Trends & Developments in Advanced Energy Recovery Technologies for Desalination

May 30, 2013
Agenda

- Who is Energy Recovery “ERI”?  
- Desalination Systems  
- The PX™ Pressure Exchanger Technology  
- SWRO Engineering Design & Optimization  
- Retrofit and Expansion Plant Designs  
- Case Studies – PX Installations  
- Centrifugal Pumps & ERD Solutions  
- PX Hands-On
Making Desalination Affordable

WHO IS ENERGY RECOVERY?
Energy Recovery Inc

HEADQUARTERS/MANUFACTURING/CERAMICS
San Leandro (San Francisco)
California USA

REGIONAL OFFICES
China, Spain, UAE
Company Profile

**Background**
- Established in 1992, Headquarters in California
- Global Sales and Technical Presence
  - More than 14,000+ Energy Recovery Devices & Pumps Installed/Contracted
  - Saving more than 10 Billion kWh of Energy per Year
- More than 400 OEMs
- PEI acquisition in 2009

**Technical Expertise**
- Highest Efficiency, Durability and Reliability ERDs
- Precision Manufacturing and Ceramics Expertise
- 24/7 Service and Support
- Technical Review, On-site Commissioning, Start-up, Training
- Best-in-it’s-Class ERD and Pump Solutions
State-of-the-Art, Materials Science Manufacturing

Creating advanced ceramics components requires specialized equipment, a fully equipped materials lab, engineers, and optimized processes.
Over 400 Clients
Desalination Plant Capital & Operating Costs

Capital Expense 43%
Operating Expense 57%

ASSUMPTIONS
- Power Cost USD/kWh: 0.09
- Debt Equity Ratio: 80/20
- Debt Interest Rate: 8%
- Equity ROI: 18%
Operating Expenses — Breakdown

- Power: 41%
- Operating Margin: 17%
- Parts Replacement: 13%
- Membranes: 8%
- Chemical / Consumables: 9%
- Labor, G&A: 9%
- Office: 3%

Perth Seawater Desalination Plant 2008
Power Use — Breakdown (Seawater RO)

- Reverse Osmosis Process: 68%
- Intake: 15%
- Pre-filtration: 8%
- Permeate Treatment: 1%
- Permeate Distribution: 7%

RO power consumption is approximately 20% (up to 45%) of total SWRO cost

Source: Affordable Desalination Collaboration, 2008
Making Desalination Affordable

DESALINATION SYSTEMS
Desalination Systems

1980
- Francis Turbine
- Dyprex
- Pelton Turbine

1990
- Turbocharger

2000
- Rotary Exchanger
- Piston Exchanger

2010
Seawater RO: Before Energy Recovery Devices

Issues: high pumping costs, wasted energy, lack of optimization
Seawater RO: Pelton Wheel/Francis Turbine Energy Recovery Devices

Hydraulic --> Mechanical --> Hydraulic
Seawater RO: ERI TurboCharger™
Energy Recovery Devices
Seawater RO: ERI TurboCharger™
Energy Recovery Devices
Seawater RO: ERI PX Pressure Exchanger™ Energy Recovery Devices

30 PSI (2.0 bar)
500 GPM
(114 m³/h)

30 PSI (2.0 bar)
200 GPM (46 m³/h)

HIGH PRESSURE PUMP

920 PSI (63.4 bar)
500 GPM (114 m³/h)

920 PSI (63.4 bar)
300 GPM (68 m³/h)

CIRCULATION PUMP

900 PSI (62.0 bar)
300 GPM (68 m³/h)

5 PSI (0.4 bar)
200 GPM (46 m³/h)

14.5 PSI (1.0 bar)
300 GPM (68 m³/h)

PX ARRAY
Seawater RO: ERI PX Pressure Exchanger™ Energy Recovery Devices
Seawater RO: Positive Displacement Energy Recovery Devices

Smaller pump, high constant efficiency, flexible operation

Hydraulic --> Hydraulic
Isobaric energy recovery systems have high efficiency regardless of system size.
An Isobaric High Efficiency Energy Recovery Solution

THE PX™ PRESSURE EXCHANGER™ DEVICE
The PX™ Device

- 2 high-pressure connections
- 2 low-pressure connections
- Ceramic cartridge

rotor/sleeve assembly, end covers
Low-pressure feed water fills rotor chamber, displacing brine

High-pressure brine pressurizes and displaces feedwater

Rotor chamber seals, containing low-pressure feed water

Rotor chamber seals, containing high pressure brine
A Look Inside the PX™ Device
Pressure Vessel

HIGH PRESSURE SIDE

CONCENTRATE SIDE

HIGH PRESSURE SIDE

LOW PRESSURE SIDE

LOW PRESSURE SIDE

SEAWATER SIDE
### Isobaric Technology:

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<td>PX-140S</td>
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</table>
GRUNDFOS

- BMEX Skid
The PX™ Energy Recovery Technology Advantage

• Highest Energy Efficiency Guarantees ~ 97.2%
  ➢ Performance never degrades over time
  ➢ Saving clients more than $1 billion in energy costs alone each year!

