



Making fluid energy work for **you**™

Product & Applications Catalog

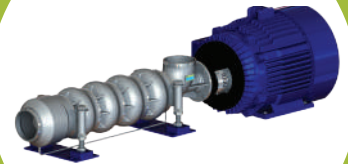
Fluid Equipment Development Company, LLC



HPB



LPH



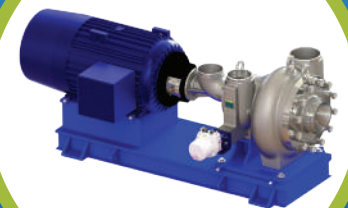
MSD



SLP



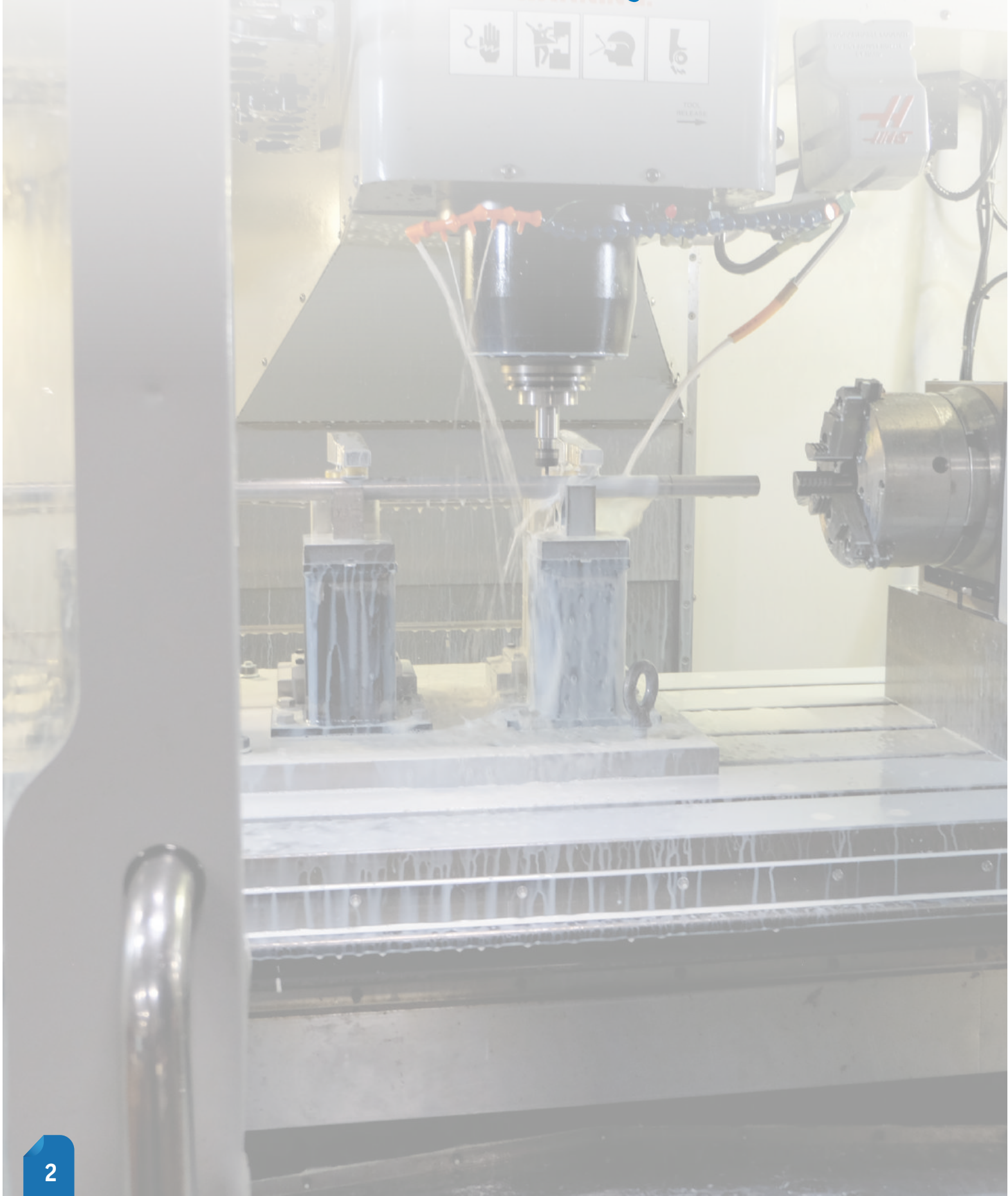
MSS



HP-HEMI

**HP Feed Pumps and Energy Recovery Boosters
for Brackish and Seawater RO Applications**

Innovative Fluid Machinery since 1997





Your Single Source for Pumps and Energy Recovery Systems

Fluid Equipment Development Company (**FEDCO**) was founded in 1997 to develop new fluid machinery to reduce the cost of reverse osmosis desalination. The results included patented concepts, highly integrated design and manufacturing software, and sophisticated manufacturing processes.

That effort culminated in multiple lines of energy recovery turbines and pumps uniquely suited for seawater and brackish RO desalination.

With the longest warranty and the highest efficiencies, **FEDCO's** product lines are unmatched in quality and performance by any manufacturer in the RO equipment market. **FEDCO** is a widely recognized supplier with thousands of units installed around the world.

Committed To Success

We know RO. **FEDCO** equipment is designed and built to meet the specific challenges of seawater and brackish water RO applications.

FEDCO knows the importance of efficiency, reliability, low capital cost and the importance of easy operation. **We know what it takes for OEMs and end users to make money from their RO systems.**



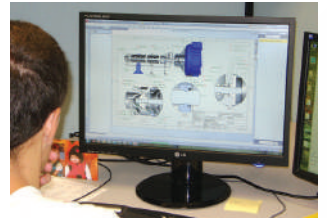
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Customer training ensures optimal results



FEDCO designs every product it offers



Integrated manufacturing eliminates potential errors



Every dimensional tolerance is checked



Every unit is performance tested

About FEDCO

Founded in 1997 as a partnership between Osmonics, Inc. and Eli Oklejas, **FEDCO's** goal was to develop innovative high pressure pumps (HPP) and energy recovery devices (ERD) for BW and SW RO systems. General Electric became **FEDCO's** partner from 2003 through 2006. Today, FEDCO is 100% privately owned and remains focused on innovation, quality and cost-effective solutions for pumping and energy recovery.

The FEDCO Advantage

Our teams of talented and energetic engineers, manufacturing specialists and systems experts have created a fully integrated enterprise with one aim - to provide our customers with **customized fluid machines with exceptional efficiency** and **low capital cost** coupled with **customer service that exceeds their expectations**. The results include new designs, technology, manufacturing processes, and standards.



Our Design - Focused on Membrane Systems

FEDCO designs fluid machines to take full advantage of the technical characteristics of the membrane process. **FEDCO** pumps only cover flows and pressures found in BWRO and seawater SWRO applications. They are designed for clean fluids and are optimized for typical suction pressures in RO systems. Our ERDs include variable area nozzles that meet typical brine pressure variations. Our products eliminate external tubing carrying high pressure feed or brine that can fail creating hazards to personnel and equipment. Our units are designed for operation and maintenance by unskilled personnel in the harshest of desert or marine environments.

Our pumps and ERDs use bearings that are lubricated by feed or brine to eliminate the numerous maintenance and logistics issues associated with oil or grease lubricated bearing systems. **FEDCO** offers three material of construction: Duplex SS, Super Duplex SS and 316 SS.

Our Technology

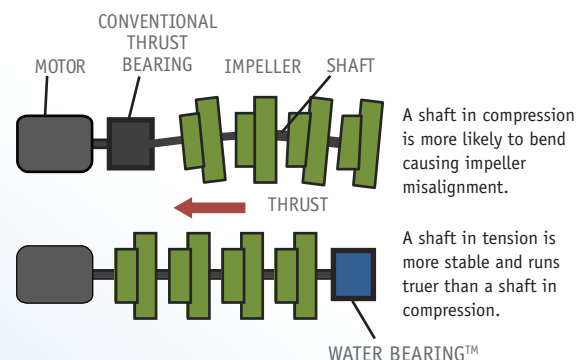
Years of continuous improvement driven by customer feed back have lead to key technical developments in **FEDCO** pumps and ERDs.

WATER BEARING™

The WATER BEARING™ eliminates virtually all pump bearing maintenance and numerous failure modes associated with oil/grease lubricated bearing systems. The WATER BEARING™ absorbs the high levels of thrust generated by centrifugal pump operation by using a balance disc integrated into the discharge of the pump housing. The pumpage (e.g. feed water) provides all lubrication and cooling. Moreover, by locating the WATER BEARING™ in the pump discharge, thrust loads act to place the pump shaft in tension. The WATER BEARING™ is standard on the MSS, MSB, MSD, SSD, and LP product lines.

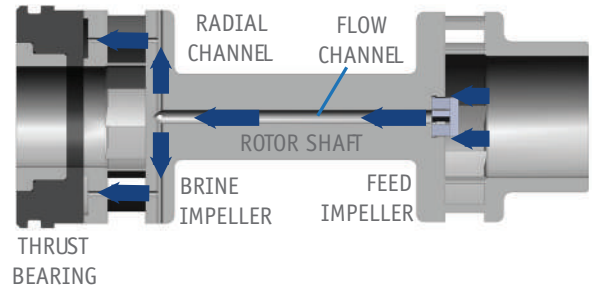


- 1 Absorbs all thrust generated by pump operation - zero thrust to the motor
- 2 Uses pumpage to cool the bearing - no ambient temperature limit
- 3 Entirely housed within pump shell - immune to dust, sand and grit
- 4 Lubricated entirely by the feed - never needs lubrication
- 5 Zero maintenance - provides years of uninterrupted service
- 6 Unique layout places pump shaft in optimal tension - no potential for shaft buckling
- 7 Easy inspection - no disturbance to motor, coupling or alignment



ROTOR-FLO™ Lubrication

This patent-pending design provides optimal lubrication to the rotor thrust bearing using feed water as the lubricant. The design was developed to meet system startup procedures where membranes, headers and associated piping partially drain during shutdown. This could result in momentary operation with a dry thrust bearing during start-up. The Rotor-Flo™ design ensures full lubrication at the instant of start-up. Moreover, the radial flow channels, automatically increases bearing pressure as rotor speed (and thrust load) increases. The Rotor-Flo™ design is used in the HPB and HP-HEMI product lines. The Rotor-Flo™ design eliminates external lubrication lines and fittings (used in competing units) thus ensuring maximum reliability and safety. The Rotor-Flo™ is standard on all HPB and HP-HEMI models.



ROTOR-FLO™ LUBRICATION CHANNELS

Customized Hydraulic Design

The hydraulic flow channels in a fluid machine determines efficiency, pressure generation and flow range. Every FEDCO HPB, SSD, HEMI, and LP turbine module is designed with customized impeller geometry, multi-vane diffusers, turbine volutes, and nozzle rings.

- Designs are generated on the shop floor within hours of order entry.
- Every FEDCO unit is optimized for your duty points - no compromises with "catalog" units with poorly matching hydraulic performance and reduced efficiency,
- Faster delivery by FEDCO's sophisticated software-based design and manufacturing process, no waiting for castings, no delays in overhaul kits even years after original installation.



CFD Analysis

Computational Fluid Dynamics (CFD) has become a standard tool in advanced pump design efforts. Yet, to turn millions of calculations into pump and turbine hardware that perform as predicted takes years of focused research, hundreds of accurate hydraulic tests and continuous refinement of the CFD model parameters.

Comprehensive CFD analysis guides the custom design of all hydraulic passages for every mega-HPB ERD and SSD pump. CFD analysis calibrates our proprietary hydraulic design software used for every FEDCO standard product. There is a CFD/testing design basis for every FEDCO unit, backed by years of testing and refinement.



Integrated Manufacturing Operations

FEDCO developed and continuously refines an integrated manufacturing operation that converts customer flow and pressure requirements into optimized hydraulic designs and then into Computer Numerical Control (CNC) machining programs with little more than a push of a button. The resulting designs represent the most advanced hydraulic designs and machining optimization in our market.

The CNC programs and work instructions are sent to the manufacturing machines via a computer network. Often, within hours of order entry, fully customized and optimized pumps and turbines are being manufactured from the specified stainless steel alloys.

Customized components are tracked through the manufacturing process. All test data is acquired through data acquisition systems with results saved on data servers.



Standards and Processes

ISO-9001:2015 Certification - **FEDCO** is certified and registered.

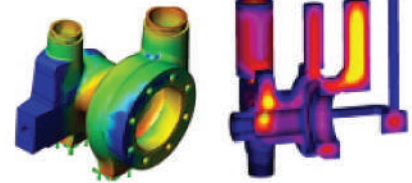
ISO-14001:2015 Certification - **FEDCO** is certified and registered.

CE Mark - Available on most **FEDCO** product lines

NSF test loop certification - Large production test loops have received NSF certification for compliance with Hydraulic Institute test standards for centrifugal pumps.

In addition to CFD software, **FEDCO** utilizes a wide variety of design and analytical software including:

- Finite Element Analysis (FEA) to verify safety factors and general stress/strain levels
- Casting Solidification Analysis (CSA) to optimize new casting designs to minimize the potential for casting defects such as porosity and shrinkage
- SolidWorks 3-D Computer Aided Design (CAD)
- A large collection of proprietary design and manufacturing software.



Product Testing

Tying together analytical designs, prototype development and production testing, **FEDCO's** five (5) test loops ensure performance that meets or exceeds the customer's expectations.

Current production test loops include mega-scale seawater systems up to 2,500 kW, brackish water testing, and power recovery turbines. **FEDCO tests 100% of all production units.**

Production test loops are certified by NSF to meet Hydraulic Institute Standards for centrifugal pump testing.



FEDCO Facilities

FEDCO operates from a 11,798 m2 facility owned by **FEDCO** and built to its specifications. The first phase was completed in 2006, a second phase in 2008, and a third phase completed in October of 2014 to meet future demand of **FEDCO** products over doubled the footprint with new office and manufacturing space totaling 6,689 m2.

