



PX-Q260, ERI Part Number 40034-01/40035-01

PX-260, ERI Part Number 40018-01

PX-Q220, ERI Part Number 40051

PX-220, ERI Part Number 40009-02

PX-Q180, ERI Part Number 40050

PX-180, ERI Part Number 40009-01

PX-Q140, ERI Part Number 40049

PX-140, ERI Part Number 40048

Energy Recovery, Inc.
1717 Doolittle Drive, San Leandro, CA 94577 USA
Tel: +1 510 483 7370 / Fax: +1 510 483 7371
www.energyrecovery.com / sales@energyrecovery.com

ERI® DOCUMENT NUMBER 80019-01 REVISION 10
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Making Desalination Affordable™

**INSTALLATION, OPERATION, & MAINTENANCE MANUAL
65-SERIES PRESSURE EXCHANGER ENERGY RECOVERY DEVICES**

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1.0 INTRODUCTION

This manual contains instructions for the installation, operation, and service of the Energy Recovery, Inc. (ERI[™]) 65-Series PX Pressure Exchanger[®] energy recovery devices in seawater reverse osmosis (SWRO) systems. This information is provided to ensure the long life and safe operation of your PX[®] energy recovery device. Please read this manual thoroughly before installation and operation, and keep it for future reference. This manual is intended for use by personnel with training and experience in the operation and maintenance of fluid handling systems.

2.0 SAFETY

The PX Pressure Exchanger energy recovery device is designed to provide safe and reliable service. However, it is a rotating industrial machine that typically operates at high pressure. Operations and maintenance personnel must exercise prudence and proper safety practices to prevent injury and to avoid damaging the equipment and surrounding areas. Use of this manual does not relieve operation and maintenance personnel of the responsibility of applying normal good judgment in the operation and care of this product and its components. The safety officer at the location where this equipment is installed must implement a safety program based on a thorough analysis of local industrial hazards. Proper installation and care of shutdown devices and over-pressure and over-flow protection equipment must be an essential part of any such program. In general, all personnel must be guided by all the basic rules of safety associated with high-pressure equipment and processes. Operation under conditions outside of those stated in Table 6.1 is unsafe and can result in damage to the PX device.

The flags shown and defined below are used throughout this manual. They should be given special attention when they appear in the text.



These flags denote items that, if not strictly observed, can result in serious injury to personnel.



These flags denote items that, if not strictly observed, can result in damage or destruction to equipment.



These flags denote highlighted items.



Energy Recovery, Inc. will not be liable for any project delay, damage or injury caused by the failure to comply with the procedures in this manual. This product must never be operated at flow rates, pressures or temperatures outside of those stated in Table 6.1, or used with liquids not approved by Energy Recovery,

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3.0 QUALITY & ARRIVAL INSPECTION

Energy Recovery, Inc.'s commitment to quality includes the procurement of top quality materials and fabrication to extremely tight tolerances. At each stage of the manufacturing process, every part is checked to ensure it meets all dimensional specifications. Assembled PX devices are subjected to extensive testing in our wet test facility. Each PX unit is tested for efficiency, sound levels, operating pressures, and flow rates. Testing records are maintained and each unit is tracked with a serial number. Each PX unit should be inspected immediately upon arrival at a customer's site and any irregularities due to shipment should be reported to the carrier. PX Pressure Exchanger devices are packed in polystyrene foam with plugs in the fittings to protect the unit from damage during transport. The PX unit has been run with a dilute biocide solution to minimize the possibility of biological growth during shipment and storage. The PX unit must never be exposed to temperatures below 33 degrees Fahrenheit (deg F) [1 deg Celsius (C)] or above 120 deg F [49 deg C] during storage or operation.

4.0 DESIGN CONSIDERATIONS

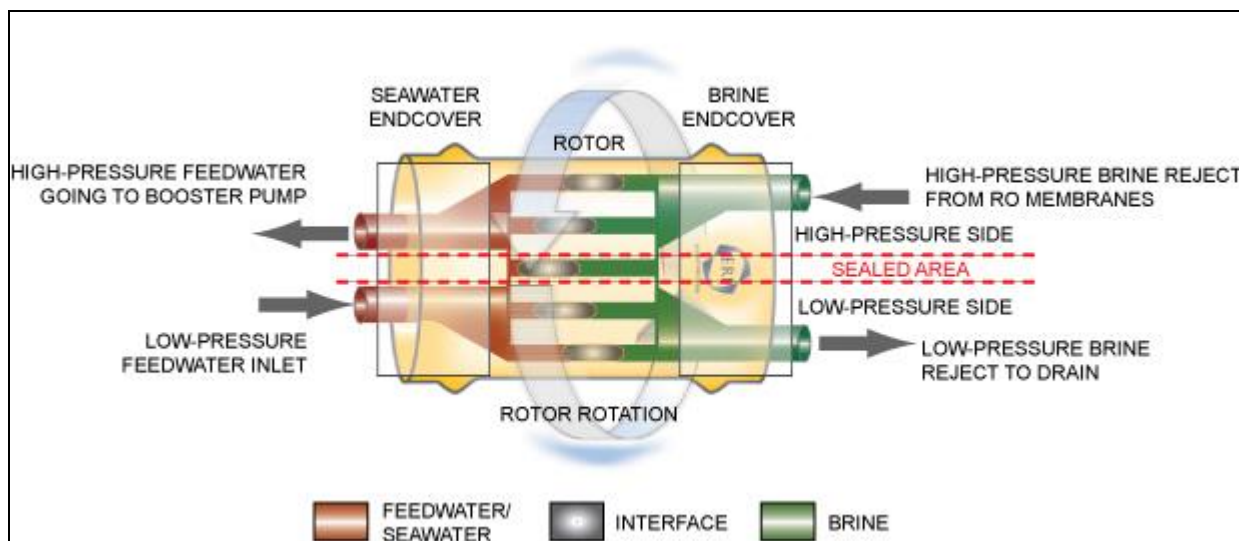
4.1 How the PX Energy Recovery Device Works

The PX Pressure Exchanger energy recovery device facilitates pressure transfer from the high-pressure brine reject stream to a low-pressure seawater feed stream. It does this by putting the streams in direct, momentary contact in the ducts of a rotor. The rotor is fit into a ceramic sleeve between two ceramic end covers with precise clearances that, when filled with high-pressure water, create an almost frictionless hydrodynamic bearing. The rotor spinning inside the hydrodynamic bearing is the only moving part in the PX device.

At any given instant, half of the rotor ducts are exposed to the high-pressure stream and half to the low-pressure stream. As the rotor turns, the ducts pass a sealing area that separates high and low pressure. Thus, the ducts that contain high pressure are separated from the adjacent ducts containing low pressure by the seal that is formed with the rotor's ribs and the ceramic end covers.

A schematic representation of the ceramic components of the PX energy recovery device is provided in Figure 4.1. Seawater supplied by the seawater supply pump flows into a rotor duct on the left side at low pressure. This flow expels brine from the duct on the right side. After the rotor turns past a sealing area, high-pressure brine flows into the right side of the duct, compressing and expelling the seawater. Pressurized seawater then flows out to the circulation pump. This pressure exchange process is repeated for each duct with every rotation of the rotor, so that the ducts are continuously filling and discharging. At a nominal speed of 1,200 rpm, 20 revolutions are completed every second.

Figure 4.1 - Flow Path through a PX Unit

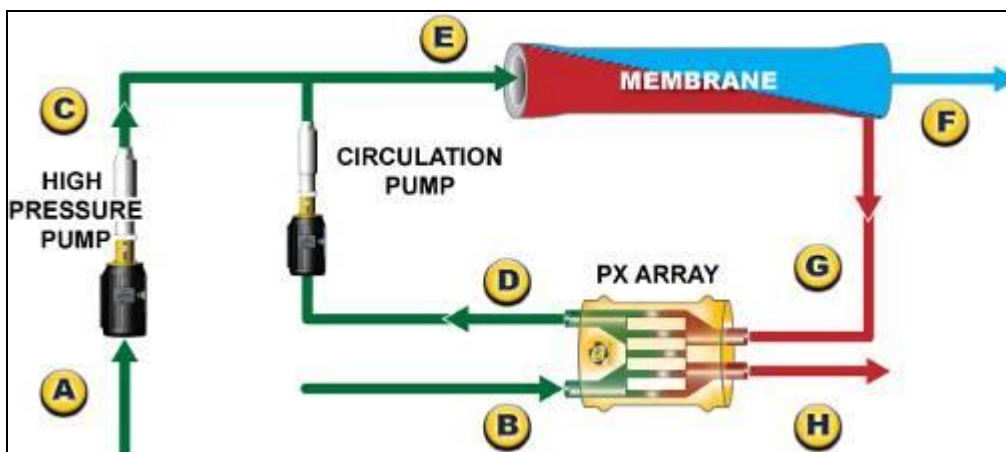


4.2 PX Energy Recovery Devices in SWRO Systems

The PX energy recovery device fundamentally changes the way a SWRO system operates. The issues presented in this and the following sections should be taken into consideration when designing a SWRO system. In addition, engineers at Energy Recovery, Inc. are available for design consultation and review of process and instrumentation diagrams.

Figure 4.2 illustrates the typical flow path of a PX energy recovery device in a SWRO system. The reject brine from the SWRO membranes [G] passes through the PX unit, where its pressure is transferred directly to a portion of the incoming raw seawater at up to 98% efficiency. This pressurized seawater stream [D], which is nearly equal in volume and pressure to the brine reject stream, passes through a circulation pump. The circulation pump propels flow in the high-pressure loop [E-G-D] at a rate controlled by a variable frequency driver on the motor. Fully pressurized seawater from the circulation pump merges with the high-pressure pump discharge to feed the membranes.

Figure 4.2 - Typical Flow Path of a SWRO System with a PX Unit



65-SERIES PX PRESSURE EXCHANGER ENERGY RECOVERY DEVICES

In a reverse osmosis system equipped with PX Pressure Exchanger energy recovery devices, the membrane brine reject is directed to the membrane feed as illustrated in Figure 4.2. The rotor, moving between the high-pressure and low low-pressure streams, removes the reject concentrate and replaces it with feed water. The rotor spins freely, driven by the flow at a rotation rate proportional to the flow rate and lubricated by high-pressure process water. Unlimited capacity is achieved by arraying multiple PX devices in parallel.

The PX devices and the check valve at the discharge of the high-pressure pump seal the high-pressure portion of the RO process. During RO-process operation, water is introduced to the high-pressure loop [D-E-G] by the high-pressure pump as stream C. Almost all of this water exits as permeate and the rest flows through narrow gaps that surround the PX device rotor, lubricating the rotor. Lubrication flow is typically about 0.5% of the total flow from the high-pressure pump and is measurable as the difference between the high-pressure pump flow rate [C] and the permeate flow rate [F]. The flow delivered by the high-pressure pump and the resistance to permeate and lubrication flows provided by the membrane elements and the PX devices, respectively, pressurize the high-pressure loop.

Sample flow rates and pressures for a SWRO system with one PX-220 are listed in Table 4.1 below, with reference to Figure 4.2. In a SWRO system with an ERI energy recovery device installed, the high-pressure (HP) pump is sized to equal the SWRO permeate flow plus a small amount of bearing lubrication flow, not the full SWRO feed flow. Therefore, PX energy recovery technology significantly reduces flow through the main HP pump. This point is significant because a reduction in the size of the main HP pump results in lower capital and operating costs. In a typical SWRO system with a PX unit operating at 40% recovery, the main HP pump will provide 41% of the energy, the booster will provide 2% and the PX unit will provide the remaining 57%. Since the PX unit uses no external power, a total energy savings of 57% is possible compared to a system with no energy recovery.

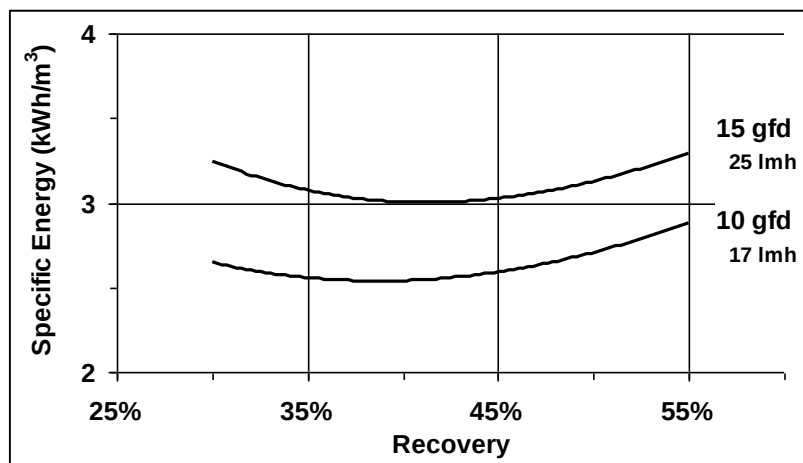
Table 4.1. Typical SWRO System Flows and Pressures

Stream	Description	Flow Rate GPM / m ³ /hr	Pressure PSI / Bar
A	Seawater Supply	330 / 75	18 / 1.2
B	PX LP IN / Seawater	195 / 44	18 / 1.2
C	Main HP Pump outlet	135 / 31	1000 / 69
D	PX HP OUT / Seawater	195 / 44	957 / 66
E	SWRO Feed Stream	330 / 75	1000 / 69
F	SWRO Product Water	130 / 30	N/A
E	Circulation Pump Outlet / Seawater	195 / 44	1000 / 69
G	PX HP IN / Reject	200 / 45	971 / 67
H	PX LP OUT / Reject	200 / 45	8 / 0.6
J	Circulation Pump Outlet / Seawater	195 / 44	1000 / 69

An SWRO system with ERI energy recovery device(s) can operate efficiently at low recovery rates because the PX units supply the majority of the membrane feed with just the energy required to drive the circulation pump. One advantage of operating at lower recoveries with PX energy recovery devices is that a lower operating pressure is required to produce a given amount

of permeate. The overall energy consumption of a SWRO plant using the PX energy recovery device typically reaches its minimum point at recovery rates of between 35-45%. Outside this recovery range, the SWRO process consumes more power to make the same amount of permeate. At lower recovery rates, the supply and pretreatment system consume excess energy. At higher recovery rates, the high-pressure pump consumes excess energy because of the higher membrane pressure. Figure 4.3 illustrates the relationship between SWRO recovery rate and overall SWRO power consumption.

