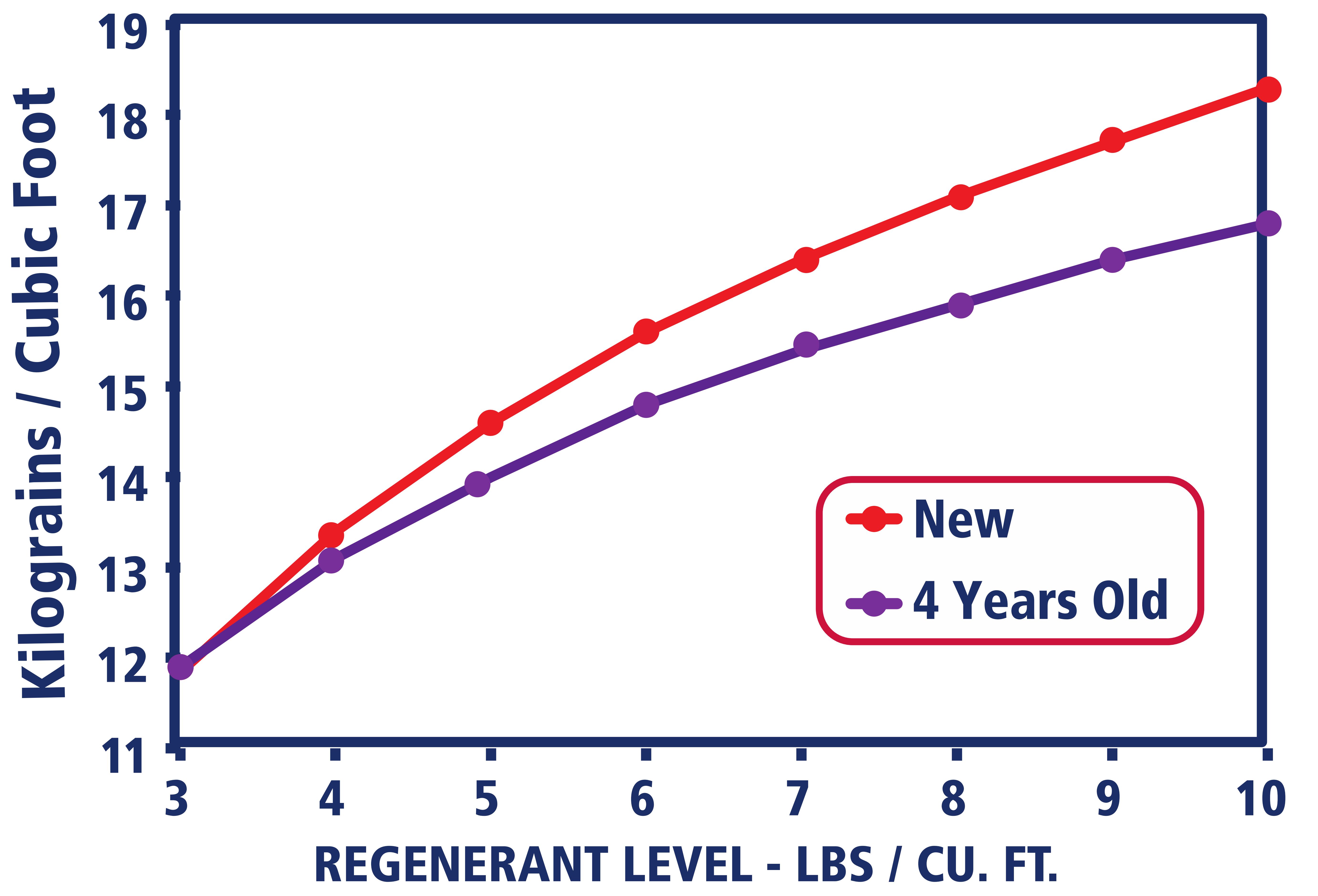
- Distribution Problems
- Control malfunctions
- Leaking valves
- Operator error

Factors Affecting Performance

- Change in Influent water Chemistry
- Loss of resin in vessels
- Poor Regenerations
- Resin Age
  - SAC – 10 years
  - SBA – 4 years

Age vs. Operating Capacity

Type 1 Porous Strong Base Anion Resin (SBG1P)



Factors Affecting Performance

- Oxidation of Resin
    - Chlorine
    - Temperature
    - Osmotic Shock
- Foulants
    - Organics
    - Oils
    - Metals (Iron, Hardness, etc.)
    - Suspended Solids (Dirt)

Mixed Bed Regeneration

- End goal to achieve highest effluent quality of water for as many gallons as possible
- Best way to achieve your goal is to pay attention to the details!