Located in the heart of the industrial area of the United States, **FEDCO** has full access to the latest in production and measurement technology. The local labor force is highly trained in all aspects of manufacturing technology and processes.

Overhead cranes ensure safe and efficient handling of components as well as complete assemblies. The entire facility is air conditioned and heated using highly efficient geothermal heat pumps. A white roof minimizes solar gain during summer months. Water recycling is used whenever feasible to recover spilled water when test loop piping is reconfigured.

ISO-14001 helps ensure that **FEDCO** seeks continuous improvement in its environmental and safety responsibilities.

FEDCO welcomes customers to inspect its facilities and operations.



Products and Services

Standard Product Line

MSS SERIES HP FEED PUMP

- 7.5 - 295 m³/h (33 - 1300 gpm) and pressures to 83 bar (1200 psi)

MSD SERIES HP FEED PUMP

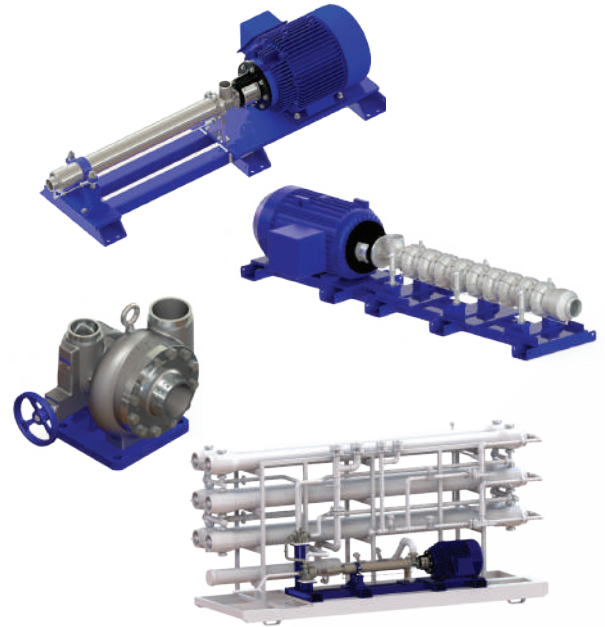
- 20 - 560 m³/h (88 - 2465 gpm) and pressures to 83 bar (1200 psi)
- All Super Duplex SS construction

HYDRAULIC PRESSURE BOOSTER (HPB) ENERGY RECOVERY TURBINE

- 10 - 3200 m³/h (30 - 14000 gpm)
- Pressures to 83 barg (1200 psig) with option up to 110 bar
- Constructed in Duplex SS 2205 or Super Duplex 2507

MSMT - MULTI STAGE MULTI TURBOCHARGER

- Recover up to 60% in SWRO
- Savings up to 20% in Total Water Cost (CAPEX+OPEX)



Mega System Products

SSD SERIES HP FEED PUMP

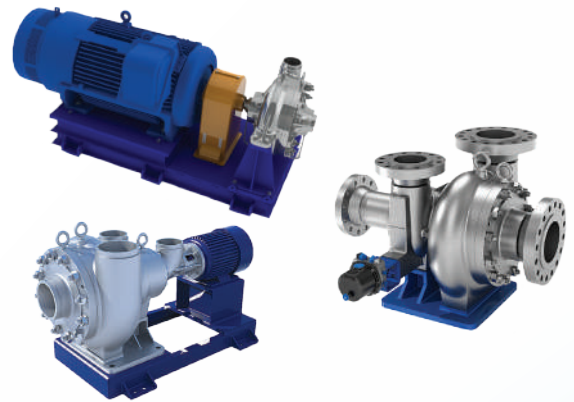
Single stage HP feed pumps for SWRO service

- 450-650 m³/h (1931-2861 gpm)
- Pressures to 35 barg (500 psig) and 68 bar (1000+ psig with HPB or HP-HEMI)
- Direct drive - 3500 RPM or 2900 RPM nominal speed

HP-HEMI AND HPB ENERGY RECOVERY TURBINE/MOTORIZED TURBOCHARGERS

Obtain total control of your membrane operating conditions with FEDCO's Hydraulic Energy Management Integration (HEMI) for SWRO system.

- 400-3200 m³/h (14000 gpm)
- Pressures to 83 barg (1200 psig)



Brackish Water/Low Pressure Products

SLP SERIES PUMP

- 30 to 850 gpm (6.8 to 193 m³/h) and pressures from 35 to 130.5 psi (2.4 to 9 bar)
- Super Duplex SS construction

MSB SERIES FEED PUMP

- 45 - 132 m³/h (198 - 581 gpm) and pressures to 35 bar (500 psi)
- 316 SS construction

LPH, LPS, LPD INTEGRATED PUMP AND ENERGY RECOVERY TURBINE MOTORIZED TURBOCHARGERS

FEDCO brings affordable energy recovery to low pressure RO systems.

- 30 - 300 m³/h (130 - 1320 gpm) brine flow
- 80 - 750 m³/h (350 - 3300 gpm) feed flow
- Pressures from 6 - 35 barg (87 - 500 psig)
- 316 SS construction

MSB-T SERIES PUMP WITH ENERGY RECOVERY TURBINE

- 7.5 - 132 m³/h (33 - 581 gpm) and pressures to 35 bar (500 psi)
- 316 SS construction

RETROFITS

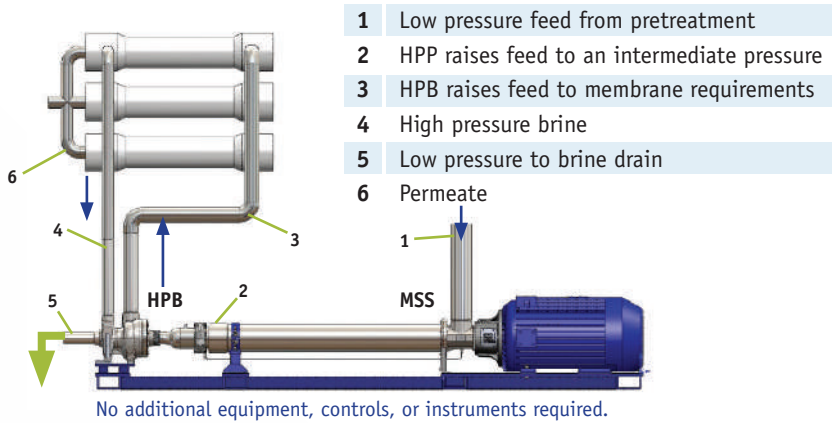
Parts & Field Service

Life Cycle Cost Analysis



Standard Products - MSS and MSD Feed Pumps with HPB

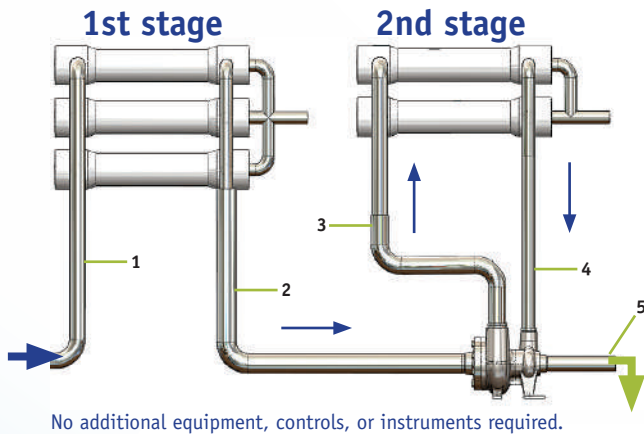
- Thousands of units in SWRO Service
- RO Feed Pumps with Energy Recovery Pressure Boosters
- Feed flows from 7.5 to 560 m³/h
- Pressures to 83 bar (optional to 110 bar on some models)



FEED BOOSTER CONFIGURATION

Simply start the pretreatment system, flush air from the membranes, start the HP pump and startup is complete. Adjust feed and brine flow for desired recovery.

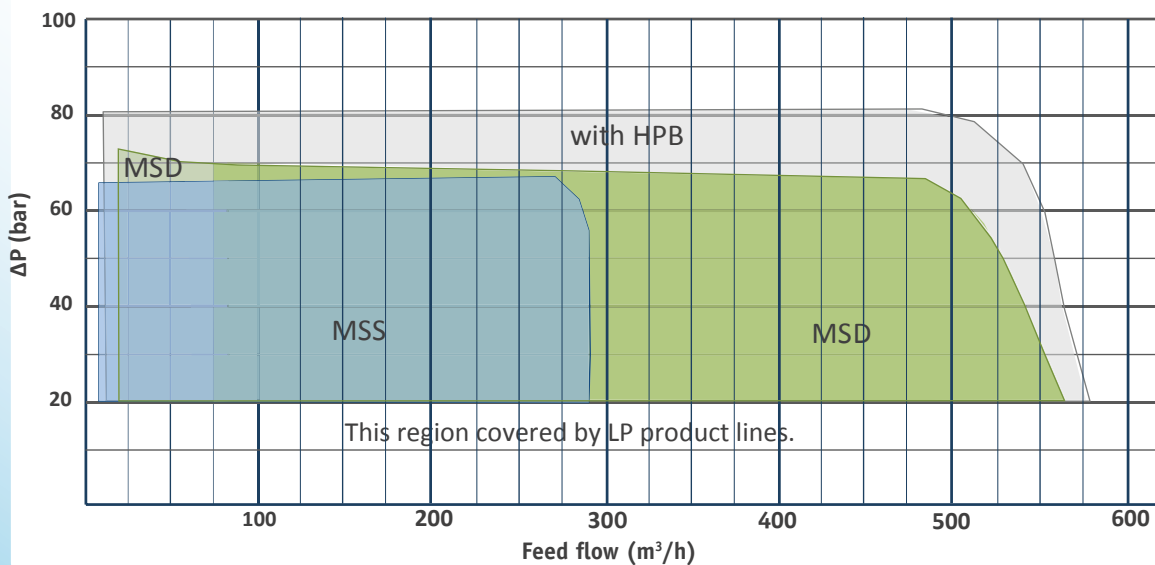
HPB shown mounted on optional extended pump base plate. HPB may also be located anywhere in the RO system to minimize piping runs.



INTERSTAGE BOOSTER CONFIGURATION

Interstage boosting balances flux rates, improves permeate quality and overall production. With optimized array design, interstage boosting can provide exceptionally low energy consumption.

Hydraulic Coverage



*Chart displays typical range of coverage.

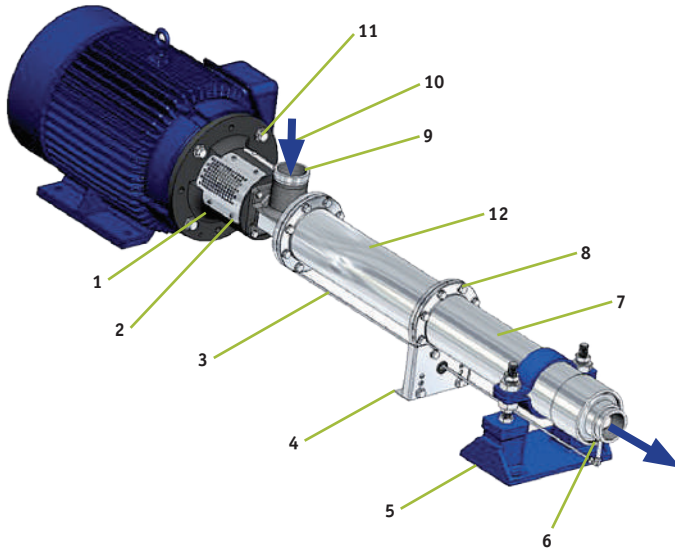
MSS Series Feed Pumps

The MSS series multi-stage centrifugal high pressure feed pumps have proved to be the most reliable high pressure feed pump available today.

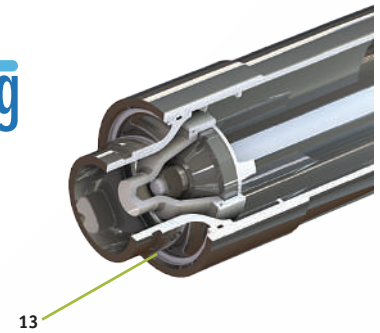
Loaded with unique features such as the patented WATER BEARING™ thrust bearing, pumpage-lubricated shaft bearings and maintenance-free design ensure years of trouble-free operation.

Models

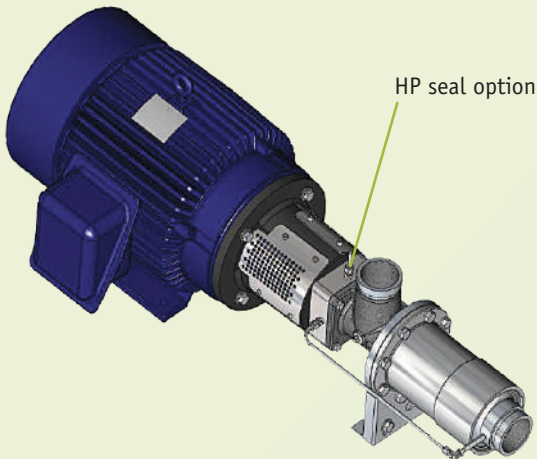
MSS-15	MSS-90
MSS-20	MSS-120
MSS-30	MSS-160
MSS-40	MSS-200
MSS-55	MSS-240
MSS-75	



PATENTED
water bearing
TECHNOLOGY



High Inlet Pressure Option



All MSS pumps can be equipped with a high inlet pressure option to allow inlet pressures to 70 barg. The unique design features:

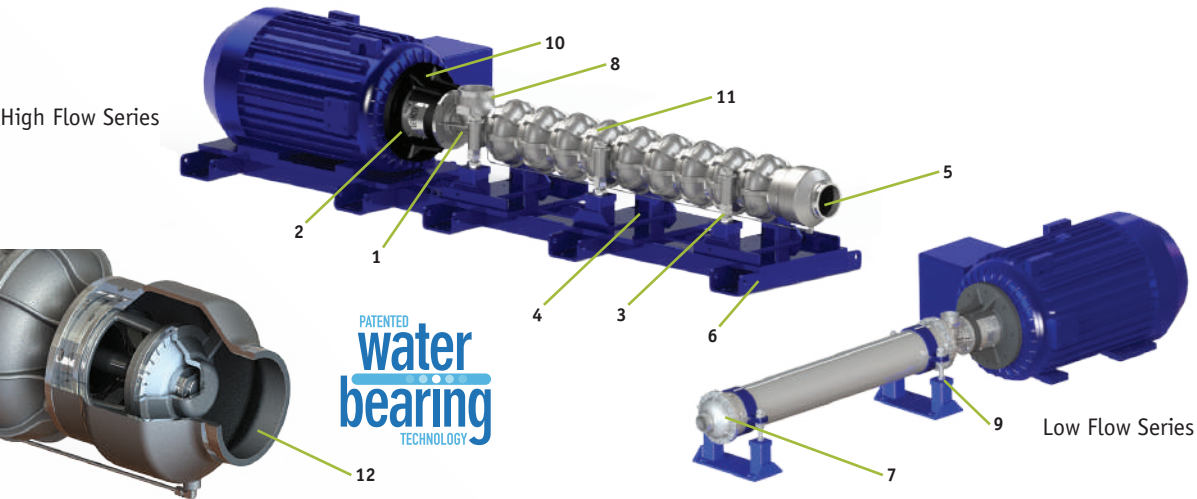
- Use of low cost, standard mechanical seals operating at low pressure (1-2 bars typical)
- Total protection of the motor from pump thrust loads - a major problem with high inlet pressure operation.