Figure 4.3 - SWRO Energy Consumption versus Recovery Rate



The operator can manipulate recovery to optimize RO system performance and/or compensate for feedwater changes. Changing recovery in an SWRO system equipped with PX technology is easy. The variable frequency drive on the circulation pump motor is adjusted to change high-pressure flow rate through the PX device, the circulation pump and the membrane array. Then the flow rate of supply water to the PX device is adjusted to assure equal flow rates of seawater to and from the PX device. As long as the flow rates and pressures to the PX device are within the rated capacity, pressure transfer efficiency and mixing will change very little.

4.3 PX Energy Recovery Device Performance

There are no direct controls on a PX device. The rotor is turned by the flow at a rotation rate that is proportional to the flow rate. Therefore, the flow rate, pressure, and quality of the feed streams to the PX unit must be monitored and controlled.

Operation and control of a PX unit in a SWRO system can be understood by visualizing two parallel pipes, one with high-pressure water and one with low-pressure water flowing through the PX unit. With reference to Figure 4.2, the high-pressure water flows in a circuit through the membranes, the PX unit or PX unit array, the circulation pump, and back to the membranes [E→G→D→E] at a rate controlled by the circulation pump equipped with a variable frequency drive. The low-pressure water flows from the seawater supply pump through the PX unit or PX unit array to the system discharge [B→H] at a rate controlled by the supply pump and a flow control valve in the brine discharge from the PX unit or PX unit array [H]. Since the high- and low-pressure flows are independent, the SWRO plant must be designed for monitoring and control of the flow rates of both streams.

PX Pressure Exchanger device performance data for a range of flow and pressure conditions is provided on Energy Recovery, Inc.'s website. The following data are given in the form of performance curves:

- Efficiency as a function of flow rate
- Mixing as a function of flow rate
- Sound level as a function of flow rate
- High- and low-pressure pressure drop as a function of flow rate
- Lubrication flow as a function of pressure

4.4 PX Rotor Lubrication

Both process flow and lubrication flow are required for the PX rotor to spin. The process flows include the feed flow from the supply system introduced to the PX devices and the concentrate flow driven by the circulation pump. Lubrication flow is normally provided by the high-pressure pump. The lubrication flow rate is typically less than 1% of the high-pressure pump flow rate or less than 0.5 m³/hr (2.2 gpm) per PX device.

Without lubrication flow, the PX device rotors may stop rotating. If this occurs, the concentrate-feed water exchange will cease. With reference to Figure 4.2, flush water introduced at process location B will exit at process location H without flowing through the membrane array. With insufficient lubrication flow, rotor rotation can result in damage to the PX device's ceramic components. A grinding sound may be heard as the ceramic components rub together without lubrication.

If the high-pressure pump is not on, such as during flushing, the lubrication flow necessary to keep the PX rotors spinning can be provided by osmotic (suck-back) flow through the membranes. However, if the RO process is fully depressurized, the lubrication flow necessary to keep the rotors spinning must be either pushed through the high-pressure pump by the supply pump or injected through some other point in the high-pressure loop such as a clean-in-place (CIP) inlet. If the flush water has very low salinity, the lubrication flow may exit the process through the membranes under low trans-membrane pressure. It may be necessary to block permeate flow to divert lubrication flow through the PX devices.

4.5 The Circulation Pump

In the typical SWRO system illustrated in Figure 4.2, a circulation pump is required to move water through the high-pressure loop. The circulation pump provides a pressure boost to compensate for friction losses in the membranes, the PX unit, and the associated piping. The speed of the circulation pump must be set with a variable frequency drive to control the high-pressure flow rate through the PX unit. Recommended practice is to use a slightly oversized circulation pump to handle projected reverse osmosis membrane flows, taking into account seasonal variations, membrane fouling, and manifold losses. Energy Recovery, Inc. carries a line of PX Booster Pumps with capacities of 20 (4.5 m³/hr) up to 300 gpm (68 m³/hr). ERI PX

Booster Pumps can be manifolded to run in parallel to achieve higher capacities. Alternately, a list of several suppliers of high-capacity circulation pumps is available upon request.

4.6 Seawater Supply

Special consideration should be given to flow, pressure and quality control of the seawater supply. As mentioned, a flow control valve in the brine discharge from the PX unit can be used to control the low-pressure flow rate through the PX unit(s). Once this valve is set, flow will remain constant as long as the feed pressure does not change. However, if the feed pressure changes, the low-pressure flow through the PX unit will change accordingly. As long as the maximum allowable feed flow to the PX unit is never exceeded, the PX unit will automatically adjust to small pressure and flow variations.

Pressure/flow spikes require particular consideration in systems with multiple SWRO trains as trains go on- and off-line. Many automatic flow control systems are not responsive enough to provide constant flow during sudden pressure changes. Momentary feed pressure increases can result in flow spikes that could overflow and damage the PX unit. Designers of large plants should consider installing a dedicated pump for supplying seawater to the PX arrays at a constant controlled flow rate. If large low-pressure spikes and overflow cannot be avoided, a pressure regulator and/or relief valve should be installed upstream of the PX units to help stabilize flow. Alternately, a fast-responding flow control valve, such as a pneumatic valve, can be utilized. Where feasible, Energy Recovery, Inc. recommends incorporation of a high-flow alarm on the seawater supply. ERI will provide specific flow control equipment and instrument recommendations upon request.

CAUTION

Do not exceed the maximum allowable feed flow rate to the PX unit. This may damage the PX device.

Supply water should be filtered to 10 microns and no chemicals should be used that may damage the membrane elements. Large bubbles in a pressurized system can result in damage to piping and equipment, including the PX unit. All air must be purged from both the low- and high-pressure circuits before the SWRO system is pressurized. If the SWRO system will be started automatically, sufficient time must be allowed in the startup sequence so that air may be purged before the HP pump is started.

4.7 Flushing

RO membranes require occasional flushing to limit biological fouling. Biological fouling can increase RO process energy consumption and cause malfunctions. There are two types of flush: Feed Water Flush and Fresh Water or Permeate Flush. Regardless of the flush water used, all parts of the PX device must be flushed, i.e. low-pressure flow channels, high-pressure flow channels, and lubrication channels.

Feed Water Flushing is part of a normal shutdown sequence as described below. After both permeate and concentrate production have ceased, flow on both the high-pressure and low-pressure sides of the PX devices continue. The flow path of the Feed Water Flush, with reference

to Figure 4.2, is B-D-E-G-H driven by the feed water pump and the circulation pump. A Feed Water Flush is typically continued until conductivity measurements at process locations G and H are satisfactory.

A Permeate Flush is performed on a partially- or fully-depressurized system. This is accomplished by introducing permeate simultaneously to the PX device low-pressure inlet [B] and either to the high-pressure pump inlet [A] or through some other injection point such as a CIP connection. Permeate may be produced during this flushing process. If so, it may be necessary to block permeate flow to divert lubrication flow through the PX devices.

CAUTION

Failing to flush the PX unit with fresh water before extended shutdowns may result in excessive biological growth that may foul the PX unit and inhibit rotation upon start-up.

4.8 Debris and Initial Flushing

Prior to initial start up, all piping associated with the PX energy recovery device should be thoroughly flushed to assure that no debris enters and/or damages the PX unit. Energy Recovery, Inc. recommends installation of basket strainers at both inlets to the PX device or PX device array. Basket strainers protect the PX unit(s) from damage caused by debris coming from upstream failures that sometimes occur as a result of corrosion, worn parts, or filter failures. As an alternative, ERI recommends installation of temporary startup strainers during startup and commissioning activities. ERI can provide a list of strainer vendors upon request.

4.9 High Pressure Remains After Shutdown

The high-pressure section of a SWRO system equipped with a PX energy recovery device can remain pressurized for a long time after shutdown. Pressure decreases as water slowly flows through the hydrodynamic bearing of the PX unit. If more rapid system depressurization during shutdowns is required, the system should be designed with accommodating valves and piping.

NOTE

If rapid depressurization is desired, a high-pressure bypass valve can be installed at the concentrate outlet of the RO membranes, which can be used to manually and/or automatically relieve the pressure at shutdowns.

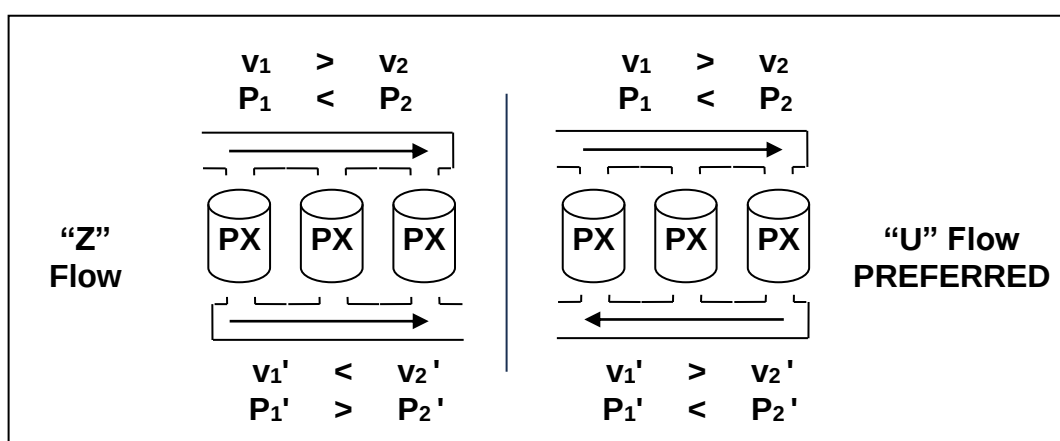
4.10 Low Pressure Isolation and Over-pressurization

If the low-pressure side of the PX energy recovery device is isolated before the high-pressure side is depressurized, there is a risk that the PX unit or the low-pressure piping could be damaged by over-pressurization. High-pressure water continuously flows through the PX device's hydrodynamic bearing to low-pressure regions in the PX unit. To prevent this over-pressurization scenario, appropriate relief valves should be used and procedures implemented to assure that the high-pressure side of the PX unit is depressurized prior to isolation of the low-pressure side.

4.11 Multiple PX Unit Manifold Design

The performance of PX arrays is identical to the performance of individual PX units. The pressure difference between the inlet and outlet manifold determines the flow through the PX units according to the characteristic differential pressure versus flow performance of the particular PX model. As with any piping manifold, there are at least two ways to assure even flow distribution in a PX array. One is to orient the inlet and outlet manifolds to provide “U” flow as opposed to “Z” flow as illustrated in Figure 4.4. In a “U” flow scheme, flow enters and leaves the array from the same end. In a “Z” flow scheme, flow enters on one end of the array and leaves on the other. PX manifolds can also be fed in the center through pipe tees. The resulting “T” flow scheme is hydraulically similar to a “U” flow scheme.

Figure 4.4 - PX Device Manifold Flow Schemes



The relationship between flow and pressure is derived by energy balance:

$$(P_2 - P_1) + \rho(v_2^2 - v_1^2)/2 + f = 0 \quad (1)$$

where:

P = pressure,

v = velocity,

ρ = density, and

f = head loss due to friction.

Considering Figure 4.4, velocity in the inlet (upper) manifold decreases in the direction of flow as water diverts into the PX units, causing a pressure increase in the direction of flow. Friction losses in the header and fittings decreases pressure in the direction of flow, however, friction in a PX manifold tends to be small because it is relatively short. Therefore, pressure tends to increase in the direction of flow in an inlet manifold. Friction losses are greater in smaller-diameter manifolds, however, the velocity change and its impact on pressure is even greater in such systems.

Similar considerations apply to outlet manifolds. The general conclusion of this analysis is that the pressure in a manifold is lowest near the open end of the header where the flow velocity is highest. In Figure 4.4, pressure in the outlet (lower) manifold in the “Z” flow configuration is

lowest at the right end, opposite from the highest pressure point in the inlet manifold. The pressure in the outlet manifold in the “U” flow configuration is lowest at the left end, opposite from the lowest pressure point in the inlet manifold.

Therefore, the pressure difference between the manifolds at any PX-unit position is more constant in a “U” flow than in a “Z” flow scheme. As illustrated in the differential pressure versus flow performance curves for PX devices, pressure difference determines the flow through a given PX unit. The resulting conclusion is that “U” flow always provides more even flow distribution among the PX units of an array than a “Z” flow does for a given manifold pipe diameter. This has been verified with computational fluid dynamics modeling of PX arrays of a wide range of lengths and diameters. More importantly, this conclusion has been verified in a number of long-running multiple-PX arrays.

A second way to assure even flow distribution in a membrane array or a PX array is to substantially reduce the ρv^2 terms in Equation (1) by specifying large header pipe diameters. A large header serves as a constant-pressure reservoir regardless of flow orientation. The obvious disadvantage of large header pipe diameters is the greater amount of material required.

Through computational fluid dynamics modeling and evaluation of PX arrays in the field, ERI has come up with general guidelines for manifold sizing. Acceptable flow balance among the PX units in an array will result if the inlet velocity is limited to less than 3.7 m/s (12 ft/s) for a “U” or a “T” flow scheme or to less than 2.1 m/s (7 ft/s) for a “Z” flow scheme. If these limits are adhered to, the high and low pressure sides of the PX units can be considered independently of each other and may be of either flow scheme. PX arrays may be fed from either end of the array as long as the inlet velocities are below the above-specified velocities.

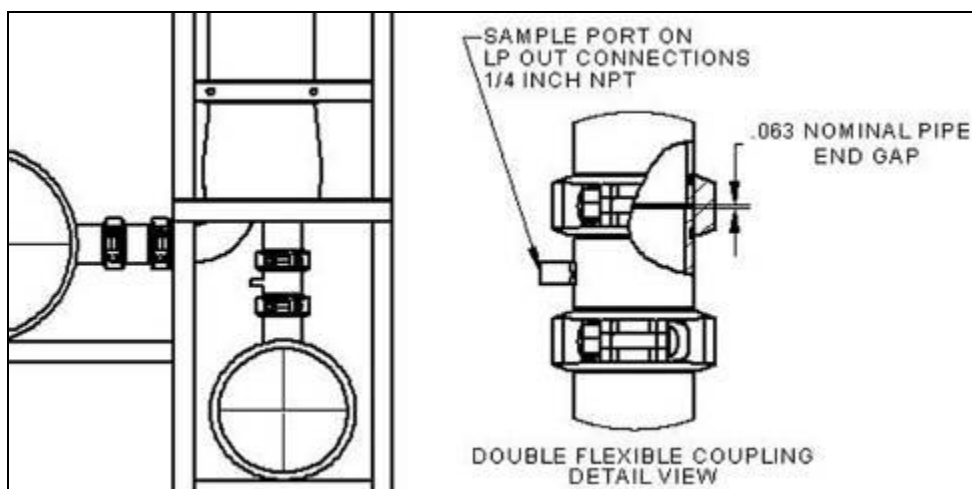
A sample connection at the low-pressure outlet of each PX unit in a PX unit array can be used to confirm the performance of individual units in a PX device array. Low-pressure sample ports are recommended over high-pressure sample ports because low-cost, corrosion-proof plastic valves can be used. When PX devices are operating normally at balanced flow, the salinity of the low-pressure outlet water from each PX unit will be approximately equal to the salinity of the brine reject water from the membranes. If the PX units are not balanced, the salinity of the low-pressure discharge from the unit will be much lower than the salinity of the brine reject water from the membranes. If one of the PX units is not functioning properly, the salinity of the low-pressure discharge from the unit will be lower than that of the other units. If a rotor is stuck, the salinity from the stuck unit will be close to the salinity of the seawater feed.

