Saltworks™

EDR 201
Electrodialysis Reversal II

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Outline

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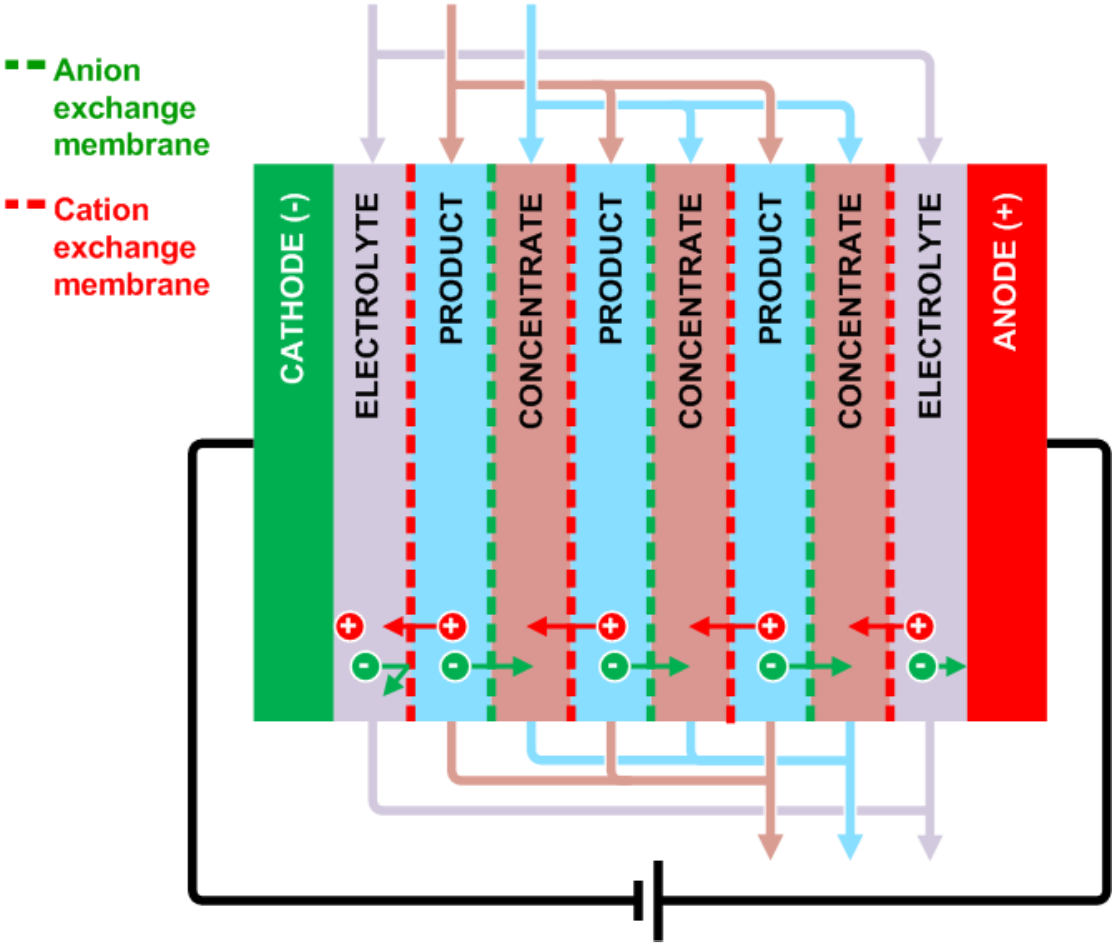
2. Type of Membranes
3. EDR Stack Components
4. EDR System Components
5. Leak Test
6. Current Limit Test
7. Desalting Run
8. Fouling/Scaling
9. Hybrid Systems

Advanced EDR Operating Principle



- Equal charge of anions and cations are transferred from the product stream to the concentrate stream.
- Electrolyte steams are next to the electrodes to carry current across the stack and maintain charge balance in each compartment.
- Electrolyte is usually Na_2SO_4 solution.

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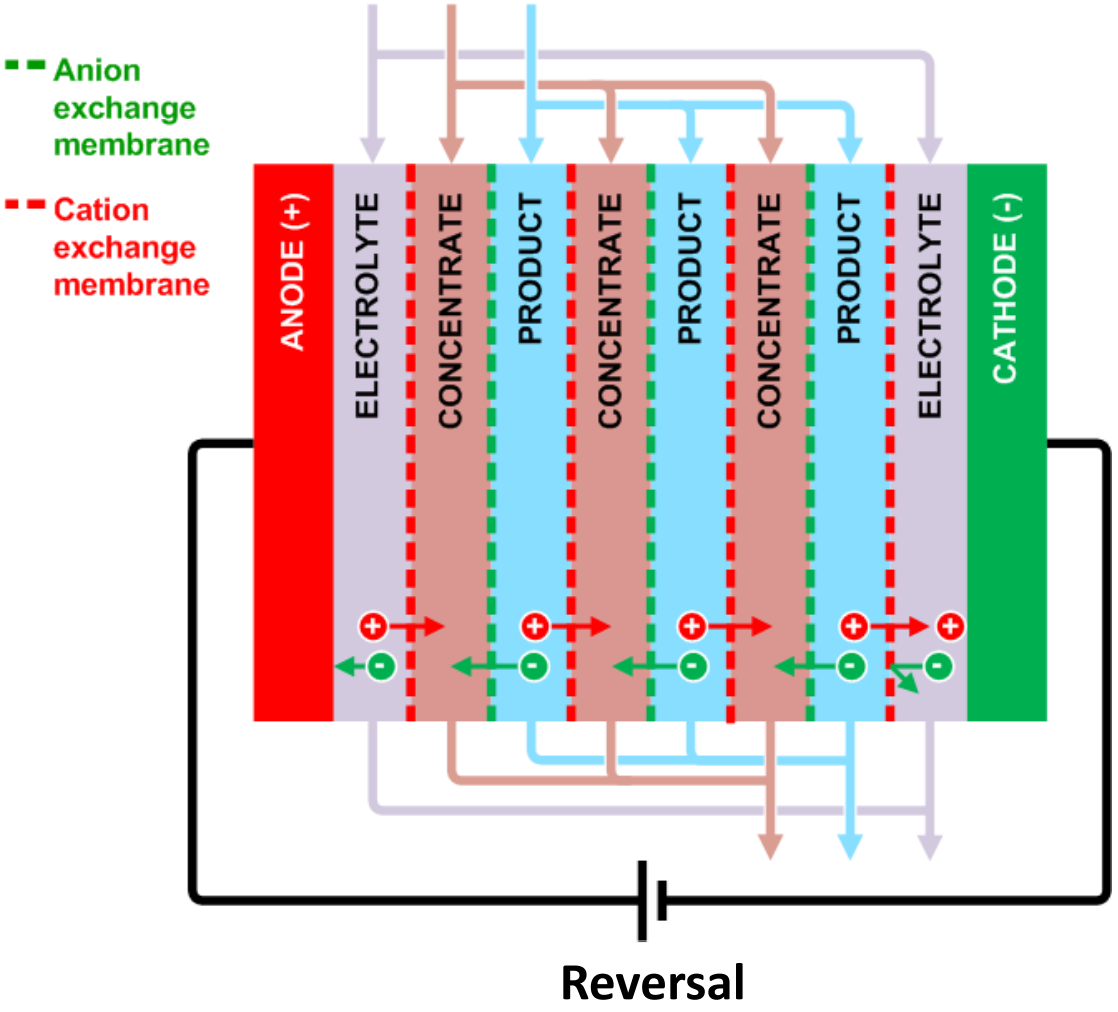
Advanced EDR Operating Principle