• Uptime: 99.8% Availability Advantage
  ➢ Zero unplanned downtime can offer average savings of $15 million over the life of a plant*
    • *estimated for a typical 100K m3/d plant
  ➢ PX energy recovery devices are never responsible for plant down-time or loss of production

• Lowest Lifecycle Costs
  ➢ Best Economics: Highest Return on Investment
Energy Recovery Device – PX™ Technology Advantages

• Durability – Designed for a lifetime
  ➢ Designed for plant lifetime (25+ years minimum)
  ➢ Robust ceramics- improved formulation
  ➢ Never corrodes or fatigues

• No Scheduled Maintenance

• Modularity & Flexibility
  ➢ Scalable (limitless capacity)
  ➢ Flexible operations (recovery/flows)
  ➢ Built-in redundancy
  ➢ Flexible orientation
Energy Recovery Device – PX™ Technology Advantages

Quickest Start-up

• Installation time - Starts up within days
  - 5-6 times faster than other piston-type isobaric ERDs
  - Weeks versus months

• No controls, wires or electrical connections
• All devices automatically adjust speed to match flow
• Lightweight/Small footprint
Energy Recovery Device – PX™ Technology Advantages

• Rotor
  - One moving part Hydrodynamic bearing
  - Automatic speed adjustment
  - No material to material contact

• State-of-the Art Materials
  - Ceramics
  - Extremely durable material (3X steel hardness)
  - Never corrodes
  - No fatigue
The Latest Generation: Q Series PX-Q300

Benefits
• Highest Efficiency Guarantee – 97.2%
• Lowest Lifecycle Costs- Best ROI
• 99.8% Uptime – zero planned down-time
• Ease of Installation – minimal footprint

Features
• Quietest PX technology – Below 81dB
• All other nice features of the PX device family..
SWRO ENGINEERING DESIGN & OPTIMIZATION
ERI Services

ERI is Pleased to offer the following Services:

- P&ID Reviews
- Control Logic Reviews
**Energy Recovery Power Models and Selector Tools**

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**1/4/2008**

**PX® Energy Recovery Device System Analysis**

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<tr>
<th>FLOW</th>
<th>US gpm</th>
<th>m3/hr</th>
<th>m3/day</th>
<th>PRESSURE</th>
<th>psi</th>
<th>bar</th>
<th>PRESSURE</th>
<th>m3/day</th>
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**FLOW US gpm**

- 408
- 222
- 186
- 222
- 408
- 183
- 224
- 224

**FLOW m3/hr**

- 93
- 50
- 42
- 50
- 93
- 42
- 51
- 51

**FLOW m3/day**

- 2,222
- 1,211
- 1,012
- 2,222
- 2,222
- 1,000
- 1,222
- 1,222

**PRESSURE psi**

- 24
- 24
- 943
- 943
- 0
- 0

**PRESSURE bar**

- 1.7
- 1.7
- 65.0
- 65.0
- 0.0
- 0.0

**QUALITY mg/l**

- 39,000
- 39,000
- 39,000
- 41,025
- 40,103
- 200
- 72,751
- 70,745

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**PX UNIT PERFORMANCE**

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<th>PX model</th>
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<td>m3/hr</td>
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<tr>
<td>PX lubrication flow</td>
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<td>Differential pressure HP side</td>
<td>bar</td>
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<td>Differential pressure LP side</td>
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<td>PX efficiency</td>
<td>%</td>
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<td>97.2%</td>
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<td>PX mixing at membrane feed</td>
<td>%</td>
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<td></td>
<td>2.8%</td>
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<td>Operating capacity</td>
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<td>Energy recovered</td>
<td>kW</td>
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**HIGH PRESSURE PUMP**

| HP pump efficiency | % |
|                   | 68% |
| HP pump motor efficiency | % |
|                   | 92% |
| HP pump power consumed | kW |
|                   | 118.0 |