For systems with large manifolds, double flexible coupling connections should be considered to facilitate alignment of the PX units. These connections are illustrated in Figure 4.4 and in ERI Document Numbers 60007 and 60008.

NOTE

ERI encourages plant designers and engineers to submit P&IDs to ERI for engineering review, especially for large or complex SWRO systems.

Figure 4.4 – Double Coupling Connections for Large Manifolds



5.0 INSTALLATION

65-Series Pressure Exchanger devices can be installed and operated in horizontal, vertical or any other orientation. Each unit has four connections labeled HP IN, HP OUT, LP IN, and LP OUT.

- **HP IN** is the high-pressure brine reject inlet.
- **HP OUT** is the high-pressure seawater outlet.
- **LP IN** is the low-pressure seawater inlet.
- **LP OUT** is the low-pressure brine reject outlet.

The external fittings on the PX energy recovery device are made of investment cast alloy CN3MN or equivalent stainless steel. The housing is made of glass-reinforced plastic. Proper piping, piping support, and housing support must be employed to minimize external stresses on all pipe fittings. Bearing pads should be used to avoid abrasion of the housing and to act as alignment shims. Flexible couplings should be used for joining fittings and piping. Use only water-soluble lubricants such as glycerin or soap on O-rings and seals. Do not use grease. Section 12.0 contains a dimensioned drawing of a PX unit and a piping detail for use for piping, manifold, and support rack design.



Do not allow the high-pressure reject feed to the PX unit to exceed 1,200 psi (83 bar). If necessary, install a pressure switch and/or safety valve in the high-pressure line(s) to ensure that the system does not exceed 1,200 psi (83 bar).



The PX unit must not be supported by its pipe fittings, nor should the PX unit be allowed to support piping or manifolds. During installation avoid lifting the PX unit by the ports.



A pressure gauge should be installed near each pipe connection to the PX unit array to facilitate monitoring of PX unit performance.

CAUTION

Thoroughly flush associated piping with water filtered to 10 microns before installing the PX unit. Foreign material may cause damage.

6.0 OPERATION

6.1 System Performance Specifications, Precautions, and Conditions

Successful operation of the PX Pressure Exchanger energy recovery device requires observation of some basic operating conditions and precautions. The PX unit must be installed, operated, and maintained in accordance with this manual and good industrial practice to ensure safe operation and a long service life. Failure to observe these conditions and precautions can result in damage to the equipment and/or harm to personnel. Table 6.1 provides a summary of system performance limits.

Table 6.1 System Performance Limits

Parameter	Specification	
	English Units	SI Units
Maximum high pressure (HP IN or HP OUT)	1,200 psig	82.7 bar
Maximum seawater inlet pressure (LP IN)	300 psig	20.7 bar
Minimum seawater inlet pressure (LP IN)	24 psig	1.7 bar
Minimum brine discharge pressure (LP OUT) ⁽¹⁾	9 psig	0.6 bar
Minimum filtration requirement (nominal)	10 micron	
Seawater temperature range	33-120 °F	1-49 °C
pH range	1-12 (short term at limits)	
Allowable flow rates ⁽²⁾		
PX-Q260	180-260 gpm	41-59 m ³ /hr
PX-260	180-260 gpm	41-59 m ³ /hr
PX-Q220	140-220 gpm	32-50 m ³ /hr
PX-220	140-220 gpm	32-50 m ³ /hr
PX-Q180	100-180 gpm	23-41 m ³ /hr
PX-180	100-180 gpm	23-41 m ³ /hr
PX-Q140	90-140 gpm	20-32 m ³ /hr
PX-140	90-140 gpm	20-32 m ³ /hr

- (1) The low pressure discharge stream from the PX must be constricted to provide backpressure on the unit. Operation with insufficient backpressure can cause destructive cavitation.
- (2) Unlimited system capacities are achieved by using multiple units in parallel.



The lock ring segments in the ends of the PX assembly must be kept dry and free of corrosion. Deterioration of these segments could lead to failure of the PX unit enclosure. Regular rinsing of the PX unit head assembly with permeate to prevent salt buildup is recommended.

CAUTION

Entrained or trapped air or other gasses must be purged from the SWRO system before pressurization.

65-SERIES PX PRESSURE EXCHANGER ENERGY RECOVERY DEVICES

CAUTION

Introduction of non-water soluble contaminants such as grease, oil, wax, petroleum jelly, etc. may inhibit rotor function.

CAUTION

Do not allow the high-pressure or low-pressure stream flow rates to exceed the flow rates listed in Table 6.1. To comply with the warranty, it is necessary to install flow meters on both the high-pressure stream and low-pressure streams. Failure to do so can result in damage or destruction of the PX unit and/or other equipment.

NOTE

The high-pressure pump should never be operated without the circulation pump. An interlock should be installed so that the high-pressure pump will automatically shut down if the circulation pump shuts down.

The following precautions / conditions apply:

- Allowable flow ranges for individual PX units are listed in Table 6.1. PX units are not designed to operate outside of these ranges.
- Seawater feed to PX units must be filtered to 10 microns or less and should be subjected to the same pretreatment as seawater being fed to the SWRO membranes.
- Entrained or trapped air or other gasses must be purged from the SWRO system before pressurization. Large bubbles in a pressurized system can result in damage to piping and equipment, including the PX unit.
- Piping connections to PX units must be designed to minimize stress on the fittings and housing.
- The PX unit housing bearing plates (end caps) incorporate interlocking restraining devices (segmented lock rings). Deterioration of the bearing plates, segmented lock rings, or the insert ring molded into the housing could lead to catastrophic mechanical failure of the PX unit enclosure. The PX unit housing has weep holes drilled through it near the bearing plates to help keep the housing heads drained. The housing heads and weep holes should be regularly flushed with permeate to help prevent salt buildup and corrosion.
- The PX unit must never be exposed to temperatures below 33 deg F [1 deg C] or greater than 120 deg F [49 deg C].
- Under no circumstances shall the brine inlet pressure (HP IN) exceed 1,200 psig (82.7 bar).
- The seawater feed inlet pressure shall not exceed 300 psig (20.7 bar). The minimum discharge pressure from the PX unit shall be 8 psig (0.6 bar) and greater than 15 psig (1.0 bar) is recommended.
- The PX unit(s) must be removed from the SWRO system when performing hydrostatic testing on piping or other SWRO system components. Never attempt to hydrostatically test a PX device.

- Install piping and fittings so that the PX unit(s) can be isolated from membrane brine reject flow during membrane cleaning. Failure to do so may introduce debris that may damage the PX unit.

6.2 Start and Stop Procedures

The following procedures are general guidelines for the startup and shutdown of PX systems. Procedure details will vary by plant design. Contact ERI if your plant significantly differs from that shown in Figure 4.2. Always ensure that the operating limits listed in Section 6.1 are not violated.

NOTE

A sample operating-log has been provided at the end of Section 8.0 and must be submitted by fax or e-mail to Energy Recovery, Inc. upon completion of startup and balancing routines. Data should be recorded daily and maintained during the life of the warranty to support any claims.

6.2.1 System Start Up Sequence

1. All valves should be in their normal operating positions.
2. Start the seawater supply pump. The feed flow through the PX unit may or may not cause the rotor to begin to rotate. Rotation will produce a humming sound that is audible at close proximity to the PX unit.
3. Adjust the seawater flow to the desired flow rate.
4. Vent the high-pressure piping. This is necessary to allow air to escape the system and to allow the high-pressure piping to flood with water pushed through the high-pressure pump by the supply pump.
5. After the high-pressure piping is full of water, start the circulation pump. Rotor speed will increase. Bleed any remaining air from the system.
6. Adjust the brine flow to balance the high- and low-pressure flows to the PX unit.
7. After the PX unit and circulation pump have run for five to ten minutes and all air and gas has been purged from the system, close the vent valve.
8. Start the high-pressure pump. The SWRO system pressure will increase to the point where the permeate flow will approximately equal the flow from the high-pressure pump. The sound level from the PX unit will increase. Small variations in sound level and rotor speed are normal.
9. Verify that brine reject pressure (LP OUT) exceeds minimum requirements.
10. Verify the high- and low-pressure flow rates. Adjust flows as necessary to achieve balanced flow to the PX unit.

6.2.2 Short Term (One to Three Days) System Shutdown Sequence

1. Shut off the high-pressure pump.

2. Wait until the system pressure drops to the osmotic pressure of the sea water, e.g. 400 psig (28 bar). If necessary, open a purge valve to expedite depressurization.
3. Shut off the circulation pump.
4. Shut off the seawater supply pump.

6.2.3 Medium Term (4-14 Days) System Shutdown Sequence

1. Feed the PX unit and the SWRO system with fresh water. It is necessary to supply the PX unit and the SWRO system separately to assure rotor rotation during flushing. A feed pressure of 20 psi (1.4 bar) is necessary to assure complete flushing.
2. With the circulation pump operating, run the system for 5 to 10 minutes until all the seawater is purged.
3. Shut off the circulation pump.
4. Isolate the fresh water supply source.

CAUTION

The PX unit must be flushed with fresh water for extended shutdowns to avoid excessive biological growth that may foul the PX device and inhibit rotation upon start-up. The high pressure and low pressure sides of the PX unit should be flushed separately.

6.2.4 Long Term (More Than Two Weeks) System Shutdown Sequence

If a plant is to be shut down for an extended period of time, the SWRO system including the PX units must be thoroughly flushed with fresh water to remove any salt, and precautions should be taken to inhibit biological growth. The high-pressure and low-pressure sides of the PX unit must be flushed separately. The low-pressure side should be flushed with fresh water through the seawater feed line to the PX unit and to the brine drain. The high-pressure flush is typically performed by circulating water through the PX unit and the membranes using the circulation pump. Lubrication flow for the PX device rotors must be provided through the high-pressure pump or some other injection point in the high-pressure loop during fresh water flushing. The PX units should receive a final flush with the same solution used to preserve the SWRO membranes.

CAUTION

Failing to flush the PX unit with fresh water may result in excessive biological growth that may foul the PX unit and inhibit rotation upon start-up. The high-pressure and low-pressure sides of the PX unit must be flushed individually.

6.2.5 Membrane Cleaning

PX unit(s) must be isolated from the reverse osmosis system whenever a chemical cleaning of the membranes is performed to prevent debris from the membrane from entering the PX device. Isolation can be done in a variety of ways, including valves, removable pipe sections, slip blinds (flanges), or removal of the PX units from the system.

CAUTION

PX units must be isolated from the reverse osmosis system whenever a chemical cleaning of the membranes is being performed.

6.3 Flow Control and System Balancing

Flow rates and pressures in a typical SWRO plant will vary slightly over the life of a plant due to temperature variations, membrane fouling, and feed salinity variations. The PX unit's rotor is powered by the flow of fluid through the device. The speed of the rotor is self-adjusting over the PX unit's operating range.

The following subsections make references to PX unit installation process and instrument diagrams provided in Section 12.0.

6.3.1 High-pressure Flow Control

The high-pressure flow through the PX unit is set by adjusting the circulation pump with a variable frequency drive or with a flow control valve and verified with a high-pressure flow meter. The flow rate of the high-pressure seawater out of the PX unit equals the flow rate of the high-pressure brine to the PX unit minus the bearing lubrication flow. The high-pressure flow rate must be verified with a high-pressure flow meter.

NOTE

The flow and pressure of the circulation pump should be controlled with a variable frequency drive and a flow meter.

CAUTION

The high-pressure flow through the PX unit must never exceed the maximum rated flow rate. The only reliable way to determine this flow rate is to use a high-pressure flow meter.

6.3.2 Low Pressure Flow Control

The low-pressure flow through the PX unit is controlled by the seawater supply pump and a control valve in the brine discharge from the PX unit(s). This valve also adds backpressure on the PX device required to prevent destructive cavitation. The low-pressure flow rate must be verified with a flow meter. The flow rate of the low-pressure brine from the PX unit equals the flow rate of the low-pressure seawater to the PX unit plus the bearing lubrication flow rate.

CAUTION

The low-pressure flow through the PX unit must never exceed the maximum rated flow. The only definite way to determine this flow rate is to use a flow meter in the low-pressure line to or from the PX unit.

6.3.3 Balancing the PX Energy Recovery Device

To achieve balanced flow through the PX energy recovery device, use flow meters installed in the low- and high-pressure lines. The high- and low-pressure brine should be set to equal flow rates to within 5% for optimum SWRO operation. Similarly, the high- and low-pressure seawater

flows should be set to equal flow rates to within 5%. If any doubt exists in reading the flow meter, see Section 6.3.4 below.

Operating the PX unit with unbalanced flows can result in contamination of the seawater feed by the brine reject. The PX device is designed to minimize mixing levels such that the salinity of the membrane feed stream is within 3% of the salinity of the raw feedwater. Balanced flows help limit the mixing of concentrate with the feed. A seawater inlet flow that is much less than the seawater outlet will result in lower quality permeate, increased feed pressure, and higher energy consumption.

The following procedure should be applied to achieve balanced flows:

1. Determine the desired flow rate of high-pressure seawater from the PX unit.
2. Adjust the variable frequency drive on the circulation pump until the desired flow rate is achieved as indicated by the high-pressure flow meter.
3. Adjust the seawater supply rate (or the control valve on the low-pressure brine reject from the PX unit) until the low-pressure seawater inlet flow rate equals the high-pressure seawater outlet flow.

6.3.4 Verification of PX Energy Recovery Device Flow Balance

Once the flow rates to the PX energy recovery device have been set, flow balance can be verified by checking the salinity of the high-pressure seawater from the PX unit. If the high- and low-pressure flows through PX unit are balanced, the conductivity at the PX unit high-pressure outlet should be 5 to 6% higher than the conductivity of the low-pressure seawater supply.