- A purge is done when changing polarity. During a purge, water from both product and concentrate compartments are sent to the concentrate stream to prevent contamination.
- Reversal events can be triggered by a set timer or when stack resistance reaches a set point

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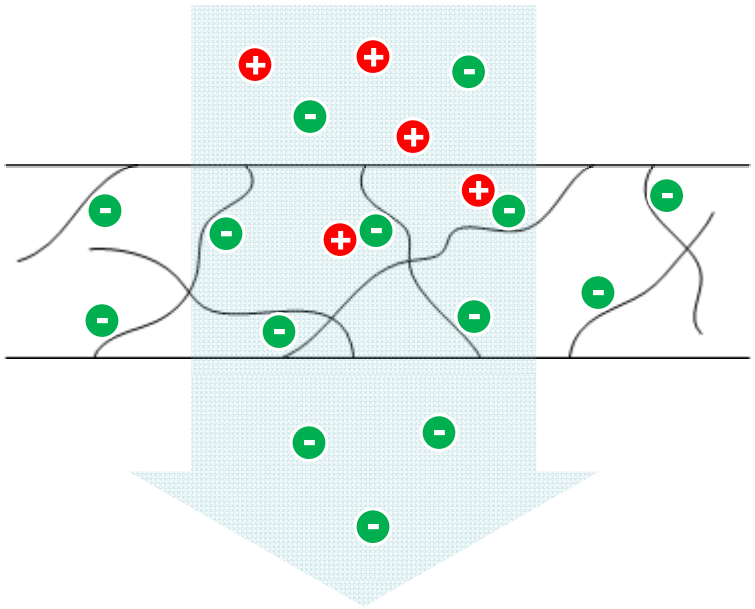
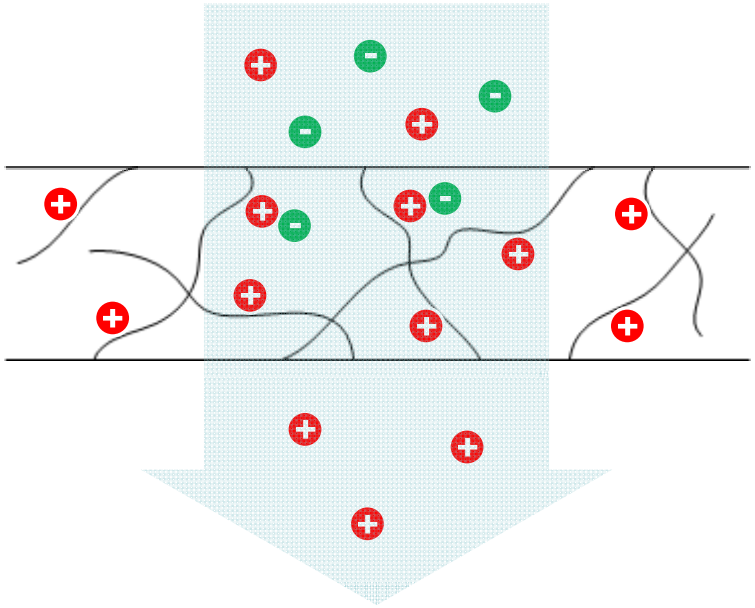
Types of Membranes

Electrodialysis reversal systems use electrically charged ion exchange membranes. These membranes have fixed ions on the pore walls that bind to oppositely charged ions in the surrounding fluid while letting similarly charged ions permeate through.

Anion Exchange Membrane (AEM)



Cation Exchange Membrane (CEM)



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Types of membranes

Saltworks offers six types of membranes under the IonFlux name:

	AEM	CEM	mAEM	mCEM	pAEM	pCEM
Type	Anion permselective	Cation permselective	Monovalent anion permselective	Monovalent cation permselective	Proton blocking anion permselective	Proton permselective
Ion Transport Cl^- SO_4^{2-} NO^{3-} Na+ Ca^{2+} H^+	 High Very High High - - Medium	 - - - High Very High Very High	 High Low Very High - - Medium	 - - - High Low High	 High High High - - Very Low	 - - - Very Low Very Low High
Max. Op. Temp	60 °C					
pH Stability	0 - 12					
Applications	Electrodialysis (EDR), Electrodeionization (EDI), Capacitive deionization (CDI)		Selective ion separation		Acid recovery, Acid and base generation	

