Electro Deionization: EDI Systems.

Electro Pure EDI, Inc.: *High technology water*™

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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™
- 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

City Water Source → MMF Pretreatment & Primary RO → RO Storage → Primary DI System → DI Storage → Polishing Loop System

EDI

To Process
First Stage: RO & Pretreatment

City Water Source → MMF Pretreatment & Dechlorination → Softening pH Adjust → RO → RO Storage
Second Stage: Primary DI System Options

- RO #2
- Anion Resin
- MB Resin
- RO Storage
- EDI
- DI Storage
- Anion Resin
- RO #2
- - CO2
- EDI
- - CO2
- RO Storage
Third Stage: Polishing DI System Options

- Primary DI Storage
- UV
- Filtration
- O2
- Non-Regen MB Resin
- EDI
- Filtration
- Point of Use

www.cswaters.co.kr Electro Pure EDI
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

anode

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water
cathode
ED Electro Dialysis

Anode

Cathode

Water
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

Feed

Na+
H+
Cl−
OH−
Na+
OH−
Cl−
Na+

Ultrapure Product

Ultrapure Product

Conc

Cl−, Na+

Conc

(+)
Anode

C

A

H+
OH−
Cl−
Na+

(−)
Cathode

C

A
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
EDI Technology

“POLISHING BED”
REMOVAL OF
CO2, SILICA, BORON

“WORKING BED”
REMOVAL OF CONDUCTIVITY

Feed → Product

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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

www.cswaters.co.kr  Electro Pure EDI
XL by Electropure™

- Variety of Module Sizes Available
### Product Flow

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<tr>
<th>Model</th>
<th>Flow Rate</th>
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<tr>
<td>XL-500</td>
<td>1.3-2.3 m³/h</td>
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<tr>
<td>XL-400</td>
<td>0.7-1.5 m³/h</td>
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<tr>
<td>XL-300</td>
<td>300-900 l/h</td>
</tr>
<tr>
<td>XL-200</td>
<td>100-300 l/h</td>
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<tr>
<td>XL-100</td>
<td>50-150 l/h</td>
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Large EDI Systems

- Systems up to 100 m³/hr or more
- Array modules in parallel, like RO, on skid
150 gpm Semiconductor System

Customer Photo: Do Not Distribute
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?
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
- CO2 under 5 ppm
- Minimum Oxidizing Agents
- Periodic Torqueing
Simple System Design

Diagram:
- **Softener**
- **Filtration**
- **RO**
- **GTM**
- **EDI**
- **Product**
- **Electrolyte (1%)**
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 (O₃, Cl₂)
- Irreversible metal ion adsorption (Fe³⁺, Mn)
- High feed conductivity (inefficient)
- Voltage too high/too low (inefficient)
- Ions with "fluffy" charge are hard to remove
  - CO₂ competes with SiO₂ 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 CO₂
- More effective at SiO₂ 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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