Electro Deionization: EDI Systems.

Electro Pure EDI, Inc.: *High technology water* [tm]

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Introduction: EDI Electro Deionization

1. Where does EDI belong in a Pure Water System?
2. How does EDI work?
3. What makes EDI work better?
4. What makes EDI perform poorly?
5. What is the future of EDI?

EDI Benefits

1. EDI is a continuous process
   - Obtain consistent water quality
   - EDI eliminates batch changeovers

2. EDI eliminates the need for regeneration chemicals
   - EDI eliminates the resulting hazardous waste

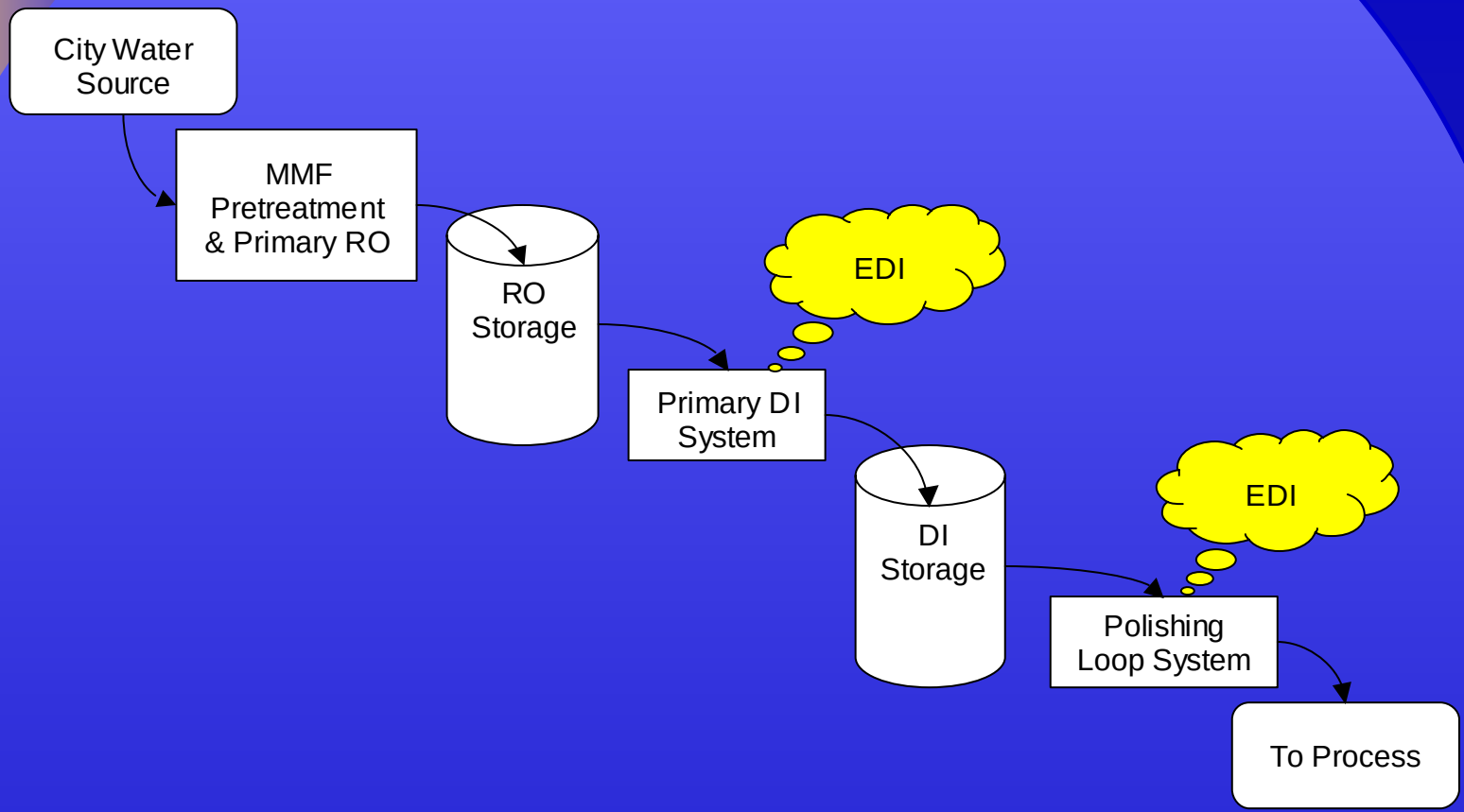
EDI History

- World War II: Development of ED (Japan/US)
- 1950's-1960's: Academic work
- 1960's: "Filled cell ED" work at Ionics & GE
- 1977: Electropure EDI prototype tested at SRI
- 1984: EDI Patent issued to Electropure
- 1985: EDI Patent issued to Millipore
- 1983-87: Understanding of role of water splitting in EDI
- 1988: First Commercial EDI (Electropure)
- 1993: Ionpure sold to USF
- 1996: Glegg builds E-cell^{tm}
- 1998: Market acceptance of EDI begins
- 2000-2001: Rapid growth of EDI in new DI installations and to replace existing DI mixed bed systems