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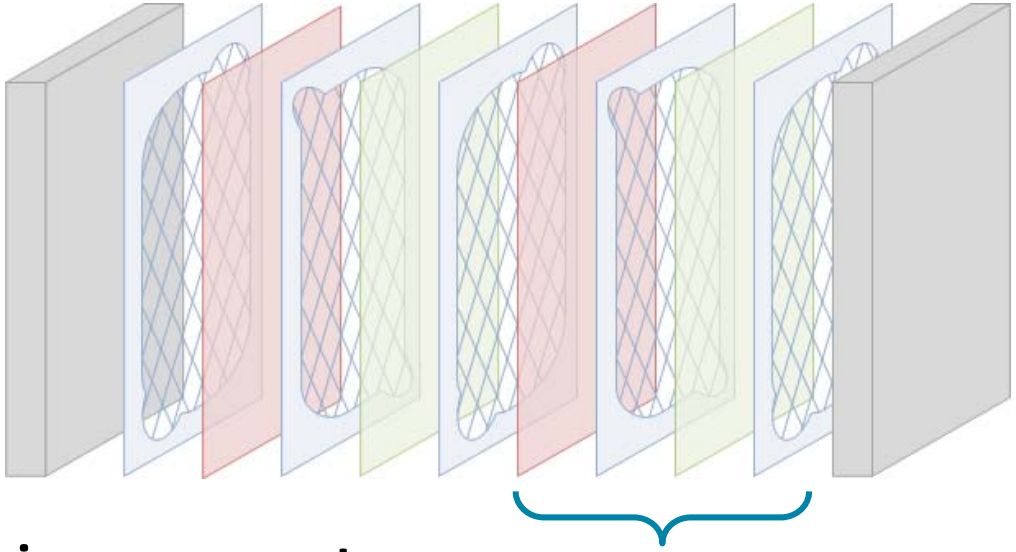
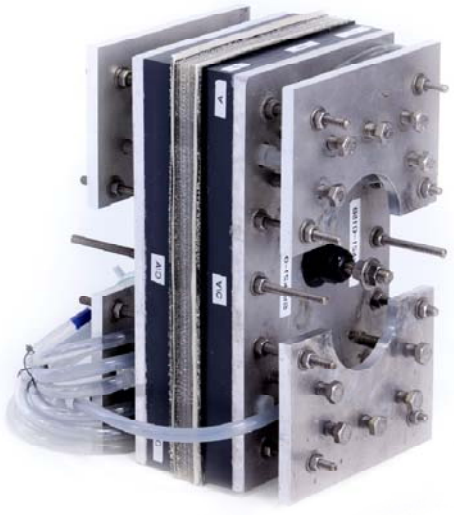
EDR Stack Components

Separation of ions occurs inside the EDR stack.





Saltworks' micro stack for bench testing

3 main components:

- **Electrodes** at the ends
- Alternating **membranes** and **spacers** in between
  - Anion Exchange Membrane
  - Concentrate spacer
  - Cation Exchange Membrane
  - Product spacer

1 cell pair

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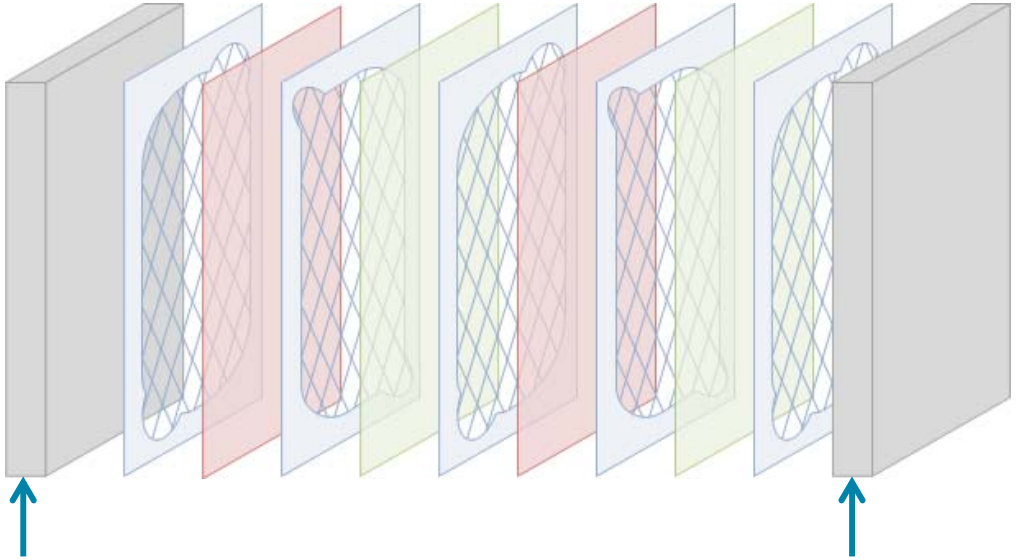
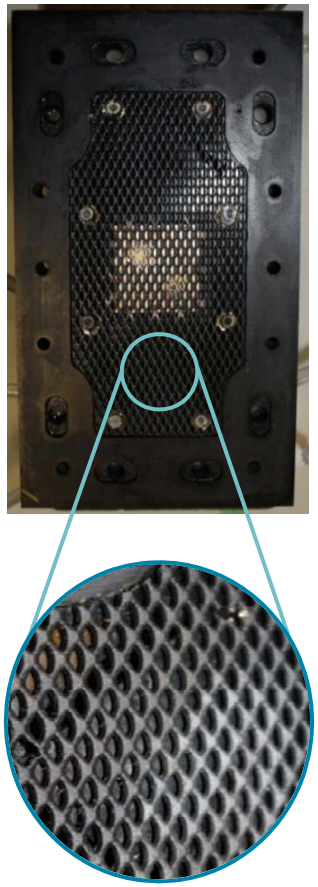
EDR Stack Components





Inside surface of electrode

Electrodes:

- Constructed of inert metals, usually platinum coated
- Conducts direct current into the stack
- Polarity can be periodically reversed

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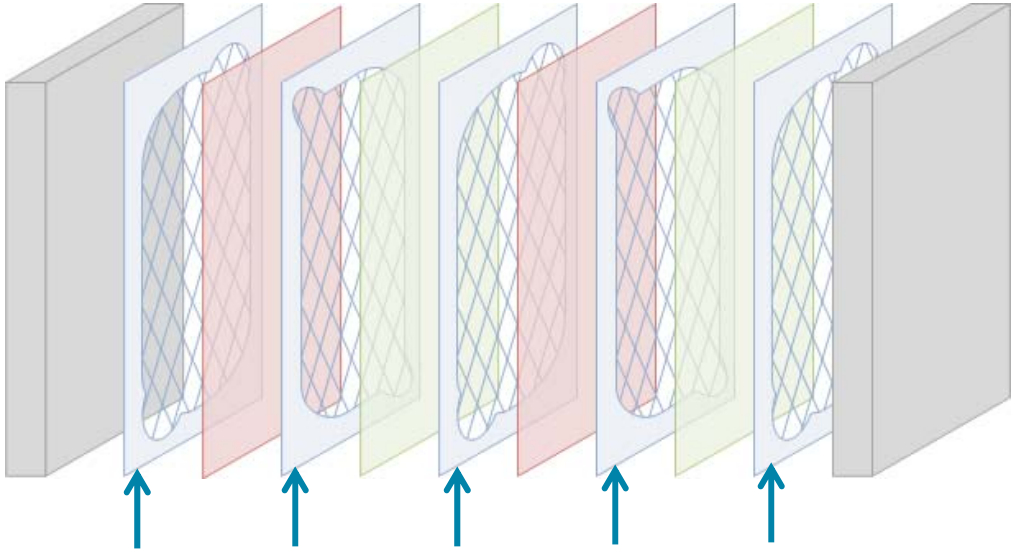
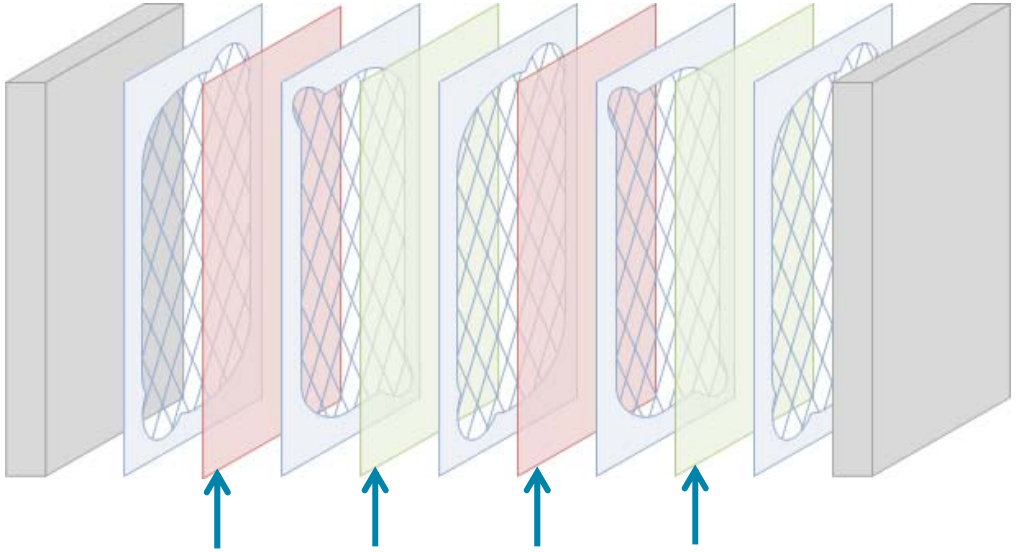
EDR Stack Components