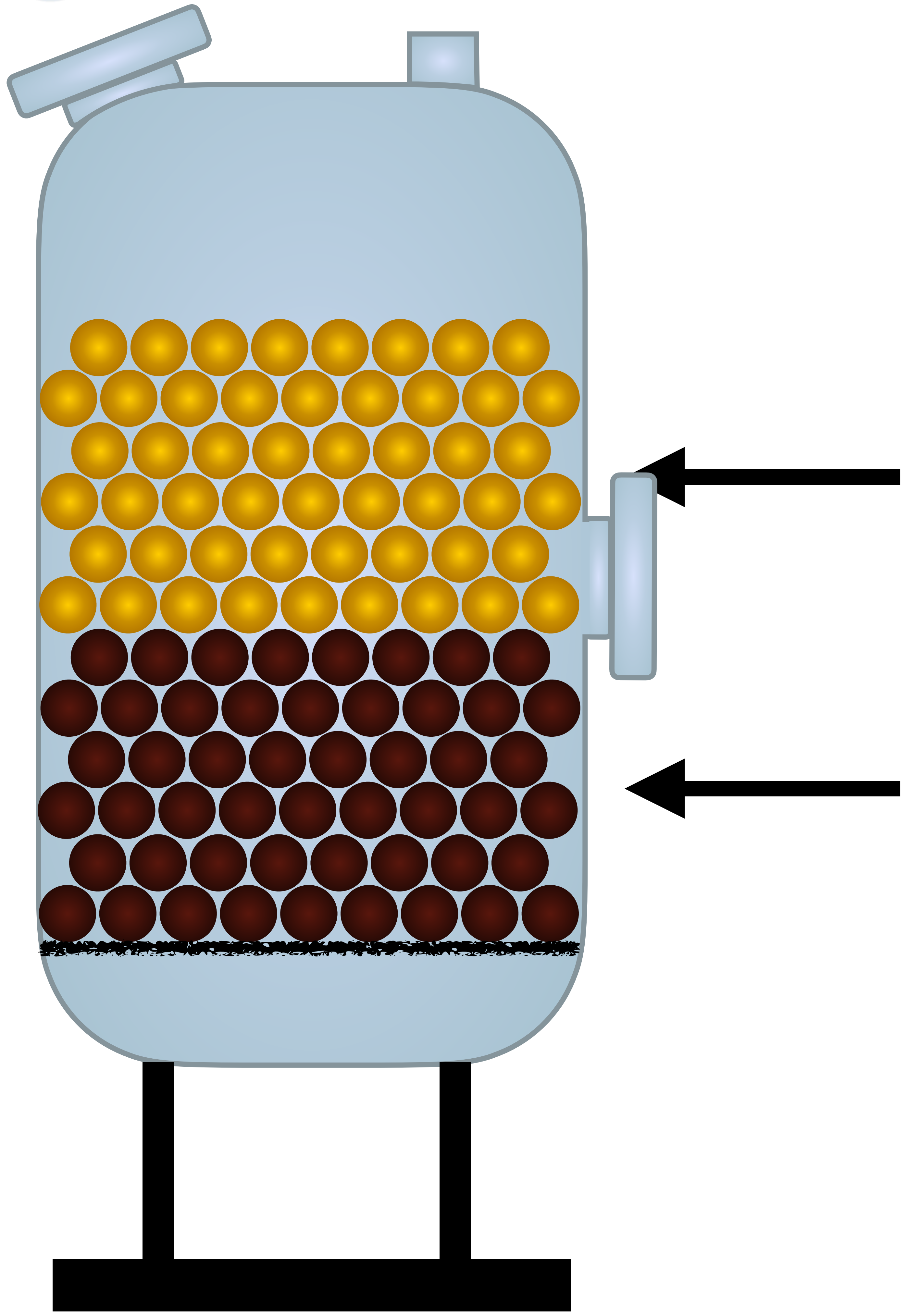
Mixed Bed Regeneration

- Backwash & Separation
- Chemical Addition & Rinse
- Mixing
- Loading into Vessels
- Storage