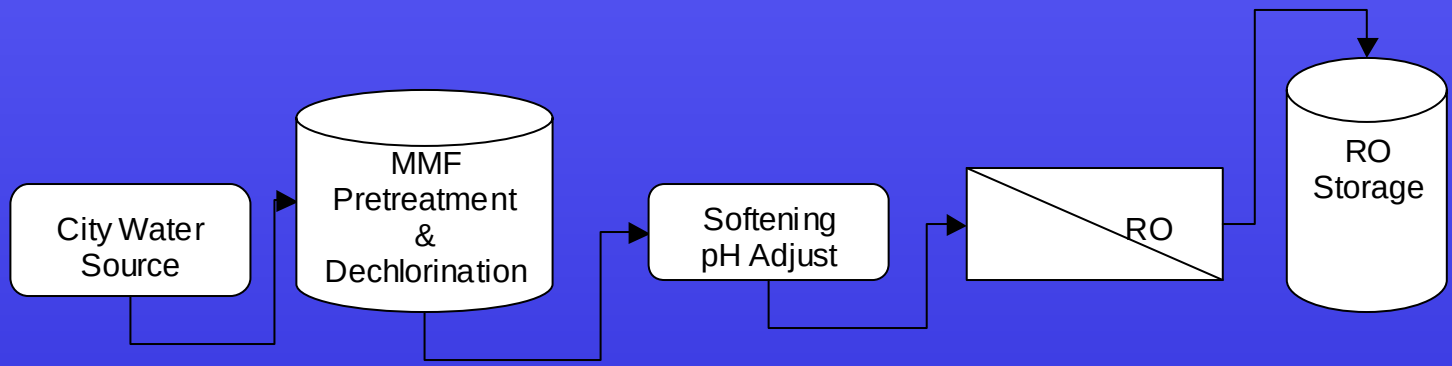
Introduction: EDI Electro Deionization

1. Where does EDI belong in a Pure Water System?

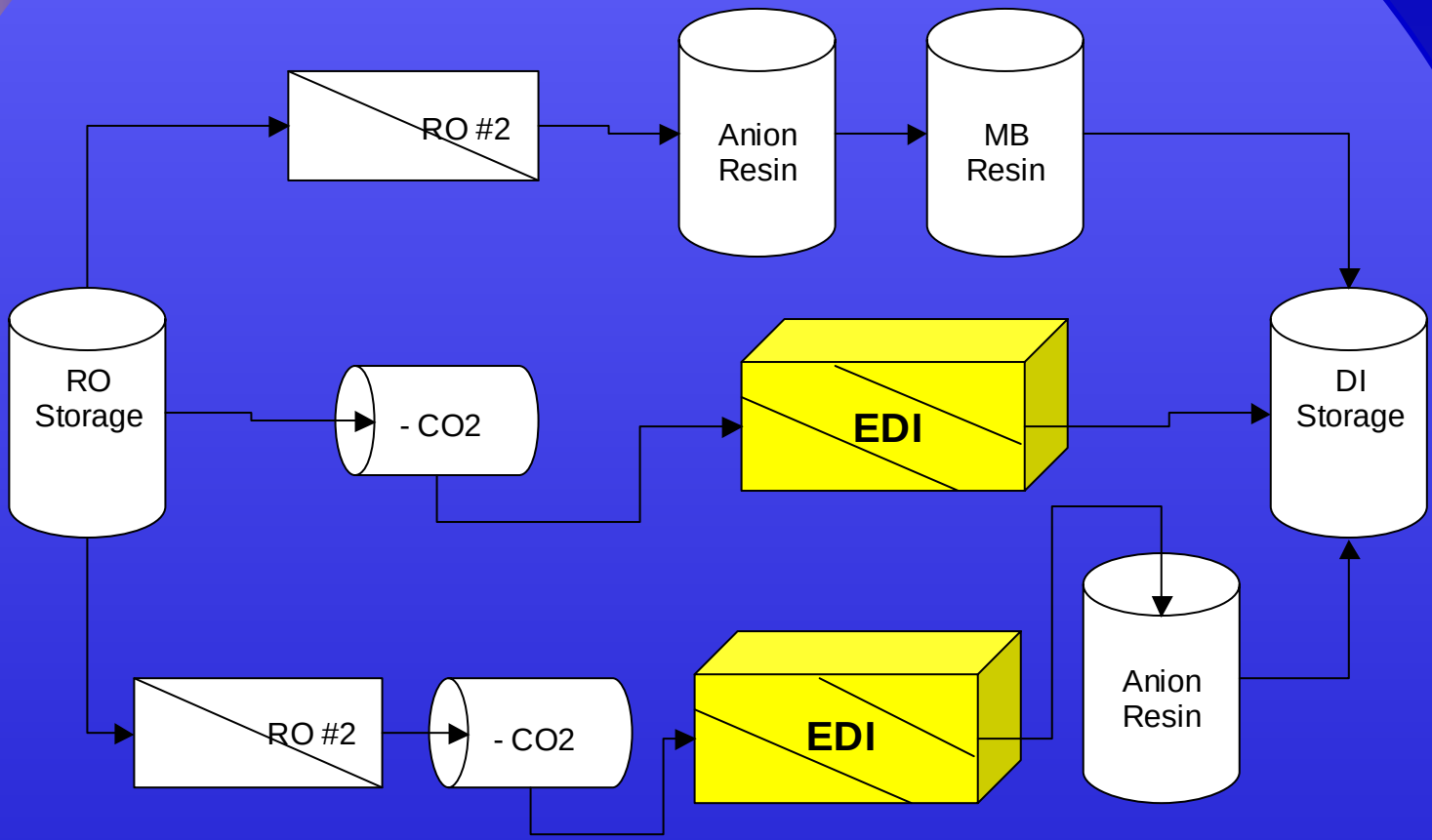
Place of EDI in a Complete System



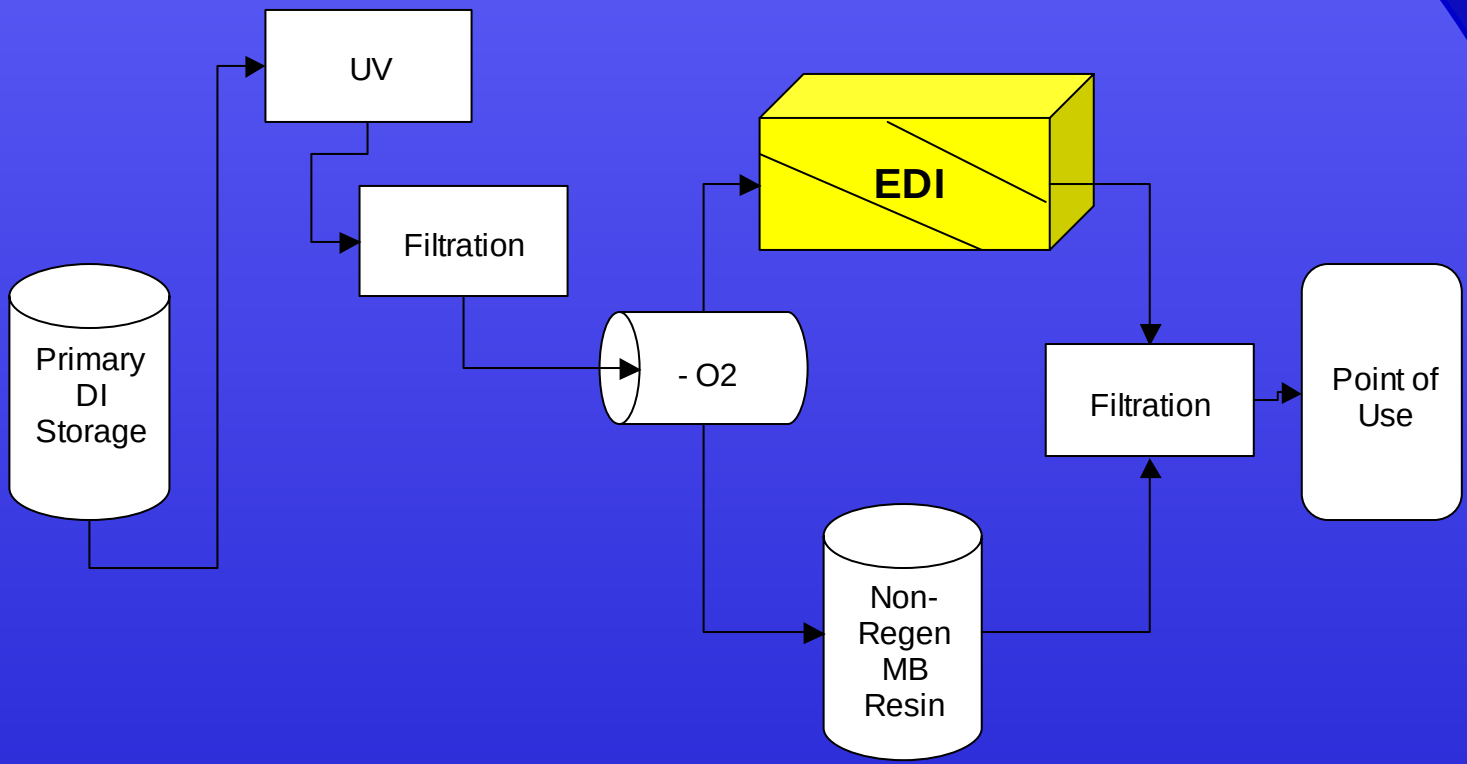