Spacers:

- Direct product and concentrate streams into separate single manifolds
- Increase turbulence to promote mixing of the water and break up particles on the membrane surfaces

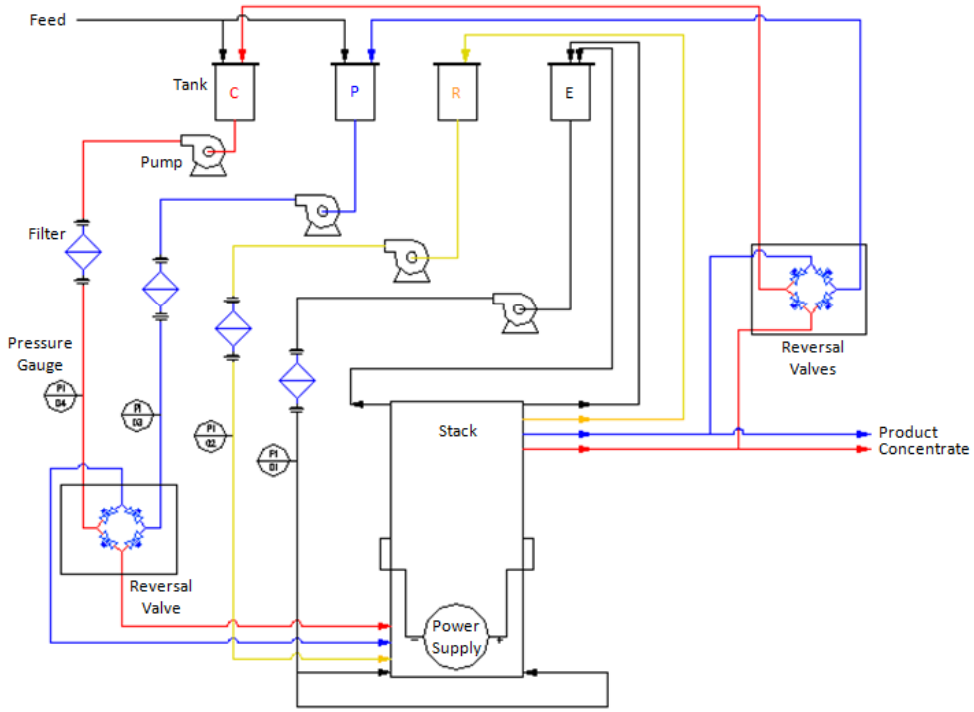
EDR Stack Components



Membranes:

- Selectively permeate anions or cations depending on membrane type
- Low electrical resistance, insoluble, impermeable to water under pressure
- Must remain moist at all times

EDR System Components



Simplified representation of a bench scale EDR system. Some instrumentations and components have been removed.

Saltworks' bench scale EDR system has been used to successfully treat mine water, recover acids, and desalinate wastewater.

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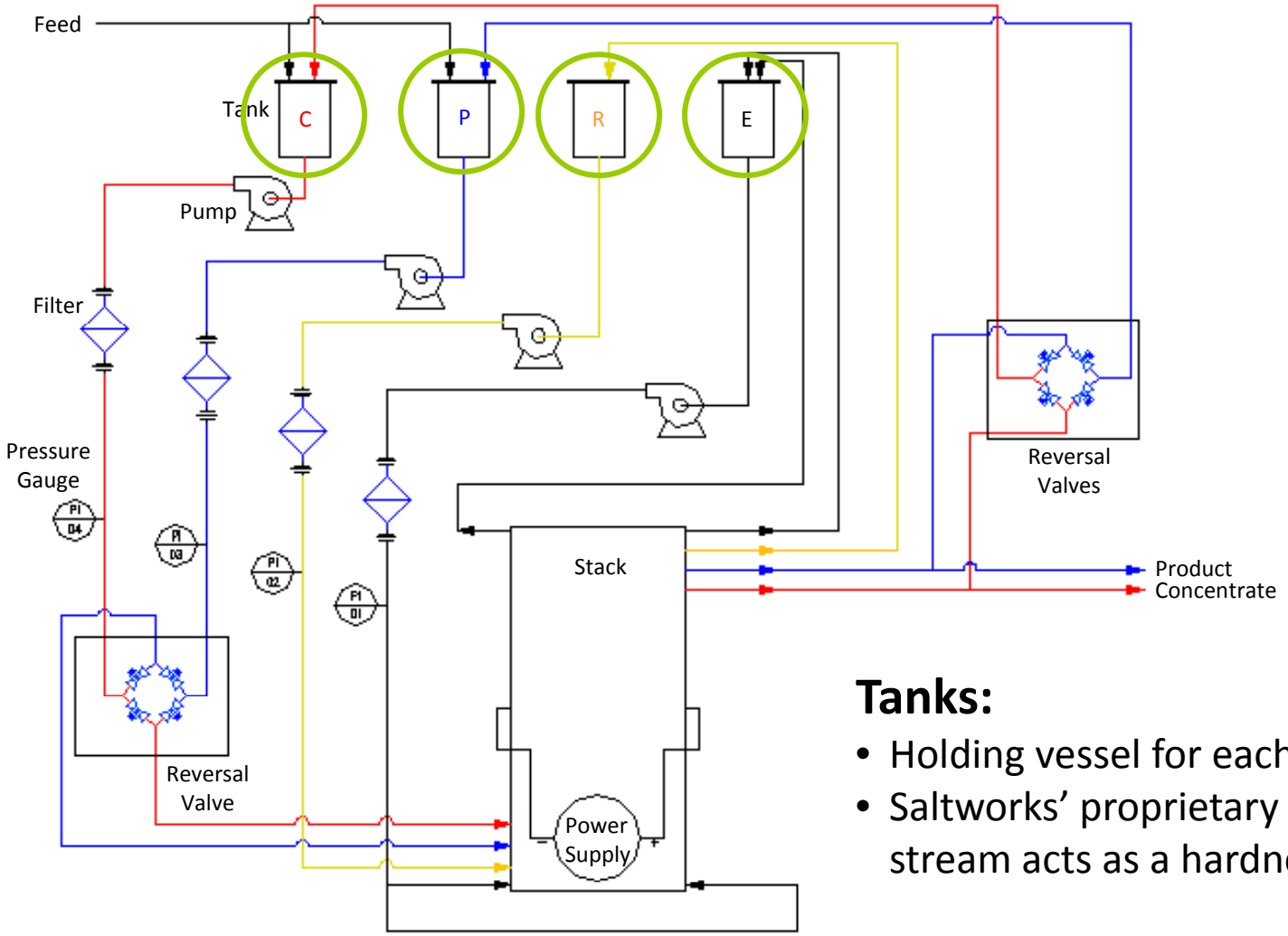
EDR System Components