- 1 Shaft seal operates at low pressure
- 2 Flexible disc coupling
- 3 Bearing drain line (low pressure)
- 4 316 SS shell support bracket
- 5 Precision leveling foot
- 6 Victaulic pipe joints
- 7 Duplex SS 2205 housing
- 8 Flanged construction for easy internal inspection
- 9 Inlet rotatable in 90° increments
- 10 Easy shaft alignment
- 11 Integrated motor adapter (anodized aluminum alloy)
- 12 316L SS stages – passivated & electropolished – proven in hundreds of SWRO applications
- 13 WATER BEARING™

MSD Series Feed Pumps

The MSD series multi-stage centrifugal high pressure feed pumps provide a new level of reliability and efficiency in SWRO pumps.

Loaded with unique features such as the patented WATER BEARING™ thrust bearing, all Duplex SS construction, product lubricated bearings and maintenance-free design ensure years of trouble-free operation. The MSD series is all Super Duplex SS 2507 with precision investment cast stages and impellers.



Models

MSD-40

MSD-70

MSD-130

MSD-160

MSD-200

MSD-270

MSD-350

MSD-400

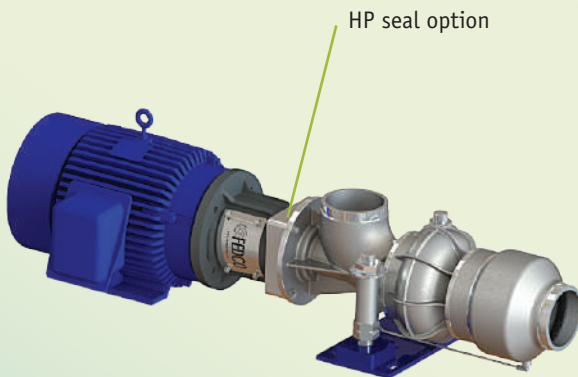
Coming soon!

MSD-650

MSD-850

in development

High Inlet Pressure Option



All MSD pumps can be equipped with a high inlet pressure option to allow inlet pressures to 70 barg. The unique design features:

- Use of low cost, standard mechanical seals operating at low pressure (1-2 bars typical)
- Total protection of the motor from pump thrust loads - a major problem with high inlet pressure operation.

- | | |
|----|--|
| 1 | Shaft seal operates at low pressure |
| 2 | Flexible disc coupling |
| 3 | Bearing drain line (low pressure) |
| 4 | Stage support blocks |
| 5 | Victaulic pipe joints |
| 6 | Baseplate |
| 7 | Flanged construction for easy internal inspection |
| 8 | Inlet rotatable in 90° increments |
| 9 | Easy shaft alignment |
| 10 | Integrated motor adapter (anodized aluminum alloy) |
| 11 | Super Duplex SS 2507 |
| 12 | WATER BEARING™ |

Hydraulic Pressure Boosters (HPB)

The World's Most Efficient Turbine Based ERD

Performance and Reliability

FEDCO leads the industry in turbocharger efficiency as the first and only company to exceed 80% transfer efficiency. The same technology used in our record-setting units is used throughout our entire HPB product line.

Superior efficiency comes with superior reliability as **FEDCO** offers the industry-leading three (3) year limited warranty on the entire HPB product line. Our high quality design includes:

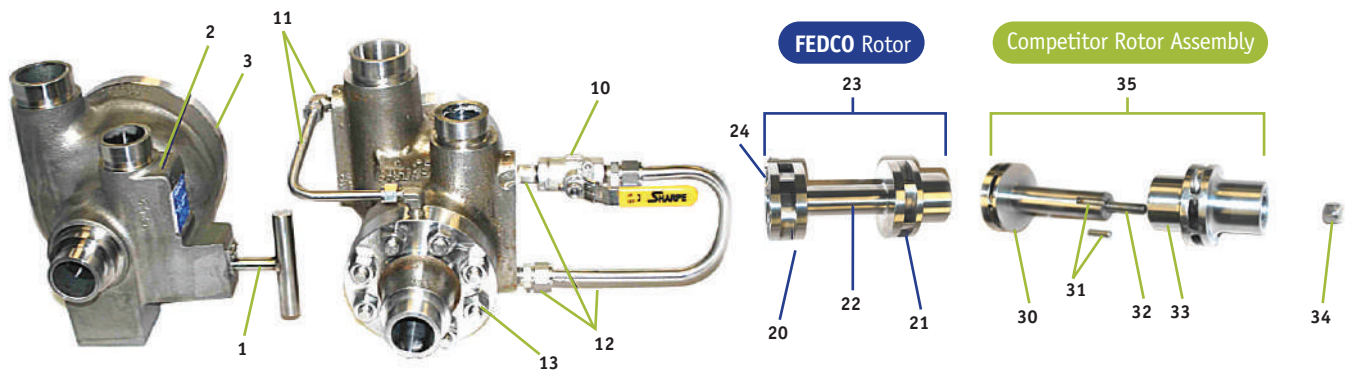
- elimination of all external tubing and valves
- one-piece rotor construction
- multi-vane diffuser
- rotor-flo thrust bearing lubrication

and many other features make the HPB the first choice for reliability.

Efficiency

Whether it is field operating log sheet data or precision test stand data, the HPB displays the highest average efficiency of any turbocharger ERD. Fully machined rotors, and CFD optimized hydraulic design makes the difference.

Why HPB has the longest warranty in the industry:



FEDCO

- 1 Integrated multi-turbine brine nozzle
- 2 Integrated brine nozzle flow channel
- 3 Single end cap designs for simplicity and machining accuracy
- 20 Turbine impeller vanes custom-machined from bar stock
- 21 Pump impeller vanes custom-machined from bar stock
- 22 Rotor is single-piece for rigidity and perfect balance for smooth operation
- 23 100% Duplex SS 2205 or Super Duplex SS 2507 construction. Dynamically balanced
- 24 Patent-pending rotor-flo bearing lubrication allows dry turbine running and greater bearing life

Competitor

- 10 1/4 turn ball valve for brine control (316 SS)
- 11 External HP feed line for bearing lubrication (316 SS). Threaded connections and tube fittings create failure points
- 12 External HP brine line (316 SS). Threaded connections and tube fittings create failure potential.
- 13 Dual end caps increase complexity and reduce manufacturing accuracy due to multiple setups in machining operations
- 30 Turbine impeller and shaft from castings — porosity & shrinkage reduce strength
- 31 Key and keyway creates looseness and lack of rigidity (316 SS)
- 32 Stud used to retain pump impeller against high thrust loads. Prone to failure (316 SS)
- 34 Retaining nut and stud (32) keeps impeller on shaft shoulder against high thrust loads (316 SS). Stud breakage is a catastrophic failure.
- 35 Rotor assembly cannot maintain dynamic balance due to need to disassemble during installation. Rotor is less rigid and uses 316 SS in highly stressed components
- 36 **SAFETY ISSUES - 316 SS tubing and fittings will fail from corrosion and vibration resulting in a potentially catastrophic high pressure spray of feed and brine**

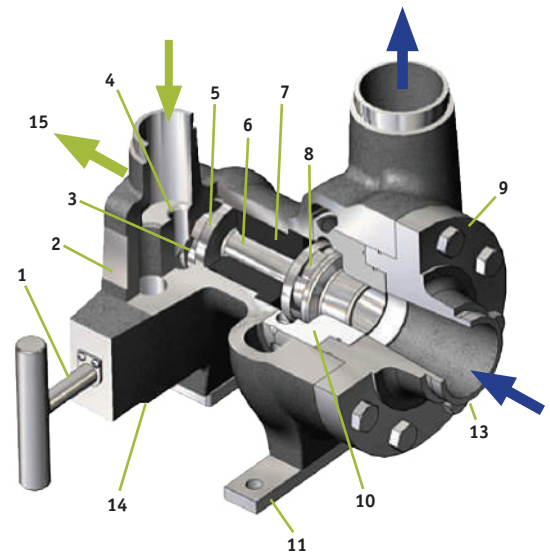
HPB Hydraulic Pressure Booster

ERD Series Features

With ten (10) models, there is a perfect fit for your most demanding performance, reliability and project schedule requirements. Standard MOC is Duplex SS 2205, however, Super Duplex SS 2507 is optional. Brine nozzle valve actuators, flanged connections and other options available. Delivery of the standard line HPBs are built to your flows and pressures specifications in three (3) to (6) weeks in Duplex SS 2205.

- 1 Variable area in nozzle (needle type for precise control)
- 2 Nameplate
- 3 Thrust bearing - patent pending design, allows dry running
- 4 Brine nozzle and volute - custom designed and machined
- 5 Brine (turbine) impeller - custom designed and machined
- 6 Rotor shaft - integral with impellers (no keys, studs, washers, etc.)
- 7 Center bearing lubricated by feed - ZERO brine leakage to feed
- 8 Feed (pump) impeller - custom designed and machined
- 9 End cap
- 10 Multi-vane diffuser - custom designed and machined to ensure radial pressure balance for long wear ring and bearing life, provides higher efficiency than volutes
- 11 Mounting foot (varies by model)
- 12 O-rings - all bearings mounted on o-rings for easy removal
- 13 Victaulic-type pipe joints (flanged joint optional)
- 14 Standard Duplex SS 2205 MOC (Super Duplex SS 2507 optional)
- 15 Can discharge brine at higher pressure for easy brine disposal

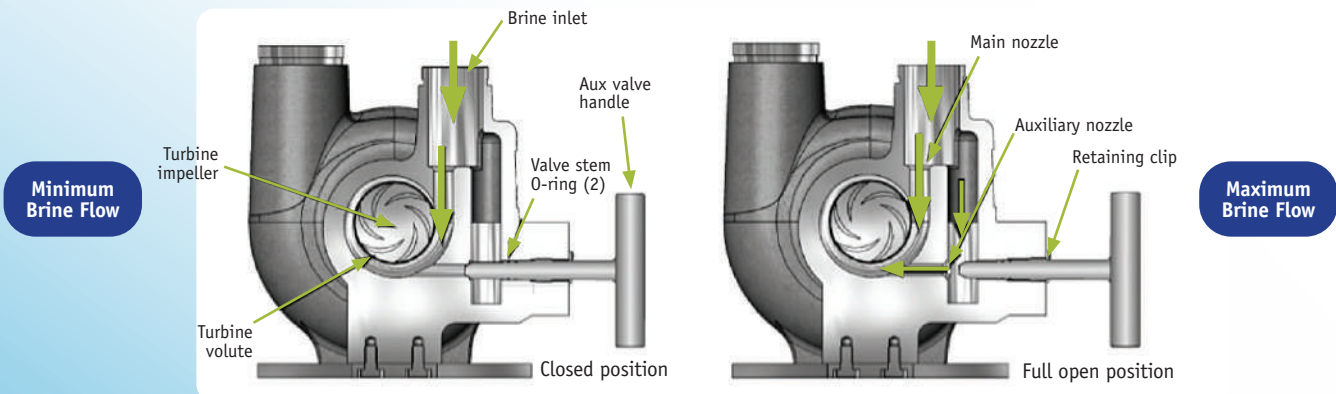
- ### Models
- HPB-10
 - HPB-20
 - HPB-30
 - HPB-40
 - HPB-60
 - HPB-80
 - HPB-90
 - HPB-130
 - HPB-180
 - HPB-250
 - HPB-350



Brine Flow Regulation

Brine flow adjustment is accomplished by simply turning the aux nozzle handle. Open to increase brine flow and close to reduce brine flow. Note that the multi-turn needle valve provides precise flow regulation.

Note that brine is not bypassed when the nozzle is open - all brine flow passes through the turbine impeller to maximize energy recovery.