First Stage: RO & Pretreatment



Second Stage: Primary DI System Options



Third Stage: Polishing DI System Options



Introduction: EDI Electro Deionization

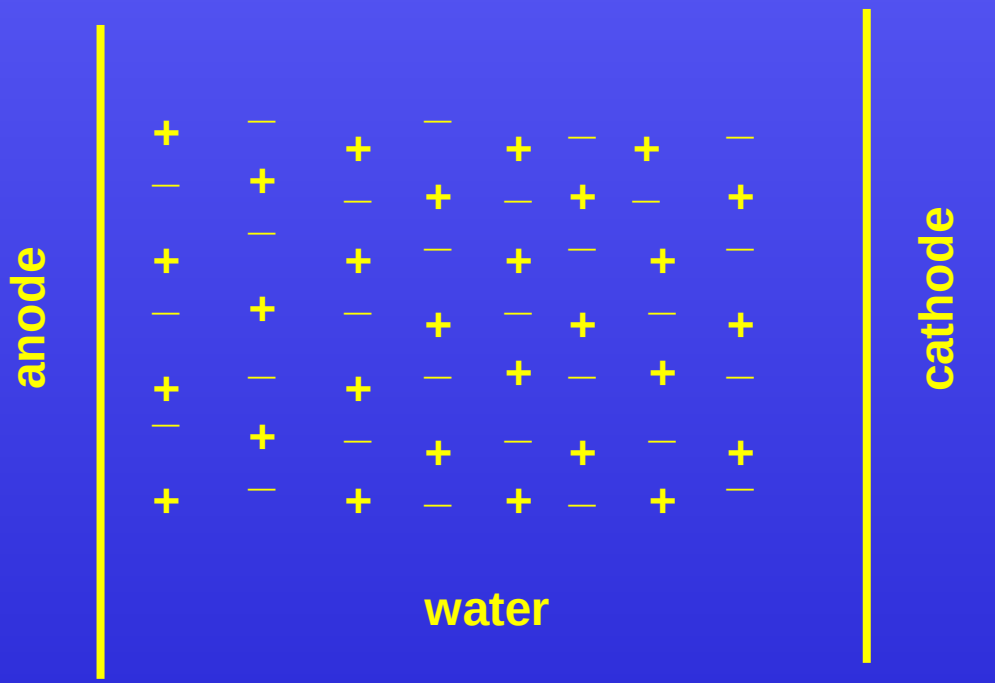
1. Where does EDI belong in a Pure Water System?
2. How does EDI work?