Tanks:

- Holding vessel for each fluid
- Saltworks' proprietary Rinse (R) stream acts as a hardness blocker

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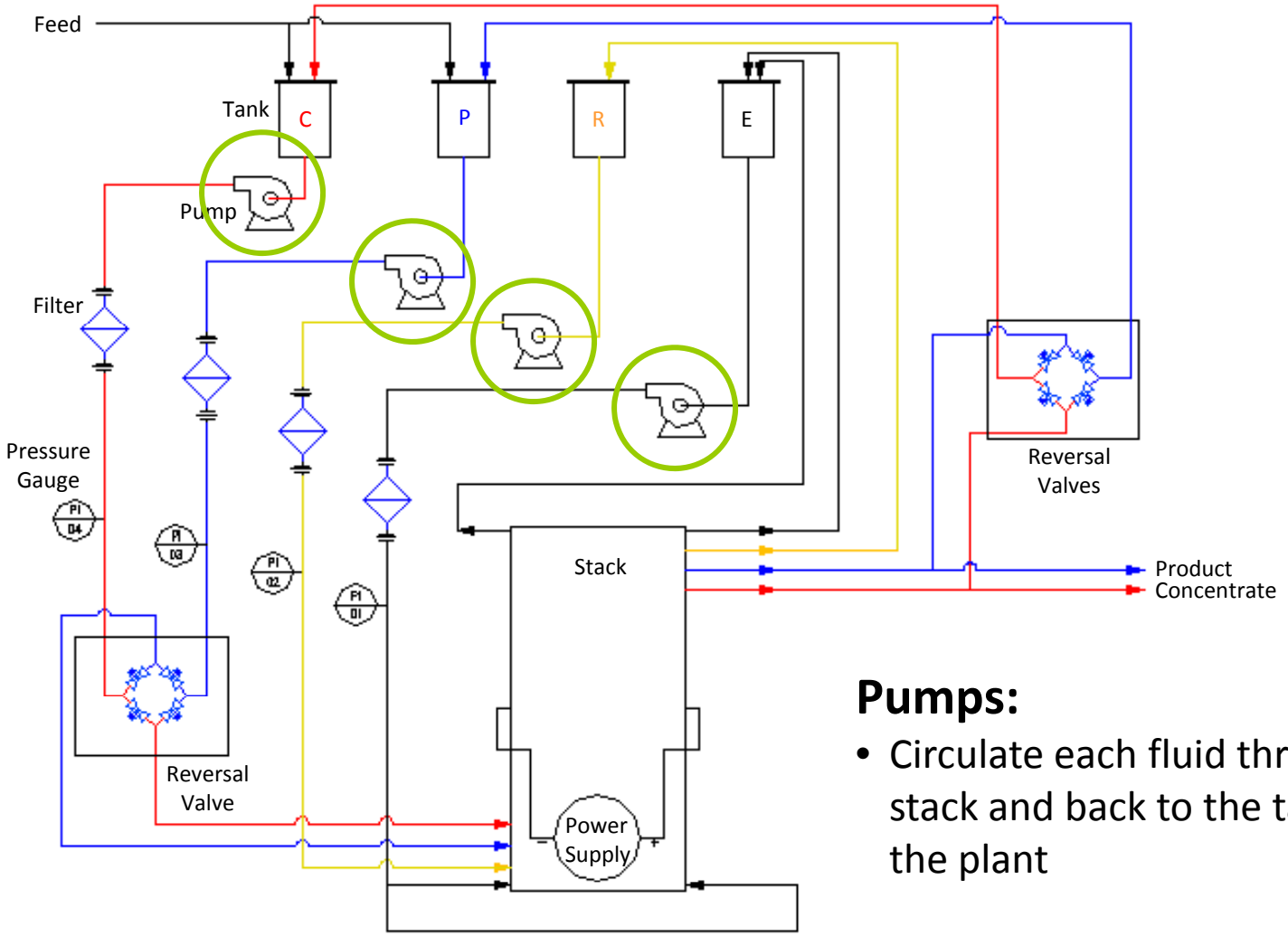
EDR System Components



Pumps:

- Circulate each fluid through the stack and back to the tank or out of the plant

