FLOWSERVE

USER INSTRUCTIONS

Flowserve FLEX™

Isobaric Energy Recovery Device

21TEM14546 EN

Original Instructions

Installation
Operation
Maintenance

⚠ ***These instructions must be read prior to installing, operating, and maintaining this equipment.***

Experience In Motion

Document Version

Initial Release, 07-DEC-2021

CONTENTS

1 General Information

1.1 Scope of manual

⚠ These instructions must be kept close to the product's operating location or directly with the product.

⚠ These instructions must be read prior to installing, operating, using, or maintaining the equipment in any region worldwide. The equipment must not be put into service until all of the safe operating conditions noted in the instructions have been met. Failure to comply with the information provided in the User Instructions is considered to be misuse. Personal injury, product damage, delay in operation, or product failure caused by misuse are not covered by the Flowserve warranty.

The following user information covers the Flowserve FLEX™ 6300 and 8600.

These instructions are intended to familiarize the reader with the product and its permitted use. Operating the product in compliance with these instructions is important to help ensure reliability in service and avoid risks. These instructions may not take into account all local regulations; ensure such regulations are observed by all, including those installing the product. Always coordinate repair activities with operations personnel and follow all plant safety requirements and applicable safety and health legislation.

Supplementary user instructions determined from the contract requirements for inclusion into User Instructions for buy-out equipment such as instrumentation, controller, coupling, mounting component, etc. are included in Annex B: Supplementary User Instructions.

The typical general arrangement drawing, and any specific drawings required by the contract will be sent to the Purchaser separately unless the contract specifically calls for these to be included into the User Instructions. If required, copies of other drawings sent separately to the Purchaser should be obtained from the Purchaser and retained with these User Instructions.

1.2 Disclaimer

Information in this User Instruction is believed to be complete and reliable. In spite of all Flowserve's efforts to provide comprehensive information and instructions, sound engineering and safety practices should always be used. Please consult with a qualified engineer.

Flowserve manufactures products to applicable International Quality Management System Standards as certified and audited by external Quality Assurance organizations. Genuine parts and accessories have been designed, tested, and incorporated into the products to help ensure continued product quality and performance in use. As Flowserve cannot test parts and accessories sourced from other vendors, the incorrect incorporation of such parts and accessories may adversely affect the performance and safety features of the product. The failure to properly select, install, or use authorized Flowserve parts and accessories is considered to be misuse. Damage or failure caused by misuse is not covered by Flowserve's warranty. In addition, any modification of Flowserve products or removal of original components may impair the safety of these products in use.

1.3 Certification instruction

It is a legal requirement that machinery and equipment put into service within certain regions of the world shall conform to the Marking Directives applicable to Flowserve products (i.e., Machinery Directive, Low Voltage Directive, Electromagnetic Compatibility (EMC) Directive, Pressure Equipment Directive (PED), Equipment for Potentially Explosive Atmospheres (ATEX), etc.).

Certificates defined in the Contract requirements are provided with these instructions where applicable. Examples of the certificates can be found in the Annex of this document. If required, copies of other certificates sent separately to the Purchaser should be obtained from the Purchaser for retention with this User Instruction.

1.4 Units

This document uses dual ISO and US units.

2 Safety Information

2.1 Intended use

The product/system must not be operated beyond the parameters specified for the application. If there is any doubt as to the suitability of the product/system for the application intended, contact Flowserve for advice, quoting the serial number.

- Installing, operating, or maintaining the product/system in any way that is not covered in this User Instruction could cause death, serious personal injury, or damage to the equipment. This includes any modification to the product/system or use of parts not provided by Flowserve.
- Only operate the product/system when it has successfully passed all inspection acceptance criteria.
- Do not operate the product/system in a partially assembled condition.
- If the conditions of service on the customer's purchase order change (i.e., pumping fluid, temperature, or duty conditions) it is requested that the user seeks written agreement from Flowserve before startup.
- Observe equipment labels, such as arrows designating the direction of flow, warning signs, etc., and keep them in a legible condition. Replace any damaged and/or illegible labels immediately.

2.2 Safety symbols and description

This User Instruction contains specific safety markings where non-observance of an instruction would cause a hazard. The specific safety markings can be found in Table 1 and Table 2.

Table 1: Definition of safety symbols and markings

SYMBOL	DESCRIPTION
DANGER	**DANGER** This symbol indicates a hazardous situation which, if not avoided, will result in death or serious injury
WARNING	**WARNING** This symbol indicates a hazardous situation which, if not avoided, could result in death or serious injury
CAUTION	**CAUTION** This symbol indicates a hazardous situation which, if not avoided, could result in minor or moderate injury
SAFETY INSTRUCTIONS	**SAFETY INSTRUCTION** This symbol indicates specific safety-related instruction or procedures
NOTICE	**NOTICE** This symbol is used to address practices not related to physical injury

SYMBOL	DESCRIPTION
	This is the safety alert symbol. It is used to alert you to potential physical injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death

Table 2: Additional symbols

SYMBOL	DESCRIPTION
	**ELECTRICAL HAZARD** This symbol indicates electrical safety instructions where non-compliance would affect personal safety and could result in loss of life
	**TOXIC HAZARD** This symbol indicates "hazardous substances and toxic fluid" safety instructions where non-compliance would affect personal safety and would damage the equipment or property
	**ATEX EXPLOSION PROTECTION** This symbol indicates explosive atmosphere marking according to ATEX. It is used in safety instructions where non-compliance in the hazardous area would cause the risk of an explosion

2.3 General hazard sources

This is a summary of conditions and actions to help prevent injury to personnel and damage to the environment and to equipment.

2.3.1 Mechanical Hazards

Lifting limits and guidelines

Note: The load values mentioned in this section are Flowserve recommendations only. All lifting must be done in compliance with site safety protocol, local regulations, and related industry standards.

 Many precision parts have sharp corners which require appropriate personal protective equipment during handling. Prior to any attempt to lift an item, employees must first determine the approximate weight and stability of the load.

- Large, unstable, or awkward loads should always be handled with the assistance of additional personnel or appropriate mechanical means.
- Loads in excess of 23 kg (50 lb) should only be lifted by appropriate mechanical means and in accordance with current local legislation or with the assistance of additional personnel.
- Lifting items less than 23 kg (50 lb) may be prohibited without assistance if the lift is repetitive and/or awkward (i.e., away from the body, above the shoulders or below the knees) thus placing excessive stress on the personnel.

- Repetitive lifting of any kind should be evaluated as part of a documented end-user safety program.

2.3.2 Additional hazards

⚠WARNING DRAIN AND ISOLATE PIPEWORK BEFORE DISMANTLING

Residual high-pressure can remain in the FLEX units depending on how the system is shut down. Ensure the FLEX units have been isolated from the system and relieved of all pressure before dismantling any connections on the device.

⚠CAUTION PREVENT EXCESSIVE EXTERNAL PIPE LOAD

Refer to documentation from pipe coupling OEM for recommendations on system design, operating limits, and allowable nozzle loads. It is not recommended to use pipe couplings to support the static or dynamic loads of the FLEX unit(s).

⚠CAUTION NEVER EXCEED THE MAXIMUM DESIGN PRESSURE

ENSURE SYSTEM IS PROPERLY GROUNDED

The FLEX vessels make direct metal-to-metal contact with high-pressure system piping through the pipe coupling connections. No specific grounding connection for the FLEX is required as long as the high-pressure system piping is grounded.