What is Electro Deionization?

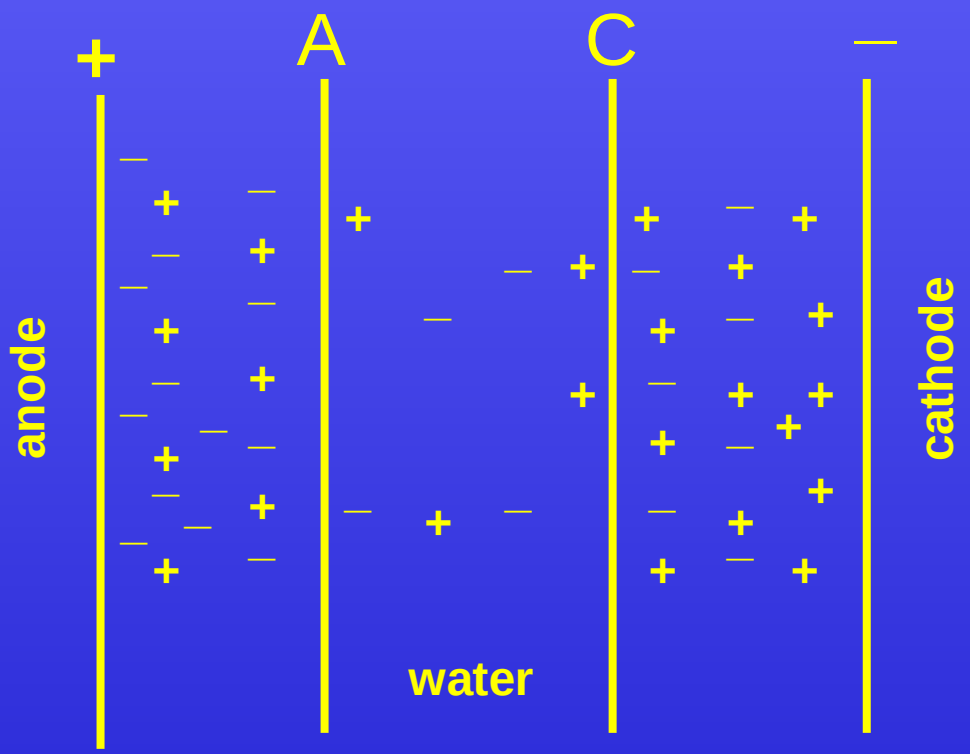
- Modified form of Electro-Dialysis (ED)
- EDI is a continuous Electro-DeIonization process that uses:
  - Ion exchange resin
  - Ion selective membranes
  - DC electricity as a driving force