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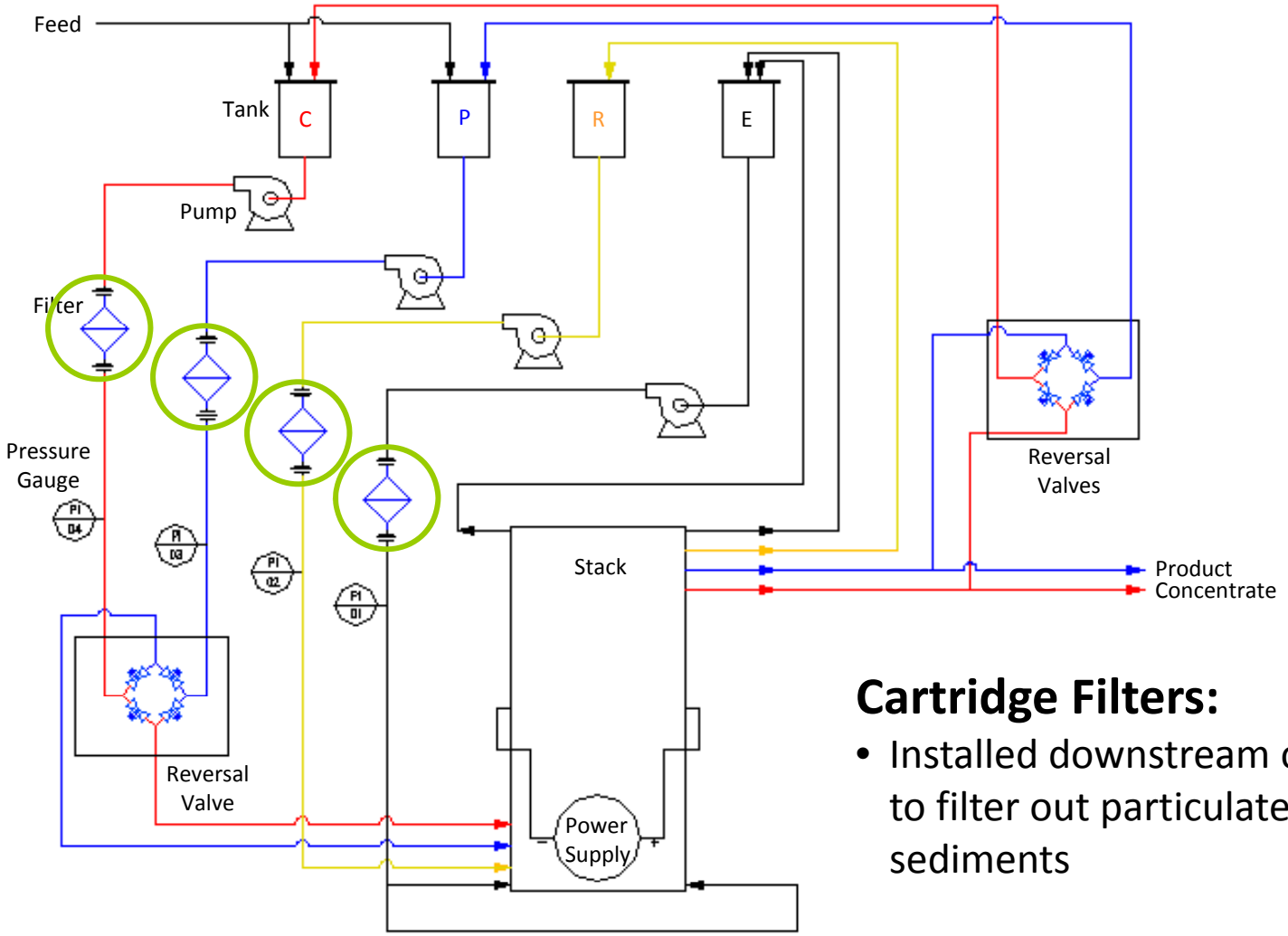
EDR System Components



Cartridge Filters:

- Installed downstream of the pumps to filter out particulates and sediments

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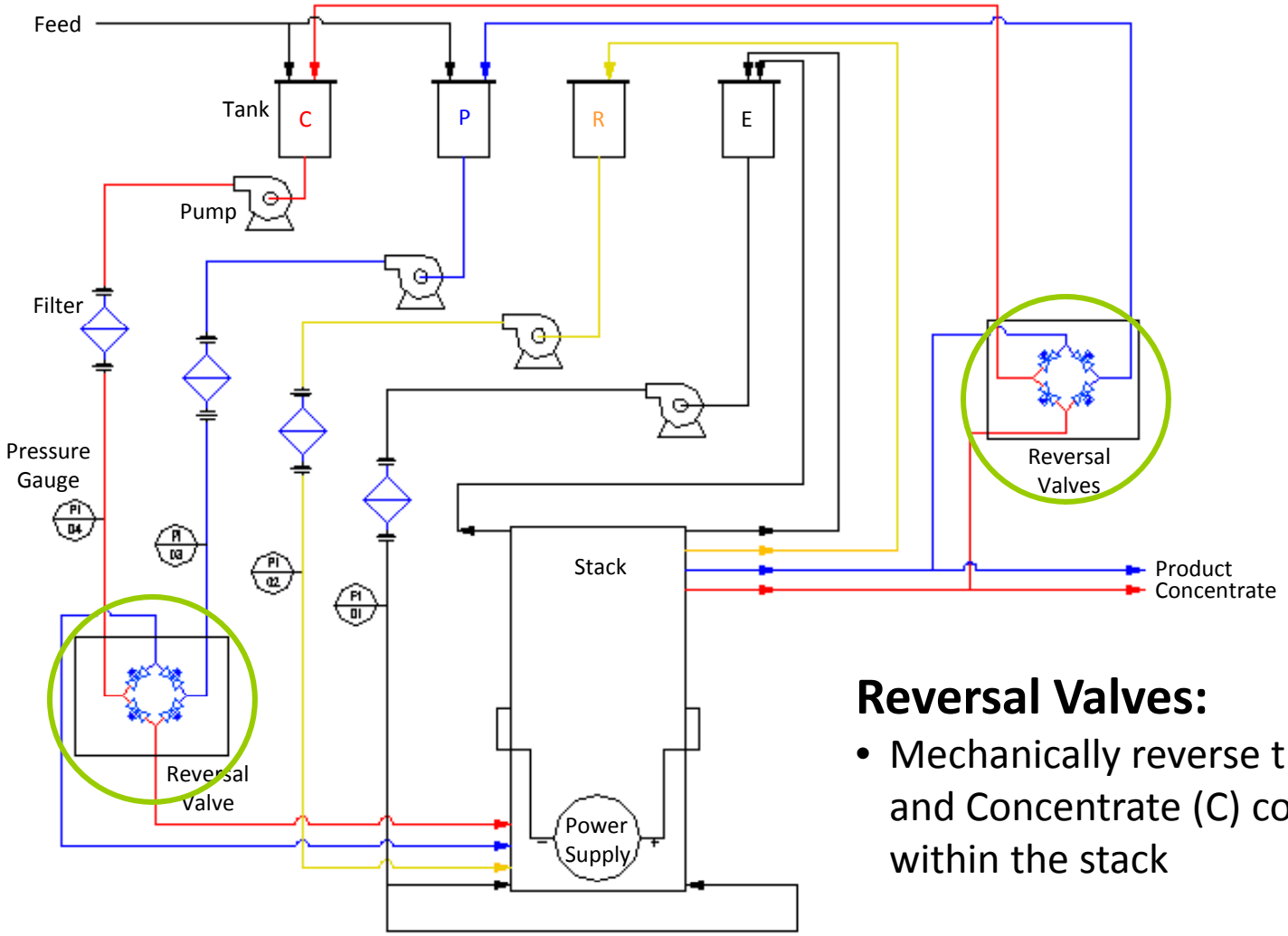
EDR System Components