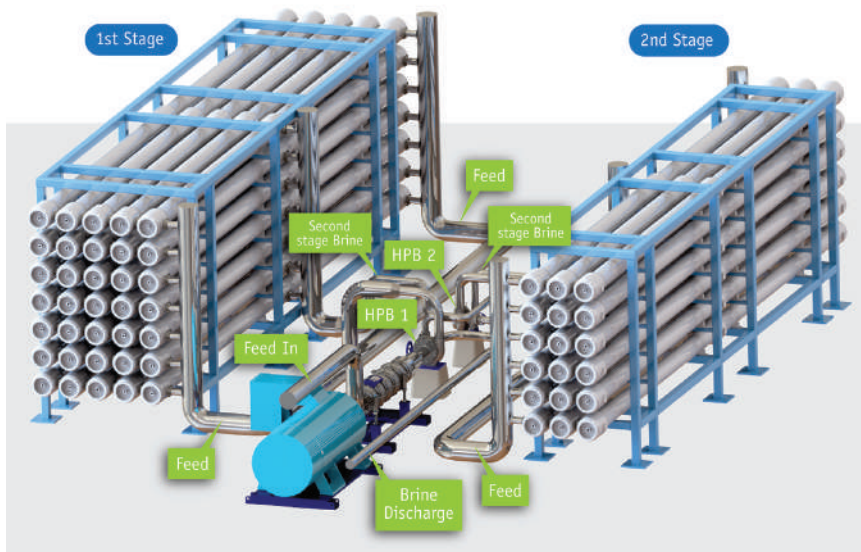
Multi Stage Multi Turbocharger (MSMT)

**MAXIMIZE
EFFICIENCY &
RECOVERY**

- Recover up to 60% in SWRO
- Savings up to 20% in Total Water Cost (CAPEX+OPEX)
- Reduction of up to 33% in pretreatment size
- Application from small to mega-scale projects

High Recovery creates savings:

- Competitive SEC
- Reduced intake costs
- Reduced brine discharge/outfall costs
- Reduced pipe and valve sizes
- Reduction in pretreatment equipment size
- Maintenance parts costs
- Footprint (civil works)
- Lead times - due to smaller size of equipment, piping, footprint
- Chemical consumptions (greener process)



Pilot courtesy Water Technologies de Mexico - 2019

Membrane performance benefits:

- Reduced fouling potential
- Highly improved flux balance between stages
- Reduction of lead flux
- Increase on tail element flux



Typical MSS Pump and HPB Standard Package Installations



HPB 40



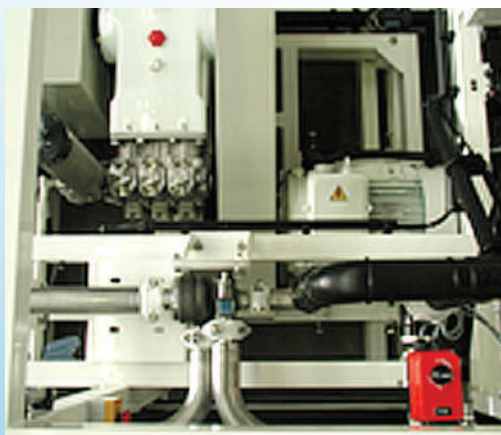
MSS and HPB in a container



MSD and HPB common baseplate



MSMT installation



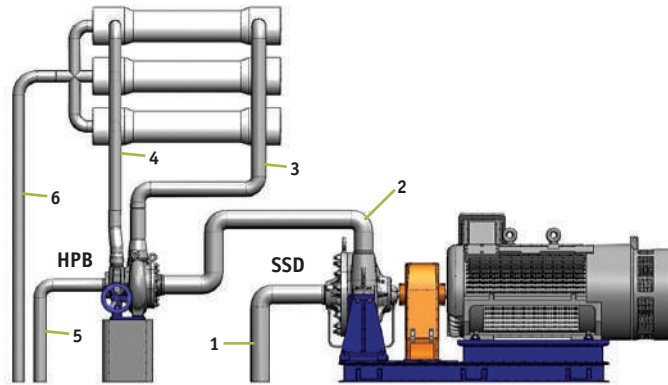
HPB with reciprocating HPP



MSS and FEDCO baseplate

Mega Products - SSD and HPB or HP-HEMI

- RO High Pressure Feed Pumps (HPP) with Energy Recovery Hydraulic Pressure Boosters
- Feed Flows from 400 to 650m³/h
- Pressure to 83 bar



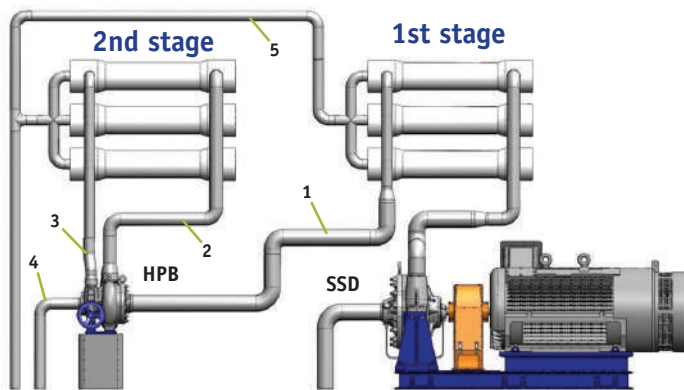
No additional equipment, controls, or instruments required.

- 1 Low pressure feed from pretreatment
- 2 HPP raises feed to an intermediate pressure
- 3 HPB raises feed to membrane requirements
- 4 Low pressure to brine drain
- 5 Permeate

FEED BOOSTING CONFIGURATION

THE HPB may be located anywhere in the system to minimize piping costs.

HPP is sized to handle feed flow at reduced pressure differential.



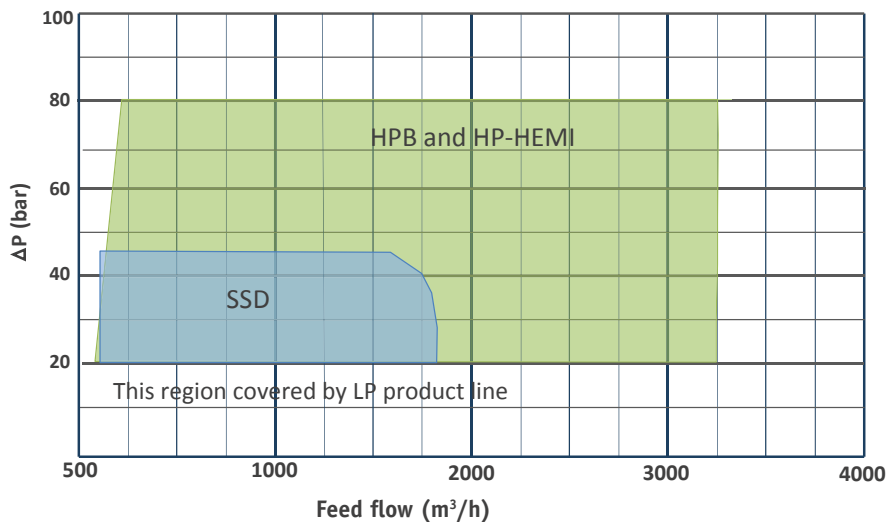
No additional equipment, controls, or instruments required.

- 1 1st stage Brine
- 2 Boosted pressure to 2nd stage
- 3 2nd stage brine to HPB
- 4 Low pressure to brine drain
- 5 Permeate

INTERSTAGE BOOSTING CONFIGURATION WITH THE HPB

Interstage boosting balances flux rates, improves permeate quality and overall production. With optimized array design, interstage boosting can provide energy efficiency as good as any other type of ERD - often at a lower capital cost.

Hydraulic Coverage

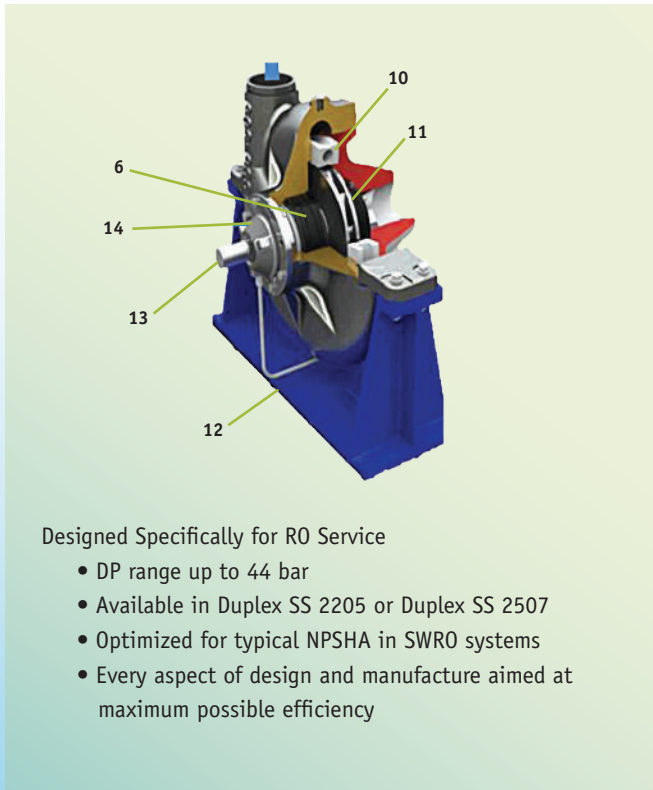
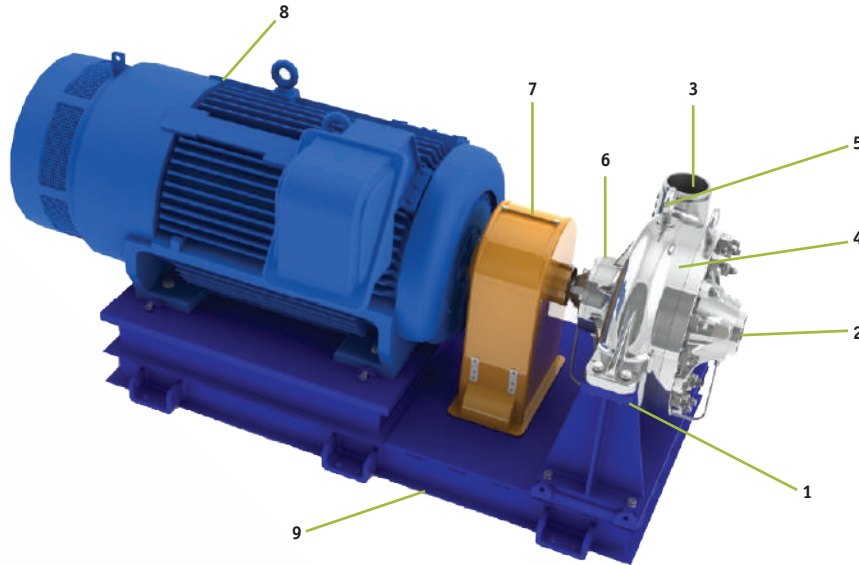


Mega Systems SSD Series Feed Pump

Models
SSD-500

The SSD series single-stage centrifugal high pressure pump (HPP) performs just like any heavy-duty SWRO feed pump; but, at higher efficiency and lower capital cost. And, with faster delivery it is ideal for the most demanding project schedule. The SSD series can reach pressures of 83 bar (1200 psi) when used with the HPB or HP-HEMI energy recovery devices. The direct drive motor can be a 50 or 60 Hz, 2-pole motor with speed of 2900 RPM to 3500 RPM.

Our mega system SSD feed pump is supplied in Duplex SS 2205 or the option of Super Duplex SS 2507. A one-piece shaft is machined from bar stock. The single-stage design provides a small footprint. The SSD series use pumpage-lubricated bearings for maintenance free operation.



Designed Specifically for RO Service

- DP range up to 44 bar
- Available in Duplex SS 2205 or Duplex SS 2507
- Optimized for typical NPSHA in SWRO systems
- Every aspect of design and manufacture aimed at maximum possible efficiency

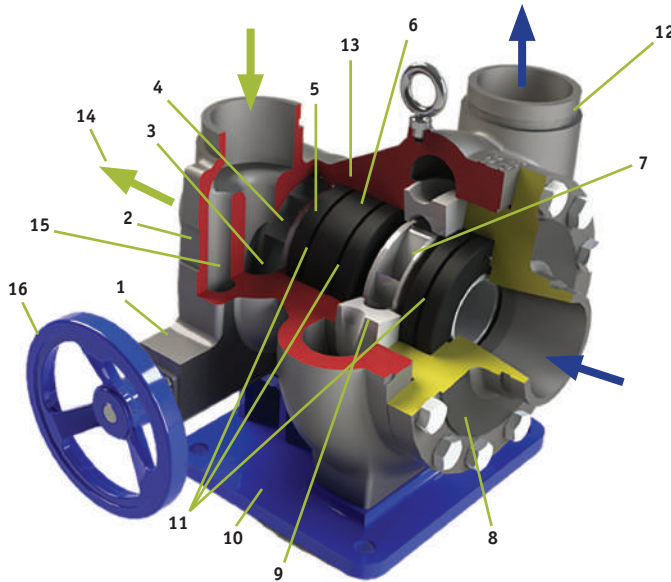
- | | |
|----|---|
| 1 | Centerline mount |
| 2 | Feed inlet |
| 3 | Feed outlet |
| 4 | Duplex SS 2205
(optional Super Duplex SS 2507) |
| 5 | Pump-lifting eye-bolt |
| 6 | Pumpage-lubricated bearings |
| 7 | Coupling guard |
| 8 | 50 or 60 Hz 2-pole motor |
| 9 | Common base plate |
| 10 | Diffuser ring-custom machined |
| 11 | Impeller-custom machined |
| 12 | Seal flush line |
| 13 | Shaft |
| 14 | Shaft seal |

Mega System HPB Design and Construction

Models

Six (6) models cover the largest current and anticipated SWRO trains. Standard MOC is Duplex SS 2205 with Super Duplex SS 2507 optional. Brine nozzle valve actuators, flanged connections and other options available.