2.4 Responsibility of the operating company

To ensure personnel safety, the operating company shall:

- Complete a risk assessment of the site where the product/system will be in operation, by observing the working conditions
- Create site specific work instructions for the operation of the product
- Ensure that the personnel have read and understand all applicable instructions
- Provide regular training to the necessary personnel in regular intervals
- Provide the required personal protective equipment

2.5 Qualified personnel and targeted group

All personnel involved in the operation, installation and maintenance of the unit must be qualified to carry out the work involved. If the personnel in question does not already possess the necessary knowledge and skill, appropriate training and instruction must be provided. If required, the operator may commission the manufacturer/supplier to provide applicable training.

Always coordinate repair activities with operation and health and safety personnel and follow all plant safety requirements and applicable safety and health laws and regulations.

2.6 Industrial health and safety measures

Follow industry safety standards including the use of appropriate equipment in required areas.

2.7 Protective equipment

Necessary protective equipment including personal protective equipment shall adhere to facility standards.

3 Product Description

3.1 General product description

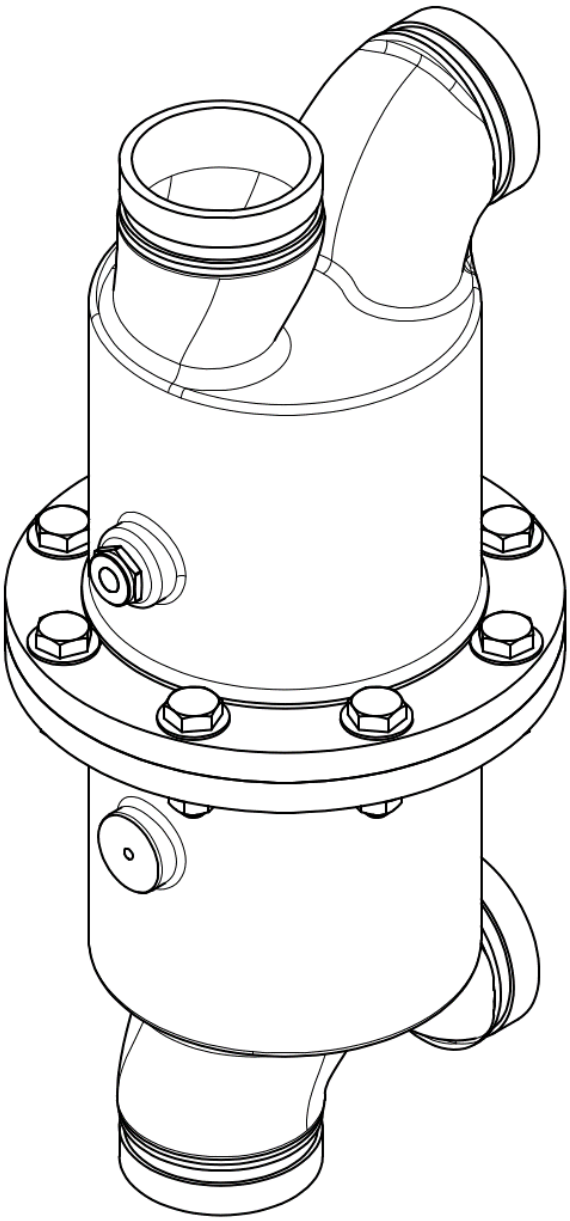

Figure 1: Isometric view of the Flowserve FLEX™

The Flowserve FLEX™ is an isobaric energy recovery device designed for reverse osmosis seawater desalination applications. It takes the energy of a high-pressure fluid waste stream and transfers the pressure energy to a low-pressure fluid supply stream. The simple design does not require any external power, has only one moving part, and uses corrosion-proof materials for high reliability and long life.

3.2 FLEX design

The following sections describe the functions of the primary components in the FLEX. For further clarity, refer to Figure 1 and Figure 12 (page 30) for isometric and exploded views of the device.

3.2.1 Vessel

The vessel acts as the primary pressure containment boundary for the device and contains passageways (called ports or nozzles) that direct flow between external pipe connections and appropriate end cover ports inside the device. The center flange allows the vessel to split in two for access to the internal ceramic cartridge during maintenance.

3.2.2 Accessories

There are two bosses on the outside of the vessel for auxiliary equipment. One boss is fitted with a sight-glass that allows direct observation of rotor speed using an optical tachometer to confirm proper operation of the unit. The other boss is machined to allow mounting of an accelerometer or other customer instrumentation.

3.2.3 End cover

The end covers on either side of the ceramic cartridge direct flow between the vessel ports and rotor ducts. Low-pressure flow is directed through the end cover in a way that drives the rotation of the rotor. The end covers also control pressure distribution around the cartridge to reduce pressure forces and control leakage.

3.2.4 Rotor

The rotor provides a series of ducts that flow back and forth as it rotates to exchange pressure between the high-pressure waste and low-pressure feed fluid streams. The rotor is designed to minimize the region inside the ducts where the two fluid streams mix, as well as handle the cyclic loading between high and low pressure as it spins.

3.2.5 Axle

The axle provides a bearing surface to support and center the rotor. Having this bearing surface on the inner diameter of the rotor minimizes the amount of lubrication flow that must leak through the bearing clearances.

3.2.6 Materials

All components that are wetted by the process fluid are made of titanium, alumina ceramic, non-metallic, and composites that will not corrode in seawater and brine. External bolting is made of duplex stainless steel to minimize corrosion in a salt air environment. Non-metallic and composite materials that contact the process fluid are compatible with potable water applications.

3.3 Function in an RO system

The Flowserve FLEX™ is an isobaric energy recovery device designed for reverse osmosis (RO) seawater desalination applications. It takes the energy of a high-pressure fluid waste stream and transfers the pressure energy to a low-pressure fluid supply stream. The simple design does not require any external power, has only one moving part, and uses corrosion-proof materials for high reliability and long life.

In an RO desalination application like the one shown in Figure 2, the high-pressure waste stream entering the FLEX is brine leaving the membrane filters. The energy from this brine is transferred to low-pressure seawater provided to the FLEX from the system's low-pressure feed pump. Seawater then leaves the FLEX at nearly the same pressure as the incoming brine. A small booster pump is used to overcome piping friction losses between the brine outlet of the membrane and the point that this seawater will be injected back into the membrane inlet. The final outlet of the FLEX unit is the brine reject leaving at low-pressure. A control valve is used at this location to maintain a minimum backpressure on the device.