Reversal Valves:

- Mechanically reverse the Product (P) and Concentrate (C) compartments within the stack

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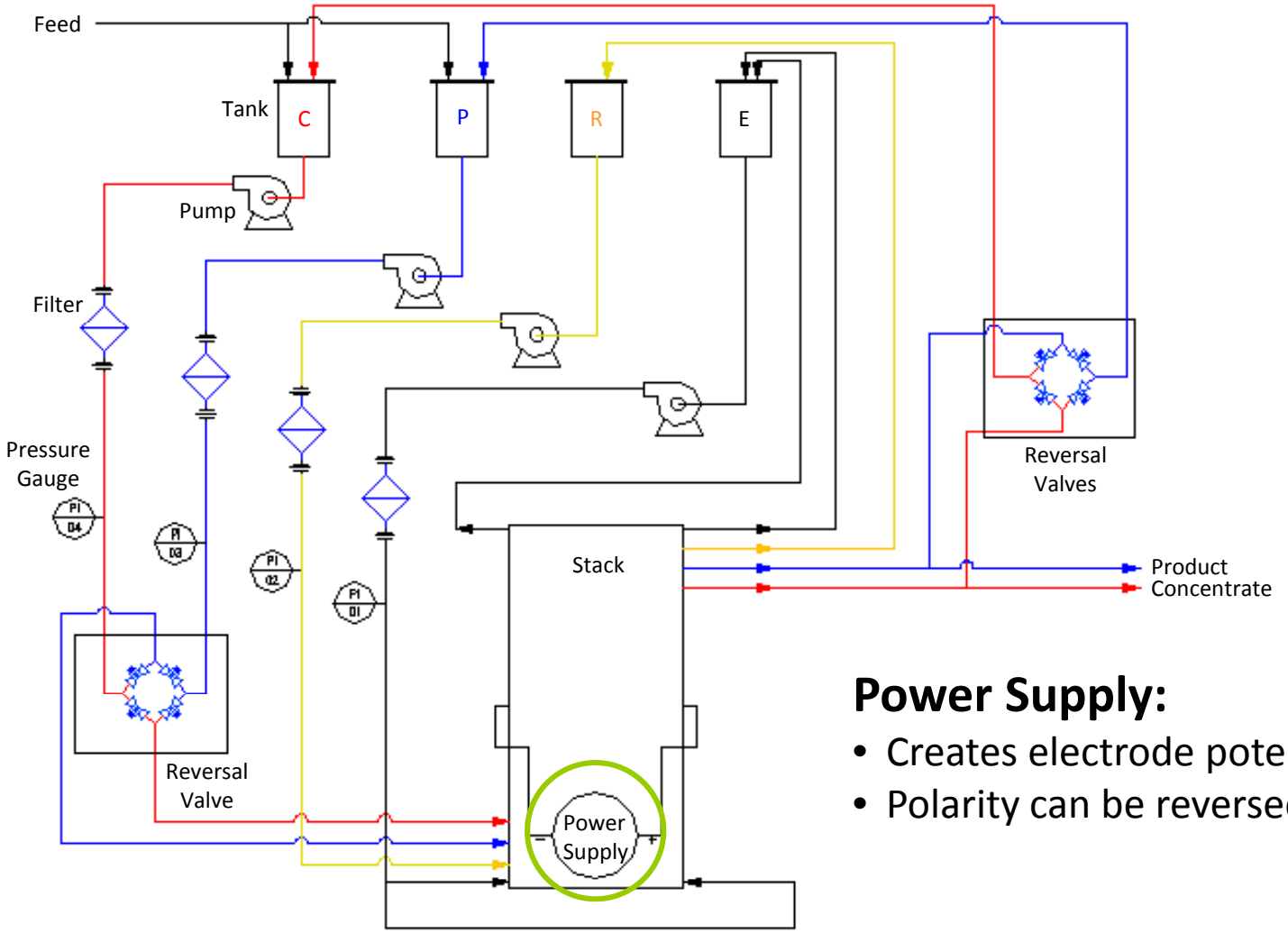
EDR System Components



Power Supply:

- Creates electrode potential
- Polarity can be reversed

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Leak Test

Purpose: to detect and minimize leaks between product (P) and concentrate (C) streams. Performed with ~20mS/cm NaCl solution in all tanks after stack assembly.

General Procedure:

1. Operate the stack without power supply for a set time
2. Measure P and C tank level changes, if level changes are greater than specified threshold, re-torque the stack according to manufacturer's setting
3. Repeat steps 1 and 2 until P and C tank level changes are within the specified threshold
4. Stack passes leak test and ready for operation

Desalting Run

Purpose: to confirm stack performance. Performed with ~20mS/cm in P and C tanks, 0.5 M Na_2S0_4 electrolyte in E tank, and 0.5 M NaCl rinse in R tank after leak test.

General Procedure:

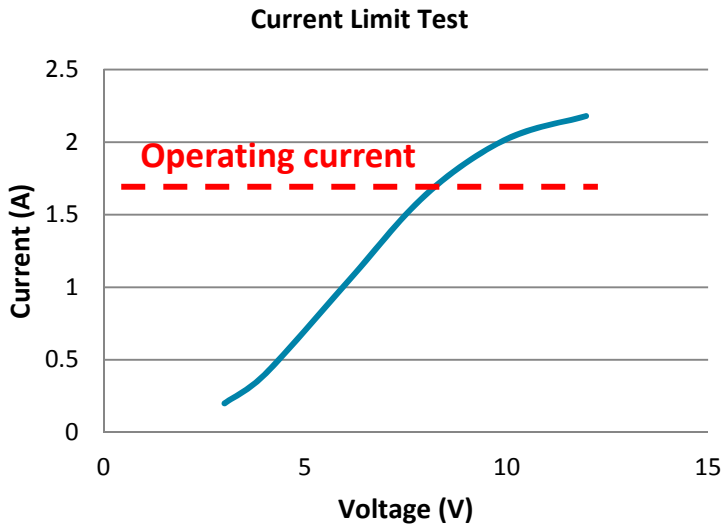
1. Operate the stack with manufacturer specified power supply setting
2. Continue desalting run until P stream reaches 3-5 mS/cm

Current Limit Test

Purpose: to determine operating current. Performed with feed water to be treated in P and C tanks, 0.5 M Na_2S0_4 electrolyte in E tank, and 0.5 M NaCl rinse in R tank after the desalting run.