---

**CIRCULATION / BOOSTER PUMP**

| Circulation pump efficiency | % |
|                            | 65% |
| Circulation pump motor efficiency | % |
|                            | 91% |
| Circulation pump VFD efficiency | % |
|                            | 97% |
| Total circulation pump power | kW |
|                            | 3.9 |

---

**SYSTEM FEED PUMP**

| kW |
| 0.0 |

---

**INPUT DESCRIPTIONS**

- Units Metric or English
- Manual or auto efficiencies
- Permeate flow
- RO recovery rate
- RO feed pressure
- Membrane differential pressure
- PX LP discharge pressure
- Feedwater salinity
- Cost of power
- HP pump efficiency
- HP pump motor efficiency
- Circulation pump efficiency
- Circulation pump VFD efficiency
- PX device design margin

---

**INPUTS**

- M or E
- M
- m or a
- a

---

**PX SYSTEM POWER RESULTS**

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<tr>
<th>kW</th>
<th>kWh/m3</th>
<th>$/year</th>
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<td>122</td>
<td>2.93</td>
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</table>

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**Warnings**

- NONE

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**Suggestions**

- NONE

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**Power cost saved with PX $/year**

- $122,510
Flow Control—Low Pressure

LP flow rate set by discharge flow control valve
Flow Control—High Pressure

HP flow rate set by booster pump
Permeate flow rate set by high pressure pump and membranes
SWRO Engineering Design

PX Flow Control
- The PX™ works like two parallel pipes
- High-pressure flow rate controlled by booster pump
- Low-pressure flow rate controlled by discharge valve
- High-pressure pump flow is permeate flow
- All three main flows are independent
- HP and LP flows must both be metered and controlled
SWRO Engineering Design

Pressure Control
- LP valve does not directly affect membrane pressure
- System pressure determined by membrane condition, feed temperature and feed salinity
- Supply pressure changes cause LP flow rate changes
- PX™ LP out pressure must be maintained above minimum
SWRO Engineering Design

Water Recovery

• Membrane water recovery = I / F
• System water recovery = I / A
• Membrane recovery = system recovery if PX™ LP flow = PX HP flow
SWRO Engineering Design

- PX Lubrication – High Pressure Flow Through Hydrodynamic Bearing
  - Lubrication = HP pump – permeate = C – I
  - Lubrication = PX HP in – PX HP out = G – D
  - Lubrication = PX LP out – PX LP in = H – B

Lubrication flow rate dictated by system pressure and temperature and PX seals
SWRO Engineering Design

Mixing Effects—Lead Flow or “Overflush”
SWRO Engineering Design

Mixing

- Feed water salinity increase @ 40% recovery = 2.5%
- Operating pressure increase = 1.3 bar
- Operator Options:
  - Accept pressure increase (= 2°C feed temp decrease)
  - Decrease recovery by 2%
  - Increase low-pressure supply to the PX™ by 5%

Paper presented at EDS Marrakech
Caramondani 40,000 m³/D SWRO Plant
Engineering Design Summary

- HP and LP flows are independent
- Good flow control: stay within limits of PX™ unit
- Constant PX device feedwater pressure
- Get the air out
- Equal flow to all PX units in arrays
- Maintain adequate back-pressure
- Lowering recovery usually improves SWRO performance
RETROFIT AND EXPANSION PLANT DESIGNS
Retrofit

- Retrofit = modifying an existing plant by adding newly developed devices that were not available when the plant was made.
- Improvements in ERD, membranes and centrifugal pumps designs have enormously reduced the RO Specific Energy Consumption.

![Graph showing energy consumption improvements over time for different locations and devices.](image-url)
Retrofit Benefits

• Highest Efficiency currently available
• Upgrade to the latest advanced technologies widely used today
• Enhance plant performance
• Expand plant capacity and production supply
• Reduce operational costs
  ➢ Significant reduction in energy costs and CO2 emissions.
  ➢ All achieved with minimum additional equipment and reduced civil works.
  ➢ Flexibility, constant efficiency over a wide range, variable recovery rate operating ability.
Retrofit with Isobaric ERD’s

- Before: Original system with Pelton Wheels

SEC: 3.2 kWh/m³
Retrofit with Isobaric ERD’s

- After: Modified system with Isobaric ERD’s

SEC: 2.3 kWh/ m³

28% reduction in energy consumption
Retrofit Case Study

Tordera SWRO Plant, Spain. Expansion Retrofit.