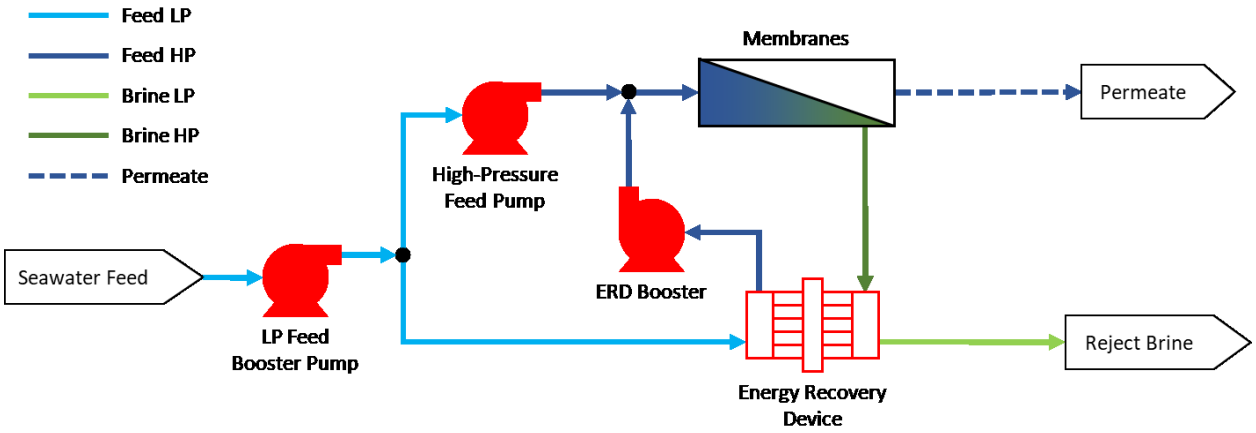

Figure 2: Process flow diagram for a typical FLEX system

There are three sources of energy loss through the FLEX device: hydraulic, volumetric, and mixing. Hydraulic loss occurs due to friction loss of fluid flowing through the device and providing energy to drive rotation of the rotor. This is measured as a pressure differential from inlet to outlet of the device on both the high-pressure and low-pressure sides. Volumetric loss is caused by fluid leaking from high-pressure to low-pressure inside the device, providing lubrication and cooling to the bearing surfaces. Mixing loss occurs due to turbulence at the interface between brine and seawater inside the rotor ducts, and results in a small increase in salinity of the seawater as it flows through the FLEX from low-pressure inlet to high-pressure outlet.

3.4 System design

A backpressure control valve must be included in the low-pressure brine discharge line. The valve should be appropriately sized and selected to allow throttling of the flow to maintain backpressure at or above the minimum level required by the FLEX. Maintaining backpressure at or above the minimum required level will reduce cavitation and prolong life of FLEX unit(s).

Filtration of the process fluid must occur upstream of the FLEX device to avoid damaging the unit and the precision clearances inside of it. Filters should have a maximum particle size of 20 µm (0.8 mils) or smaller.

A circulation pump (or booster pump) is required on the high-pressure side of FLEX system piping. This pump is used to overcome system resistance as process fluid flows from the membrane outlet, through the FLEX, and back to the high-pressure feedwater inlet of the membranes. This pump should be installed with either a variable speed drive or a throttling valve to control high pressure flow rate through the FLEX.

Pressure relief devices should be provided on system piping to prevent over pressurization of either the FLEX device or low-pressure system piping. Over pressurization may create a hazard for personnel or result in damage to the FLEX device. It is recommended to install appropriately sized and rated pressure relief devices on the high-pressure and low-pressure inlets to the FLEX.

Flushing lines should be connected to the system in a way that allow independent flushing of the high-pressure and low-pressure system piping around the FLEX device.

Vent connections should be placed to ensure that system piping and FLEX units can be completely flooded, and all air can be purged from the system before startup.

Isolation valves and drain lines should be appropriately placed in system piping to allow isolation of the FLEX units(s) from the system for safe inspection and maintenance.

3.5 Header design

Headers can be used to place multiple FLEX units in parallel and achieve higher total system flow than would be possible with any single unit. Care should be taken in designing the header system to ensure that an even flow distribution between FLEX units is achieved. An uneven flow distribution can result in excessive mixing and unreliable operation.

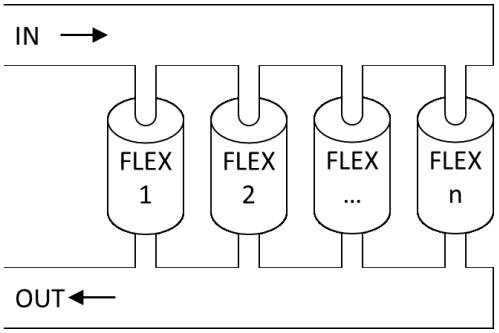

Figure 3: U-flow configuration

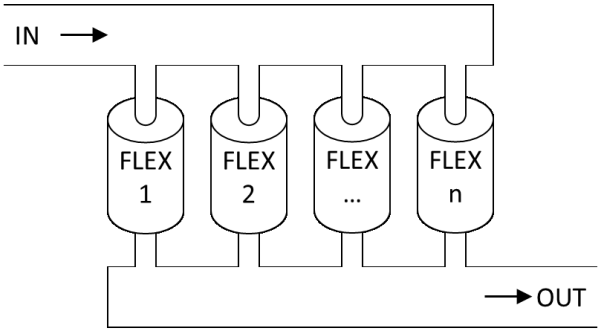

Figure 4: Z-flow configuration

Two flow configurations can be used to design the headers for a rack of FLEX units: U-flow and Z-flow configurations. U-flow has flow that enters and leaves on the same side of the rack. Z-flow has flow that enters on one side of the rack and leaves on the other size. Examples of these configurations are shown in Figure 3 and Figure 4.

An analysis of the total system resistance from header inlet to header outlet provides some important guidelines on how to design headers to achieve an even flow distribution between FLEX units operating in parallel with each other:

1. Maintaining low header flow velocity is more important than which configuration is chosen. Lower header flow velocity will result in more even flow distribution between FLEX units, but as a general guideline header flow velocity should be maintained below 3 m/s (10 ft/s).
2. A Z-flow configuration provides more even flow distribution between FLEX units than a U-flow configuration.
3. A Z-flow configuration can have high-pressure and low-pressure flow enter and exit on either side of the rack and maintain the same flow distribution between units in the rack; however, a U-flow header should have high-pressure and low-pressure flow enter and exit on the same side of the rack so that any uneven flow distributions are equal on the high-pressure and low-pressure sides, and the flow balance for each individual unit will remain equal. Guidelines for acceptable header configurations are shown in Figure 5.