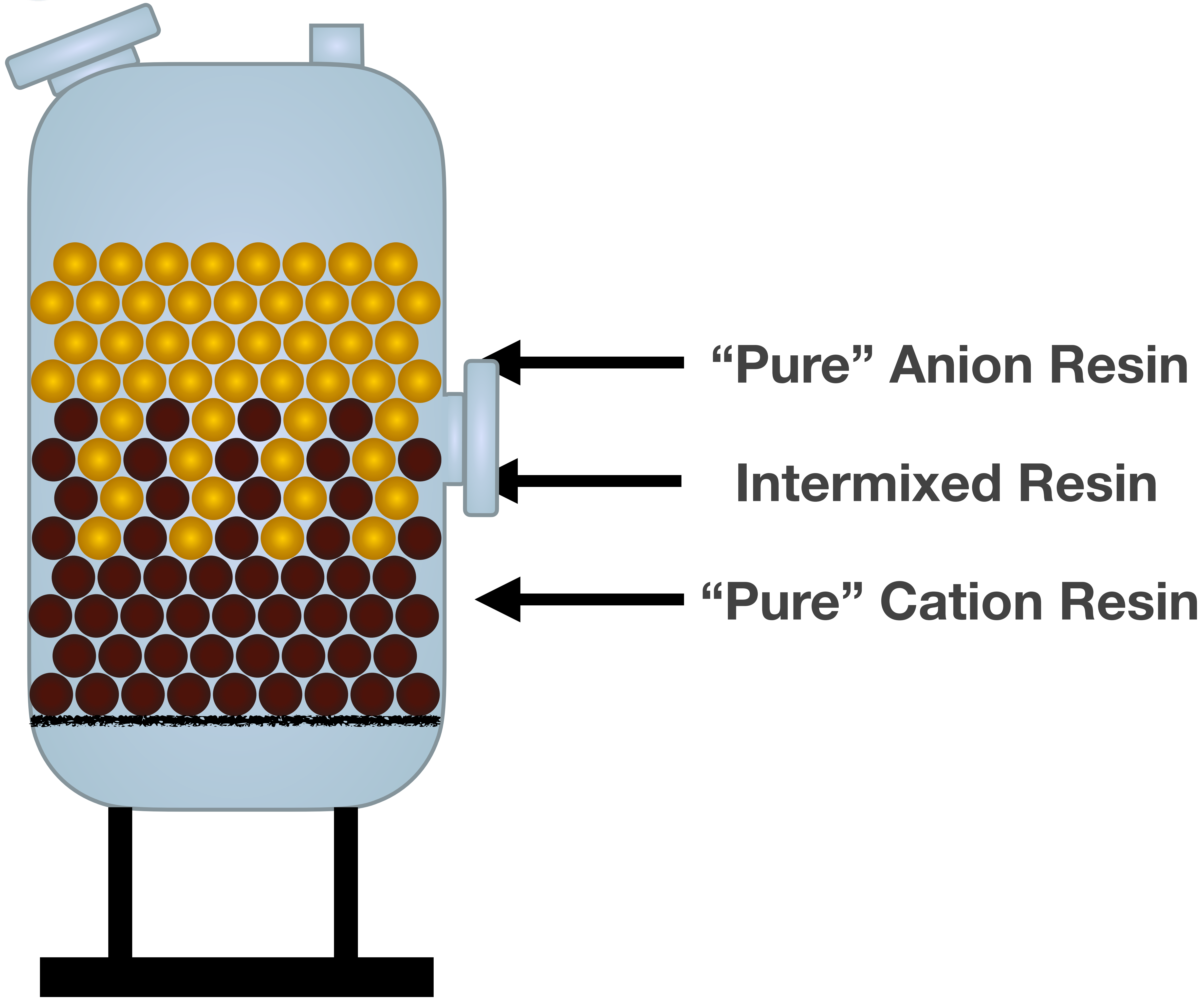
Backwash & Separation

- A flow of water is passed upward through the resin bed
- The resin bed expands and fluidizes
- Purpose
  - To remove suspended solids and resin fines
  - Cation and anion resin separate

Ideal Resin Separation



Realistic Resin Separation



Factors Effecting Separation

- Limited expansion space
  - Don’t overload separation column
- Static attraction (stickiness) of resin
- Ionic forms of resin
  - Exhausted resin separates easier
- Separation column internals
- Too high of BW flow rate