Concurrently, the conductivity of the PX unit low-pressure outlet should be 5 to 6% lower than the conductivity of the high-pressure brine. If the conductivity of the PX unit high-pressure outlet is too high, the high-pressure flow rate is probably higher than the low-pressure flow rate causing “blow through” of brine inside the PX unit. High salinity from the PX unit increases osmotic pressure in the membranes which may reduce membrane productivity. See the Troubleshooting Guidelines in Section 9.0 for more information.

Low conductivity in the PX unit low-pressure outlet is an indication of low-pressure overflow. Although membrane productivity is not typically compromised by excess low-pressure flow, the excess flow goes to the brine discharge and represents losses in terms of plant pretreatment costs and capacity. Care should be taken to prevent overflow of the PX unit by high low-pressure flow.

6.3.5 Measurement of PX Device Lubrication Flow Rate

In a PX energy recovery device, some of the high-pressure water flows through the hydrodynamic bearing to low-pressure regions in the assembly. The lubrication flow rate varies with system pressure according to performance curves available on Energy Recovery, Inc.’s website. If the PX device is damaged by debris, overflow or insufficient discharge pressure, excess lubrication flow may occur. Inversely, monitoring lubrication flow is a good way to check the integrity of an operating PX unit. Lubrication flow can be determined using any of the following three methods:

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1. Measure the flow rate of the low-pressure seawater to the high-pressure pump and the flow rate of the permeate. The difference is the lubrication flow rate.
2. Measure the flow rate of the high-pressure brine to the PX unit and the high-pressure seawater from the PX unit. The difference is the lubrication flow rate.
3. Measure the flow rate of the low-pressure brine from the PX unit and the low-pressure seawater to the PX unit. The difference is the lubrication flow rate.

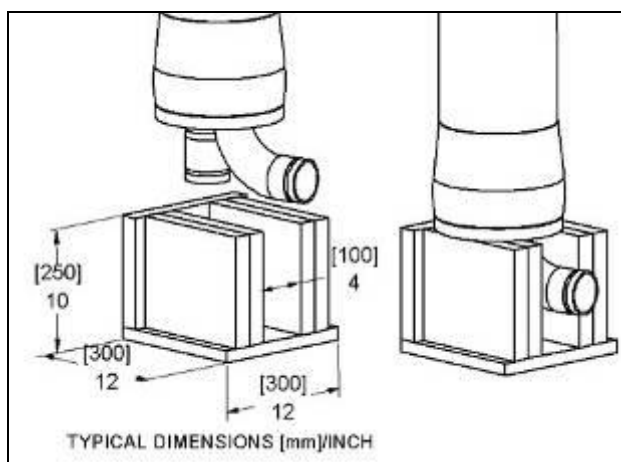
7.0 SPARE PARTS AND TOOL KITS

The PX Pressure Exchanger energy recovery device needs no scheduled periodic maintenance. However, in the event that disassembly is desired or required, the PX unit is designed so that it can be assembled and disassembled in the field with only basic tools and equipment. These tools are listed in Table 7.1. These tools, with the exception of the hoist, are included in the ERI-supplied tool kit (ERI Part Number 20000-01). In addition, the PX unit can be mounted on a stand or on blocks to facilitate service. Figure 7.1 provides dimensions for a simple service stand.

Table 7.1 - Tools and Fixtures Required for Assembly and Disassembly

EQUIPMENT	PURPOSE
threaded stud (typically supplied with order)	to attach to housing for lifting
lifting eye (typically supplied with order)	to attach to threaded stud or tension rod for lifting housing or rotor subassembly
hoist, capacity: 500-pound (227 kg)	for lifting housing or rotor subassembly
1/4 – inch Allen wrench	for removing 5/16-inch hex screws from securing rings or port-bearing plates
2 3/4-inch box wrenches	to assemble and disassemble the ceramic rotor subassembly
torque wrench	to assemble the ceramic rotor subassembly
port bearing plate puller tool	to facilitate removal of ceramic rotor subassembly
water-soluble lubricant such as glycerin or abrasive-free liquid soap	for installing O-rings
PX stand or blocks (see diagram below)	for standing PX unit on
9.2-inch (23 cm) piece of PVC, 3 to 6-inch diameter	temporary shim for reassembly of PX unit

Figure 7.1 - PX Device Service Stand



Replacement seals and pins are included in ERI-supplied spare parts kits (ERI Part Number 20014-01). One spare parts kit should be used each time a PX unit is opened for service.

Replacements for other components in the PX assembly are available. Refer to Section 12.0 for PX component names and the bill of materials for the PX assembly.

CAUTION

Metal objects can chip or crack ceramic. Use caution when handling ceramic components to avoid damage.

8.0 SERVICE

If the inlet and outlet flows are measured and balanced properly, the seawater is filtered and the PX unit is properly flushed before extended shut downs (as described in Section 6.2), the PX unit should operate maintenance- and trouble-free for many years. PX devices need no scheduled periodic maintenance. There are no shafts, couplings, seals, or lubrication systems to maintain or monitor.

If a PX unit must be assembled or disassembled, the procedures provided in this section should be followed carefully. The tools and fixtures listed in Table 7.1 are required. The procedures provided in this subsection are for complete assembly or disassembly of a PX unit. Depending upon the reason for the maintenance work, complete assembly or disassembly may not be required. Refer to Section 12.0 for PX device component names and the bill of materials for the PX unit assembly. Refer to Section 7.0 for recommended spare parts and tool kits.

8.1 Disassembly Procedure

The following procedure is for disassembling a 65 Series PX energy recovery device to inspect the ceramic components. The internal ceramic components can be reached through the brine end of the housing, therefore only the brine access cover needs to be removed. Refer to Section 7.0 for a listing of spare parts and tool kits useful for disassembly and reassembly of a PX unit. Refer to Section 12.0 for PX component names and the bill of materials for PX assembly.

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CAUTION

When handling and installing a PX unit, do not drop the unit or put undue strain on the port fittings to avoid internal damage. Hoist the PX unit using the lifting eye supplied with the PX unit.

DANGER

Make sure the system is fully depressurized prior to disconnecting the PX unit.

1. Depressurize all high-pressure and low-pressure piping to and from the PX unit.
2. Close all valves to and from the PX unit.
3. Disconnect all flexible couplings from the high- and low-pressure ports.
4. Screw the threaded stud into the 5/8-inch threaded hole in the brine side (HP IN) port bearing plate. Screw the lifting eye onto the threaded stud.
5. Hoist the PX unit by the lifting eye.
6. Stand the PX unit on a PX stand. See Figure 8.1 and Figure 7.1. The weight of the PX unit should rest on the fiberglass housing, not on the ports. The brine side (HP IN) should be on top. Leave a hoist attached to the lifting eye.
7. Remove all the 5/16-inch socket-head cap screws from the top of the PX unit using a 1/4-inch Allen wrench as shown in Figure 8.2. Remove the fiberglass securing ring.

Figure 8.1 – Stand PX unit on blocks

**Brine (HP IN)
end up**

**Fiberglass
PX housing**

Stand

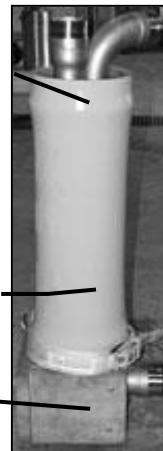
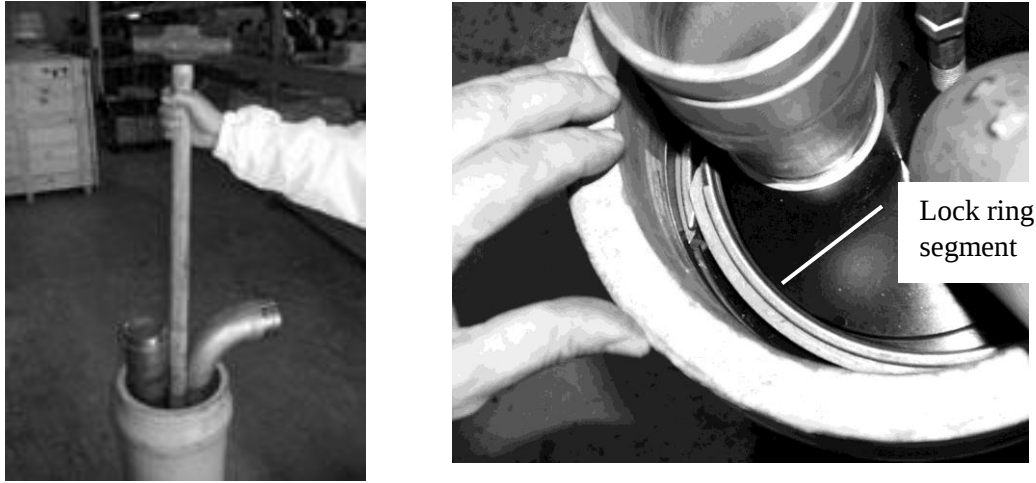


Figure 8.2 – Remove 5/16-inch socket cap screws and remove the securing ring



8. Tap down on the port bearing plate to loosen the lock ring segments as shown in Figure 8.3. Remove the 3-part segmented lock ring.

Figure 8.3 – Tap on Port Bearing Plate to Loosen Lock Ring and Remove Lock Ring

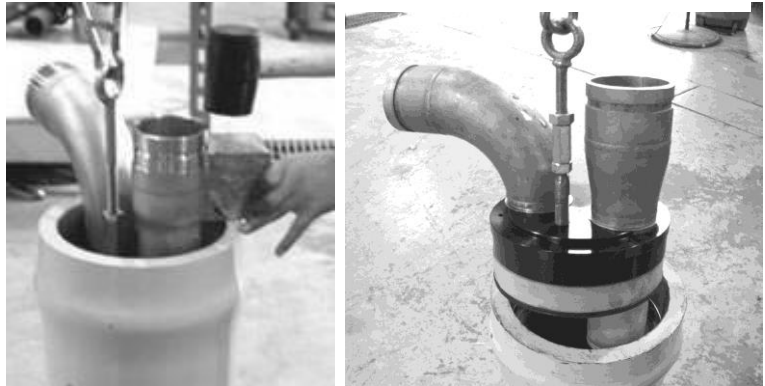


9. Extract the port bearing plate assembly from the housing using an ERI-supplied puller tool or a hoist and mallet as shown in Figure 8.4. Always use a wood block to protect the edge of the housing if force is necessary to remove the endcover.

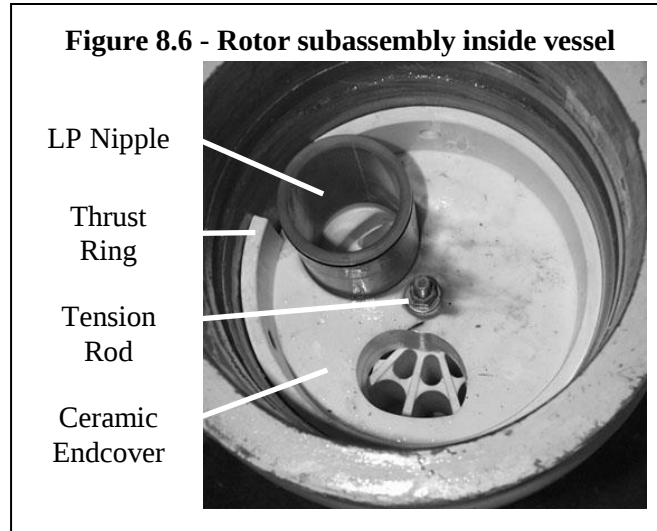
Figure 8.4 – Extract port bearing plate subassembly with puller tool



Figure 8.5 – Extract port bearing plate subassembly with hoist and mallet



10. Remove the thrust ring. Remove the LP nipple. See Figure 8.6.
11. Screw the lifting eye onto the end of the tension rod. Attach a hoist to the lifting eye.



12. Lubricate the inside of the housing with a water-soluble lubricant such as glycerin or nonabrasive liquid soap.
13. Extract the ceramic rotor subassembly from the brine end (HP IN) of the housing. It may be necessary to apply downward force to the edge of the housing while hoisting to get the ceramic rotor subassembly to slide out of the housing. See Figure 8.5 above. Always use a wood block to protect the edge of the housing if force is necessary to remove the rotor subassembly. Be careful not to hit the rotor subassembly.
14. The ceramic rotor subassembly must be returned to the housing in the same orientation it was removed. Mark the housing and the ceramic cartridge with a pencil or marker to assure that correct orientation is retained as shown in Figure 8.7. The brine endcover has an O-ring on the outside. The brine end of the housing is marked “HP IN” and “LP OUT”. Use a pencil or marker to write “SEAWATER” or “BRINE” on the sleeve to assist with reassembly.
15. Stand the ceramic rotor subassembly on blocks allowing clearance for the tension bolt and nuts on the bottom of the assembly. See Figure 8.8 which illustrates correct rotor subassembly orientation.

Figure 8.7 – Mark rotor subassembly to preserve correct orientation

Label ceramic with pencil or marker

Brine end = LP
OUT = HP IN



Figure 8.8 - Rotor subassembly standing on blocks

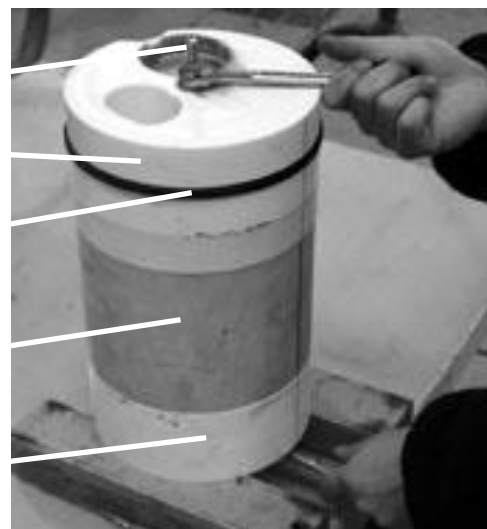
Tension Rod

Brine
Endcover

O-ring/
Quad Ring

Rotor/sleeve
assembly

Seawater
Endcover



16. Remove the hex nuts from the top end of the tension rod.
17. Lift the ceramic endcover off the rotor and sleeve.
18. Lift the rotor and sleeve off the bottom endcover. DO NOT ALLOW THE ROTOR TO COME OUT OF THE SLEEVE.
19. If the rotor comes out of the sleeve, the following procedure should be applied:
 - a. Clean the rotor and sleeve. Rinse liberally.
 - b. Inspect rotor and sleeve. Remove all debris. Avoid getting lint or dirt onto the ceramic. Re-rinse if necessary.
 - c. Identify the end of the rotor marked “CHK”. Place the rotor on a flat clean surface with the end marked “CHK” oriented upward.
 - d. Identify the end of the sleeve marked “CHK” and orient it upward. The sleeve is marked “CHK SWP” should be oriented downward.
 - e. Hold the sleeve over the rotor. Slowly slide the sleeve onto the rotor. This is a very tight fit and requires a gentle touch. Do not force the sleeve on by pressing or hitting it. The sleeve should slide on easily. If the rotor and sleeve become bound, use hot water on the sleeve to loosen it from the rotor.
 - f. Contact Energy Recovery, Inc. if problems are encountered.