HPB-500	HPB-1400
HPB-700	HPB-2000
HPB-1000	HPB-2800



- | | |
|----|---|
| 1 | Brine aux nozzle valve (needle type for precise control) |
| 2 | Nameplate |
| 3 | Thrust bearing — patent pending design, allows dry running |
| 4 | Brine (turbine) impeller — custom designed and machined |
| 5 | Rotor shaft — integral with impellers (hidden in this view) |
| 6 | Center bearing — lubricated by feed, ZERO brine leakage to feed |
| 7 | Feed (pump) impeller, custom designed and machined |
| 8 | End cap |
| 9 | Multi-vane diffuser — customer designed and machined to ensure radial pressure balance for long wear ring and bearing life, provides higher efficiency than volutes |
| 10 | Baseplate |
| 11 | O-rings — all bearings mounted on o-rings for easy removal |
| 12 | Victaulic-type pipe joints (flanged joints optional) |
| 13 | Standard Duplex SS 2205 MOC, Optional Super Duplex SS 2507 |
| 14 | Can discharge brine at high pressure for easy brine disposal |
| 15 | Integral brine passage for auxiliary turbine nozzle |
| 16 | Hand wheel, optional valve actuator, for brine flow regulation |

Hundreds of Tests, Years of CFD Analysis Yields Record-Setting Efficiency

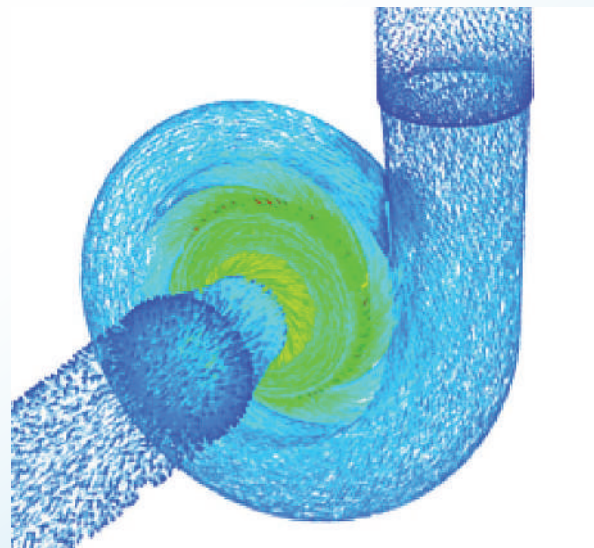
The HPB is the first and only turbocharger to achieve 80+% transfer efficiency. CFD (Computational Fluid Dynamics) runs involving trillions of calculations helped to optimize every inch of the flow passages.

Proprietary software converted the CFD designs into CNC (Computer Numerical Control) programs to turn Duplex SS or Super Duplex SS plate into ultra-smooth and hydraulically optimal feed and brine channels.

Patent-pending bearing systems ensure reliable operation with minimal bearing losses.



Record setting HPB-1400 displays 80+% transfer efficiency



Visualization of flow data from a CFD analysis

Hydraulic Energy Management Integration (HP-HEMI)

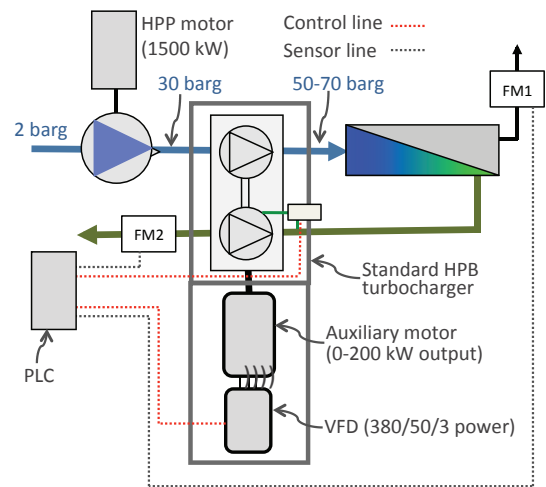
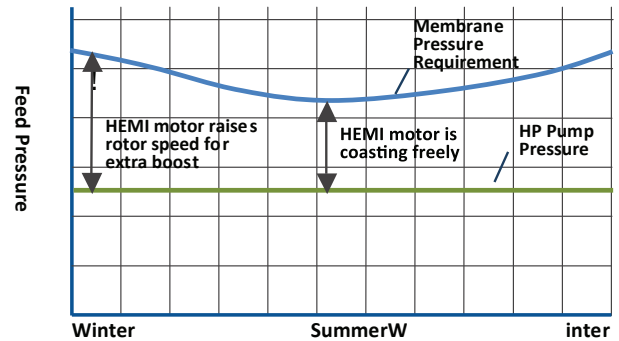
- Feed flows from 400 to 3200 m³/h
- Pressures to 83 bar

Every SWRO system must be able to supply a varying pressure to the membrane array to accommodate changes in feed temperature, salinity and membrane fouling. The upper curve in the adjacent graph illustrates a typical annual membrane pressure variation.

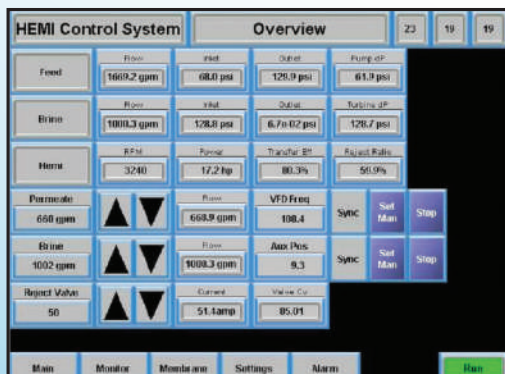
However, centrifugal HPPs cannot provide a variable discharge pressure without use of a very expensive and failure-prone medium/high voltage variable frequency drive (VFD). In addition, the VFD imposes a 3% energy loss. The HPP operating at constant flow and speed produces a constant discharge pressure as depicted by the green line. The function of the HEMI is to bridge the gap between the HPP constant-pressure characteristic and the membrane variable pressure requirement.

The HEMI is a modified HPB with a motor attached to its rotor. As illustrated by the adjacent figure, the motor may be 200 kW and is driven by a standard low voltage VFD. The HPP motor may be 1500 kW and may be a direct start. In this example, the HPP delivers a constant 30 barg discharge pressure while the membrane pressure varies between 50 and 70 barg. At low membrane pressure conditions, the entire energy required for the 20 bar boost is provided by the HPB's turbine section. At the maximum boost of 40 bar, the turbine provides most of the power while the motor provides the balance.

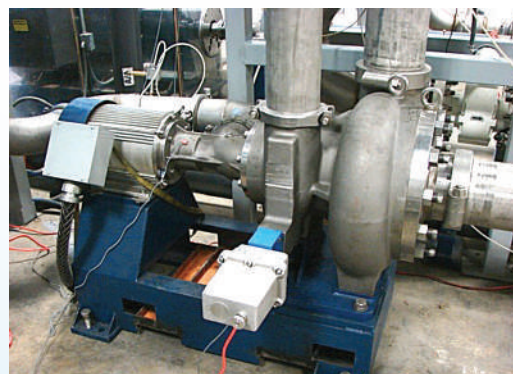
The HEMI can provide entire SWRO control of feed and brine flows by the addition of a basic PLC. The permeate flow meter (FM1) controls the HEMI VFD and the brine flow meter controls the HPB turbine variable nozzle via signals from the PLC. The basic control philosophy is illustrated in the adjacent table.



Permeate flow too high	HEMI VFD reduces rotor speed (reduces feed boost)
Permeate flow too low	HEMI VFD increases rotor speed (increases feed boost)
Brine flow too high	Turbine nozzle area reduced (reduces brine flow)
Brine flow too low	Turbine nozzle area increased (increases brine flow)



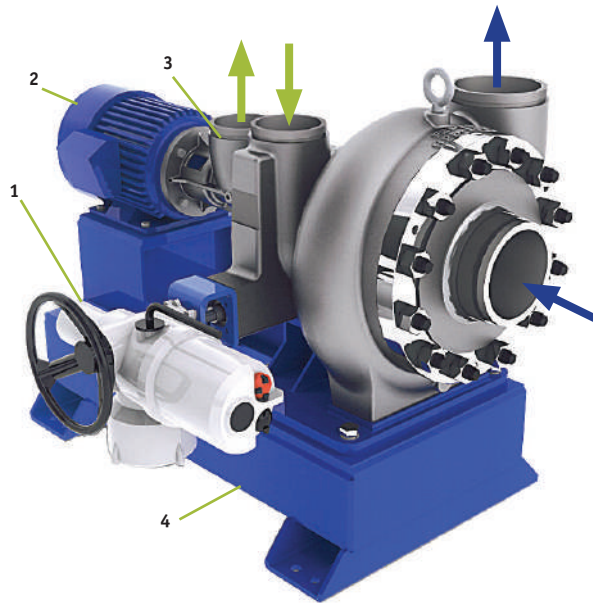
Typical HEMI PLC Display



HP-HEMI-1000

Mega System High Pressure Hydraulic Energy Management Integration (HP-HEMI)

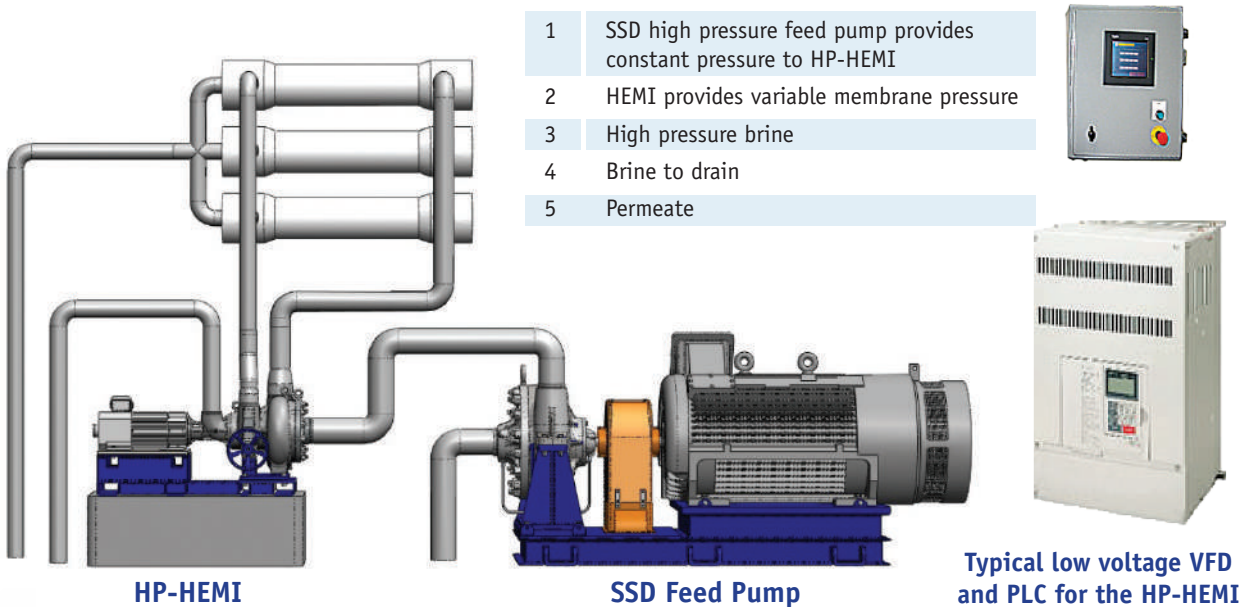
Six (6) models cover the largest current and anticipated SWRO trains. Standard MOC is Duplex SS 2205 with Super Duplex SS 2507 optional. Brine nozzle valve actuators, flanged connections and other options available. **FEDCO** provides the complete HEMI package including motor, VFD and valve actuator.



- 1 Brine aux nozzle actuator
- 2 HEMI motor
- 3 Brine discharge module
- 4 Common baseplate

HP-HEMI System for SWRO

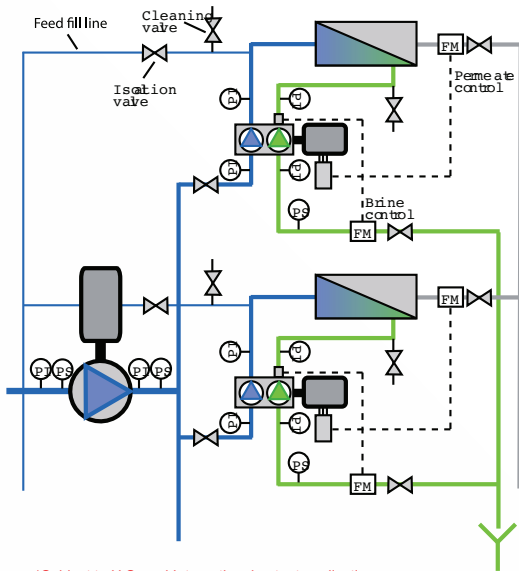
The HEMI control can be integrated into the plant SCADA or **FEDCO** can provide a stand-alone PLC. Requiring only two process signals, permeate and brine flow, the HEMI control system is easy to install and operation is simple and intuitive.



Mega Systems Design Options

FEDCO research into the basic hydraulic response of RO systems operating with variable membrane conditions has lead to two new plant designs that maximize energy efficiency, simplifies control, and minimizes capital costs.

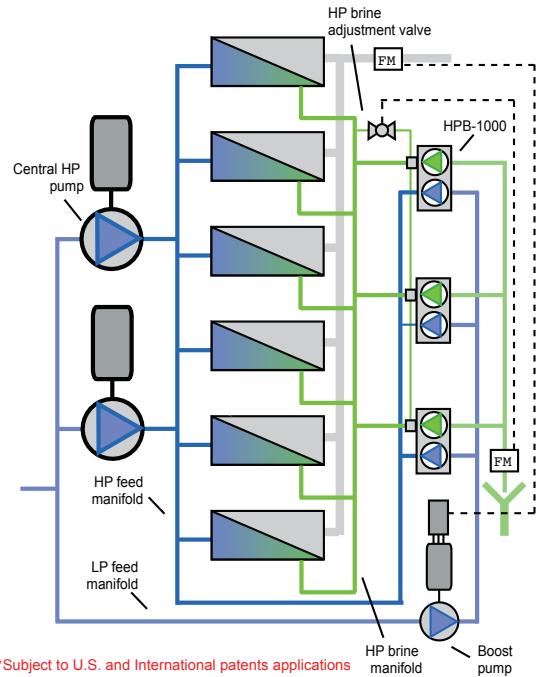
Hybrid Centralization



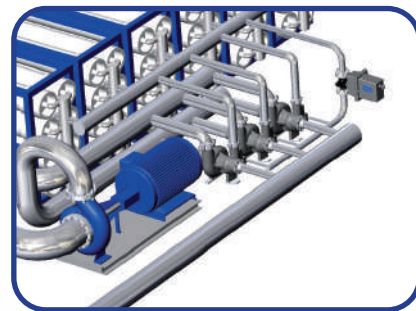
*Subject to U.S. and International patent applications

Hybrid centralization combines the benefits of centralized feed pumping and discrete RO train control. This design permits dynamic addition and removal of trains without interruption of production. The control scheme is simple and permits optimization of membrane conditions on a train-by-train basis.