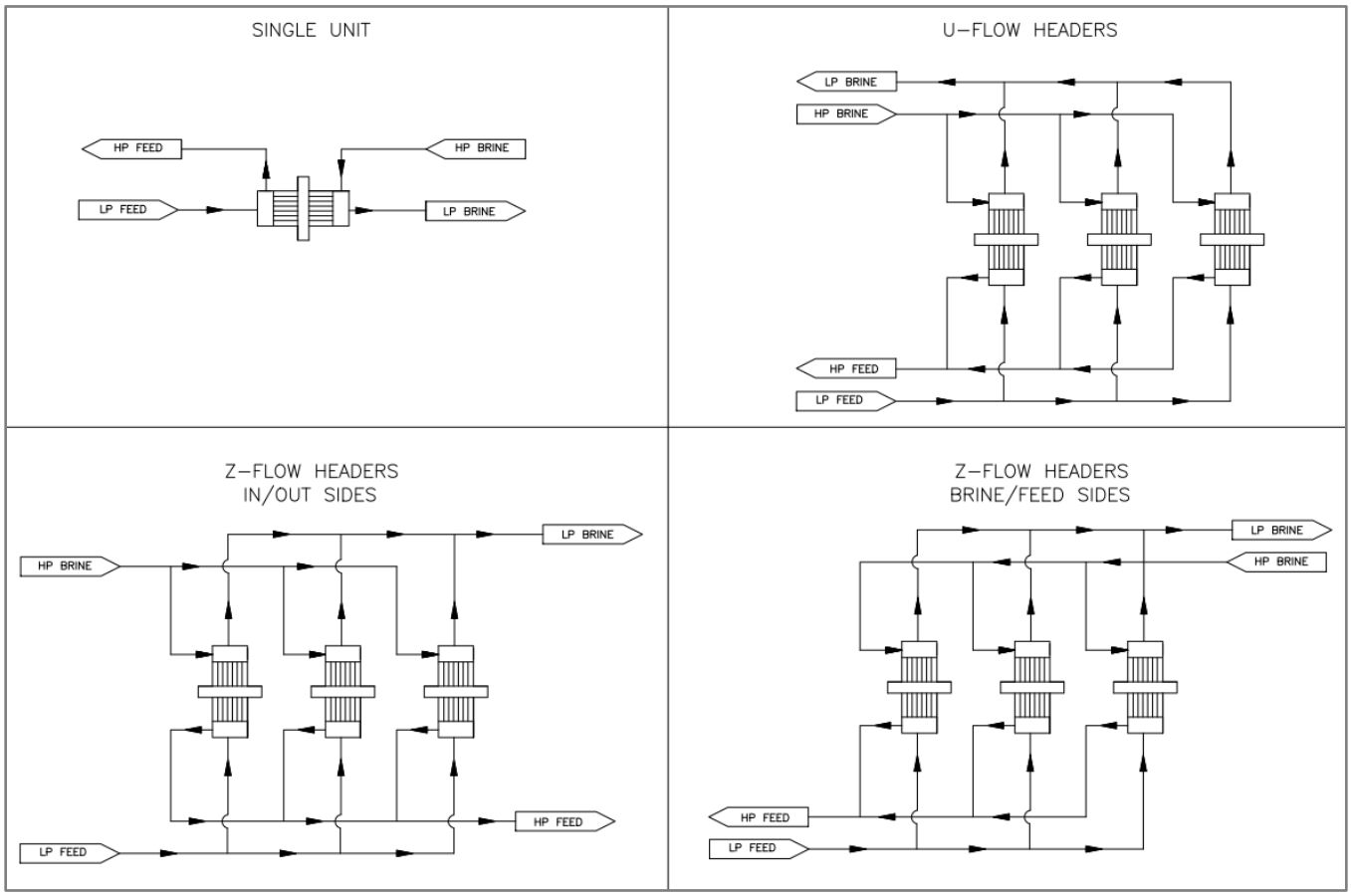

Figure 5: Acceptable header flow configurations

Mounting orientation is important for the design of mounting fixtures and system piping but does not affect operation of the FLEX. FLEX units can be mounted in any orientation in the headers: horizontal, vertical with brine on top, or vertical with brine on bottom.

Adapter pipes should be placed between the headers and FLEX units to provide a more robust and forgiving connection than can be achieved by simply coupling the FLEX units directly to the headers. The adapters should have grooved pipe connections on both ends and use flexible split style couplings on both the header and FLEX connections. Refer to documentation from the pipe coupling OEM for further guidance on proper piping design.

Material selection is important for both the high-pressure and low-pressure headers and adapter pipes. High-pressure headers and piping are typically made of duplex or super duplex stainless steel because of its corrosion resistance and strength. For the low-pressure headers and piping, Flowserve recommends the use of Polyethylene (PE) or Polypropylene (PP) rather than Polyvinylchloride (PVC) wherever possible.

3.6 Connections

3.6.1 Piping connections

Each FLEX unit has four pipe end connections with grooved ends for split couplings:

- FLEX 6300 3-inch NPS pipe Grooved pipe end (to Victaulic OGS specifications)
- FLEX 8600 4-inch NPS pipe Grooved pipe end (to Victaulic OGS specifications)

⚠ REMOVE PROTECTIVE COVERS FROM NOZZLES PRIOR TO INSTALLATION

Protective covers are fitted to all pipe connections on the device to prevent foreign objects and debris from contaminating the device. Covers should remain in place until the unit is ready to install. These covers must be removed prior to connecting the unit to any pipes.

⚠WARNING USE APPROPRIATELY RATED COUPLINGS ON HIGH-PRESSURE CONNECTIONS

Pipe couplings with pressure ratings above the highest expected system pressure must be used on high-pressure connections to the device.

⚠CAUTION PREVENT EXCESSIVE EXTERNAL PIPE LOAD

Refer to documentation from pipe coupling OEM for recommendations on system design, operating limits, and allowable nozzle loads. It is not recommended to use pipe couplings to support the static or dynamic loads of the FLEX unit(s).

3.6.2 Auxiliary connections

A ¼"-24 UNF threaded connection on the vessel can be used to attach an accelerometer or other auxiliary instrumentation.

3.7 Accessories

No accessories are required to operate the device. Optional accessories include an optical tachometer and an accelerometer to confirm proper operation and flow balance between units in a rack and to monitor the device for issues over time.

4 Packaging, Lifting and Storage

4.1 Consignment receipt

Immediately after receipt of the products, customer should verify that the goods received exactly match the delivery/shipping documents, and that there has been no damage in transportation. Any shortage or damage must be reported immediately to Flowserve and must be received in writing within one month of receipt of the goods. Later claims cannot be accepted.

The following symbols are used to label the packaging:


This side up


Fragile


Keep dry


Protect from direct sunlight


Center of gravity


Do not use hooks


Attachment point

4.2 Unpacking

The FLEX and its associated equipment are carefully inspected at the factory prior to shipment to ensure quality compliance. Customer should visually inspect the goods on arrival and report any irregularities or damage to the carrier immediately.

The condition of the skid and covering is indicative of the way the shipment was handled. Broken skids, torn covering, bent hold-down bolts, broken straps, etc., indicate rough handling. The protective covers on the FLEX nozzles should be in place and undamaged.

Take care when removing crating, coverings, and strapping in order not to damage any equipment and/or the FLEX's finish.

Inspect all crates, boxes, or wrappings for any accessories or spare parts that may be packed separately with the equipment or attached to the side wall of the box or equipment.

Each FLEX has a unique serial number. Check that this number corresponds with that advised and always refer to this number in correspondence as well as when ordering spare parts or further accessories.

4.3 Packaging

4.3.1 General FLEX packaging guidelines

It is the responsibility of the Facility to ensure packaged items are in a suitable container or transporting device that protects the items from exterior forces, impact, vibration, and environmental conditions. Before packaging items, ensure the following:

1. Inspect all items for cleanliness immediately before packaging. Dirt, oil residue, metal chips, or other forms of contamination shall be removed by approved cleaning methods.
2. Components which are not immediately packaged must be protected from contamination. Use nozzle covers to prevent foreign objects and debris from entering the device. Package with a barrier to prevent water vapor, salt air, dust, dirt, and other forms of contamination from penetrating the package.
3. Items and their containers shall be properly identified by markings.

Before shipping, prepare a packing slip and fasten it to the unit. The packaging slip shall contain the following information:

1. Customer's purchase order number
2. Flowserve job number
3. Customer's name and address
4. "Ship to" address
5. Quantity
6. Description
7. Date shipped
8. Carrier used

For shipments with more than one unit container or package for any given order, each parcel shall be properly marked (such as 1 of 3, 2 of 3, etc.) and contain a copy of the packing list.

4.3.2 Typical Flowserve packaging

FLEX units shipped from a Flowserve facility will typically be packaged in the following manner: (see the pictures in Figure 6 through Figure 10 for examples)

- Protective covers will be fitted to each of the four nozzles to prevent internal contamination.
- Individual containers will be used to package each unit.
- Protective padding will be fitted in each container to prevent external forces, impact, or vibration during transport from damaging the device.
- Appropriate labels will be fastened externally to each container.
- Multiple containers will be appropriately stacked and fastened together on a pallet.

Figure 6: Multiple containers on a pallet

Figure 7: Single FLEX container

Figure 8: Top of protective padding

Figure 9: Top protective padding removed

Figure 10: FLEX unit with nozzle covers

4.4 Lifting

Use a choker hitch sling pulled tight around the nozzles to lift an assembled FLEX unit.

