TO: SWRO Industry, ERI Customers and Interested Parties

FROM: G.G. Pique, CEO Energy Recovery Inc

DATE: September 14, 2006

SUBJECT: ERI Advantages and Misconceptions

Energy Recovery, Inc.'s (ERI) PX Pressure Exchanger technology has been commercially available since 1997 for energy recovery in seawater reverse osmosis (SWRO) desalination plants. Because of its simplicity, endurance and reliability, the ERI PX energy recovery device (ERD) operates without scheduled maintenance or elaborate controls.

ERI customers and smart SWRO plant designers appreciate the superior performance and reliability of the PX Pressure Exchanger. For this reason ERI has become the largest ERD manufacturer in the world with the greatest installed capacity in the SWRO industry, and PX technology has been selected or specified for over 90% of the large desalination plants awarded since 2005.

Our operating base of thousands of installed PX units gives us the experience to thoroughly understand the performance of our product with many different types of seawater and operators. This gives us the confidence to back our products with some of the most solid warrantees in the industry. Our global service network and customer training and support are quickly becoming legendary, worldwide. We are proud of the fact that the global rate of PX service returns in 2005 and 2006 has been less than 1/2 of 1%. We thank our customers for our success and pledge to continue manufacturing the high-quality, high-performance products our customers have come to expect.

However, we note that our position in the market has exposed us to attack by several of our less fortunate competitors. This memorandum is intended to clarify some specific facts about the performance and reliability of ERI's PX Pressure Exchanger technology. Most ERI customers will find nothing new in this analysis. However, for SWRO designers and operators that have been exposed to anti-PX propaganda, we hope this memo will correct any misconceptions that may exist.

Detailed and accurate information about PX technology is available on ERI's website: www.energyrecovery.com or from customer reference contacts available from any ERI sales representative. Please contact ERI at sales@energy-recovery.com.

Mixing

ERI competitors have claimed that mixing of brine into seawater in a PX device is exceedingly high and even higher if multiple units are operated in parallel, if the PX is not operated at an optimal design point or if a PX is damaged or worn out.

ALL THESE CLAIMS ARE INCORRECT. In all isobaric ERDs, some contact between the brine and seawater streams occurs. As a result, these streams mix slightly. The PX rotor contains no pistons or barriers; however, mixing between the brine and seawater streams is limited because the rotor ducts are long and narrow. The PX is designed so that the interface between the brine and seawater never reaches the end of the rotor before the duct is sealed.

In an ERI PX, mixing results in a salinity increase at the membrane feed of less than 3% at a 45% water recovery rate when the high-pressure seawater flow from the PX equals the seawater feed to the PX (balanced flow). This increase in salinity, negligible in many SWRO applications, is the same when operating with a single PX or with many and is constant over the operating range of most PX models and can be reduced or eliminated with excess seawater fed to the PX array. In the hundreds of PX installations, mixing has not been observed to increase with time even in instances when a PX has been damaged by debris or overflow. ERI routinely guarantees low mixing performance.

PX Arrays

ERI competitors have claimed that when multiple PX units are operated on a manifold, the performance of the array is worse than that of individual units, flow distribution is difficult to control such that all the units operate at different flow rates, individual units require flow control instrumentation, and if one units fails, flow is diverted to the other units.

THIS IS INCORRECT. PX devices are usually installed in multiple-PX arrays. PX devices perform as well on manifolds as they do individually as has been demonstrated in many long-running multi-PX arrays. The pressure drop through a PX (about 1 bar) is generally much greater than the pressure drop along the length of a PX manifold providing even flow distribution without the need for valves or flow controls on individual devices.

PX manifold header design is the same as piping design in any plant: liquid velocity should not exceed about 3 meters per second in metallic piping or about 2 meters per second in non-metallic piping. PX arrays are similar to membrane arrays providing the operator with beneficial redundancy. In the rare instance that a PX rotor stops due to debris, flow through the stuck rotor is the same as flow through a spinning rotor. Therefore, a stopped rotor does not alter flow distribution in a PX array. In applications where several rotors are arrayed in parallel, a stopped rotor has minimal impact on SWRO membrane performance and the plant can typically keep running until scheduled maintenance corrects the problem. In contrast, the failure of large- or piston-based ERDs can necessitate plant shutdown.

The performance of an individual PX unit in an array can be verified with a salinity sample from a plastic valve installed on the low-pressure discharge of each unit. Based on such samples and years of operating experience, there are no reported instances of flow imbalance in a PX array in hundreds of multiple-PX installations.

Cavitation and Erosion Damage

ERI competitors have claimed that ceramic damage by cavitation or erosion is common and that most PX internals must be replaced within 2 years.

THIS IS ABSOLUTELY INCORRECT. The rate of service returns for the PX has been less than 1% since 2002 and less than 2% through the lifetime of the technology. No plant has had to replace their ceramic components every 2 years, and if one did, such repairs would likely be covered by ERI's standard free 2-year warranty. Of the hundreds of PX installations, there are a few limited instances of units that have suffered cavitation damage as a result of repeated or continuous massive overflows or operation below minimum required backpressure. However, most operators have experienced no loss of performance or wear after many years of continuous operation.

Regrettably, ERI competitors have obtained photographs of damaged ceramic from a now-obsolete PX model from one such installation. Notably, three PX-220s operating in the same plant under the same conditions have had no ceramic problems in nearly 4 years of operation. Most rotating hydraulic equipment can suffer cavitation or erosion damage after long service lives or if operated under extreme conditions. However, the PX's ceramic is three times harder and much more wear-resistant than most other materials including stainless steel and is therefore highly resistant to such damage. This has been proven by a number of PX units operating since 1997 and the reliable, continuous operation of thousands of PX units deployed worldwide.