General Procedure:

1. Operate the stack with power supply settings of voltage at 1V and current at 2A
2. Record current after it stabilizes then increase voltage by 1V. Repeat until specified max voltage is reached
3. Plot voltage vs. current. Find at what voltage current begins to plateau (current limit)
4. Set operating current as 80% of current limit



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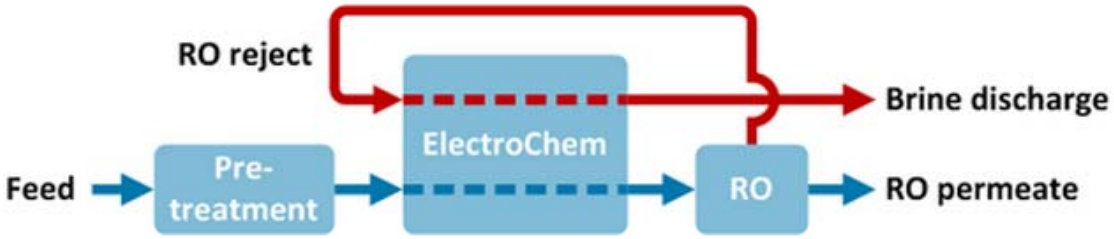
Hybrid Systems

- Remove hardness from reverse osmosis feed water
- Eliminate chemical costs and safety risks associated with chemical softening
- Extremely high recoveries
- Reduce reject volume and disposal



Saltworks' EDR-RO hybrid system

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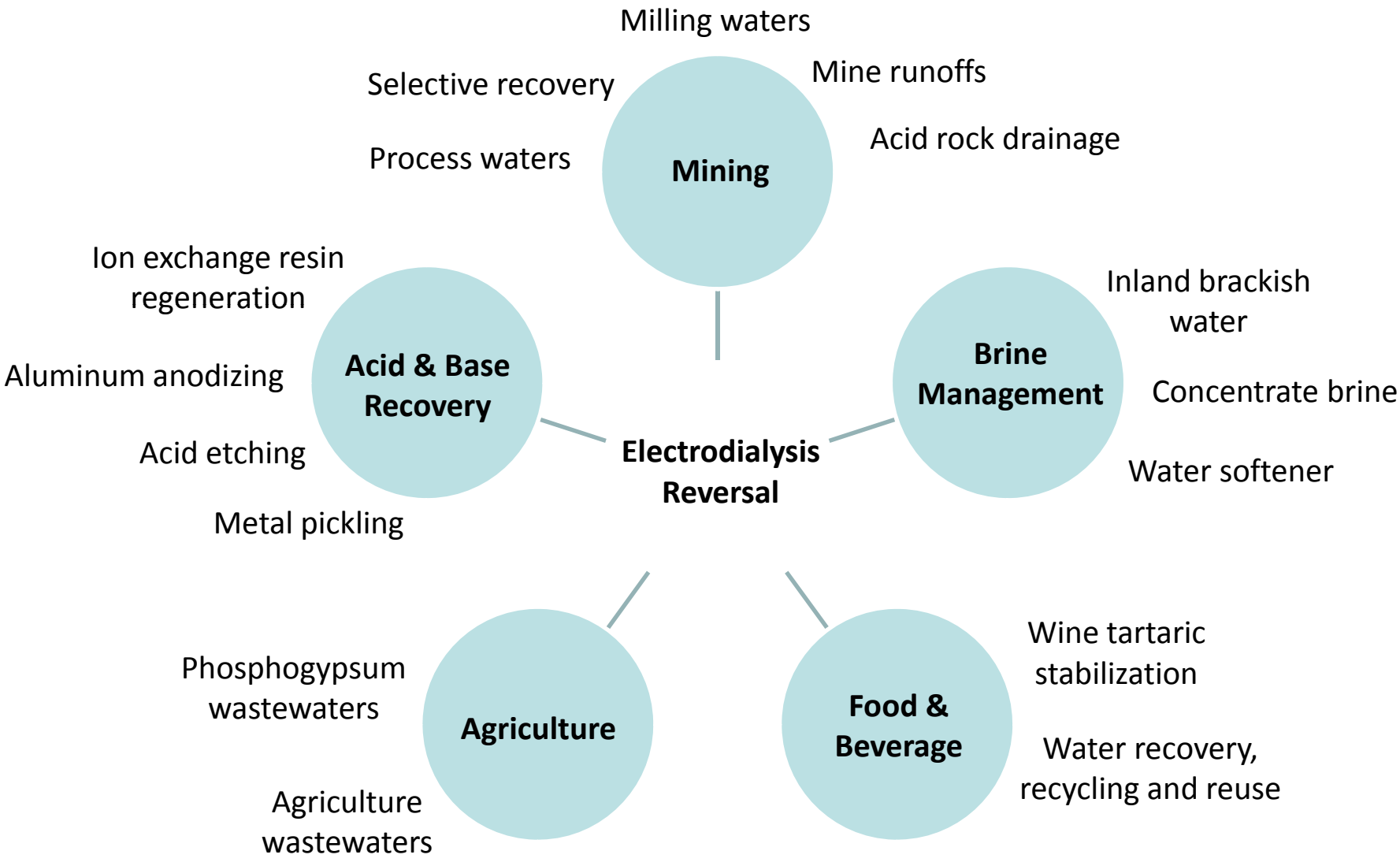
Advanced EDR Applications



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Case Studies

Product	Feed Source	Result	Applications
ElectroChem Acid Recycle System (pAEM/pCEM)	Representative ion-exchange regeneration wastewater	• 91% acid recovery • Acidic wastewater de-acidified • Acid transferred to freshwater (pH 6.5 acidified to pH 0.5)	• Aluminum anodizing, etching, brightening • Battery acid and electronics recycling • Steel pickling; mineral extraction • Ion-exchange resin regeneration
ElectroChem Produced Water Desalter (AEM/CEM)	High salinity EOR produced water	• 100% recovery • 80% total dissolved solids removed	• Water flood enhanced oil recovery water reuse • Polymer recycling and reuse • Produced water desalination
ElectroChem Salt Splitter (mAEM/mCEM)	Highly scaling brackish water	• 93% recovery • 67% reduction in waste brine volume	• Wastewater treatment • Reverse Osmosis hybrids • Water softening • Selective recoveries and separations

All case studies are available at http://www.saltworkstech.com/case-studies/

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