⚠ USE LIFTING ASSISTANCE FOR HEAVY OBJECTS AND AWKWARD LIFTS

Flowserve recommends a crane be used for all devices in excess of 23 kg (50 lb). Fully trained personnel must carry out lifting in accordance with local regulations.

⚠ LIFT THE DEVICE ABOVE THE CENTER OF GRAVITY

Care must be taken to lift components or assemblies above the center of gravity to prevent the unit from flipping.

NOTICE THE FLEX DEVICE CONTAINS FRAGILE CERAMIC PARTS

When handling FLEX units or any internal parts, be careful not to hit or drop them against any hard surfaces, as this may damage the ceramic components.

4.5 Storage

Store the device in a clean, dry location away from vibration. Leave nozzle covers in place to keep foreign objects and debris out of the device. The device may be stored in this way for up to six months. Consult Flowserve when a longer storage period is needed.

4.5.1 Short term storage

Normal packaging is designed to protect the device and parts during shipment and for dry, indoor storage for up to six months or less.

4.5.2 Long term storage

Long term storage is defined as more than six months, but less than twelve months. For long term storage, Flowserve uses the same normal packaging procedure with the addition of the following steps: Each package is hermetically sealed from the atmosphere by means of heat shrink wrap sheeting. Desiccant bags are placed inside the shrink wrap packaging. After unpacking, protection will be the responsibility of the user.

5 Installation

5.1 Inspection and preparation

5.1.1 Location

The FLEX should be located to allow room for access, maintenance, and inspection with ample headroom for lifting.

5.1.2 Protection of openings

NOTICE **USE PROTECTIVE COVERS ON FLEX PORTS WHEN NOT IN SERVICE**

When the FLEX is shipped, all openings are covered. These protective coverings should not be removed until installation. If for any reason a FLEX is removed from service, the protective covers should be reinstalled.

5.1.3 Support

A mounting bracket should be provided to support the weight of the FLEX when it is installed. The bracket should support the unit by the vessel body or vessel flange (not by the pipe connections) and provide means (such as shims) to adjust the position of the unit to align with system piping.

5.1.4 System piping

NOTICE **SYSTEM PIPING MUST BE CLEAN AND FREE OF ALL DIRT AND DEBRIS**

System and header piping connected to FLEX units must be clean and free of all dirt, debris, and foreign objects to avoid any contamination of the FLEX units that might cause damage to close internal clearances and brittle ceramic components.

5.1.5 Free spinning rotor check

This free spinning rotor check is optional and should only be performed immediately prior to installation or assembly of the device. This check can help ensure a successful start-up of the device.

⚠CAUTION **DO NOT INSERT HANDS OR FINGERS INSIDE THE DEVICE**

Pinch points and sharp edges inside the device can result in injury and potential finger amputation.

NOTICE **DO NOT INSERT METAL OBJECTS INSIDE THE DEVICE**

Do not use any metal object to push internal ceramic parts, such as the rotor, as this may cause cracking, chipping, or other damage to the parts, which may result in failure of the device.

Prior to installing a FLEX, a check can be performed to verify that the rotor is able to spin freely inside the device. There are two ways to perform this verification:

1. Rock the FLEX back and forth while looking into one of the low-pressure ports to see that the rotor spins freely from the rest of the device.
2. Reach a plastic or wooden rod (ensure it is in good condition and will not leave any debris inside the FLEX) into one of the low-pressure ports and gently push the rotor while watching to see that the rotor spins freely.

Figure 11: View of rotor ducts through LP port

5.2 Mounting and installation

The following steps are instructions to install the FLEX unit.

1. The FLEX should be located with adequate space for workers to install, operate, and maintain the device.
2. The foundation should be sufficient to absorb any vibration and should provide a rigid support for the unit.
3. Mount the FLEX on a bracket that supports the weight of the device by the vessel body or vessel flange. Do not use pipe couplings to support the weight of the device.
4. Ensure the FLEX is in the proper orientation with flow direction (IN/OUT) and pressure rating (HP/LP) on each nozzle matching the system piping. There is a label on each pipe nozzle of the FLEX to indicate proper flow direction and pressure.
5. If necessary, place shims between the vessel and the support bracket to align the FLEX pipe nozzles with system pipe connections.

6. A mounting strap can be used around the vessel body or vessel flange to secure the device from vibration and pressure loads.

NOTICE **DO NOT OVERTIGHTEN VESSEL CLAMPS**

Overtightening clamps around the vessel body can cause distortion of the FLEX and affect performance of the unit.

7. Do not couple the FLEX pipe nozzles to system piping until the support bracket and shims are completely installed, the device is aligned with system piping, and any mounting straps or tie-downs are in place.

⚠CAUTION **PREVENT EXCESSIVE EXTERNAL PIPE LOAD**

Refer to documentation from pipe coupling OEM for recommendations on system design, operating limits, and allowable nozzle loads. It is not recommended to use pipe couplings to support the static or dynamic loads of the FLEX unit(s).

8. Attach system piping to each of the four FLEX pipe nozzles using appropriate pipe couplings. There should be no piping loads transmitted to the device after connections are made.
9. Ensure the coupling pressure rating on each nozzle matches the system pressure at that location.

6 Operation

6.1 Commissioning

Prior to starting the FLEX system, it is essential that the following checks be made.

1. FLEX unit properly secured to the mounting bracket
2. All fasteners tightened to the correct torque
3. Pipe couplings with appropriate pressure rating in place and properly tightened
4. FLEX unit orientation matches system piping (HP/LP and in/out connections)
5. Piping is completely flooded and vented

⚠WARNING USE APPROPRIATELY RATED COUPLINGS ON HIGH-PRESSURE CONNECTIONS

Pipe couplings with pressure ratings above the highest expected system pressure must be used on high-pressure connections to the device.

6.2 Start-up

1. Partially close the backpressure regulating valve on the low-pressure discharge from the FLEX system.
2. Ensure the FLEX unit and system piping is fully vented and flooded.
3. Start the low-pressure feed pump.
4. Slowly adjust the backpressure valve and the feed pump speed until the desired flow and backpressure is reached.
5. Start the high-pressure booster pump to begin flow through the high-pressure line of the FLEX.
6. Start the high-pressure feed pump to bring the high-pressure system up to the desired operating pressure.
7. Adjust the high-pressure booster pump speed, low-pressure feed pump speed, and backpressure valve position until the desired flow rates and backpressure are reached.
8. The FLEX should be spinning at this point. An optical tachometer can be used to look through the sight-glass on each unit to confirm the rotor speed.
9. Check that no leaks exist from the pipe connections or the FLEX.

Keep in mind the minimum required backpressure and maximum flow rating (section 11.3).

⚠CAUTION NEVER ISOLATE LOW-PRESSURE LINE WHEN FLEX IS OPERATING OR PRESSURIZED

Never fully close the low-pressure inlet and outlet valves to the FLEX while it is operating or under pressure. This can cause a dangerous build-up of pressure in the low-pressure system piping due to internal leakage in the FLEX device. Appropriate pressure relief devices should be installed to prevent damage to equipment or injury to personnel in this situation.

6.3 Normal operation

The FLEX is a completely passive device with no controls, speed, or position settings of its own. The device is controlled by the amount of flow and pressure put into it by other pumps and valves in the system.

When operating a system with a FLEX installed in it, there are a few key things to control in the system in order to obtain optimal performance and life of the FLEX device and overall system.