CAUTION

Thoroughly flush all PX components with water filtered to 10 microns before assembling PX unit. Foreign material may inhibit rotor movement.

8.2 Assembly Procedure

This assembly procedure assumes that the PX unit has been disassembled per the previous section. All parts should be carefully cleaned with soap and water prior to assembly to ensure that no dirt or debris contaminates the PX device. All parts should be thoroughly inspected for

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damage and/or debris prior to reassembly. O-rings should be carefully inspected for damage and should be replaced if damage is apparent. Do not attempt to reassemble a PX unit with damaged or broken parts. Refer to Section 7.0 for a list of spare parts and tools for PX unit service. Refer to Section 12.0 for a complete listing of PX component names and the bill of materials for PX assemblies.

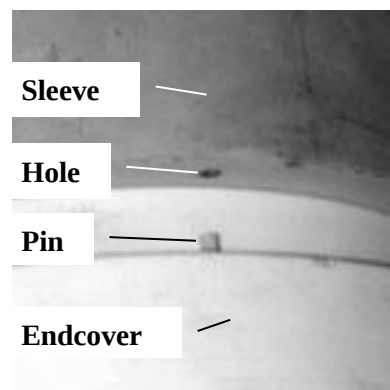
To assemble the unit, follow these steps:

1. Insert dowel pins into the 3 holes in the face of one endcover as shown in Figure 8.9. Make sure the dowel pins insert fully without binding and without being shaved. If pins bind, remove and clear pins and holes of any debris.
2. Place the rotor and sleeve on the endcover. Make sure that the dowel pins in the endcover line up with the 3 holes in the sleeve as illustrated in Figure 8.10.

Figure 8.9 - Insert dowel pins into endcovers



Figure 8.10 – Align endcover pins with holes in sleeve

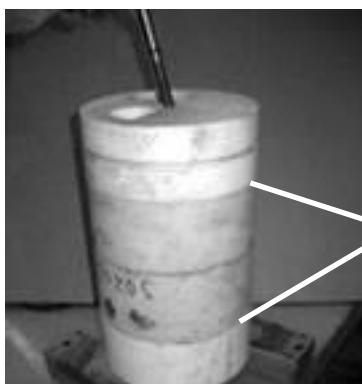


3. Stack the ceramic as shown in Figure 8.11. The end of the rotor/sleeve assembly marked "BRINE" must be oriented toward the brine endcover, which has an O-ring on it.

CAUTION

Alignment pins must not bind or be shaved during installation. Carefully inspect ceramic contact lines after installation for any indication of pin damage or binding.

Figure 8.11 – Complete ceramic stack



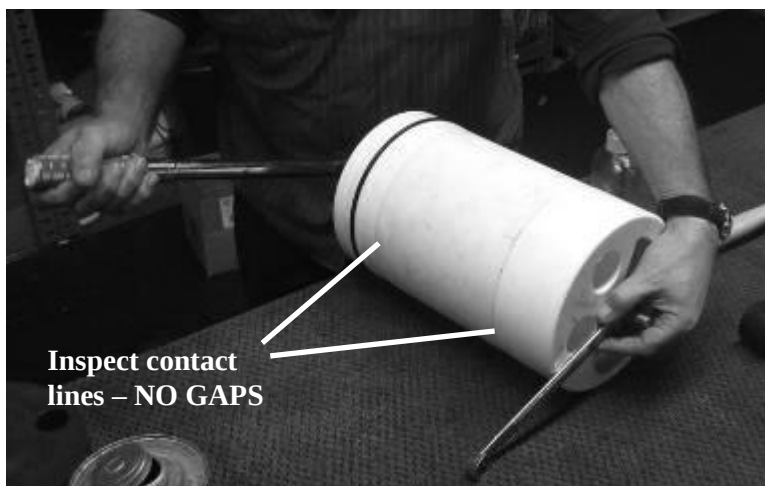
Inspect contact lines. Absolutely no gaps allowed.

CAUTION

Introduction of non-water soluble films such as grease, oil, wax, petroleum jelly, etc. may inhibit rotor function.

4. Carefully inspect the contact lines between the sleeve and the endcovers to be sure there are no gaps. See Figure 8.11. Occasionally, the assembly process will shave one or more of the pins and the debris that is generated will prevent the sleeve and the endcover from coming into intimate contact. If this occurs, remove the rotor and sleeve assembly, rinse ceramics, and remove all debris. Repeat assembly.

Figure 8.12 – Torque inside nuts to 15 ft-lbs (20 N-m)



Inspect contact lines – NO GAPS

5. Replace tension rod O-rings.
6. Lubricate the tension-rod O-rings and the inside of the center hole of both endcovers with a water-soluble lubricant such as glycerin or nonabrasive liquid soap. Do not use grease!
7. Insert the tension rod through the ceramic endcovers and rotor as shown in Figure 8.11.
8. Center the rod on the assembly.

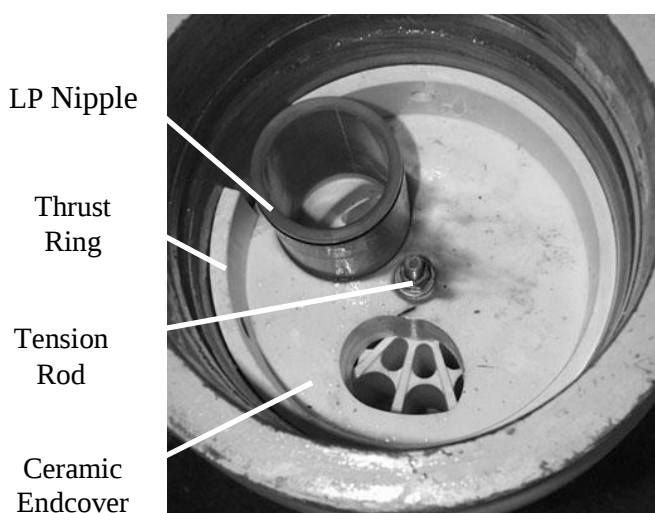
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9. Install the washers and one pair of hex nuts. The fiberglass/plastic washer should be stacked onto the tension rod so that it comes into contact with the ceramic.
10. Torque nuts into ceramic rotor subassembly to 15 ft-lb (20 N-m) as shown in Figure 8.12.
11. Thread the second pair of hex nuts (stop nuts) onto the tension rod. Torque each stop nut to 40 ft-lb (56 N-m) against the first nut.
12. Verify that the rotor can spin freely.
13. Lubricate the O-ring. The ceramic rotor subassembly is now ready to be inserted into the housing.
14. Stand the housing on one end with the brine end oriented upward. The port bearing plate on the seawater end of the unit should already be in the housing.
15. Lubricate the inside of the housing with a water-soluble lubricant.
16. Attach the lifting eye to the ceramic rotor subassembly. Attach a hoist to the lifting eye. Hoist the rotor subassembly as shown in Figure 8.13 below.
17. Line up the ceramic rotor subassembly with the markings on the outside of the housing. The LP nipples should line up with the "LP IN" and "LP OUT" labels on the housing.
18. Insert the rotor subassembly into the housing as shown in Figure 8.13. Slide the rotor subassembly to the center of the housing.
19. Disconnect the hoist from the rotor subassembly.
20. Lubricate the O-rings of one low-pressure nipple with a water-soluble lubricant. Insert the nipple into the countersink of the brine (top) endcover.
21. Insert a thrust ring into the housing as shown in Figure 8.14. The ring must be compressed slightly during insertion.

Figure 8.13 - Insert rotor subassembly into vessel

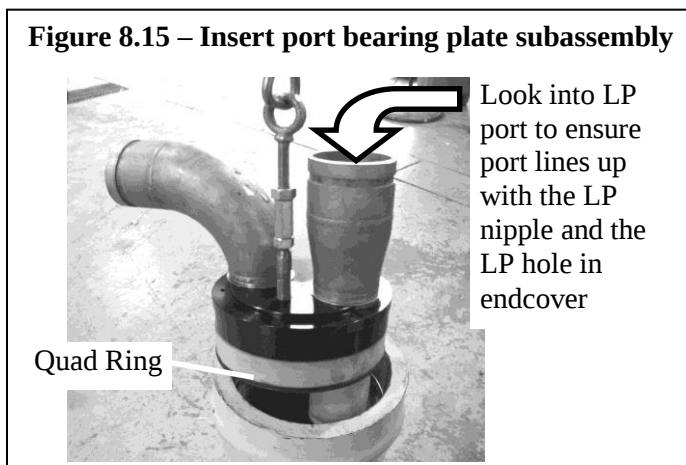


Figure 8.14 - Rotor subassembly inside vessel



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22. Assemble the ports, the securing ring, the port bearing plate, the port locking rings, the seal plate and the O-rings as shown in the assembly drawing included in Section 12.0. A completed port bearing plate subassembly is shown in Figure 8.15. Be sure to lubricate all O-rings with a water-soluble lubricant or a non-abrasive liquid soap.



23. Mount the quad ring onto the port bearing plate subassembly. Lubricate the quad ring.
24. Insert the port bearing plate subassembly into the top of the housing. Make sure the low-pressure port lines up with the low-pressure nipple. This can be verified by looking down through the low-pressure port while inserting the port bearing plate subassembly. See Figure 8.15. If the port bearing plate does not insert fully, the low-pressure nipple may not be correctly aligned with the port bearing plate subassembly or the low-pressure hole in the ceramic endcover. Look down into the low-pressure port as illustrated in Figure 8.15 to verify alignment. If the low-pressure port, nipple, and endcover are not aligned, remove the port bearing plate assembly completely, remount the quad ring, and try again.
25. Insert the 3-part segmented lock ring into the space between the port bearing plate and the housing as shown in Figure 8.16. If the lock ring segments will not fit into the gap, make sure the segments are correctly oriented as shown in Figure 8.16. If the segments still do not fit, this may be an indication that the low-pressure nipple is not correctly aligned. If so, remove the port bearing plate and repeat the previous step.

Figure 8.16 – Insert 3-part segmented lock ring



26. Insert the fiberglass securing ring. Bolt down the securing ring with three 5/16-inch socket-head cap screws.

CAUTION

When handling and installing a PX unit, care should be taken to avoid dropping the unit or putting undue strain on the port fittings to avoid internal damage. Do not lift the PX unit with the ports. Use the lifting eye provided with the PX unit.

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ENERGY RECOVERY, INC. SAMPLE OPERATING LOG

NOTE: Daily data must be collected and maintained to support any warranty claims.

Fax: +1 510 483 7371 Attn: Warranty Administration Department

Total number of Pressure Exchangers in parallel _____

Model of Pressure Exchanger(s) installed _____

Serial Number(s) _____

Units (please circle one): psi/gpm bar/m³/hr

Date	Total Hours	HP Inlet Pressure	HP Inlet Flow	HP Inlet Salinity	HP Outlet Pressure	HP Outlet Flow	HP Outlet Salinity	LP Inlet Pressure	LP Inlet Flow	LP Inlet Salinity	LP Outlet Pressure

9.0 TROUBLESHOOTING

This section is designed to guide the operator in identifying and correcting most of the problems that could occur in the PX Pressure Exchanger energy recovery device. The instructions provided below are intended for use by personnel with general training and experience in the operation and maintenance of fluid handling systems. This is not intended as a comprehensive maintenance guide. The best troubleshooting tool is the knowledge, experience, and day-to-day observations compiled by the SWRO plant operator. Conditions not covered in this section may be resolved by contacting Energy Recovery, Inc.'s Service Department. Contact information is provided in the following section.

Preliminary procedures:

1. Always check for proper valve configuration for the operation mode selected.
2. Always check for loose connections or broken wires when checking electrical parts.
3. Always inspect and test equipment or apparatus for possible causes of malfunctions before performing replacements.

When using this troubleshooting guide, please read all the probable causes before taking any action. Use common sense and select the cause that seems to best fit the given situation.

Table 9-1. Troubleshooting

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
A. Excessive sound levels	1. Operating PX unit(s) above rated flow rates on low-pressure side, high-pressure side or both	Immediately reduce flow rate by adjustment of circulation pump and LP control valve. Balance the system as described in Section 6.3. To increase system capacity, add PX unit(s) in parallel to existing units.
	2. Operating PX unit(s) below minimum back-pressure	Increase back-pressure by adjusting the LP control valve. Re-balance the system as described in Section 6.3.
	3. Air in system	Bleed air.

65-SERIES PX PRESSURE EXCHANGER ENERGY RECOVERY DEVICES

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
	4. PX unit or ceramic cartridge installed upside down	Verify that the PX unit has been installed with the end marked “HP IN” oriented toward the brine inlet. If service was performed, verify the orientation of the ceramic cartridge by removing the brine-side port bearing plate assembly. The endcover marked “B” should be oriented toward the brine inlet/outlet.
	5. Damaged ceramic	Contact the Energy Recovery, Inc. Service Department
B. Excessive high pressure in SWRO system.	1. High-pressure pump is operating at too high a flow rate.	Verify that main HP pump flow rate does not exceed the membrane array production capacity for a given temperature, salinity, and fouling factor.
	2. Excessively high recovery in the SWRO system.	Reduce recovery by increasing and balancing flows through the PX unit(s). Do not exceed recommended maximum PX unit flow rates. To increase capacity, add PX unit(s) in parallel to existing units.
	3. Low pressure flow is less than high-pressure flow, resulting in mixing and high SWRO feed water salinity.	See Section 6.3.
	4. Stuck rotor.	See Symptom D.
C. High salinity in high-pressure seawater feed stream	1. Unbalanced system - low-pressure flow rate too low or high-pressure flow rate too high	See Section 6.3.