… to produce high-quality DI water

ED Electro-Dialysis



ED Electro Dialysis



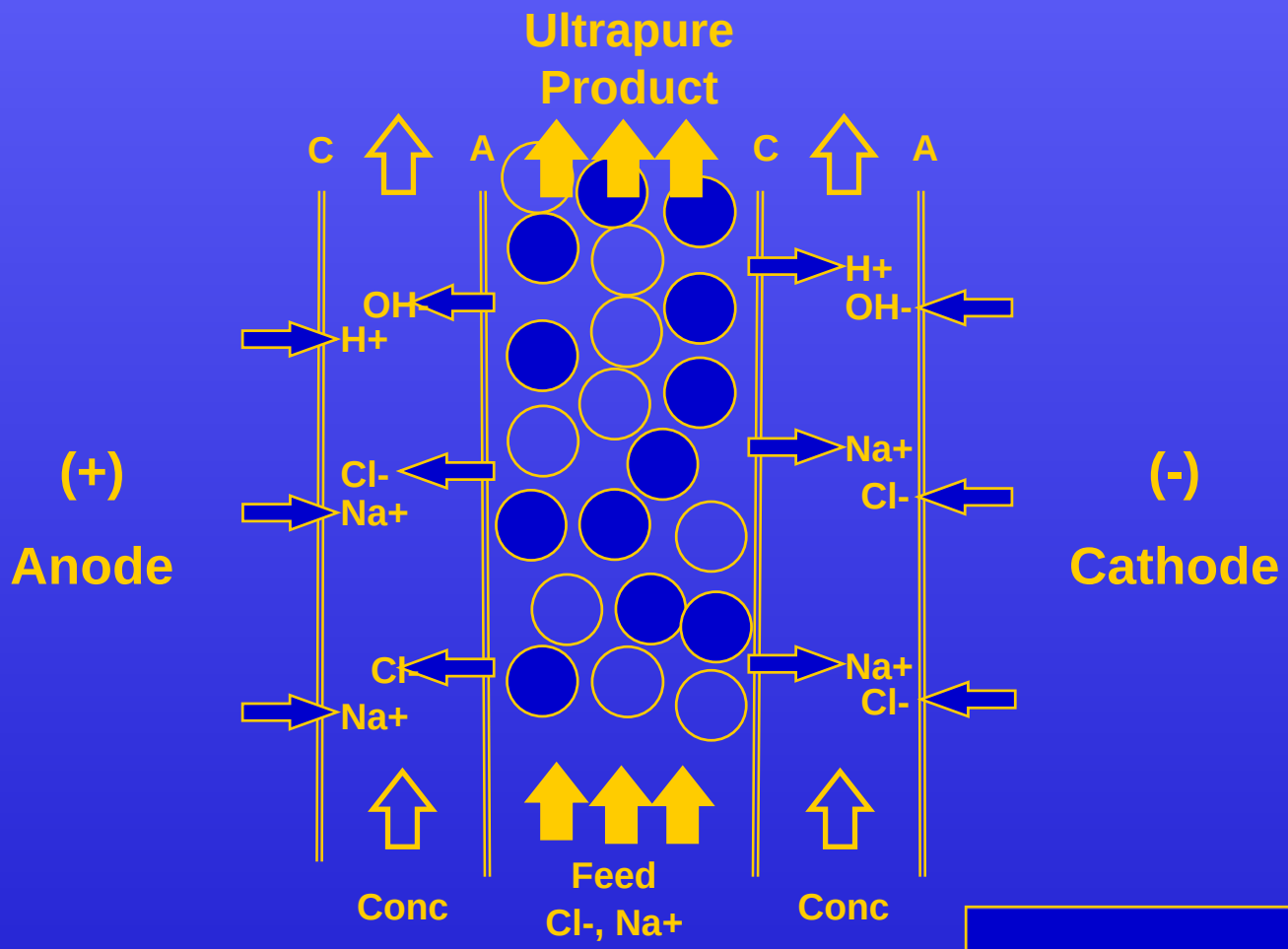
ED limitations for Deionizing Water

- Operation of ED is limited by the low diffusion velocity of ions in water
- The purer the water (high resistivity), the more difficult it becomes to remove ions by electrical voltage
- Residence time in an ED module is too limited to fully remove ions

ED transforms into EDI

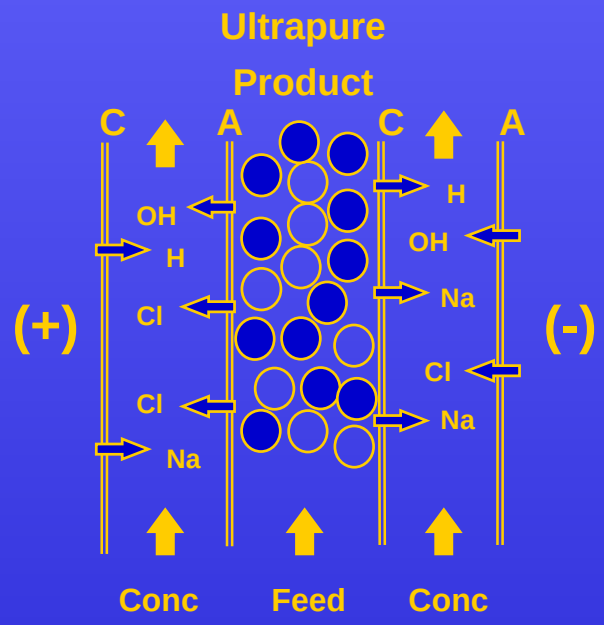
- Solution:
  - Add ion exchange resin between the ion selective membranes
- Benefits:
  - IX Resins trap ions and extend ion residence time by 100x
  - IX Resins provide mobility conduit
  - IX Resins allow efficient splitting of water to form H+ and OH- locally