6.3.1 Flow control

High-pressure flow through the FLEX is controlled by the high-pressure booster pump.

Low-pressure flow through the FLEX is controlled by the low-pressure feed pump.

Both pumps can be controlled with either a variable speed drive or a throttling valve at the discharge of the pump. If a variable speed drive is used, pump speed will control the flow rate through the FLEX. If a fixed speed pump and throttling valve is used, the position of the valve will control the flow rate through the FLEX.

6.3.2 Backpressure control

Backpressure on the FLEX is controlled by a throttling valve at the low-pressure outlet. The position of this valve is adjusted to ensure that the pressure at the low-pressure outlet of the FLEX is at or above the minimum required level. Operating the system at a backpressure lower than the minimum required level will result in cavitation that can damage the FLEX and shorten its lifespan, as well as increase the noise and vibration produced by the unit.

⚠ **NEVER FULLY CLOSE BACKPRESSURE VALVE WHEN FLEX IS OPERATING OR PRESSURIZED**

6.3.3 Leakage

The rotor inside the FLEX is supported on bearing surfaces that use the process fluid for lubrication and cooling. During normal operation, a small amount of fluid will be leaking from the high-pressure inlet side of the device across the precise internal clearances between the rotor and stator, and out the low-pressure outlet of the device.

6.3.4 Rotor speed

The speed of the rotor in the FLEX is not directly controlled but it indicates whether the device is operating properly for the given high-pressure and low-pressure flow rates through the device.

Rotor speed is driven by the low-pressure flow path, so if there is no low-pressure flow, or if the low-pressure flow is below the rated operating range of the device, the rotor will not spin. Increasing low-pressure flow through the device will increase rotor speed, while increasing high-pressure flow through the device will decrease rotor speed.

A sight glass in the vessel allows observation and measurement of rotor speed with an optical tachometer. Measured speed can be compared to the rated speed on the data sheet at the conditions of operation. A speed significantly higher or lower than expected may indicate a malfunction of the FLEX, an imbalance of high-pressure and low-pressure flow, or an imbalance of flow between units when multiple units are installed in parallel.

6.3.5 Mixing and flow balance

During normal operation, the brine and seawater come into direct contact with each other inside the ducts of the rotor in the FLEX. A small amount of mixing between the two fluids occurs at this location. The result of this mixing is that the feedwater will leave the FLEX at a slightly higher salinity than it entered, and the brine will leave with a slightly lower salinity than when it entered.

While the FLEX has been designed to minimize mixing, the balance of brine and feedwater flow rates can be used to further control the amount of mixing in the overall system.

There are three ways that the flow rates through the FLEX can be set to control mixing:

- Balanced flow is when brine and feedwater flow rates are equal. In this case, mixing is determined by the design of the FLEX and the mixing region inside the rotor ducts.
- Over-flush is when feedwater flow is higher than brine flow. This causes the rotor to spin faster which reduces the duct utilization, and the extra feedwater flow flushes the brine out of the rotor ducts. These two effects result in reduced mixing, and a lower feedwater salinity leaving the FLEX. The benefit of this is a lower feedwater salinity at the membranes to reduce high-pressure requirements. The drawback is that it requires more input power from the feedwater pump.
- Under-flush is when feedwater flow is less than brine flow. This reduces rotor speed thereby reducing rotor utilization and allows some of the brine flow to leave the feedwater side of the device. This results in increased mixing with higher feedwater salinity leaving the FLEX. The benefit is that the feedwater input power is reduced, but the drawback is that higher feedwater salinity requires higher pressures at the membranes.

6.4 Shut down

When the unit is being shut down, the procedure should be the reverse of the start-up procedure.

1. Shut down the high-pressure feed pump.
2. Allow the high-pressure booster pump to keep operating for a few minutes to flush brine from the train and allow system pressure to drop to seawater osmotic pressure.
3. Shut down the high-pressure booster pump. The FLEX may speed up at this point.
4. Shut down the low-pressure feed pump. The FLEX will stop spinning at this point.
5. Leave an outlet on the low-pressure system open to allow depressurization.

If the system is to be shut down for an extended period, the following steps must be taken.

1. Flush the system and FLEX units (both high-pressure and low-pressure sides) with fresh water to remove salt and prevent mineral buildup.
2. Preventative measures should be taken to inhibit biological growth.

⚠CAUTION HIGH-PRESSURE REMAINS AFTER SHUTDOWN

Even when the pumps are shut down, high-pressure can remain in the system due to osmotic pressure at the membranes. To completely depressurize the FLEX units, flush brine out of the membranes, use isolation valves between the FLEX and membranes, and leave an outlet of the low-pressure system.

⚠CAUTION NEVER ISOLATE LOW-PRESSURE LINE WHEN FLEX IS OPERATING OR PRESSURIZED

Never fully close the low-pressure inlet and outlet valves to the FLEX while it is operating or under pressure. This can cause a dangerous build-up of pressure in the low-pressure system piping due to internal leakage in the FLEX device. Appropriate pressure relief devices should be installed to prevent damage to equipment or injury to personnel in this situation.

7 Maintenance

The FLEX does not require scheduled or preventative maintenance. As long as the device is properly operated and flushed before extended shutdowns, the device is designed to operate maintenance free for many years.

7.1 Maintenance procedure

Any work on the FLEX must be performed when it is at a standstill and de-energized state. It is imperative that the procedure for shutting down the device is followed, as described in Chapter 6.

⚠CAUTION SHUT DOWN, DEPRESSURIZE, AND ISOLATE BEFORE PERFORMING MAINTENANCE

Ensure the system has been shut down and completely depressurized before disassembling any connections to the FLEX units or system piping. Use valves to hydraulically isolate FLEX units from the rest of the system and prevent accidental pressurization.

⚠CAUTION DO NOT APPROACH A HIGH-PRESSURE LEAK

Do not approach the FLEX equipment when a high-pressure leak has been detected. Shut down and relieve pressure on the entire train before further inspecting or repairing any high-pressure leaks.

Before working on the equipment, take measures to prevent an uncontrolled start.

- Put a warning board on the starting device with the words: "***Machine under repair: do not start***"
- Use lockout tagout equipment on valves used to hydraulically isolate the FLEX units from the rest of the system.

NOTICE METAL OBJECTS CAN CHIP OR CRACK CERAMIC

Use caution when handling ceramic components to avoid damage.

7.2 Cleanliness

One of the major causes of FLEX failure is the presence of contaminants in the device. This contamination can be in the form of dust, dirt, and other solid particles such as metal chips. Contamination can be harmful to the ceramic components, especially the precise clearances between the rotor, axle, and end covers. For this reason, it is very important that proper cleanliness be maintained. Some guidelines are listed below.

- The work area should be clean and free from dust, dirt, debris, oil, grease, etc.
- Hands and gloves should be clean.
- Towels, rags, and tools should be clean.
- Covers should be used to prevent ingress of contaminants.

7.3 Tools, equipment, and fixtures

The device can be completely assembled and disassembled with standard tools and equipment. All hardware is in nominal English sizes.