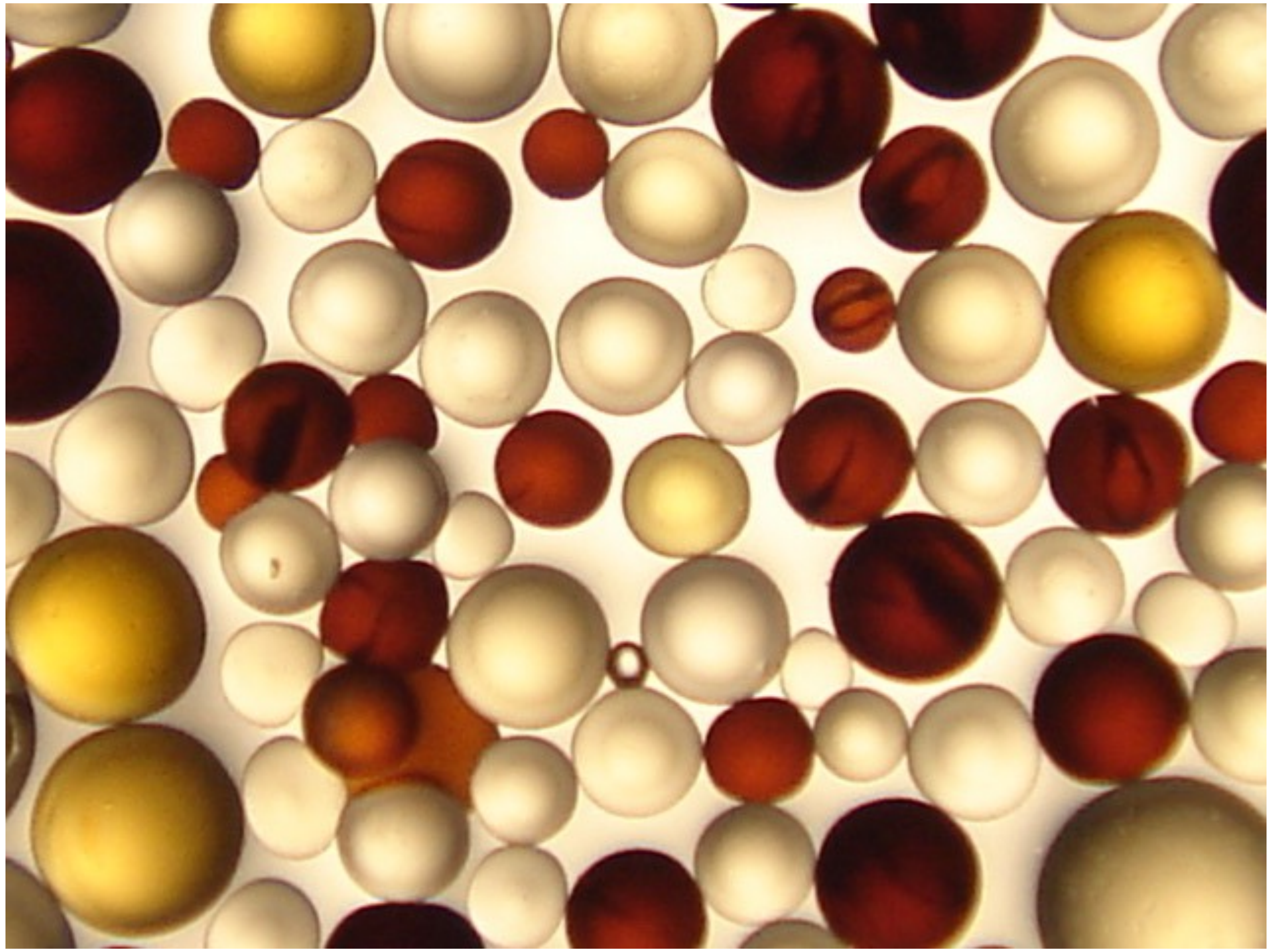
Brine Separation

- Referred to as “Brine Kill”
- Na^+ and Cl^- exchange for any remaining H^+ and OH^- on resin
- Eliminates clumping (stickiness)
- Easiest separation