Electropure EDI Technology

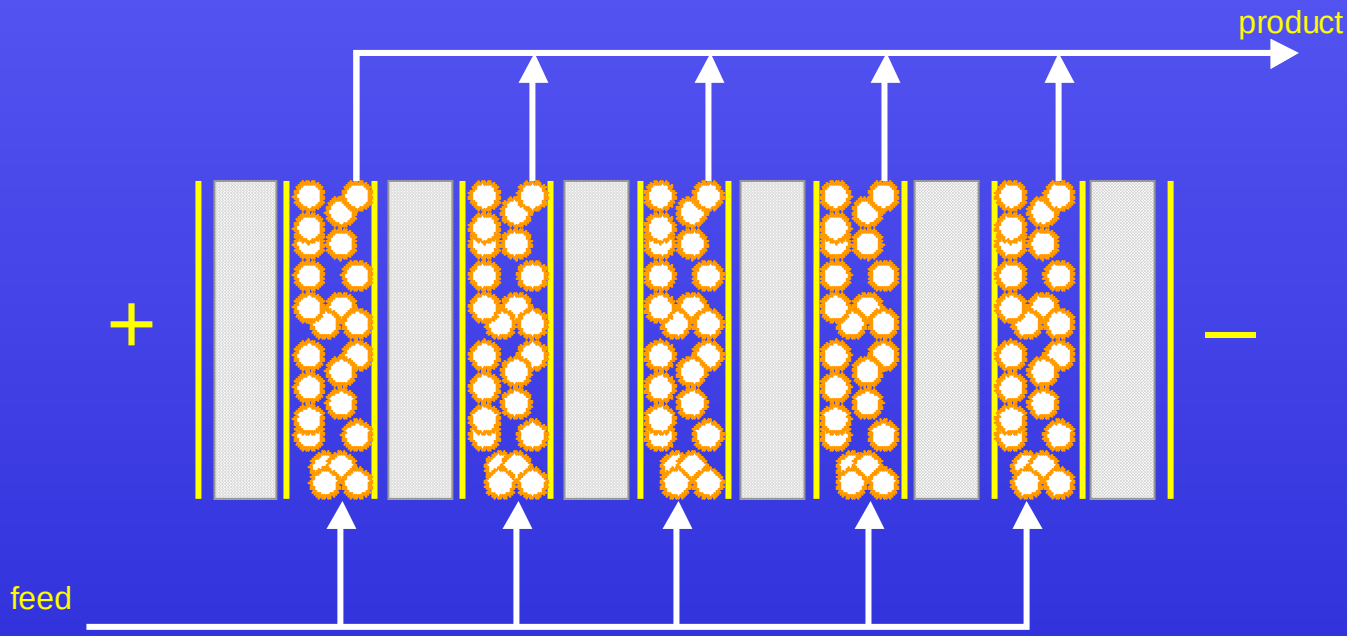


Electropure EDI Technology

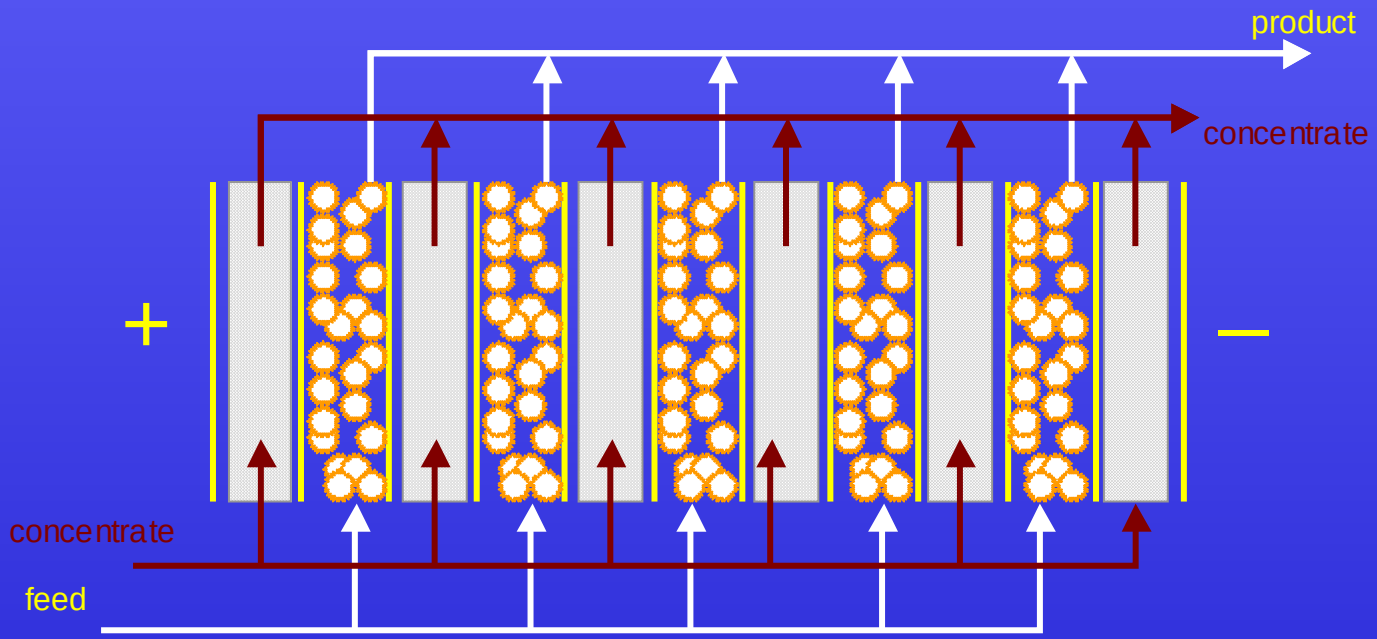
- Ions removed continuously
- Resins in Steady State (no regen)
- No chemicals
- Upflow design
- Thin cells for better ion removal
- Mixed bed resins for best silica removal