Table 3: Required wrench and socket sizes (inches)

LOCATION	FLEX 6300	FLEX 8600
Flange bolts	3/4	15/16
Tension rod nuts	15/16	1-1/8

7.4 Torque requirements

Table 4: Torque requirements

DESCRIPTION	FLEX 6300		FLEX 8600	
	SIZE	TORQUE N·m (ft·lb)	SIZE	TORQUE N·m (ft·lb)
Flange Bolts	1/2-13 UNC	53 (39)	5/8-11 UNC	106 (78)
Tension Rod, Cartridge	5/8-11 UNC	66 (49)	3/4-10 UNC	116 (86)

7.5 Disassembly

⚠CAUTION FLEX MUST BE DULY SUPPORTED TO ENSURE STABILITY DURING ASSEMBLY

1. Remove vessel flange fasteners.
2. Remove one of the vessel halves. Use caution to avoid damaging ceramic cartridge components with the metal vessels.
3. Discard the vessel flange O-ring.
4. Remove the remaining vessel from the cartridge. Use caution to avoid damaging ceramic cartridge components with the metal vessels.
5. Remove and discard the balance pocket O-rings and end cover O-rings.

Disassembly of the cartridge without training from Flowserve personnel is not recommended.

Table 5: Parts list

ITEM	QTY	DESCRIPTION	ITEM	QTY	DESCRIPTION
1	1	Cartridge	6	2	O-Ring, End Cover
2	1	Vessel, Brine	7	2	O-Ring, Balance Pocket
3	1	Vessel, Seawater	8	8	Bolt, Flange
4	1	Sight-glass	9	8	Nut, Flange
5	1	O-Ring, Flange	10	16	Washer, Flange

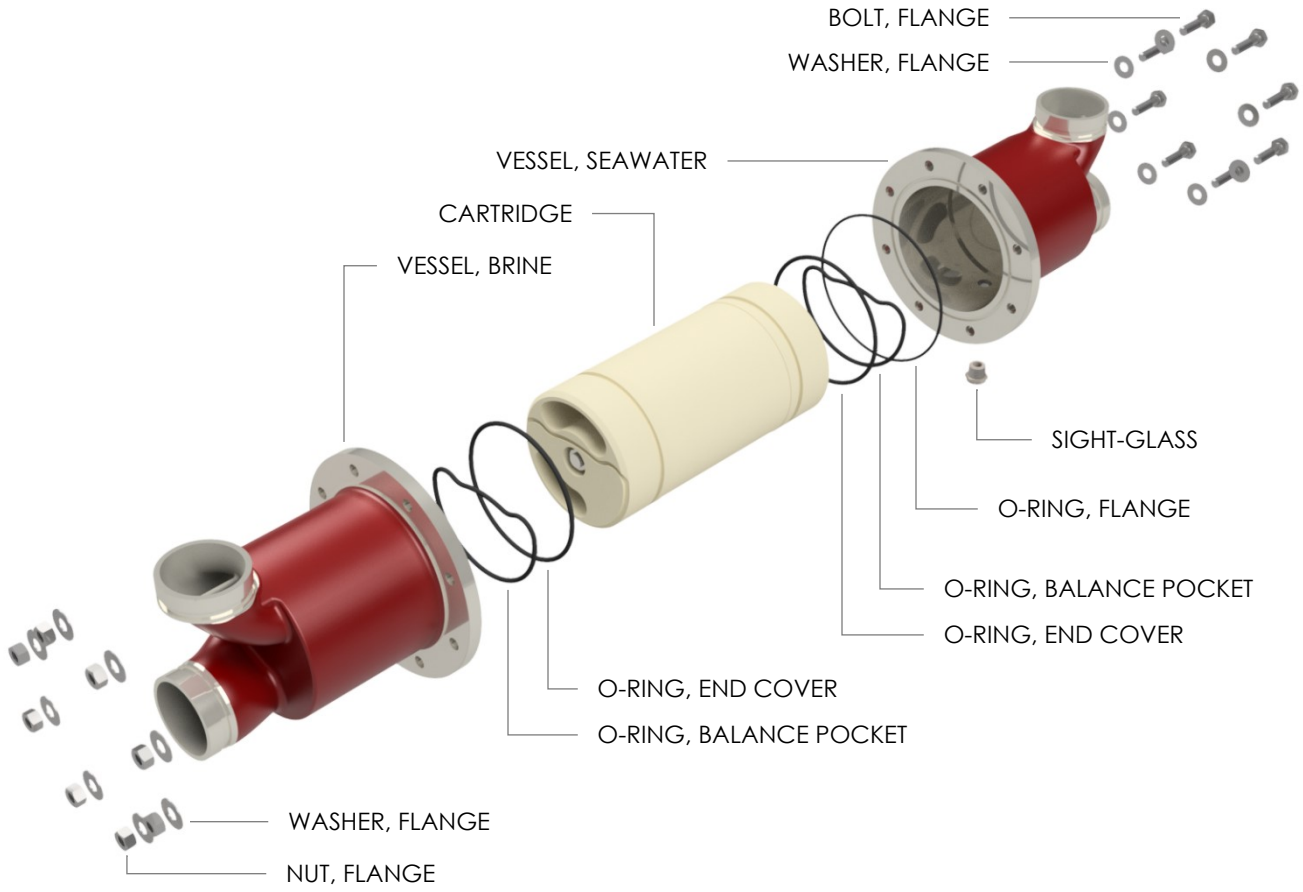

Figure 12: Exploded view

7.6 Reassembly

1. Check that cartridge rotor spins freely before assembling unit. (See section 5.1.5)
2. Lightly lubricate end cover O-rings and install in grooves around end covers. Use food grade silicone-based lubricant.
3. Lightly lubricate balance pocket O-rings and install in grooves on end cover faces. Use food grade silicone-based lubricant.
4. Notice the markings on the OD of each end cover to identify which side of the cartridge is seawater or brine side. The cartridge has a proper orientation in the vessel and is not reversible.
5. Slide seawater vessel (with sight-glass installed) over the seawater end of the cartridge.
    a. Align straight through port of end cover with 90-degree elbow port of vessel.
    b. Ensure balance pocket O-ring is evenly and fully covered by the vessel. Confirm by looking through the high-pressure port as shown in Figure 13 through Figure 15.

Figure 13: Vessel shifted left


Figure 14: Centered

Figure 15: Vessel shifted right

6. Lightly lubricate flange O-ring and install in face groove of vessel flange.
7. Slide brine vessel (no sight-glass or flange groove) over exposed brine end of the cartridge, aligning elbow port on brine vessel with elbow port of seawater vessel. Ensure balance pocket O-rings are evenly and fully covered by the vessels by looking through vessel ports.
8. Assemble vessel flange hardware with washers between the bolt/nut and flange. Torque vessel flange hardware to proper specification per Table 4.

7.7 Post-maintenance inspection

1. Check the FLEX is clean and free of all dust, dirt, and foreign debris.
2. Check that the rotor spins freely in the assembled unit. See section 5.1.5 for this procedure.
3. Ensure covers are placed over the vessel ports to prevent ingress of contaminants.

7.8 Spare parts

When ordering spare parts, the following information should be provided to Flowserve:

a) Product serial number
b) Product size
c) Part name – taken from the parts list/sectional drawing
d) Part number – taken from the parts list/sectional drawing
e) Quantity of the parts required

The product size and serial number are provided on the nameplate.

To ensure continued satisfactory operation, replacement parts to the original design specification should be obtained from Flowserve. Any change to the original design specification (modification or use of non-standard part) will invalidate the product safety certification.

8 Troubleshooting Guide

The following table provides useful guidance on troubleshooting the FLEX energy recovery device. This guide is meant to cover the most common problems that might occur. If situations outside this scope are encountered, and experienced operators and maintenance personnel are unable to remedy the situation, please consult with Flowserve's field service department.