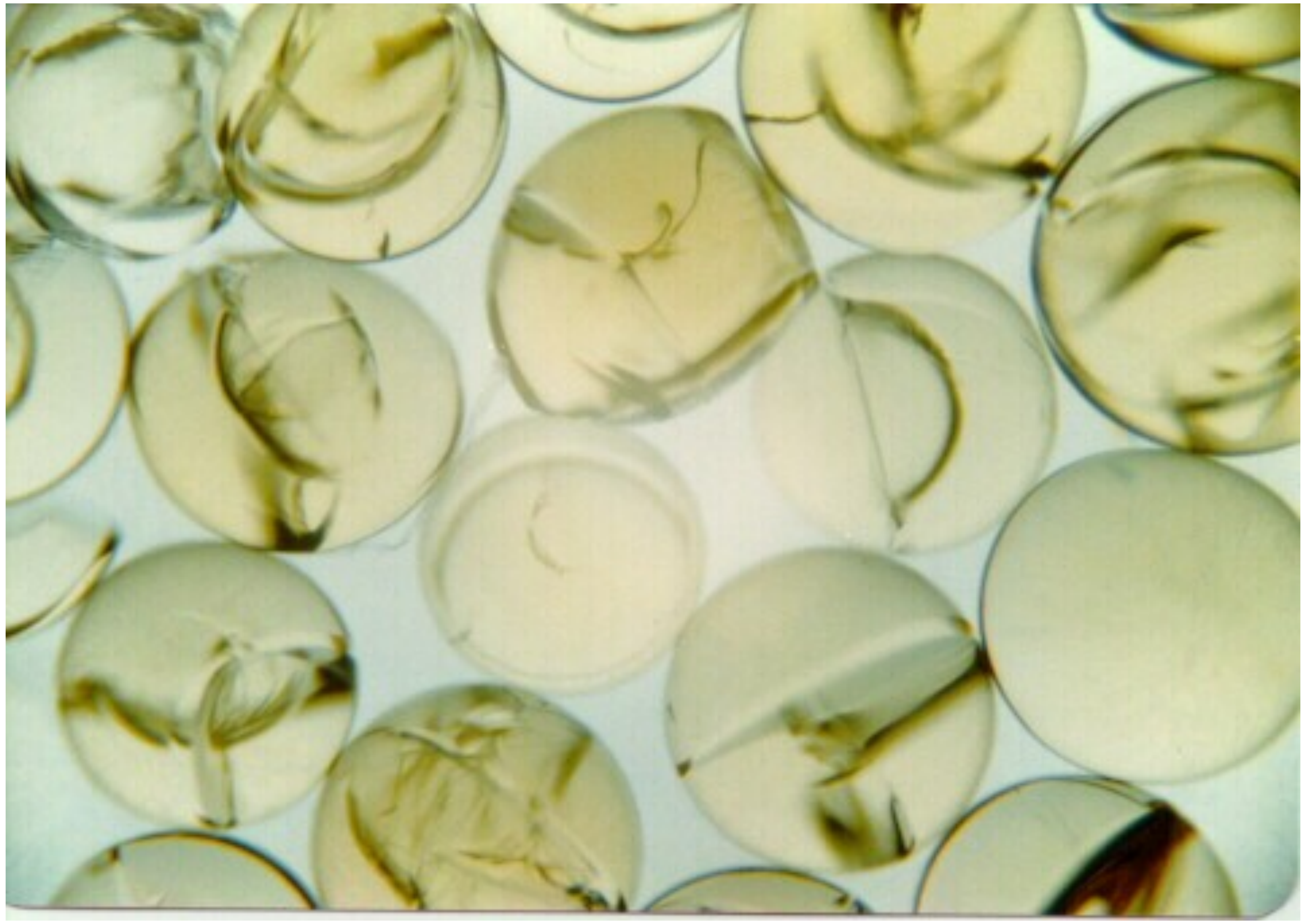
Drawbacks of Brine Kill

- Having Na+ and Cl- on resin require higher doses of chemicals to remove from resin.
- Resin beads can fracture due to osmotic shock.
  Cracked beads lead to broken beads which leads to resin loss
- Anion more fragile than cation. Will lose volume faster.