Allowable Flow Range

ERI competitors have claimed that the acceptable flow range of a PX unit is relatively small, that operation outside the rated range voids the warranty.

THIS IS AN EXAGGERATION. All hydraulic components in an SWRO plant have high-flow limits. In a PX, rotor speed is proportional to flow rate, so very high flow rates can result in very high rotor speeds, excessive noise and possible damage. The response of the PX to out-of-control high flow conditions is immediately evident to plant personnel and can be remedied before damage occurs. Flow below the PX's rated range is fairly common, acceptable to ERI and does not undermine warranty coverage. The PX is a positive displacement device with a flat efficiency curve so that there is not one optimum point for efficiency. This gives the operator the flexibility to operate the PX at or below it's rated range and still enjoy very high energy recovery efficiency.

Noise

ERI competitors have claimed that the noise emitted by the PX is a significant problem.

THIS IS AN EXAGGERATION. The maximum sound produced by a PX-220 is 92 dB and the average is 87 to 88 dB. Although the cumulative noise of multiple units can be higher, noise can be abated to below 80 dB by draping a PX array with an acoustic blanket. PX noise is an indication of normal PX operation.

Internal Leakage

ERI competitors have claimed that leakage inside a PX is high and gets higher as the PX gets older because of wear.

THIS IS AN EXAGGERATION. The PX utilizes brine to create a hydrodynamic bearing and lubricate the rotor. This lubrication flow rate is tightly controlled. In the PX-220, the loss is 1 to 2.2% of the brine flow rate over its typical service range and averages 1.6% making it the lowest of any isobaric ERD. Leakage can occur in a PX if ceramic is damaged in the seal areas, however, ceramic is three times harder than most other materials including stainless steel and is therefore highly resistant to damage. Most operators have experienced no loss of performance or wear after many years.

External Leakage

ERI competitors have claimed that leaks and cracks in PX vessels and ports are common.

THIS IS INCORRECT. Some early PX models exhibited leaks after years of service. Several PX enclosure materials have been upgraded and components have been re-designed based on field experience. The current component designs have been standard since at least 2004. When necessary, ERI has recalled defective or poor performing components. No PX vessel or port has ever cracked or failed catastrophically.

Instrumentation

ERI competitors have claimed that significant, costly instrumentation is required to operate and control PXs and this necessary instrumentation, which is not included in the price of a PX, is a cost disadvantage.

THIS IS INCORRECT. The instruments required in a SWRO system for safe, optimum operation of a PX array include one low-pressure flow meter, one high-pressure flow meter, one low-pressure pressure gauge and a low-pressure (plastic) salinity sample valves at the LP outlet of each PX unit for each PX array. No flow or control instrumentation is required on individual devices in a PX array and in practice are never used. In contrast, significant dedicated instrumentation and controls are required for the operation of all other commercially available isobaric ERDs. These complex and sensitive instruments represent potentially significant maintenance and failure points in these systems.

Biological Growth

ERI competitors have claimed that the PX must be flushed with fresh water after each shutdown, that biological growth in the PX can cause the rotor to stick and that chemicals cannot be used to clean a PX.

THIS IS AN EXAGGERATION. Fresh water flush is only recommended for shutdowns to exceed three days. Although biological conditions have resulted in rotors getting stuck, the occurrences have been rare and limited to small PX models exposed to very high biological loads. In these instances and in general, the SWRO membranes are more sensitive to fouling than the PX. PX units can be cleaned with the same chemicals used to clean membranes, however, PX units should be isolated from the debris generated by membrane cleaning. In the rare instances when it occurs, stuck PX rotors can usually be loosened with a stick from outside the vessel making it unnecessary to open the units.

Particles and Filtration

ERI competitors have claimed that small particles can stall or damage a PX and that additional filtration is required.

THIS IS INCORRECT. Although debris such as welding slag or large pieces of broken PVC, for example, can stop a PX rotor, there are no known incidences of small particles causing rotors to stick or causing severe damage. Most ERDs require the use of screens for commissioning. For day-to-day operation, the filtration requirement of the PX (10 microns) is less than that of most SWRO membranes (5 microns).

Required Discharge Pressure

ERI competitors have claimed that the PX requires that the brine discharge pressure from a PX must exceed 0.6 bar.

THIS IS CORRECT! However the low pressure differential through a PX is so low that the resulting supply pressure requirement – 1.2 to 1.6 bar depending upon the flow rate – is less than that required by other ERD suppliers. The minimum PX backpressure requirement is similar to the NPSH requirement of pumps. Greater than 0.6 bar discharge pressure is often necessary for brine disposal in SWRO systems regardless of PX requirements.

Overflush

ERI competitors have claimed that excess seawater or overflush is required for PX operation and such overflush is difficult to control.

THIS IS ABSOLUTELY WRONG. Most PXs are operated with zero overflush. This is explicitly clear in ERI's documentation and is guaranteed in most ERI proposals. If a customer chooses to apply overflush, control is accomplished with simple, already-installed low-pressure flow controls.

<u>Size</u>

ERI competitors have claimed that a PX array including the manifolds can have a larger footprint than a piston-based isobaric ERD.

ABSOLUTELY INCORRECT. PX-220 arrays including manifolds have 1/6 the footprint of most piston-type isobaric ERDs of comparable capacity, even if the piston units are stacked.

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