Three-Center



*Subject to U.S. and International patents applications



The HPB is ideal for three-center design by providing a large capital cost savings, simple control schemes and low specific energy consumption.

Typical Mega System Installations



HPB-700 (retrofit of competitors unit)



HPB-1000 in Jeddah, Saudi Arabia



SSD-500 with HPB-5000 SWRO Facility



SWRO train with HPB at lower right



HPB-1400 SWRO - Saudi Arabia



HPB-2800 installation SWRO - Saudi Arabia

SLP Series Pump

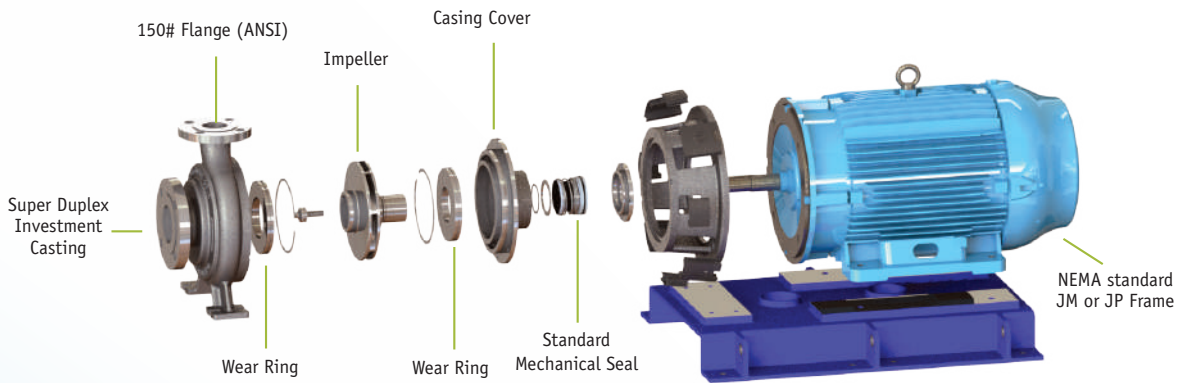
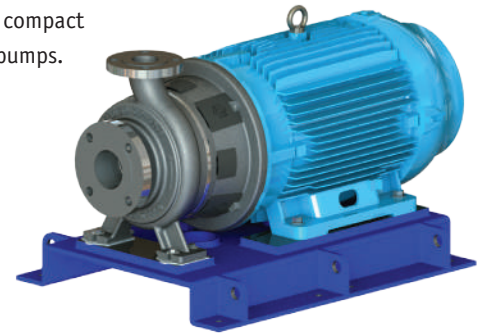
Model
 SLP-15
 SLP-30
 SLP-60
 SLP-90
 SLP-160

- High efficiency
- Super Duplex material of construction
- Capacity from 30 to 850 gpm (6.8 to 193 m³/h)
- Heads up to 167 ft (51m)
- Pressures 35 to 130.5 psi (2.4 to 9 bar)

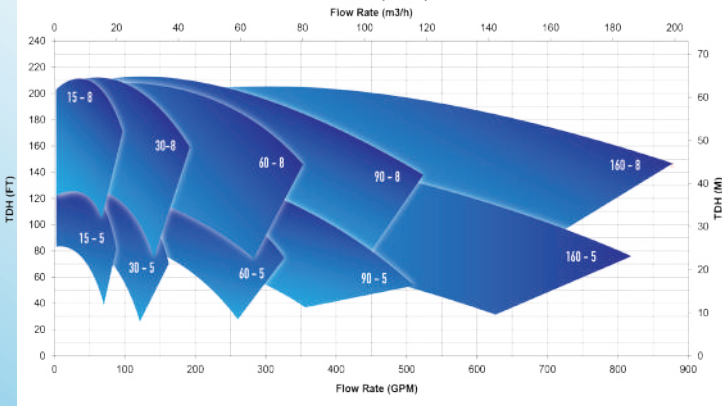
The SLP pump series is a low pressure end suction, close-coupled horizontal pump for general water process applications. It was designed with high efficiency and Super Duplex stainless steel construction for reliability and longevity in harsh environments. This pump series features a standard mechanical seal with seal flush to ensure long life, centerline discharge, self-venting design and no oil or grease lubrication for simple installation and maintenance. The SLP is offered in five ANSI 150lb flanged models with a set of customizable impellers, coupled with a NEMA standard TEFC, JM or JP motor frame mounted on a common baseplate. The compact footprint and robust construction gives the SLP series a superior advantage over similar pumps.

Applications:

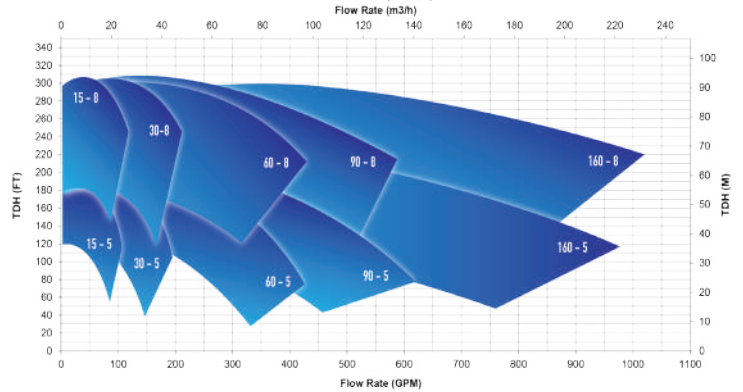
- Reverse Osmosis
- Backwash
- Pretreatment
- Permeate Transfer



**SLP Pump Curves
 2900RPM (50Hz)**



**SLP Pump Curves
 3500RPM (60Hz)**



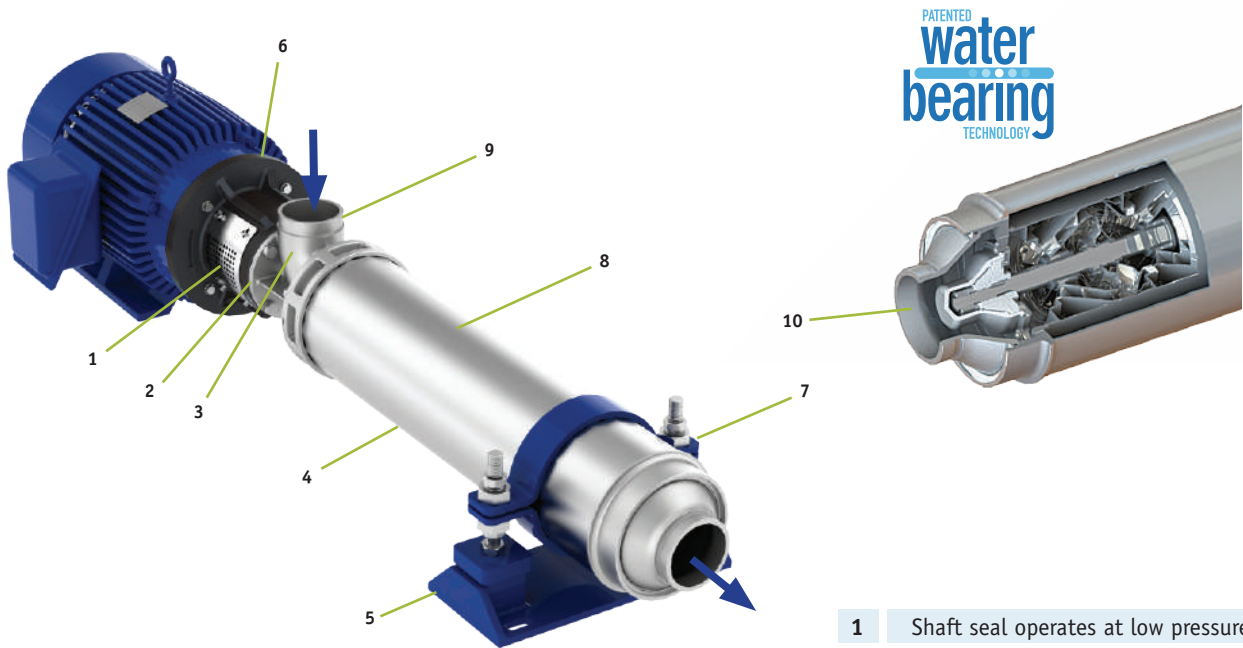
MSB Series Feed Pumps

- Brackish/Low Pressure RO Feed Pump
- Feed flows from 45 to 132 m³/h (200 to 580 gpm)
- Pressures to 35 bar (500 psi)

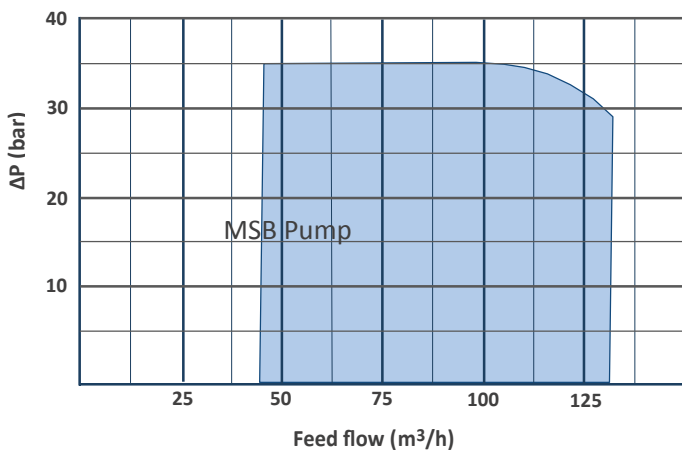
Models
MSB-90
MSB-120

The MSB series multi-stage centrifugal low pressure feed pumps provide a new level of reliability and efficiency in brackish RO pumps. The MSB pump series applications include use as a feed pump, product transfer pump, and an interstage booster.

Special features of the MSB will prove to be an exceptional efficiency and quality pump. The unique design such as the patented WATER BEARING™ thrust bearing, product lubricated bearings, and maintenance-free design ensure years of trouble-free operation. This series is 316 SS components with Duplex SS shaft. This unit features fast delivery.



Hydraulic Coverage



- 1 Shaft seal operates at low pressure
- 2 Flexible disc coupling
- 3 Victaulic pipe joints
- 4 316 SS stages
- 5 Precision leveling foot
- 6 Integrated motor adapter (anodized aluminum alloy)
- 7 Easy shaft alignment
- 8 Single shell housing
- 9 Inlet rotatable in 90° increments
- 10 WATER BEARING™

Integrated Brackish Water/HP Feed Pump and Brine Energy Recovery

The **FEDCO** low pressure (LP) product line uses standardized pump, turbine and motor modules to achieve unprecedented hydraulic flexibility, excellent efficiency and low costs. The modules can be configured as a pump with a large flow range by using up to three (3) pump modules in parallel, a pump with integrated energy recovery, or as an energy recovery turbine/generator.

Let no energy go to waste in your brackish water RO system.

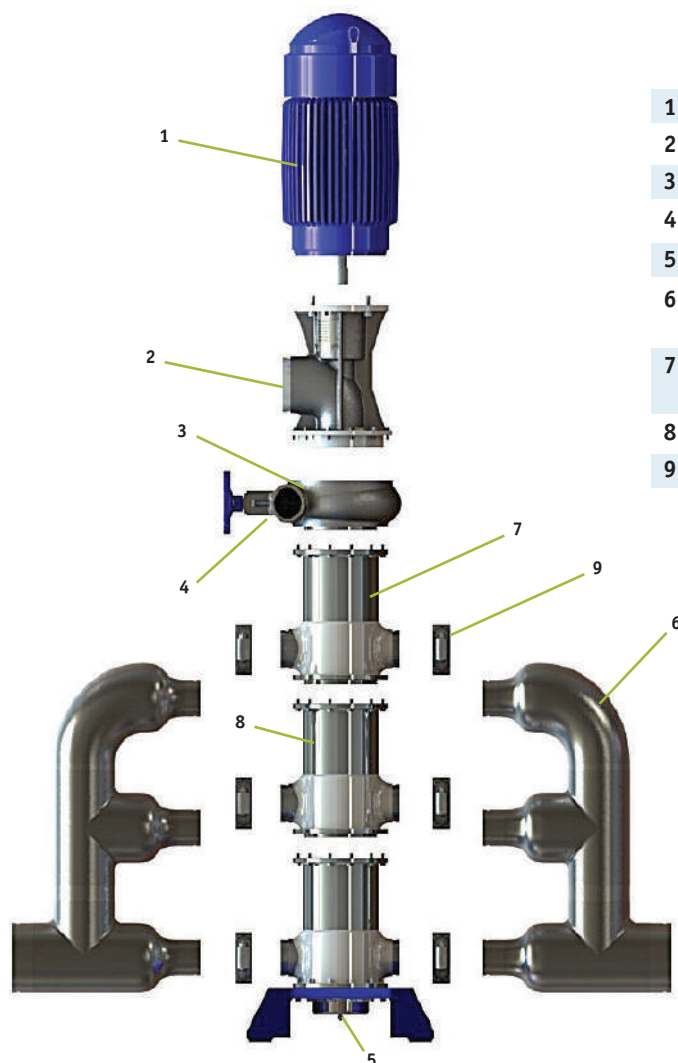
Performance

- Rated to 35 barg
- Flows to 750 m³/h
- Up to 350 kW

Features

- 316 SS construction
- Vertical or horizontal configuration
- Inline flow
- Compact size, low weight

Modular design reduces costs and increases application flexibility



- | | |
|---|--|
| 1 | Motor |
| 2 | Brine discharge module |
| 3 | Turbine module |
| 4 | Brine flow nozzle control |
| 5 | Thrust bearing, patented design - water lubricated |
| 6 | Manifold (if more than one pump module)
316 SS construction, provided by FEDCO |
| 7 | Pump module - up to three (3)
depending on flow requirement |
| 8 | All wetted metallic parts are 316 SS or better |
| 9 | Pipe joint connectors |

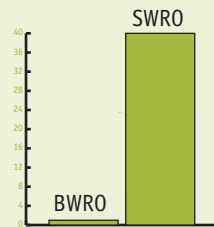
LPH - Low Pressure HEMI Hydraulic Energy Management Integration

The LPH is revolutionizing pumping and energy recovery in brackish water reverse osmosis (BWRO). The rapid acceptance is driven by simple economics - an ERD is only worth using if the cost of saved energy can quickly offset the capital and installation costs of the ERD (a quick return on investment or ROI).