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SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
	2. A jammed or stalled rotor short circuits high-pressure brine reject water with high-pressure feed water. No exchange occurs; no audible rotation. 3. Malfunctioning and/or stalled circulation pump	See Symptom D. Check circulation pump's rotation, operation, flows, and pressures.
D. Stalled rotor - no audible rotation	1. Operating system above rated pressure or below rated permeate flow capacity 2. Foreign debris or particles lodged in device.	Check pressures and flows. See Table 6.1. Contact the Energy Recovery, Inc. Service Department.
E. Low permeate flow	1. Malfunctioning high-pressure pump. 2. High lubrication/leakage flow through PX unit(s)	Verify high-pressure pump flow rate and pressure. Leak inside PX unit or stalled rotor. Confirm that all rotors are rotating. If not, see Symptom D. If all rotors are rotating, contact the Energy Recovery, Inc. Service Department.
F. Low brine reject flow	1. Excessive pressure losses through SWRO system 2. Malfunctioning and/or stalled circulation pump	Contact SWRO supplier. Check circulation pump operation, flows, and pressures.

10.0 FIELD COMMISSIONING AND SUPPORT SERVICES

The Technical Services staff of Energy Recovery, Inc. offers commissioning service for all ERI products during field installation and/or at a SWRO system manufacturer's location. Although not required, ERI offers commissioning as an additional service for those customers who may find it beneficial. Rate quotes are available upon request.

Should a problem develop with any ERI product, the Energy Recovery, Inc. Technical Services group is prepared to handle customers' concerns whether the location is domestic or abroad. Service rates are available upon request.

Energy Recovery, Inc.
1717 Doolittle Drive
San Leandro, CA 94577 USA
Tel: +1 510 483 7370
Fax: +1 510 483 7371
Email: sales@energyrecovery.com
Web: www.energyrecovery.com

11.0 REVISION LOG

Revision Log

Revision	Description	Date	Approval
A	Initial release	11/8/02	R. Stover
B	Updated operating conditions for PX 220	12/18/02	R. Stover
C	Added PX 180, decreased allowable backpressure to 1.0 bar	7/31/03	R. Stover
0	Added membrane cleaning provisions, spare parts list, P&ID to appendix, drawing list, revised assembly/disassembly procedures	6/29/04	R. Stover
1	Added trademarks, removed performance curves	8/10/04	R. Stover
2	Added air warnings	1/25/05	R. Stover
3	Revised warranty, clarified trapped air warnings, revised standard P&ID, added PX stand, added double couplings, edited	8/11/05	R. Stover
4	Reduced discharge pressure, revised warranty	10/3/05	R. Stover
5	Increased max. inlet pressure, max. temp., updated logo	7/19/06	R. Stover
6	Updated part numbers, torque specification, warranty to appendix	2/22/07	I. Cameron
7	Added PX-260, updated flushing procedure	1/2/08	I. Cameron
8	Increased flow range of PX devices	8/18/08	I. Cameron
9	Added PX-Q260	4/13/12	
9	Added New ERI logo	5/6/14	B. Biche
10	Added 140, Q140, Q180 and Q220 models	4/30/18	R. Bosleman

12.0 DRAWINGS AND DATA

<u>Drawing / Document</u>	<u>ERI Document Number</u>
65 Series PX Assembly Drawing	40009
PX-260 Assembly Drawing	40018
PX-Q260 Assembly Drawing	40034/40035
General Train Array	60007
General Cell Array	60008
Process and Instrumentation Diagram	80046-01

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• OR EQUIVALENT

Description

Page	1
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TOLERANCES: (IN INCHES)

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ENERGY RECOVERY SYSTEMS, INC.
1808 Doolittle Drive, San Leandro, CA 94577
Ph. (510) 483-7370 / Fax (510) 483-7371
www.enienergyrecovery.com

ARC (td)	JGNI	12220
ARC (td)	PIS	12300

Technical drawing of a part. The top view shows a circle with a crosshair. The side view shows a rectangle with a dashed line indicating a hidden edge.

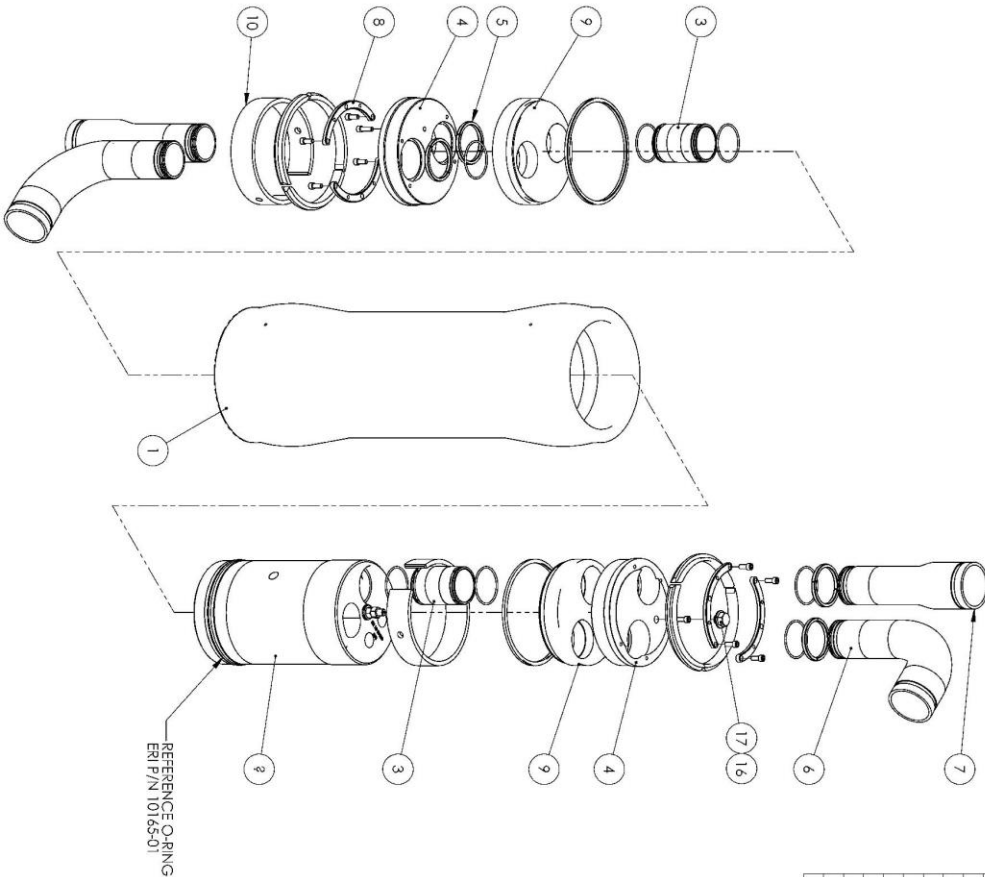
THIRD ANGLE PROJECTION

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65-SERIES PX PRESSURE EXCHANGER ENERGY RECOVERY DEVICES

- NOTES:
1. INSTALL O-RINGS WITH APPROVED WATER BASED LUBRICANT
 2. REFER TO OPERATIONS AND MAINTNANCE MANUAL FOR ASSEMBLY, DISASSEMBLY INSTRUCTIONS AND REQUIREMENTS.



BILL OF MATERIALS			
ITEM NO.	43006-01 /QTY.	PART NO.	DESCRIPTION
1	1	43007-01	HOUSING
2	1	43046-01	ASSY. INTERNALS, PX-260
3	2	43019-01	NIPPLE, LOW PRESSURE
4	2	43009-01	PLATE BEARING, PORT
5	8	43031-01	RING, LOCKING, PORT
6	2	43042-01	PORT, ELBOW, 3X2.5, AL6 IC, 65
7	2	43043-01	PORT, STRT, 3X2.5, AL6 IC, 65
8	4	43056-01	RING, LOCK, 65 SERIES
9	2	43010-01	PLATE, SEALING
10	2	43012-01	RING, THRUST, 65 SERIES
11	8	10162-01	O-RING, NSF, -231, EPDM
12	6	10013-01	SEGMENT, LOCK RING, 8"
13	2	10078-01	SHCS, 5/16-18 X 1" LG
14	2	10065-02	SEAL, QUAD RING, NSF, 442, EPDM
15	8	10077-01	SHCS, 5/16-18 X 3/4" LG
16	1	10235-01	WSHR, FLAT SEALING, 5/8, EPDM
17	1	10234-01	SCREW, HEX, 5/8-11 X 5.1, NITLON

* OR EQUIVALENT

Part Number:	Description
40018-01	PX-260 ASSY LABELED FOR SEAWATER SIDE UP
40018-02	PX-260 ASSY LABELED FOR CONCENTRATE SIDE UP

INCH

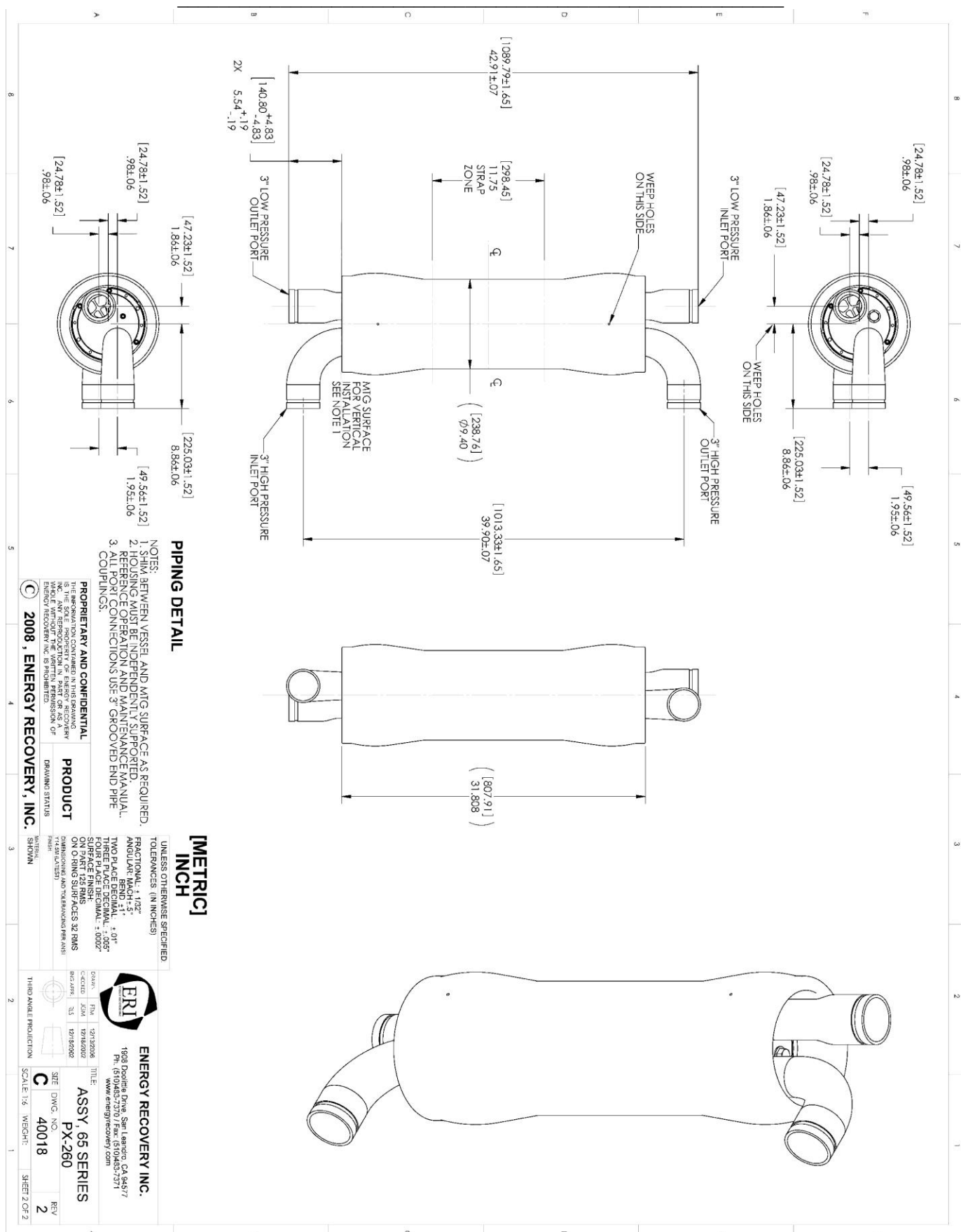
UNLESS OTHERWISE SPECIFIED

TOLERANCES:
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ANGULAR: BEND $\pm .5"$
TWO PLACE DECIMAL: $\pm .01"$
THREE PLACE DECIMAL: $\pm .005"$
SURFACE FINISH:
ON PART 725 RMS
ON OTHER SURFACES 32 RMS
FINISH TO BE SPECIFIED
ON DRAWING AND TOLERANCE SURFACES
FINISH TO BE SPECIFIED

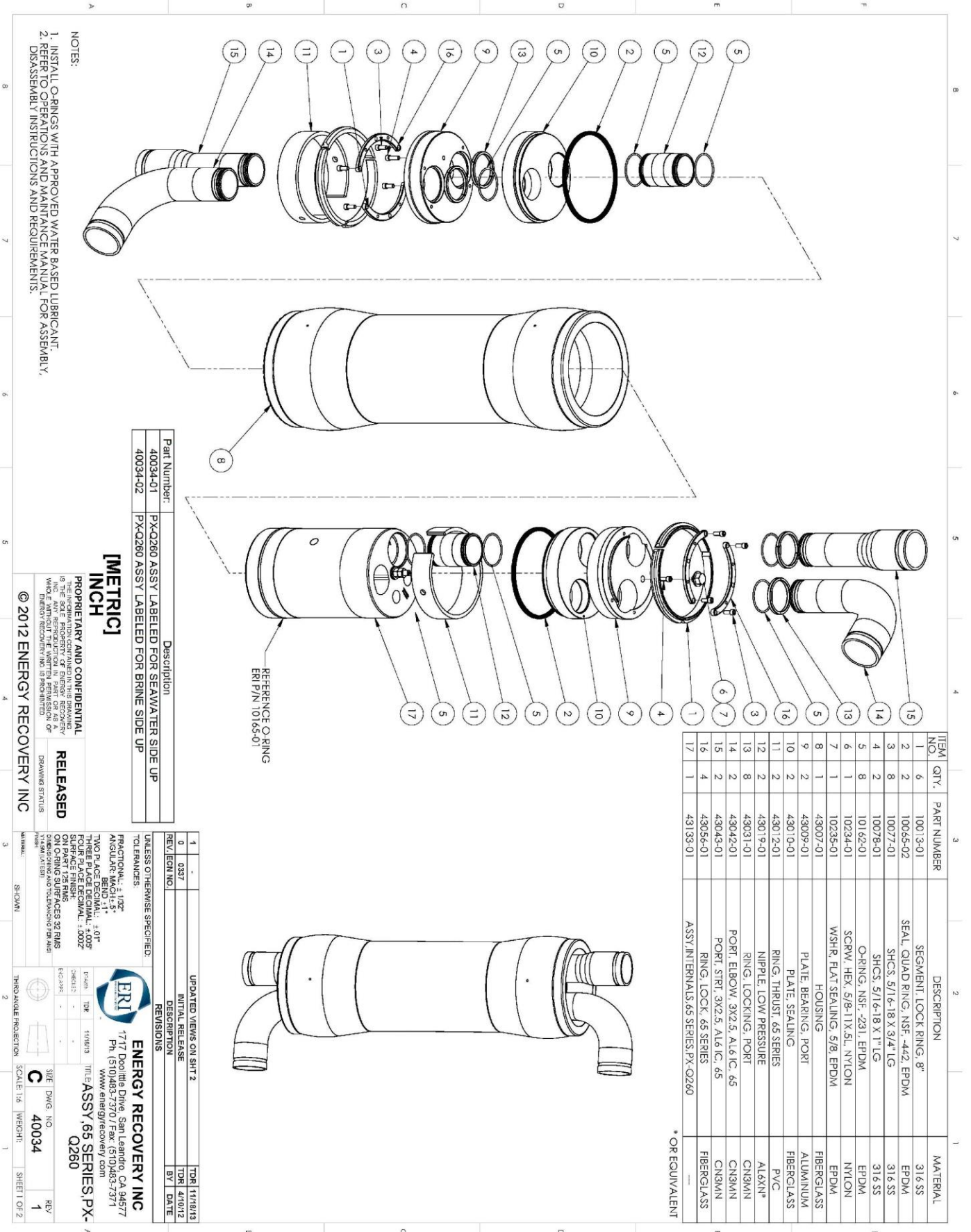
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DRAWING STATUS
C 2008, ENERGY RECOVERY, INC.