- Original capacity 28,000 m³/d, 4 trains 7,000 m³/d each.
- Expanded capacity 64,000 m³/d. 4 trenes de 16,000 m³/d c/u.
- Recovery 45%, 15 PX-260 units per train

Before: SEC with Pelton:
3.06 kWh/m³

After: 2.56 kWh/m³
16.3% reduction in SEC

Same HPP, new motor, new membranes in the new trains.
Retrofit in two-stage systems

- SWRO system with inter-stage booster pump

SEC: 3.48 kWh/m³
Retrofit in two-stage systems

- SWRO system with inter-stage booster pump

AFTER

SEC: 2.68 kWh/m³
23% reduction

Las Palmas III SWRO Plant, Grand Canary, Spain
Retrofit Case Study

- Las Palmas III SWRO Plant. Retrofit of two-stage system
- Two 7,500 m³/d RO trains combined in a single 15,000 m³/d train.
- 15 PX 220 units
- 48% Recovery

- Original HPP’s and motors were used
- Almost 0.8 kWh/m³ in reduction
- Performed in less than 6 months
- Payback in less than 18 months
Retrofit Case Study

• Palmachim SWRO Plant, Israel – Partial (Hybrid) Retrofit

• Original system
  - 100,800 m³/day, 6 trains 16,800 m³/day each
  - 88% efficiency on Pelton wheels.
  - Feed Booster pump to the HPP with VFD.

• Retrofitted system
  - All the HPP’s, Pelton wheels and electrical motors were keep in place without any modification.
  - 120,000 m³/day, 6 trains 20,000 m³/day each
  - Added flexibility by the Isobaric ER system. Trains can increase their production up to 26,000 m³/day while maintaining the HPP close to its BEP. Additional required feed flow is supplied by the energy recovery system.
  - No additional civil works, wall-mounted installation
  - 8% reduction in SEC.
Retrofit Case Study

- Palmachim SWRO Plant, Israel – Partial (Hybrid) Retrofit
More examples

- Pembroke – Malta 40,000 m³/day
More examples

- Dekhelia - Cyprus 60,000 m³/day
Why a retrofit?

• Undeniable energy savings → Lower cost of water produced
• Extend the life time and/or plant capacity, optimizing and modernizing the plant equipment.
• Improve environmental impact - energy saving programs and reduction of emissions, e.g. “carbon credits”
• Regain competitiveness among newer plants being built with the latest technologies.
• Increase system availability
PX™ TECHNOLOGY INSTALLATIONS
Perth, Australia —
140,000 m³/day (36.9 MGD)

- GWI Award 2007
Environmental Contribution of the Year
Hadera, Israel: 465,000 m³/day

- World’s Largest SWRO Plant in Operation
- 16 Trains of PX-220 devices
Minjur - Chennai, India: 100,000 m³/day

- Minjur Seawater Desalination Plant – Befesa CTA
- 5 Trains of PX devices
Nemmeli - India: 100,000 m³/day
Hamma, Algeria — 200,000 m³/ day (53 MGD)

- Largest membrane trains in the world
- 25,000 m³/ day
Al Shoaibah (Saudi Arabia) — 150,000 m³/day (40 MGD)
Barcelona (Spain) 200,000 m³/ day (53 MGD)
Small to Medium Installations

**MV Pacific Star**
Sun Cruise Ship
(Australia)
- 570 m³/day

**Sharm El-Sheikh**
(Egypt)
- 6,000 m³/day

**La Marina Cope**
(Spain)
- 16,000 m³/day
14,000+ Devices Installed Globally
~ 75% Market Share

Sales Offices
- PX™ Installations

- Headquarters
  San Leandro, California
- Madrid, Spain
- Dubai, UAE
- Shanghai, China

6,300,000 m³/day
12 Billion kWh Energy per year

$1.2 Billion of Savings per year for our clients

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CENTRIFUGAL PUMPS & TURBOCHARGER ERD SOLUTIONS
Core Competences

**Engineering**
- CFD Analysis & Simulation
- Custom Design
- Extensive R&D
- MSU Turbo Machine Lab
- PWR Co-op

**Machining**
- Large VTL
- CNC Lathes
- 5 Axis CNC
- Grinding
- Honing
- Dynamic Balancing

**Assembly**
- Prep & Polish
- QC
- Torque control
- CMM Analysis

**Testing**
- Full Power Performance Testing
- Efficiency Validation
- Hydrostatic test
- Performance baseline
Agile Engineering