Picture of Good Resin



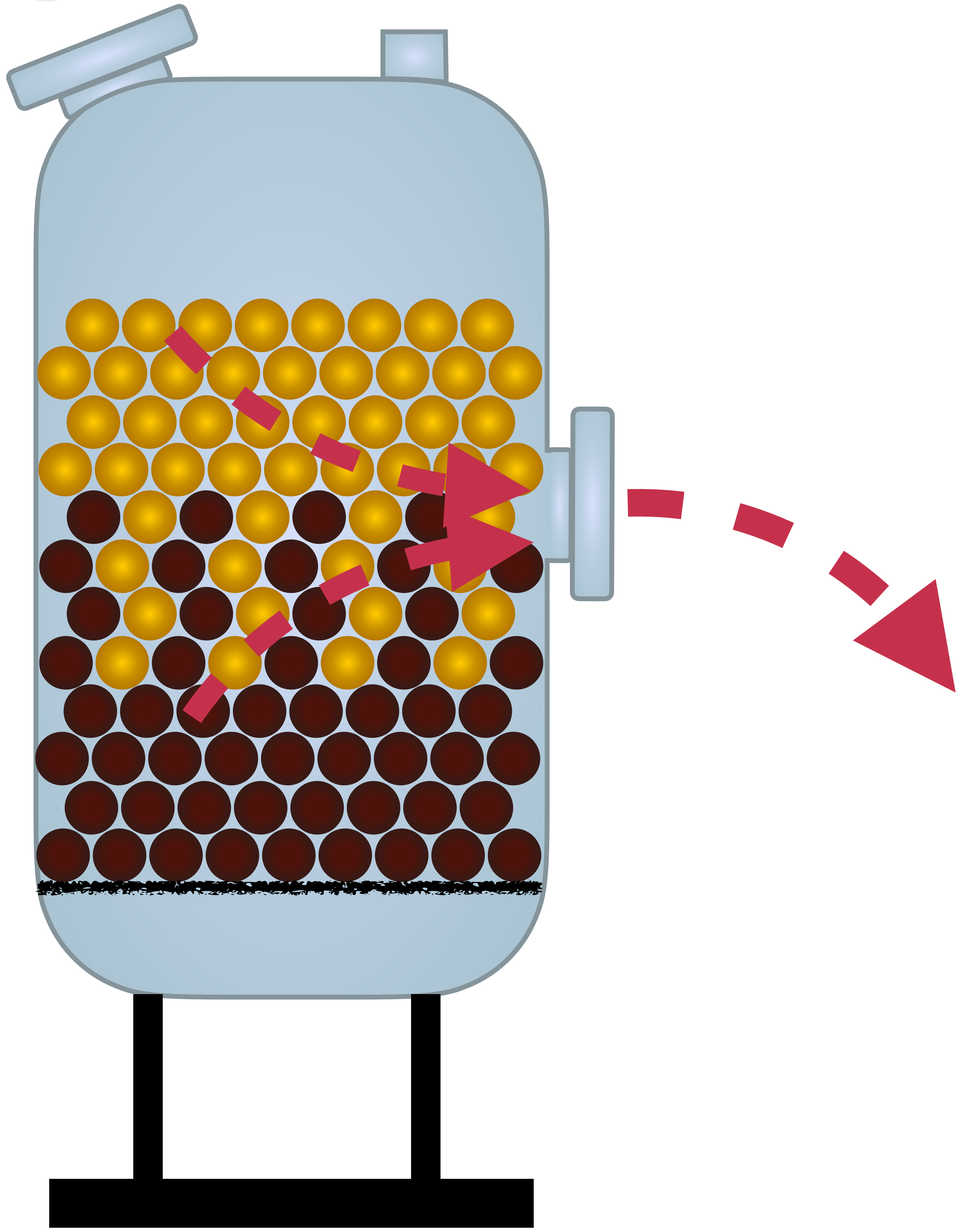
Osmotically Damaged Resin



Importance of Separation

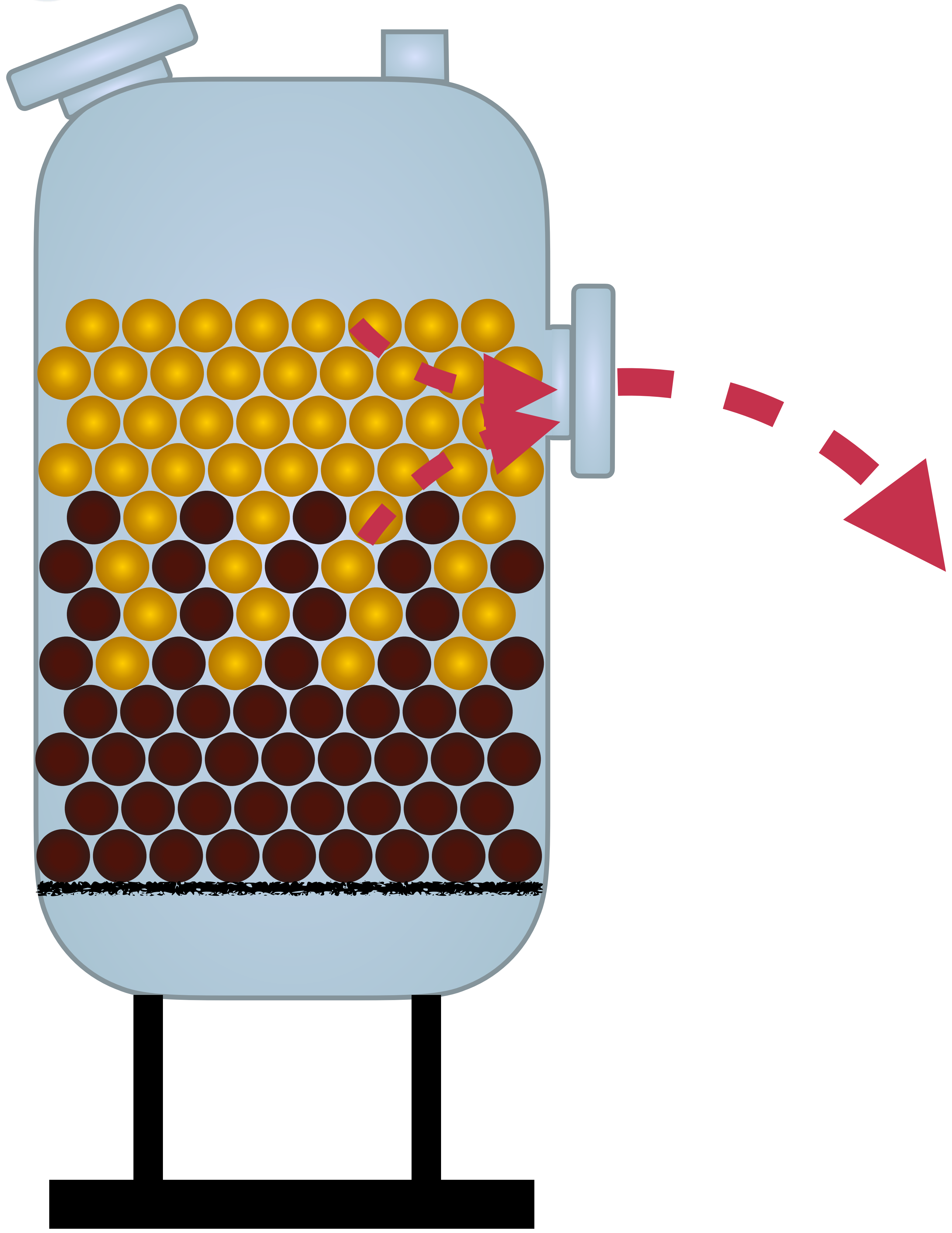
- Minimize cross-contamination
    - Anion in Cation - OK- minimize
    - Cation in Anion - Very Bad!!