2	DATE	12/13/2008	DESIGNED BY	TRM	12/13/2008	REVISION	1	DATE	12/13/2008	DESCRIPTION	REVISION	2	DATE	12/13/2008	DESCRIPTION	REVISION	3	DATE	12/13/2008	DESCRIPTION	REVISION	4	DATE	12/13/2008	DESCRIPTION	REVISION	5	DATE	12/13/2008	DESCRIPTION	REVISION	6	DATE	12/13/2008	DESCRIPTION	REVISION	7	DATE	12/13/2008	DESCRIPTION	REVISION	8	DATE	12/13/2008	DESCRIPTION	REVISION	9	DATE	12/13/2008	DESCRIPTION	REVISION	10	DATE	12/13/2008	DESCRIPTION	REVISION	11	DATE	12/13/2008	DESCRIPTION	REVISION	12	DATE	12/13/2008	DESCRIPTION	REVISION	13	DATE	12/13/2008	DESCRIPTION	REVISION	14	DATE	12/13/2008	DESCRIPTION	REVISION	15	DATE	12/13/2008	DESCRIPTION	REVISION	16	DATE	12/13/2008	DESCRIPTION	REVISION	17	DATE	12/13/2008	DESCRIPTION	REVISION	18	DATE	12/13/2008	DESCRIPTION	REVISION	19	DATE	12/13/2008	DESCRIPTION	REVISION	20	DATE	12/13/2008	DESCRIPTION	REVISION	21	DATE	12/13/2008	DESCRIPTION	REVISION	22	DATE	12/13/2008	DESCRIPTION	REVISION	23	DATE	12/13/2008	DESCRIPTION	REVISION	24	DATE	12/13/2008	DESCRIPTION	REVISION	25	DATE	12/13/2008	DESCRIPTION	REVISION	26	DATE	12/13/2008	DESCRIPTION	REVISION	27	DATE	12/13/2008	DESCRIPTION	REVISION	28	DATE	12/13/2008	DESCRIPTION	REVISION	29	DATE	12/13/2008	DESCRIPTION	REVISION	30	DATE	12/13/2008	DESCRIPTION	REVISION	31	DATE	12/13/2008	DESCRIPTION	REVISION	32	DATE	12/13/2008	DESCRIPTION	REVISION	33	DATE	12/13/2008	DESCRIPTION	REVISION	34	DATE	12/13/2008	DESCRIPTION	REVISION	35	DATE	12/13/2008	DESCRIPTION	REVISION	36	DATE	12/13/2008	DESCRIPTION	REVISION	37	DATE	12/13/2008	DESCRIPTION	REVISION	38	DATE	12/13/2008	DESCRIPTION	REVISION	39	DATE	12/13/2008	DESCRIPTION	REVISION	40	DATE	12/13/2008	DESCRIPTION	REVISION	41	DATE	12/13/2008	DESCRIPTION	REVISION	42	DATE	12/13/2008	DESCRIPTION	REVISION	43	DATE	12/13/2008	DESCRIPTION	REVISION	44	DATE	12/13/2008	DESCRIPTION	REVISION	45	DATE	12/13/2008	DESCRIPTION	REVISION	46	DATE	12/13/2008	DESCRIPTION	REVISION	47	DATE	12/13/2008	DESCRIPTION	REVISION	48	DATE	12/13/2008	DESCRIPTION	REVISION	49	DATE	12/13/2008	DESCRIPTION	REVISION	50	DATE	12/13/2008	DESCRIPTION	REVISION	51	DATE	12/13/2008	DESCRIPTION	REVISION	52	DATE	12/13/2008	DESCRIPTION	REVISION	53	DATE	12/13/2008	DESCRIPTION	REVISION	54	DATE	12/13/2008	DESCRIPTION	REVISION	55	DATE	12/13/2008	DESCRIPTION	REVISION	56	DATE	12/13/2008	DESCRIPTION	REVISION	57	DATE	12/13/2008	DESCRIPTION	REVISION	58	DATE	12/13/2008	DESCRIPTION	REVISION	59	DATE	12/13/2008	DESCRIPTION	REVISION	60	DATE	12/13/2008	DESCRIPTION	REVISION	61	DATE	12/13/2008	DESCRIPTION	REVISION	62	DATE	12/13/2008	DESCRIPTION	REVISION	63	DATE	12/13/2008	DESCRIPTION	REVISION	64	DATE	12/13/2008	DESCRIPTION	REVISION	65	DATE	12/13/2008	DESCRIPTION	REVISION	66	DATE	12/13/2008	DESCRIPTION	REVISION	67	DATE	12/13/2008	DESCRIPTION	REVISION	68	DATE	12/13/2008	DESCRIPTION	REVISION	69	DATE	12/13/2008	DESCRIPTION	REVISION	70	DATE	12/13/2008	DESCRIPTION	REVISION	71	DATE	12/13/2008	DESCRIPTION	REVISION	72	DATE	12/13/2008	DESCRIPTION	REVISION	73	DATE	12/13/2008	DESCRIPTION	REVISION	74	DATE	12/13/2008	DESCRIPTION	REVISION	75	DATE	12/13/2008	DESCRIPTION	REVISION	76	DATE	12/13/2008	DESCRIPTION	REVISION	77	DATE	12/13/2008	DESCRIPTION	REVISION	78	DATE	12/13/2008	DESCRIPTION	REVISION	79	DATE	12/13/2008	DESCRIPTION	REVISION	80	DATE	12/13/2008	DESCRIPTION	REVISION	81	DATE	12/13/2008	DESCRIPTION	REVISION	82	DATE	12/13/2008	DESCRIPTION	REVISION	83	DATE	12/13/2008	DESCRIPTION	REVISION	84	DATE	12/13/2008	DESCRIPTION	REVISION	85	DATE	12/13/2008	DESCRIPTION	REVISION	86	DATE	12/13/2008	DESCRIPTION	REVISION	87	DATE	12/13/2008	DESCRIPTION	REVISION	88	DATE	12/13/2008	DESCRIPTION	REVISION	89	DATE	12/13/2008	DESCRIPTION	REVISION	90	DATE	12/13/2008	DESCRIPTION	REVISION	91	DATE	12/13/2008	DESCRIPTION	REVISION	92	DATE	12/13/2008	DESCRIPTION	REVISION	93	DATE	12/13/2008	DESCRIPTION	REVISION	94	DATE	12/13/2008	DESCRIPTION	REVISION	95	DATE	12/13/2008	DESCRIPTION	REVISION	96	DATE	12/13/2008	DESCRIPTION	REVISION	97	DATE	12/13/2008	DESCRIPTION	REVISION	98	DATE	12/13/2008	DESCRIPTION	REVISION	99	DATE	12/13/2008	DESCRIPTION	REVISION	100	DATE	12/13/2008	DESCRIPTION	REVISION	101	DATE	12/13/2008	DESCRIPTION	REVISION	102	DATE	12/13/2008	DESCRIPTION	REVISION	103	DATE	12/13/2008	DESCRIPTION	REVISION	104	DATE	12/13/2008	DESCRIPTION	REVISION	105	DATE	12/13/2008	DESCRIPTION	REVISION	106	DATE	12/13/2008	DESCRIPTION	REVISION	107	DATE	12/13/2008	DESCRIPTION	REVISION	108	DATE	12/13/2008	DESCRIPTION	REVISION	109	DATE	12/13/2008	DESCRIPTION	REVISION	110	DATE	12/13/2008	DESCRIPTION	REVISION	111	DATE	12/13/2008	DESCRIPTION	REVISION	112	DATE	12/13/2008	DESCRIPTION	REVISION	113	DATE	12/13/2008	DESCRIPTION	REVISION	114	DATE	12/13/2008	DESCRIPTION	REVISION	115	DATE	12/13/2008	DESCRIPTION	REVISION	116	DATE	12/13/2008	DESCRIPTION	REVISION	117	DATE	12/13/2008	DESCRIPTION	REVISION	118	DATE	12/13/2008	DESCRIPTION	REVISION	119	DATE	12/13/2008	DESCRIPTION	REVISION	120	DATE	12/13/2008	DESCRIPTION	REVISION	121	DATE	12/13/2008	DESCRIPTION	REVISION	122	DATE	12/13/2008	DESCRIPTION	REVISION	123	DATE	12/13/2008	DESCRIPTION	REVISION	124	DATE	12/13/2008	DESCRIPTION	REVISI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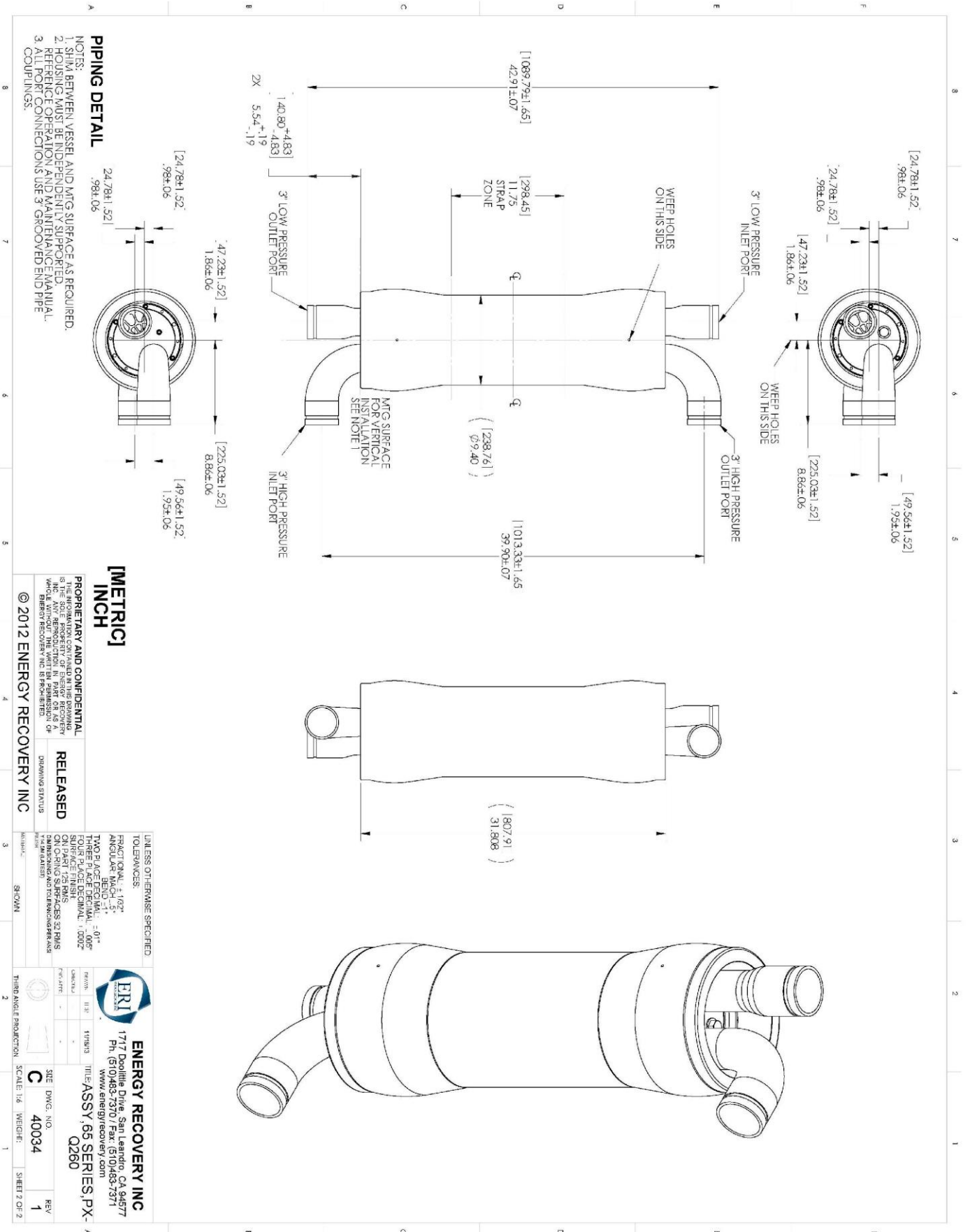
Energy Recovery, Inc.