1. Customer Requirements
2. Agile Engineering
3. Machining of Hydraulic Passages
4. CNC Programming
5. Performance Test
6. Quality Control
7. Shipment
Manufacturing Capability Expansion
ERI (Centrifugal Technology) Products

**Pumps**
- ERI™ AquaBold™ High Pressure RO Pumps
- ERI™ AquaSpire™ Single-stage Pump

**Energy Recovery Devices**
- Advanced Technology TC (HTC AT)
- AT Advantages now available for the small capacity plants replacing the Turbocharger (HALO)
- Low Pressure Turbocharger (LPT)
TURBOCHARGER GENERAL THEORY
SWRO Engineering Design – Single Stage

• The ERI™ TurboCharger™ device uses brine energy to boost the full feed stream to the RO, thereby reducing the required boost from the high pressure pump.
**Turbo Pressure Boost – Example II.**

- Large SWRO plant, Membrane feed flow 2,453 m³/h, conversion 45 %, membrane feed pressure 57.9 bar, brine pressure 57.2 bar, brine back pressure of 0.5 bar.

What is the pressure boost???

\[ dP = (N_{te}) \times (R_r) \times (P_{br} - P_e) \]

\[ \text{AT-7200} = (0.82) \times (0.55) \times (57.2 - 0.5) = 25.6 \text{ bar boost} \]

Where
- \( R_r \) = ratio of brine flow to feed flow
- \( P_{br} \) = brine pressure at turbine inlet
- \( P_e \) = Turbo exhaust pressure
- \( N_{te} \) = Hydraulic Energy Transfer Efficiency from Curve
LPT Process Design

- Inter-stage pressure boosting: LPT

1ST STAGE MEMBRANES

- 250 PSI (17.24 bar)
- 2000 GPM (454.2 m³/h)

2ND STAGE MEMBRANES

- 326 PSI (22.48 bar)
- 1000 GPM (227.1 m³/h)

HIGH PRESSURE PUMP

- 2000 GPM (454.2 m³/h)
- 30 PSI (2 bar)

LPT TURBO CHARGER

- 311 PSI (21.44 bar)
- 500 GPM (113.6 m³/h)

- 5 PSI (.35 bar)
- 500 GPM (113.6 m³/h)
- 1000 GPM (227.1 m³/h)

- 230 PSI (15.86 bar)
- 1000 GPM (227.1 m³/h)
Advanced Technology (AT) Turbocharger
Advanced Technology (AT) Turbocharger

• Application
  ➢ Medium to large scale energy recovery device for SWRO

• Advantages
  ➢ Reliability
    • Product lubricated bearings
    • No scheduled maintenance
    • Ease of installation
  ➢ Designed for Optimum Efficiency
    • Customized Hydraulic Design for each specific application
    • Customized 3-D geometry Impellers
  ➢ Removable volute inserts
  ➢ Compact design allowing for smallest foot print available
  ➢ Feed pump size reduction
Advanced Technology (AT) Turbocharger (Cross Section)
Advanced Technology (AT)
Turbocharger Con’d

Main
Turbine
Nozzle

Turbine Side
Volute

Pump Side
Diffuser

Pump Side
Volute

AT
Flows 1,200 to 12,000 gpm
Pressures 600 to 1,200 psi

AVS
Flows 250 to 12,000 gpm
Pressures to 700 psi

PEI Patent Pending
Volute Insert Technology

- ERI’s unique ability to improve efficiency and reduce water cost over the life of the plant
- Does not require complete equipment replacement
- Simple field retrofit with virtually no downtime

HTCAT

AquaSpire
Volute Insert Technology Con’d

• Ability to adapt to improvement in desalination technology
• Enhanced membrane recovery (Impact on feed flows)
  ➢ 10 years ago 35% recovery was industry norm
  ➢ Now 40 – 45 % recovery is the norm
• Reduction in operating pressure
  ➢ 10 years ago 70 -74 bar was SWRO norm
  ➢ Now 64 -68 bar is the norm
• Improved pretreatment technology
• Ability to take advantage of desal technology improvement without negative impact on efficiency

1.5% - 2% of Efficiency will save a customer Millions $ over the entire Plant Life
Volute Insert Technology Con’d

• 10% change in flow = 1.5% drop in efficiency

- Easily replicable volute and diffuser components allow for best efficiency point operation even when operating requirements change
SYSTEM CONTROL AND OPTIMIZATION
How does an ERI™ TurboCharger™ ERD work?

- The auxiliary nozzle valve on the turbocharger provides brine flow and pressure adjustment to accommodate typical variations in membrane requirements.