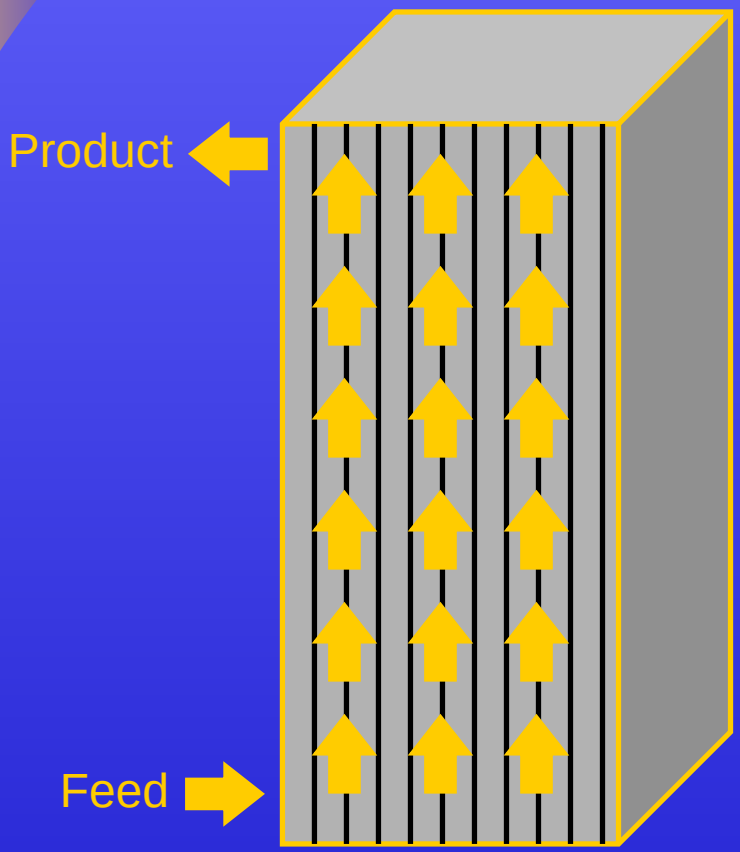
EDI Module: multiple cells in parallel



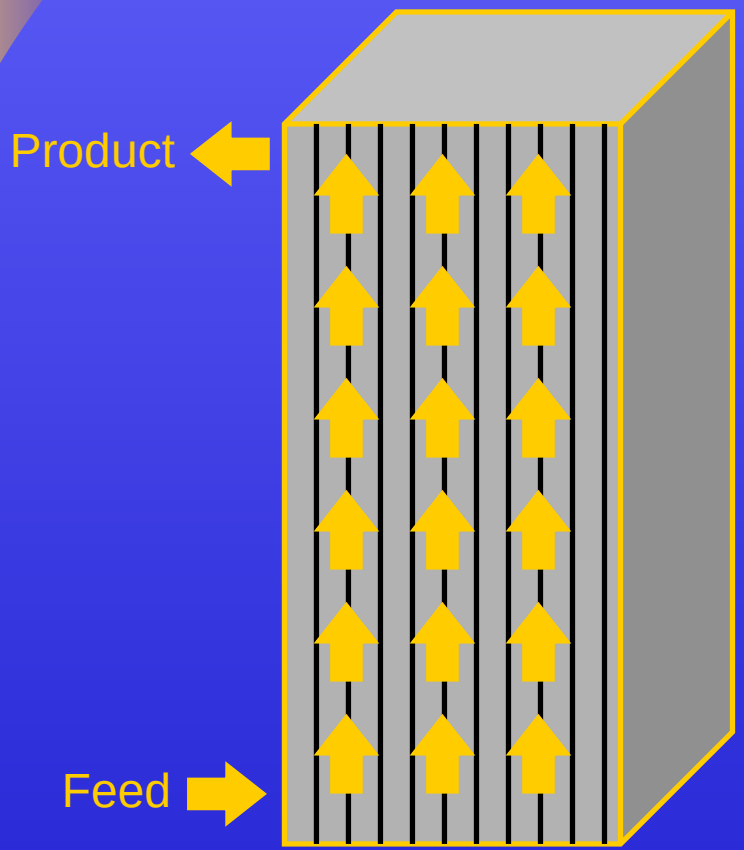
EDI Module: multiple cells in parallel



XL by Electropure™



EDI Technology



"POLISHING BED"

REMOVAL OF

CO_2, SILICA, BORON

"WORKING BED"

REMOVAL OF CONDUCTIVITY

XL by Electropure™

- Simple Systems: No Concentrate Recirculation
- Small, compact modules
- Lightweight
- Patented Design
- Easy to Connect
- Produces Water up to 18,1 Megohm.cm

EDI Module

XL-500

XL-100- S

XL-500-HTS

XL by Electropure™

- Variety of Module Sizes Available

XL by Electropure™

	Product Flow
XL-500	1,3-2,3 m^3/h
XL-400	0,7-1,5 m^3/h
XL-300	300-900 l/h
XL-200	100-300 l/h
XL-100	50-150 l/h

Large EDI Systems

- Systems up to 100 m^3/hr or more
- Array modules in parallel, like RO, on skid

150 gpm Semiconductor System

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3. What makes EDI work better?

What makes EDI work better?