- Keep interface as small as possible
- Draw anion off top very slowly and meticulously

Anion Resin Transfer Side Take off



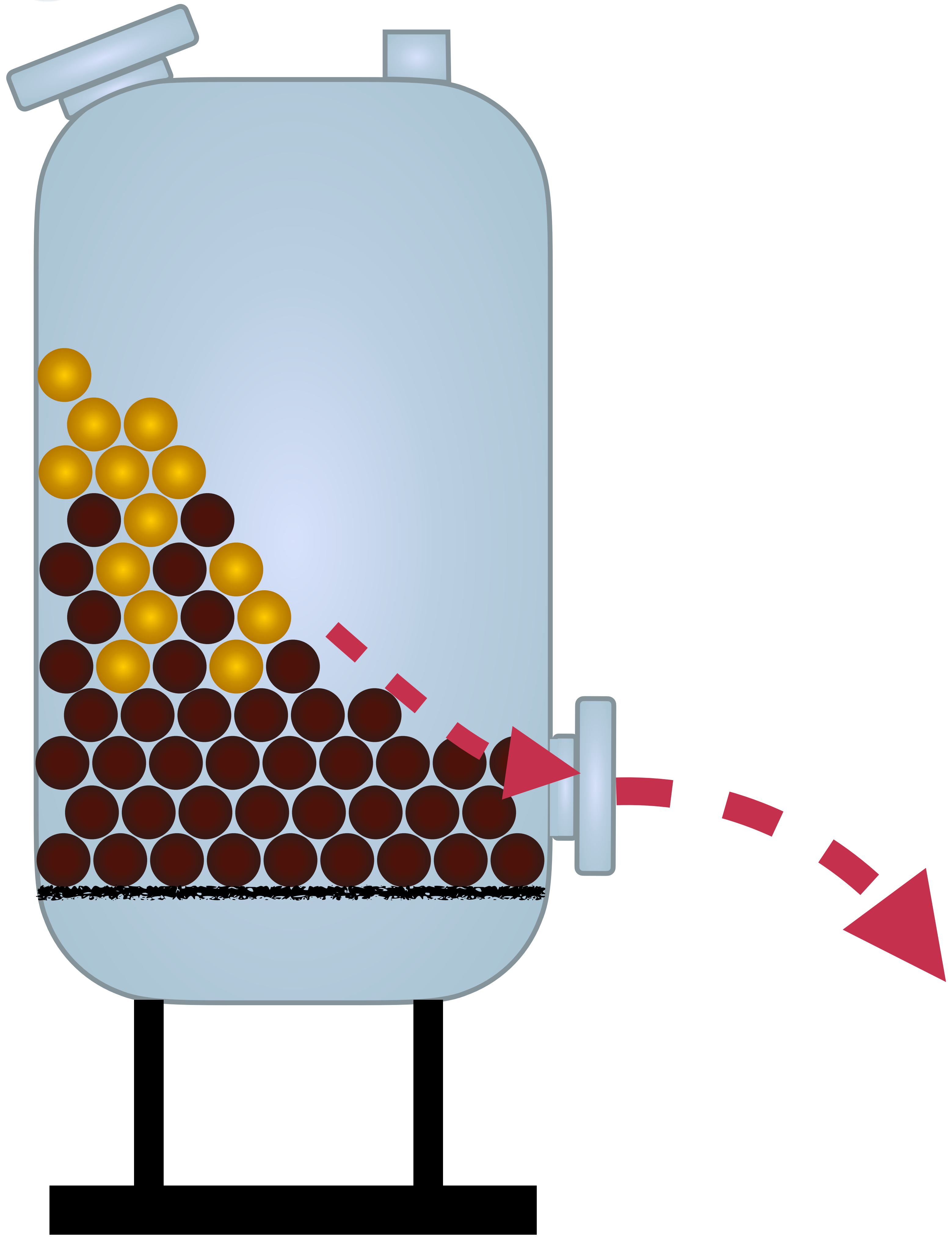
If anion draw off point is too low, some intermixed resin will transfer