Table 6: Troubleshooting recommendations

SCENARIO	CAUSES	REMEDIES
Excessive sound levels	Backpressure below minimum requirement	Increase feedwater system backpressure by adjusting valve on brine out flow
	Flow rate too high	Reduce flow rates
		Add units in parallel to increase total system capacity
	Air in system	Bleed air
	Unit or cartridge installed upside down	Verify the unit has been installed in the correct orientation with port labels matching system pipe services.
		Dismantle unit and check for proper cartridge orientation: seawater end cover on the same side as seawater vessel.
	Damaged cartridge	Replace cartridge or entire unit
Excessive high pressure	High pressure pump flow is too high	Adjust pump flow rate
	High salinity in high pressure feedwater	See scenario below
High salinity in high pressure feedwater	Unbalanced flow	Check and balance system flow rates. Increase feedwater flow to reduce mixing.
	Stalled rotor	See scenario below
Stalled rotor (no measurable or audible rotation)	Foreign debris, scaling, or biological growth in device	Flush the device and system with fresh water. Disassemble, remove debris, and clean components. Replace cartridge or unit if damaged by foreign debris.
	High pressure is above rated maximum	Reduce system pressure
	Feedwater flow is below minimum	Increase feedwater flow
	Insufficient lubrication flow across bearing surfaces	Increase high pressure to provide lubrication to rotor bearing surfaces
	Cartridge rotated inside vessel	Disassemble unit, replace O-rings, reassemble unit with proper cartridge orientation in vessels.
Excessive leakage flow (HP feedwater flow significantly lower than HP brine flow)	Worn or damaged clearances	Replace cartridge or unit
	Damaged end cover or balance pocket O-rings	Replace damaged O-rings
	Cartridge rotated inside vessel	Disassemble unit, replace O-rings, reassemble unit with proper cartridge orientation in vessels.

9 Decommissioning and Recommissioning

9.1 Decommissioning

See the instructions in section 6.4 for proper shut down procedures.

9.2 Recommissioning

See sections 5 and 6.1 for proper installation and commissioning procedures.

10 Returns and Disposal

10.1 Returns

Contact Flowserve to obtain a return material authorization (RMA), instructions, and a contamination declaration before returning any products to Flowserve.

Returned products shall be emptied, cleaned, and preserved before returning the equipment to Flowserve. Flowserve will open the returned equipment only if the contamination declaration is present.

See section 4.3 for guidelines on appropriate FLEX packaging.

Note: the terms and conditions associated with returning a product/system shall be addressed within the purchasing agreement or contract, and not part of this User Instruction.

10.2 Disposal and recycling

At the end of the equipment service life, the relevant materials and parts should be recycled or disposed of using local environmental regulation methods. If the product contains substances which are harmful to the environment, then the removal or disposal of the equipment must be in accordance with local/regional regulations. This includes any liquid and/or gas in the "seal system" or utility.

 Refer to Safety Data Sheets and make sure that hazardous substances or toxic fluids are disposed of safely and that the correct personal protective equipment is used. All activities involving hazardous substances or toxic fluids must be in compliance with published safety standards.

11 Technical Data

11.1 Equipment dimensions and weights

Approximate weights are shown in Table 7. For exact dimensions and weights of the product ordered, refer to the general arrangement drawing included upon receiving the product.

Table 7: Equipment dimensions and weights

DESCRIPTION	UNITS	FLEX 6300	FLEX 8600
Dry weight	kg (lb)	29 (63)	72 (158)
Wet weight	kg (lb)	33 (73)	83 (182)
Port size (nominal diameter)	---	3 inch	4 inch
LP port spacing (end-to-end)	mm (in)	533.4 (21.00)	762.0 (30.00)
HP port spacing (center-to-center)	mm (in)	444.5 (17.50)	635.0 (25.00)
Port offset (HP face to LP center)	mm (in)	152.4 (6.00)	203.2 (8.00)

11.2 Nameplate

ISO 9001 Certificate					
Model				Product of the USA	
HP Connection				Date of Construction	
LP Connection				Job N°	
	min	max		Serial N°	
Allowable Pressure			bar	Material	
			psi	Project Rating	
Allowable Flow			m3/h	Rated Capacity [m³/h]	
			gpm	Rated Pressure HP in [bar]	
AllowableTemperature			°C	Rated Pressure LP out [bar]	
Weight Dry			kg	Rated Temperature [°C]	

Figure 16: Nameplate

11.3 Operating limits

Table 8: Operating limits

DESCRIPTION	UNITS	FLEX 6300	FLEX 8600
Maximum Flow	m³/h (gpm)	68 (300)	136 (600)
Minimum Flow	m³/h (gpm)	34 (150)	68 (300)
Maximum Low Pressure	bar (psi)	18 (260)	12 (180)
Maximum High Pressure	bar (psi)	83 (1,200)	
Minimum Backpressure	bar (psi)	1.0 (15)	
Maximum Temperature	°C (°F)	50 (120)	
Maximum Filter Size	µm (mils)	20 (0.8)	

11.4 Noise level

Attention must be given to the exposure of personnel to noise. Local legislation will define when guidance to personnel on noise limitation is required, and when noise exposure reduction is mandatory. This is typically 80 to 85 dBA. The usual approach is to control the exposure time to high noise levels, use hearing protection, or to enclose the machine to reduce emitted sound.

FLEX noise level is dependent on a number of operational factors including flow rate, high pressure, back pressure, piping design, and acoustic characteristics of the building. For these reasons, noise levels that a customer will encounter in the field are project specific.

Factory testing has shown that noise levels at or below 85 dBA are possible.

Annex A: Declaration of Conformity

If the product/system is being sold into a country which requires a Declaration of Conformity (DoC), an example of each DoC for the subject product/system must be included in this Annex.

Below is an example of Declaration of Conformity for the product/system.

FLOWSERVE

EU declaration of conformity

SIHI® Pumps CE

The manufacturer: - Original -
Sterling SIHI GmbH
Lindenstraße 170
D-25524 Itzehoe

declares herewith that the product

Pump: Boost CAXXXX X XX

Serial number: XX-XXXXXX-XXX

fulfils all relevant provisions of the Directive machinery 2006/42/EC.
Furthermore the aforementioned product complies with the provisions of the EC directives:

- Electromagnetic compatibility 2014/30/EU

Harmonised standards used:
EN 1012-2
EN ISO 12100

Other technical standards and specifications used:
EN 61800-3

Person authorised to compile the technical file:
Sönke Siebels
Sterling SIHI GmbH
Lindenstraße 170
D-25524 Itzehoe

Place, date:
Itzehoe, 10.11.2016

Person empowered to draw up this declaration:

Annex B: Supplementary User Instructions

Supplementary instructions such as instrumentation, controller, coupling, mounting component, etc. are provided as separate documents in their original format. If further copies of these are required, they should be obtained from the supplier for retention with these User Instructions.

NOTES:

NOTES:

Flowserve factory contacts:

Flowserve Temecula
27455 Tierra Alta Way, Suite C
Temecula, CA 92590 USA
Email FLEX@Flowserve.com

FLOWSERVE REGIONAL SALES OFFICES:

Flowserve World Headquarters
5215 N. O'Connor Blvd, Suite 700
Irving, TX 75039 USA
Email FLEX@Flowserve.com

Sales and Services
Av. Fuentemar 26-28
28823 Coslada, Madrid (Spain)
Email FLEX@Flowserve.com

Local Flowserve representative:

To find your local Flowserve representative use the Sales Support Locator System found at www.flowserve.com