- “Easy” ions in feed water
  - Na^+, Cl^-, etc.
- Fewer ions in feed water
- Proper voltage driving force
  - depends on %recovery and temperature
- No oxidizers, no metals, no debris, no organics (TOC)
- Good internal pressure balance
- Proper and Simple system design

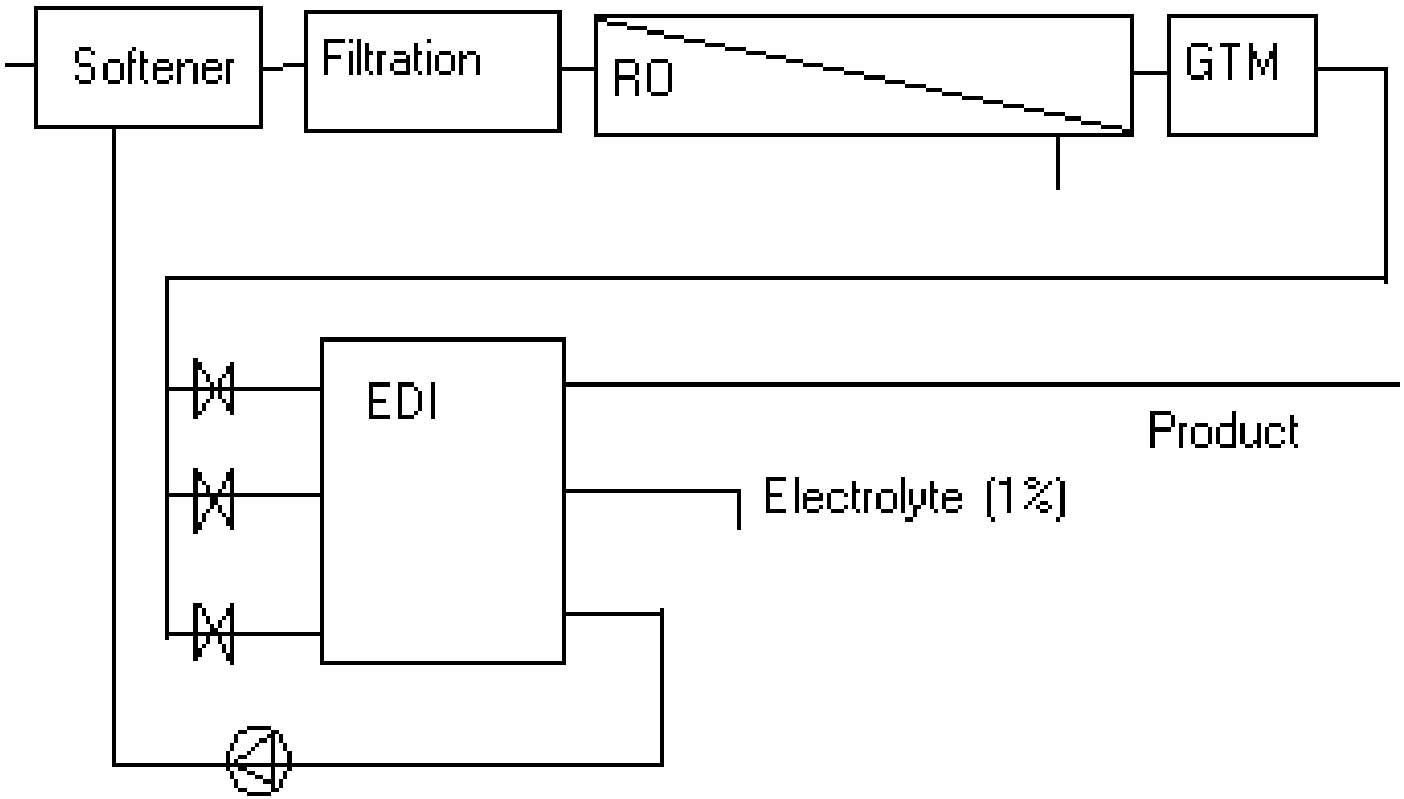
EDI Performance: Conductivity

- Typical XL Performance: 17.0-17.5 Megohm.cm
- Best XL Field Performance: 17.9-18.1 Megohm.cm
- Reduces Ion Load on Mixed Bed Polisher
- Keys to Performance….

Keys to EDI Performance

- Proper Pretreatment
- Proper Feedwater Constituents
- CO_2 under 5 ppm
- Minimum Oxidizing Agents
- Periodic Torqueing

Simple System Design



Silica Numbers

- RO Feed: 5-70 ppm
- RO Silica Rejection: 99.7% per Hydranautics (CPA4: 2x Chloride)
- Silica EDI Inlet Maximum: 0.5 ppm
- 20 ppm - 99% System - 0.2 ppm to EDI
- XL: typical 88-92% by Hach 5000 with 200 ppb feed
- …. 20 ppb feed to MB polisher
- …. 1-3 ppb from MB polisher

What makes EDI perform poorly?

- Oxidizers hurt lifetime (O_3, Cl_2)
- Irreversible metal ion adsorption (Fe^{+3}, Mn)
- High feed conductivity (inefficient)
- Voltage too high/too low (inefficient)
- Ions with “fluffy” charge are hard to remove
  - CO_2 competes with SiO_2 and Boron
- Organic contamination (requires module cleaning)
- High hardness in feed will cause scale (requires module cleaning)

EDI Lifetime

- Economic: 3 years
- Actual:
  - *“Depends on Pretreatment, just like RO”*
- Maximum: 7-8 years

The future of EDI?

- Predictions
  - EDI will parallel RO experience
  - Early adopters will have advantage
  - EDI will replace all batch resin systems
  - Improvement in water product quality
  - More robust to CO_2
  - More effective at SiO_2 removal
  - Specialization of products by industry/market need
  - System skills developed by Customers/users will greatly enhance performance in the field

Summary: EDI Electro Deionization

1. Where EDI belongs in a Pure Water System...
2. How EDI works...
3. What makes EDI work better...
4. What makes EDI perform poorly...
5. What the future of EDI is…

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