Anion Resin Transfer Side Take off



Moving the anion draw off point up prevents intermixing but leaves some anion resin behind.

Cation Resin Transfer Side Take off



During transfer, some mixed resin is pulled down into the draw off collector along with cation resin.

Minimizing contamination during transfer

- Slow backwash during transfer
    - Maintaining a slow backwash during transfer helps prevent funneling by keeping the bed surface relatively flat
- Stop Transfer/ Level Bed/Resume Transfer
    - This technique is more effective than backwashing alone.

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Chemical Addition

- Acid solution through cation bed- HCl
- Caustic solution through anion bed- $NaOH$
- The relatively high concentration of hydrogen or hydroxide ions causes the reverse exchange
- The resin is restored to the hydrogen or hydroxide form

Chemical Addition

- Concentration + Flow Rate + Time = Dose
- Dose controls the capacity and ion leakage of both ion exchange resins
- Very important to insure all parameters are met
- Improve anion regeneration by utilizing warm NaOH (100-120º F)

Displacement or Slow Rinse

- Increases contact time between regenerant and the bottom of the bed
- Helps push remaining regenerant through the bed without significant mixing
- Begins the rinse process

Fast Rinse

- Removes the last traces of regenerant chemical from the resin
- Warm water (100-120º F) will decrease amount of time needed to rinse anion resin
- Any HCl/NaOH left on the resin will decrease capacity and increase ion leakage of resulting mixed bed

RO vs. City Water Floats

- RO water float will require higher doses of chemicals due to amount of Na^+ and Cl^- on resin.
- Poor regenerations are easier to notice
- Inversely, City water float will regenerate a little easier
- Organics can foul anion resin and may require cleaning
- Indication of organics is long rinses
- Warm brine/caustic treatment is best

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Mixing of Components

- Dry mixing is best
  - Most intimate
  - Labor intensive
- Wet mixing is okay
  - Risk of resin separating
  - Very quick process

- Dry loading is best
    - Labor intensive
    - Prevents separation
- Wet loading is okay
    - Risk of resin separating
    - Very quick process
- No Freeboard in tanks!

Storing Regenerated Resin

- Regenerated Cation and Anion resin
- Store freshly regenerated components wet, sealed in drums
    - Minimizes odor from anion resin
    - Prevents CO_2 intrusion (1% in 24 hours)
- Ideally, mix immediately to minimize amine odor from anion (fishy)

Storing Regenerated Resin

- Regenerated Mixed Bed Resin
- Store resin dry, sealed in tank or drums
  - Wet storage with free board, can cause separation
  - Remove water from tanks, air is best
  - Prevent CO_2 intrusion (top 1”can be lost to conversion in 24 hours)

Housekeeping

- Store regenerated resins properly
- Mix components immediately
- Clean up all resin spills, safety!
- Keep floats separate- City vs. RO
- Take your time and pay attention to details

Questions?

THANK YOU

Bill Koebel

Eastern Regional Sales Mgr

p. 412-716-7921

e. wkoebel@resintech.com

RESINTECH® INC.

INNOVATIONS IN ION EXCHANGE