- The Main Nozzle is sized to provide a concentrate system resistance (concentrate pressure) equal to the maximum design pressure at a constant design concentrate brine flow rate. The auxiliary nozzle is sized to about 20-25% of the area of the Main Nozzle. The ANCV controls flow to the AN in the turbine casing. The ANCV will provide a 10-15% pressure range at a constant brine flow.
System control and optimization

- To reduce brine pressure, open the auxiliary nozzle valve until the desired brine flow and pressure are obtained.
- Opening the ANCV reduces the brine pressure and consequently reduces the boost pressure. Opening the ANCV increases the total nozzle area, allowing more flow and/or a lower pressure. This is typically done during those periods of RO plant operation that require less pressure than the maximum designed membrane pressure.
- To increase brine pressure, close the auxiliary nozzle valve until the desired brine flow and pressure are obtained. The TURBO will produce the most boost pressure when the ANCV is fully closed.

- The Aux Nozzle valve can be manual (as shown) or actuated.
- If automated, the best control signal is the brine flow.
Low Pressure Turbocharger (LPT)
Low Pressure Turbocharger (LPT)

• Application
  - Designed for use in low pressure, multi-stage Brackish Water RO systems

• Advantages
  - All components made from cast parts for long life
  - Custom designed for customer specific conditions
  - Balances first and second stage flux rates
  - Eliminates interstage booster pump
  - Reduces first stage fouling potential
  - Replaces brine control valves
**LPT Turbocharger Features**

- Inter stage boost balances permeate flux rates between stages
- Turbocharger combines energy recovery turbine and interstage booster pump in single unit
- Can reduce fouling potential in 1st stage by reducing its flux.
- Entirely energized by brine pressure – no electrical components, consumption, or cost.
- Lowest Life Cycle Cost pump for interstage booster service
- No Maintenance: Water lubricated bearings
- Low Noise: Vibration-free
Low Pressure Turbocharger (LPT)

LPT TurboCharger
Flows 30 to 4,000 gpm
Pressures to 650 psi
ERI™ AquaBold™ Pump Line
ERI™ AquaBold™ Pump Overview

• High-Efficiency Centrifugal High Pressure RO Pump

• Uniquely designed for desalination applications
  ➢ Custom designs for specific operating conditions allows for optimum pump efficiencies

• Quality materials & manufacturing
  ➢ Designed for 20 year service life

• Designed for use with PX energy recovery devices
  ➢ Highest efficiency package solution with minimal power consumption

• Available with short lead-times

• Customer service, training and support
  ➢ Highly qualified technical field services and training programs
ERI™ AquaBold™ Pump Advantages

- **Industry-leading high efficiencies**
  - Performance-enhanced fluid modeling
  - Proprietary thrust technology eliminates losses

- **State-of-the-art construction for RO industry**
  - Precision machined investment-cast components
  - Standard Duplex 2205
  - Super Duplex 2507 optional

- **Simple to maintain**
  - No disassembly required for mechanical seal replacement
  - All product-lubricated bearings
  - Thrust bearing can be replaced without removing pump or motor
ERI™ AquaBold™ Pump - Features

- Motor-Pump Adapter eliminates alignment procedure
- Elastomeric or stainless steel DBC coupling
- Optional flange connections
- Mechanical seal requires no pump disassembly for maintenance
- Square tube rigid base
- SCH. 80 duplex stainless steel barrel casing
- Product lubricated bearings (eliminates thrust balance line)
ERI™ AquaBold™ Pump (Cross Section)
Proprietary Thrust Bearing

• Product lubricated bearings – eliminates maintenance of grease bearings and auxiliary oil systems and associated seals
• Simple, efficient design – allows field retrofits without the need for bearing change
• Reduced friction provides lower power losses within the bearing system, improving overall efficiency
•Eliminates need for costly external thrust bearing system
ERI™ AquaBold™ Pump Line (Current Products)

AquaBold High Pressure Pump

![Graph showing efficiency vs. flow rate for different pump models: 2x3x5-, 3x4x7-, 3x4x7-C, 4x6x9-, 4x6x9, 4x6x9-]
Ancol SWRO, Jakarta, Indonesia - 1,680 m³/day

- ERI™ TurboCharger™ ERD installation
- ERI™ AquaBold™- High Pressure Pump (4x6x9-4)
Turbocharger Installation: 3,000 m³/day
Distributor in Germany, Austria, Switzerland, Czech and Slovak Republic

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