The unique modular construction of the **FEDCO** LP product line allows a few components to be configured in dozens of ways to achieve the performance requirements of a wide range of BWRO systems without high capital and installation costs. Maintenance costs are likewise reduced as maintenance spares and procedures are minimized for large installations.

The LPH takes full advantage of the modular concept with two (2) turbine options (LPT), five (5) stage options and up to three (3) pump modules (LPS) per LPH. Moreover, the turbine module is custom-designed and manufactured to match the specified range of turbine brine flow and pressure ranges.

SWRO ERDs have a much easier task of achieving a good return on investment (ROI). Up to **40 times** more brine energy is available per m³ of permeate produced than in a BWRO system. Only an ERD with both a low capital costs and good energy recovery efficiency can be considered in a BWRO system.



Modules

Turbine

LPT-80

LPT-125

LPT-250

Pump

LPS-90

LPS-120

LPS-160

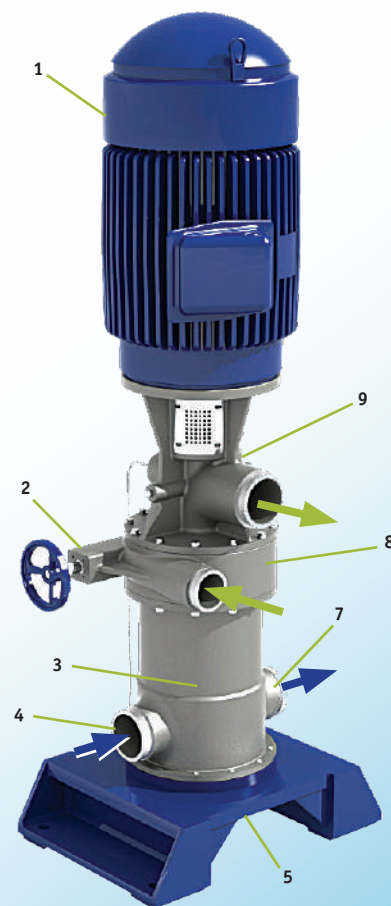
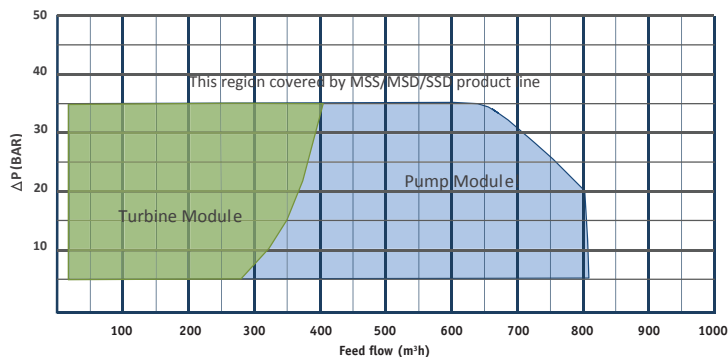
LPS-200

LPS-240

(Up to 3 modules in parallel)

- 1 TEFC motor, rated for vertical operation and with a VFD
- 2 Variable brine nozzle for flow and pressure control
- 3 316 SS or better material of construction
- 4 In-line connections for easy installation
- 5 Integrated water-lubricated bearing absorbs all rotor thrust
- 6 Base plate - powder coated or paint option
- 7 Victaulic type pipe joints
- 8 Turbine nozzle ring and impeller custom-manufactured
- 9 Rotatable turbine section for piping flexibility

Hydraulic Coverage



LPS - Low Pressure Pump

BWRO Membrane Supply, Product Transfer, and More

With efficiency up to 80%, flows up to 750 m³/hr and pressures up to 35 bar, the LPS is the ideal pump for a wide range of BWRO applications. 316 SS construction meets the most demanding corrosion requirements.

The vertical configuration and low weight virtually eliminates foundation requirements. Shaft alignment is assured by highly accurate machine fits of the components.

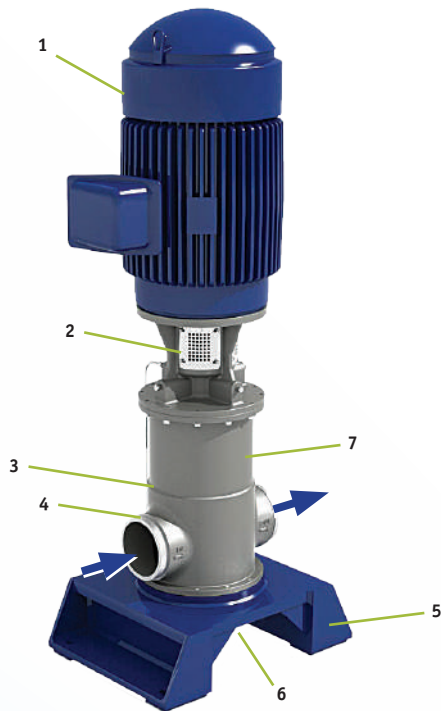
Model

LPS-160

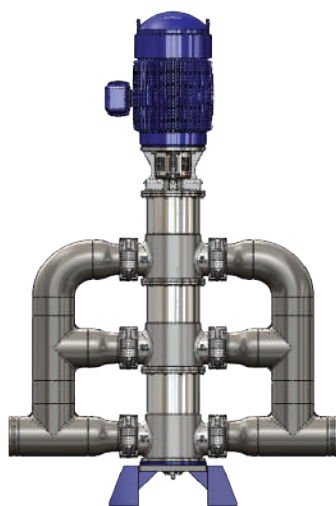
LPS-200

LPS-240

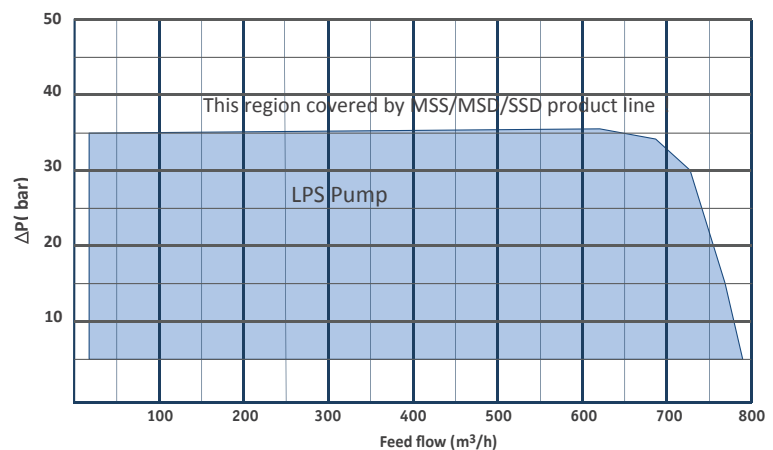
(Up to 3 modules in parallel)



- | | |
|---|--|
| 1 | Motor - rated for VFD usage, vertical operation, TEFC, NEMA or IEC frame |
| 2 | Mechanical seal housing |
| 3 | Pump module - up to three (3) in parallel |
| 4 | Victaulic style pipe joints |
| 5 | Baseplate- powder coated or paint option |
| 6 | Thrust bearing - water lubricated |
| 7 | 316 SS construction |



Hydraulic Coverage



LPD - Low Pressure Drive Conversion of Brine Hydraulic Energy into Electricity

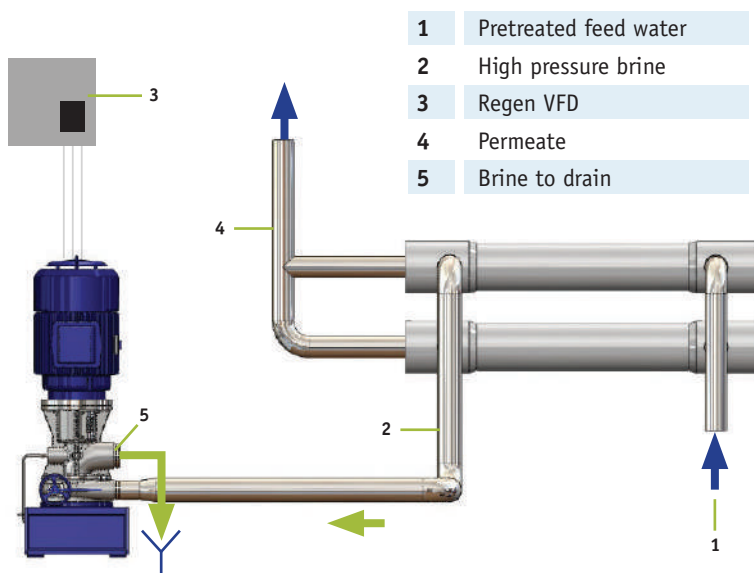
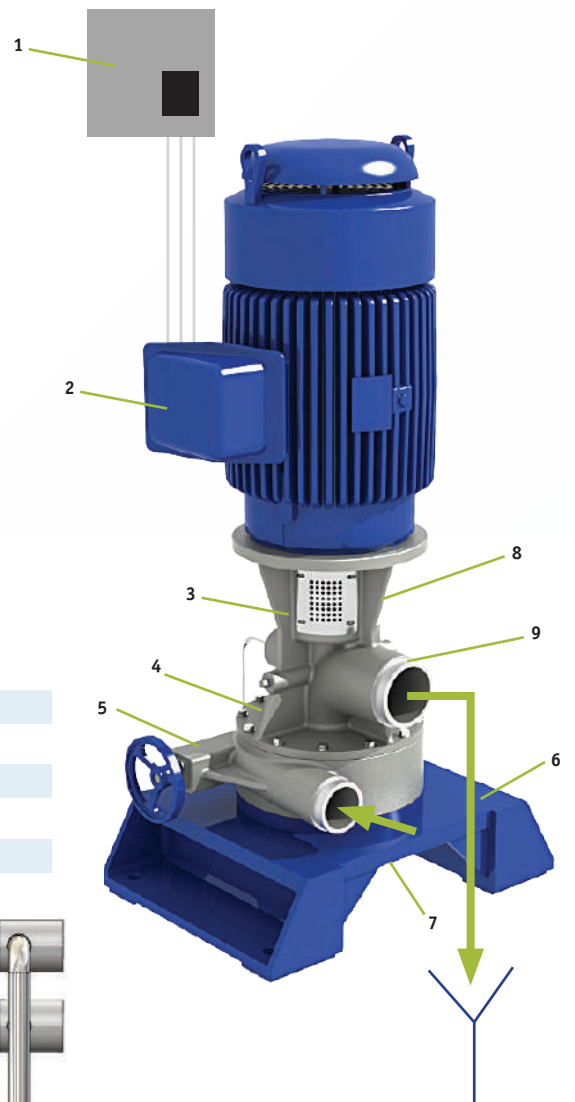
Modules
Turbine
 LPD-80
 LPD-125
 LPD-250

The LPD turbine generator ERD uses brine hydraulic energy to drive a standard induction motor that acts as a generator to produce electrical energy. Integrated into the unit is a regenerative VFD that regulates the LPD to achieve brine flow and pressure as required for the desired membrane operating conditions while extracting the maximum amount of electrical energy available from the brine stream. The vertically mount motor eliminates a large baseplate. The shaft alignment is assured by highly accurate machine fits of the components.

Applications:

- BWRO systems
- Retrofit in existing BWRO
- Replacement of Pressure Release Valve

1	Regenerative VFD - supplied by FEDCO
2	Motor - rated for VFD usage, vertical operation, TEFC, NEMA or IEC frame
3	Mechanical seal housing
4	Turbine module
5	Brine nozzle flow control
6	Baseplate - powder coated or paint option
7	Thrust bearing - water lubricated
8	316 SS or better material of construction
9	Victaulic type pipe joints

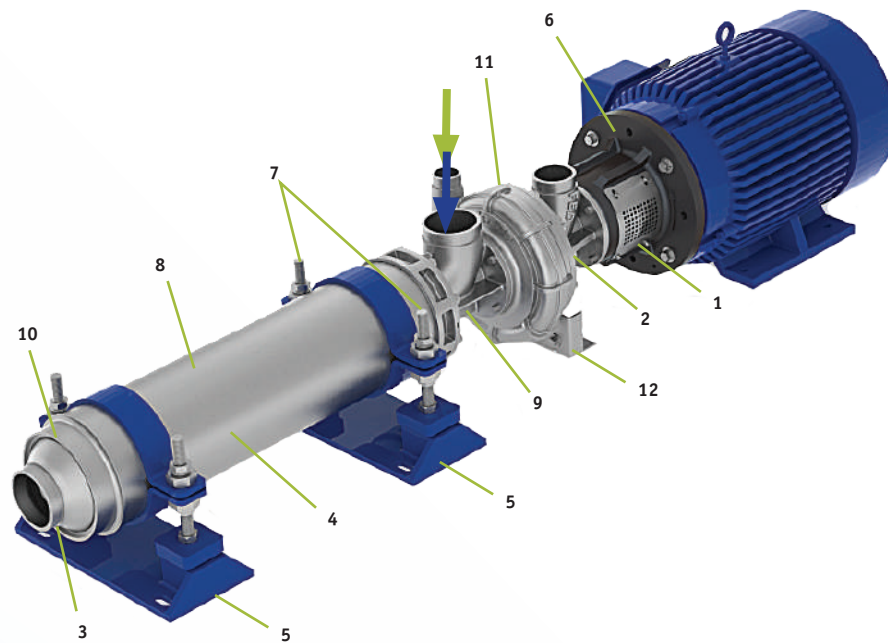


MSB-T - Brackish Feed Pump with Integrated Energy Recovery Turbine

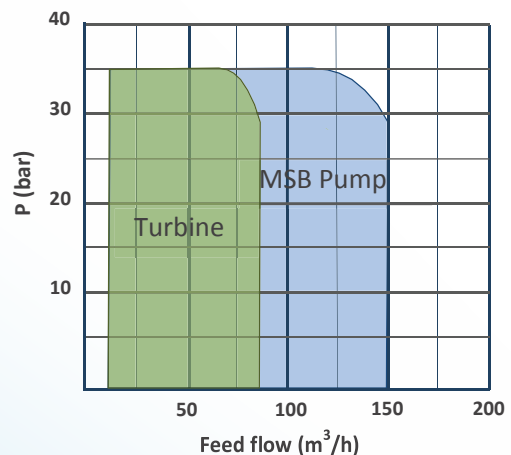
Modules
Turbine
 MSB-T-90
 MSB-T-120

The MSB-T combines the proven MSB multi-stage centrifugal feed pump coupled with a turbine module for brine energy recovery. The MSB-T delivers unprecedented energy efficiency in brackish RO systems over a broad range of flows and pressures. Applications include pure water RO, beverage RO, semi-conductor RO, DAF Systems and other industrial RO systems.