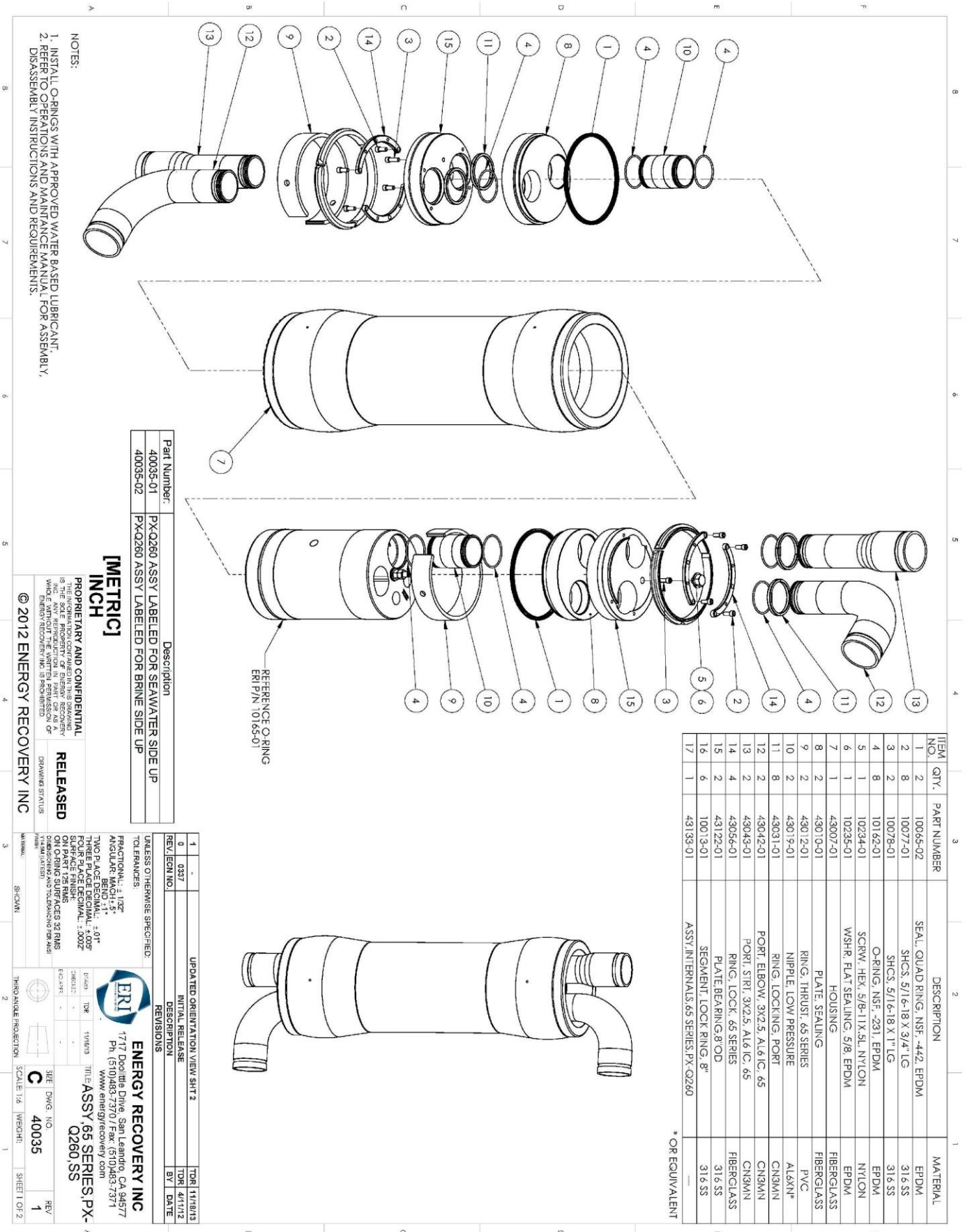
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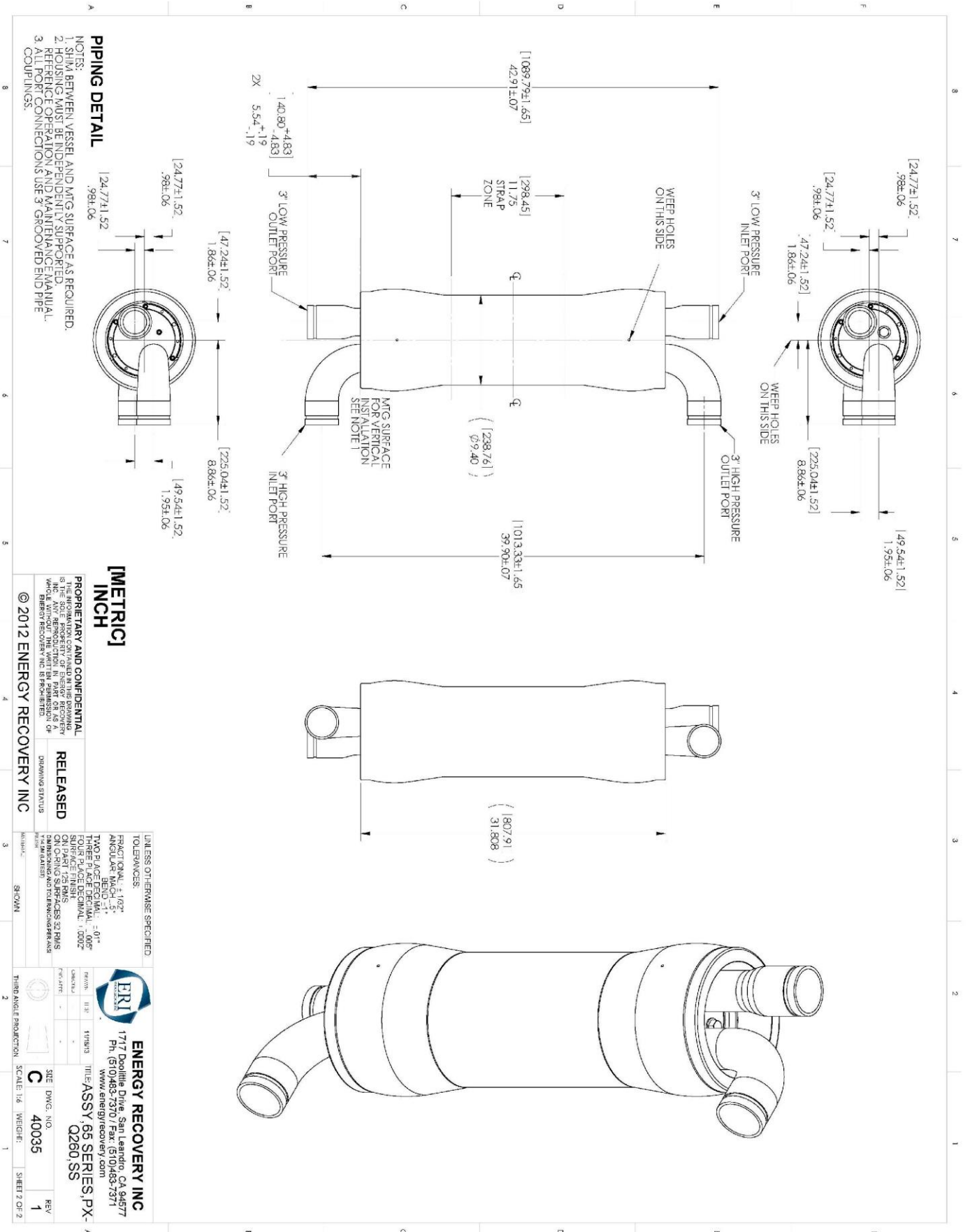
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65-SERIES PX PRESSURE EXCHANGER ENERGY RECOVERY DEVICES

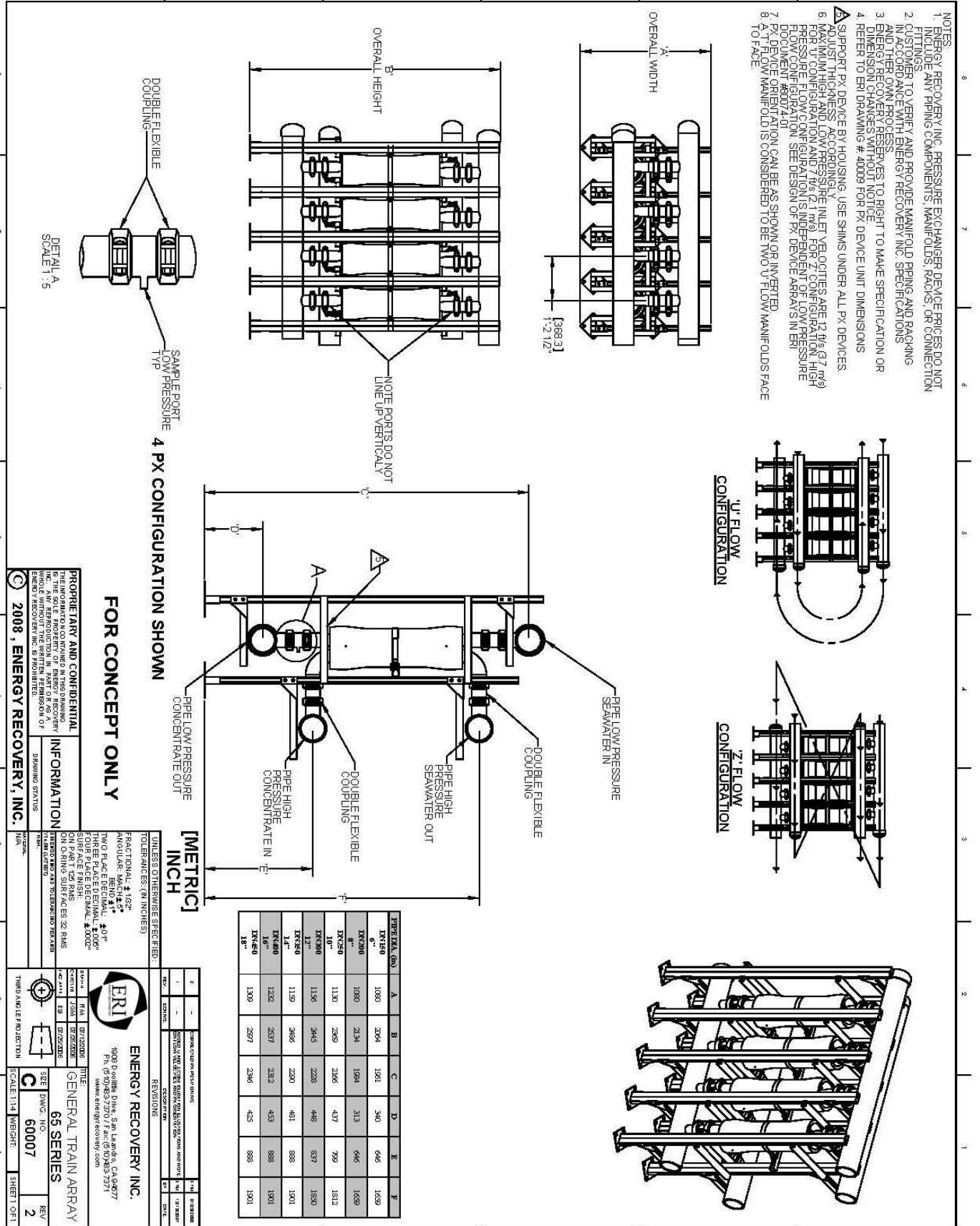


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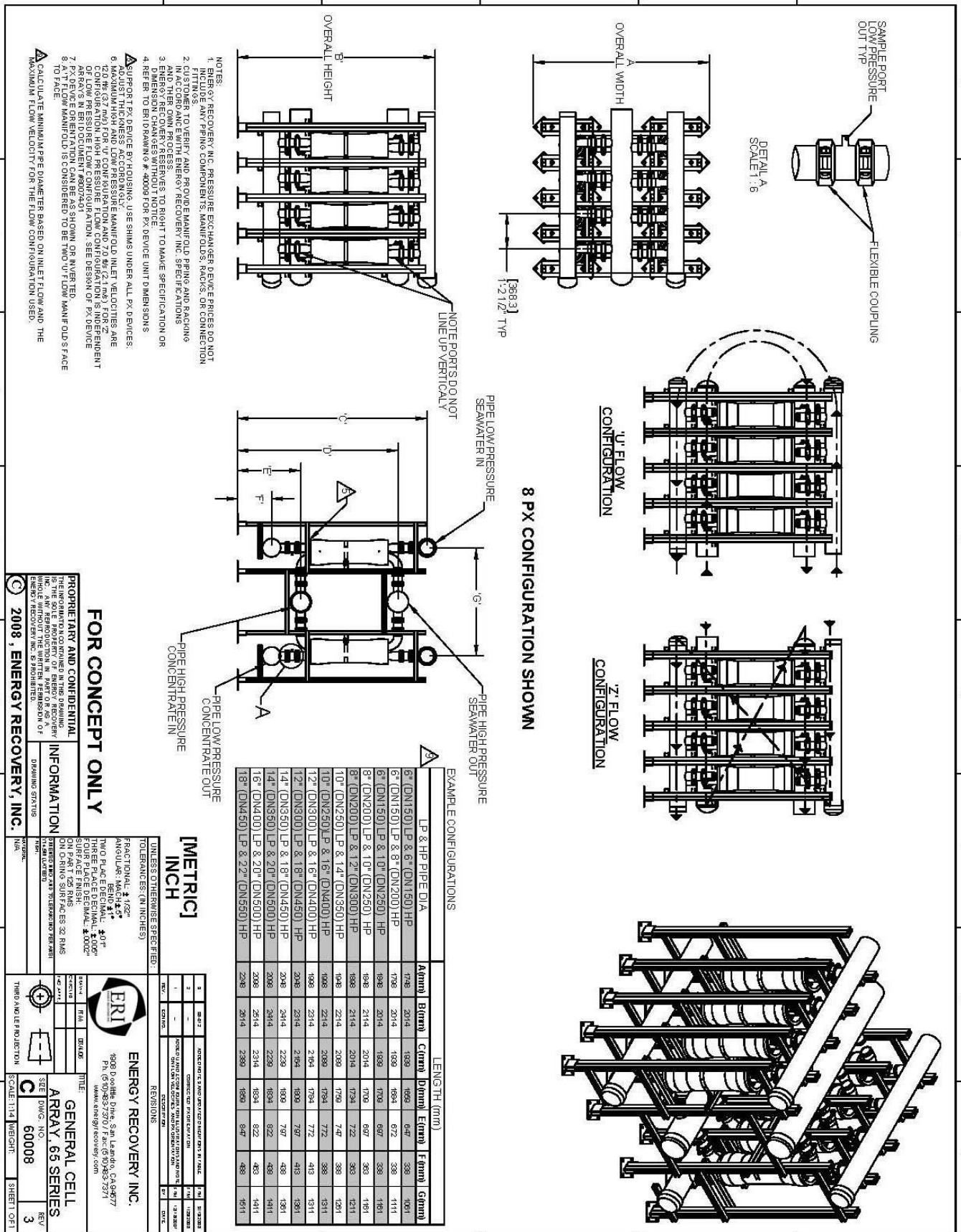
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