The low pressure MSB-T is loaded with unique features including the patented Water Bearing™. Pump and turbine materials of construction are 316SS with a Duplex SS shaft to meet the challenges of the harshest brackish water conditions. The turbine module utilizes custom-designed multi-vane turbine nozzles and impeller to achieve turbine efficiencies up to 85%.



- | | |
|----|--|
| 1 | Shaft seal operates at low pressure |
| 2 | Flexible disc coupling |
| 3 | Victaulic pipe joints |
| 4 | 316 SS stages |
| 5 | Precision leveling foot |
| 6 | Integrated motor adapter (anodized aluminum alloy) |
| 7 | Easy shaft alignment |
| 8 | Single shell housing |
| 9 | Inlet rotatable in 90° increments |
| 10 | WATER BEARING™ |
| 11 | Turbine module |
| 12 | Turbine module SS bracket |



Typical Brackish Water or Low Pressure Installations



LPH with 3 modules in Singapore



LPD-125 in Spain



LPH-240/125 in Florida, USA



LPH-240/125 in California, USA

Upgrading Existing SWRO Systems with Modern High Efficiency Pumps and ERDs

Pumps and ERDs are undergoing continuous improvement which is especially true with **FEDCO** products. Performance considered industry-leading, even a few years ago can be eclipsed by newer designs and improved manufacturing processes.

FEDCO offers many ways to revitalize old RO systems to achieve performance rivaling new systems.

Retrofits - Upgrading High Pressure Feed Pumps

Replace noisy and unreliable Positive Displacement (PD) pumps with smooth and quiet **FEDCO** MSS pumps. FEDCO pumps eliminate:

- | | |
|-----------------------------|-----------------------|
| Pulsation dampeners | Belts and belt guards |
| Suction stabilizers | Sheaves/pulleys |
| Packing and packing leakage | Special motors |
| Oil and grease lubrication | Unsightly corrosions |

Are you satisfied with your PD pump? Then consider adding a **FEDCO** HPB as an ERD. The FEDCO unit reduces pump discharge pressure by up to 50% resulting in a large energy savings, reduction in cross-head and crank bearing loads, reduction in bearing temperatures, improved valve life and quieter operation.

Retrofits - Replacing Old Low Efficiency Turbochargers

Why replace an old inefficient turbocharger with another inefficient turbocharger? **FEDCO's** high efficiency HPB turbochargers will save more energy and provide a three year (36 months) warranty. Its a smart way to save energy and raise plant reliability.

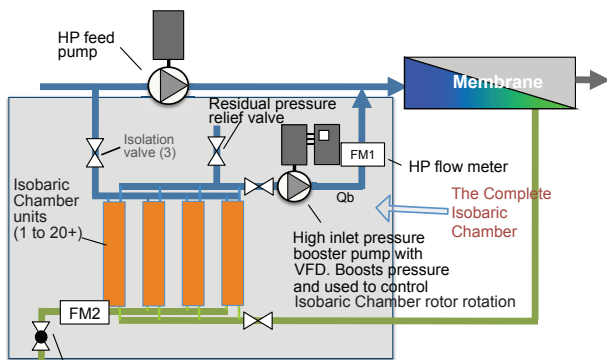
Retrofits - Replace Isobaric Chambers

Isobaric chambers are noted for good efficiency, high complexity, daunting maintenance and brine mixing. **FEDCO** offers a package that directly replaces an existing isobaric chamber without disturbing the existing HP pump or membrane array. With the **FEDCO** replacement package, you will enjoy improved permeate quality, quieter operation, reduced maintenance and most important - lower cost permeate!



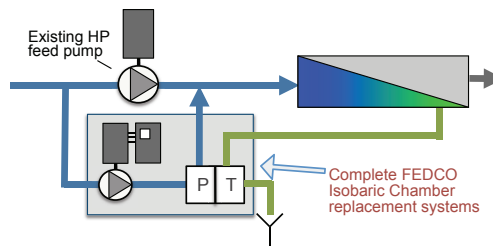
Retrofit installation at a power station in India

From this...
Typical Isobaric Chamber ERD System



Control valve. Provides back pressure to prevent cavitation and control fill/purge rate of rotor passages.
A simplified system diagram[1] – special flushing piping, safety interlocks, Isobaric Chamber sample ports, etc. omitted for clarity. Indicated flows are approximate.

to this!
FEDCO Isobaric Chamber Replacement Package



Complete FEDCO Isobaric Chamber replacement systems

FEDCO Spare Parts, Training and Field Service



Spare Parts

FEDCO maintains a complete inventory of spares for all of its product lines. Even major components such as rotors for turbochargers can be quickly dispatched using FEDCO's unique "loaner rotor" program for minimal equipment down time.

Since **FEDCO** machines its HPB, turbine, and SSD rotors from bar stock, in the event a replacement is needed, there is no long wait for castings to be poured and machined. **FEDCO** can begin manufacture from its extensive inventory of bar stock and plate to provide fast supply of any size rotor.



Training

FEDCO welcomes the opportunity to train customers on the installation and maintenance of **FEDCO** equipment. Our classroom and shop training facilities provide a comprehensive training in 2 to 3 days. We also offer training at customer locations around the world.



Field Service

Our field service personnel know our products and they know RO systems. Some are machinists, PLC programmers and mechanics. When our field service specialists study a problem, they look at every aspect to quickly identify the root cause and apply the most appropriate solution.

FEDCO USA Technical Support
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techsupport@fedco-usa.com
www.fedco-usa.com



Life Cycle Cost Analysis

A systematic procedure defined by Europump and U.S. Hydraulic Institute to evaluate life-time costs of pumping equipment based on all cost factors.

The life cycle costs (LCC) weighs these factors to determine the **optimal investment** for an ERD or pump. The LCC tells you how much money you have **at the end of the day**.

Every cost factor associated with a piece of equipment needs to be considered including auxiliary equipment, engineering and procurement costs, administration costs, etc. In addition the timing of the costs must be considered. For example, the combination of inflation and the cost of capital (interest charges) must be normalized to a **Net Present Value**.

The Best Value in LCC

FEDCO equipment is designed to optimize the LCC value by providing a balanced combination of excellent efficiency, low capital costs, single source of supply, reliability, and long warranty.



Don't Be Surprised by Energy Consumption

An RO plant is a complex hydraulic system with high-pressure pumps, energy recovery devices and membranes. Interactions between these devices are complex. The effects of variable membrane pressure brought about by changing feed TDS and salinity as well as membrane fouling add to the complexity.

The result is that the energy consumption measured during operation can be much different from predicted values. And, as the plant ages, energy consumption can sharply deteriorate resulting in a significant change in the cost of permeate.

Know Realistic Energy Estimates Before the Plant Design is Finalized...

FEDCO has applied its hydraulic machine performance expertise to develop software that can accurately predict pump and ERD performance in response to changing operating conditions. The detailed predicted performance may be presented in graphic or tabular form.

Date:	System Performance Analysis	
Com: 127		
LCC PARAMETERS		
Life cycle period (years)2	0	
Electric cost (\$/kW-Hr)	0.3	
Inflation rate (annual)	0.03	
Interest rate (annual)	0.07	
Duty cycle	0.9	
Field service rate (USD/day)	950	
Profit + overhead (\$/m3)	2	
LCC COSTS		
	HPP	
Ci Initial Cost	152,832	311,375
Cin Install & Commis.	31,716	74,800
Ce Energy cost	15,091,962	14,966,326
Co Operating cost	0	0
Cm Maintenance cost	132,053	450,426
Cs Downtime cost	14,426	30,913
Cd Decommission	234	2,666
TOTAL	15,423,223	15,836,506

Date:	System Performance Analysis	
Com: 127		
HPP COST DATA		
Procurement (days)	1	
Design and engr.1		
Unit cost	70,000	
Foundations	182	
TOTAL	78,082	
INSTALLATION COSTS		
O&M training (days)	1	
ERD Installation	1	
Feeds and brine piping	8,243	
Victrolux1	2,36	
TOTAL	11,379	
MAINTENANCE		
Overhaul unit cost	23,000	
Period (years)	6	
Annual maintenance	950	
AVAILABILITY		
System uptime0	.998	
MISC ONE-TIME COSTS		
Decommissioning	-1,649	
TOTAL	-1,649	
HPP COST DATA		
Installation design (days)	3	
Procurement (days)	2	
Pump and base cost	70,000	
Motor0		
Contractor or VFD	0	
Control valve0		
TOTAL	74,750	
INSTALLATION COSTS		
O&M training (days)	2	
HPP Installation	7,507	
Foundation	11,310	
TOTAL	20,337	
MAINTENANCE		
Overhaul unit cost	23,000	
Period (years)	6	
Annual maintenance1	.100	
AVAILABILITY		
HPP availability0	.995	
MISC ONE-TIME COSTS		
Decommissioning	2,162	
TOTAL	2,162	

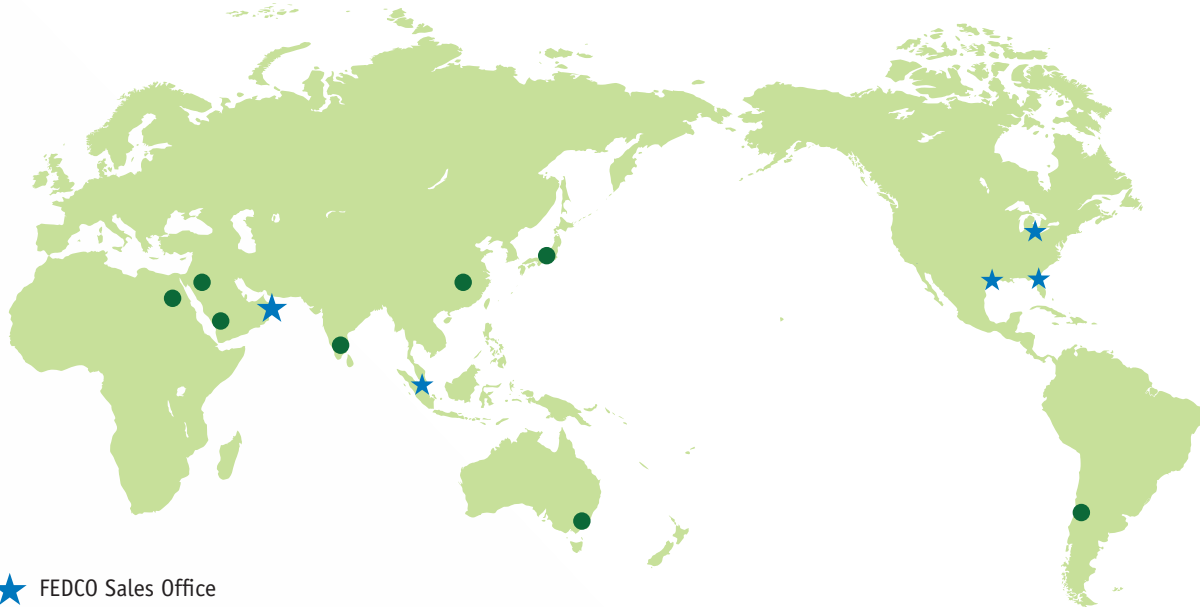
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- 1 Allows specific pump performance curves to be defined or use generic curves with estimated efficiencies.
- 2 Motor and VFD efficiency including part-load efficiency may be inputted or generic values may be used.
- 3 Up to forty-eight (48) sets of duty points with time-weighted averages can be specified to cover virtually every operating mode of the plant.
- 4 Turbochargers, Pelton turbines, and pressure exchangers can be analyzed and compared.
- 5 All calculations are based on published data or reasonable engineering estimates. All calculations are fully transparent.
- 6 Data may be expressed in graphic form for easy analysis and data presentations.

Global Service and Sales Office

FEDCO world headquarters are located in the state of Michigan in the United States. The facility houses our administrative, engineering, manufacturing, and sales departments. Our staff is committed to the success of our customers. You can reach FEDCO personnel between 8:00 AM and 5:00 PM EST (USA).

Worldwide sales representatives offices can be found in: **Australia, Chile, China, India, Israel, Japan, Singapore, UAE.** The **Dubai, UAE** sales office offers complete sales and service for our customers in the MENA region. The **Singapore** sales office offers sales and service for the Asia Oceania region. Our sales department, field service department, and manufacturers representatives are trained in installation, maintenance, and repair of FEDCO equipment. Our affiliate TORISHIMA Pump Mfg. Co., Ltd. expands further our sales and service presence around the world.



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- FEDCO Representatives



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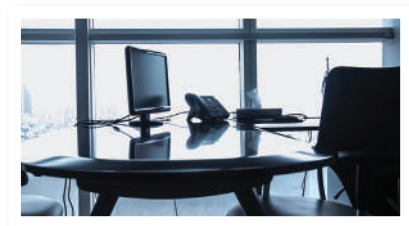
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A detailed view of a hydraulic system. The system consists of several white cylindrical components, likely hydraulic cylinders or accumulators, arranged in a grid. These are connected to a network of pipes and hoses. In the foreground, there is a large blue electric motor with a fan cover. A control panel with a digital display is also visible. The entire system is mounted on a metal frame. The background is slightly blurred, showing more of the machinery.

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