

## Technical Service Bulletin

January 2021 TSB122.08

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### RO/NF Element Loading and Unloading Guidelines

This bulletin provides general information and guidelines for installing Hydranautics elements in order to provide optimally reliable performance.

#### Storage of elements prior to loading

If the elements cannot be loaded upon delivery, be sure to store elements out of direct sunlight. Do not expose elements to temperatures below freezing, 32°F (0°C), or above 95°F (35°C). (Please refer to Hydranautics Technical Service Bulletin 108 for composite elements storage guidelines).

<https://membranes.com/wp-content/uploads/Documents/TSB/TSB108.pdf>

#### Flushing

If the system is new, it is strongly recommended to flush the system (pipes, pumps, pressure vessels, etc.) with clean, fresh water prior to element loading. This allows any debris, preservatives, and solvents to be flushed out so that they do not come in contact with the membranes.

Detailed information on flushing is covered in TSB118.

<https://membranes.com/wp-content/uploads/Documents/TSB/TSB118.pdf>

#### Material, tools and equipment requirements

- Glycerin – estimated 1 gallon / 4 litres of 100% food grade for every 20-30 vessels
- Pure silicone lubricant (Molykote 111 / 7 or Parker Super O-Lube)
- Permeate or fresh water
- PVC pipe or rope – length depends on the length of pressure vessels
- Sponge ball (to be fixed at one end of PVC pipe or rope)
- Towel or cotton rag
- 6" (150 mm) PVC Cap (when loading 8" (200 mm) pressure vessels)
- Shims (sizes of 1, 2, 2.5 and 5 mm thickness recommended)
- Brush or dauber for lubrication of brine seals
- Tools as per pressure vessel manufacturer recommendations for removing and installing of end cap assembly
- Spare parts for end caps (e.g. o-rings, lock rings, Victaulic clamps, nuts, bolts)
- Personal protection equipment (gloves, glasses, shoes, hard hat)

**Note:** When loading elements into a system, **do NOT use oil, grease, or petroleum based compounds** to lubricate o-rings and brine seals as these may cause damage to membrane or other components of the element. Use only silicone based gel or 100% glycerin to lubricate o-rings and brine seals. Glycerin will completely wash away during flushing and startup, therefore where allowed, silicone based lubricants help with long term maintenance when endcaps need to be pulled at future times. For electronics high purity applications verify that a silicone based lubricant is acceptable.

## Pressure Vessel Preparation

1. Remove pressure vessel end caps from both sides of the vessel (**Note:** Refer to pressure vessel manufacturer's manual for removal and re-installation of end caps assembly). It is recommended to label or write on piping, end caps, and fittings for their respective vessel position so that they may be assembled back to their original place, especially for custom fabricated fittings.
2. Disassemble and wash all end cap parts (i.e. o-rings, end adapters, etc.) in fresh water and keep them clean for re-installation. Perform an inspection and count all parts prior to reassembling to ensure integrity and inventory.
3. Clean the inside of the vessels to remove any dust and debris that could mechanically damage the membrane surface. Hosing down the insides of the pressure vessels with water usually **will not** be sufficient to clean the vessels. Either of the next 2 methods should be used to get the inside surface of the pressure vessels cleaned before lubricating prior to loading. Glycerin is not needed to clean, but the use of some detergent and water in solution may help to further remove build up. Change out towels / rags often enough to effectively clean and not redistribute unwanted dirt and debris. Then rinse thoroughly.
4. Use a sponge ball wrapped in a towel or cotton rag and soaked in a 50-75% solution of glycerin and water. The sponge ball can be pushed/pulled through the vessel with a piece of rope or long PVC pipe. Alternatively, the sponge ball can be pushed through the length of the vessel with a piece of PVC pipe with a PVC flange attached to the end. The glycerin solution will lubricate the inside surface of the pressure vessel to ease the loading of elements.
5. Another method is to use a 6" (150 mm) PVC cap covered in rags, referred to as the "pig" (should fit snugly into the pressure vessel), attached to a rope slightly longer than the length of the vessel and also attached to a smaller diameter stick of PVC pipe, now referred to as the "javelin." Throw the javelin through the vessel to the opposite side where the rope will be used to pull the pig, soaked in a 50-75% solution of glycerin and water, which will lubricate the inside surface of the pressure vessel to ease the loading of elements.

6. After cleaning the pressure vessel, re-install the brine side end cap assembly without covering side port openings with the thrust cone/sleeve. Before installation, lubricate end plate permeate adaptor O-rings and head seal with thin layer of pure silicone lubricant (Molykote 111 / 7 or Parker Super O-Lube) or 100% glycerin.

**Note:** A Glycerin/Water/SBS (sodium metabisulfite) solution can be safely used to help disinfect the vessels and neutralize any potential Cl<sub>2</sub> residual. Also, a 15:1 mixture of water and SBS (add about 1 cup of SBS powder to ½ gallon / 2 litres water and ½ gallon / 2 litres glycerin) can be made to swab the vessels for disinfection and lubrication.

**Caution:** If any hypochlorite / Cl<sub>2</sub> bleach is used during disinfection, it is extremely important to thoroughly rinse down all areas, endcap parts, inside and outside of vessels, piping, structure supports, etc. to ensure NO Cl<sub>2</sub> residual is present when loading.

**Caution:** Be sure to avoid scraping the pipe along the vessel surface. Also, take care to push the end cap in squarely to avoid rolling the head seal.

## Loading of elements

1. Prior to loading, ensure all brine side end cap assemblies (including thrust cone/sleeve, head seal, end adapters, O-rings, etc.) are installed in the pressure vessels.
2. Maintain a loading record of each element serial number, vessel location, and position.
3. Open the element bag partially and expose the upper one-third of the element. This allows for the operator to have minimum exposure to the Fiberglass Reinforced Plastic (FRP) shell, while installing each element.
4. Gently slide the first element into feed side of the pressure vessel three-quarters of the way and remove the plastic bag. **Note:** Always load elements in feed flow direction with brine seal properly seated in seal groove of anti-telescoping device (ATD) and facing the flow direction. If the element uses a V-cup brine seal, ensure that the V-cup seal opens in the flow direction – Figure 1.

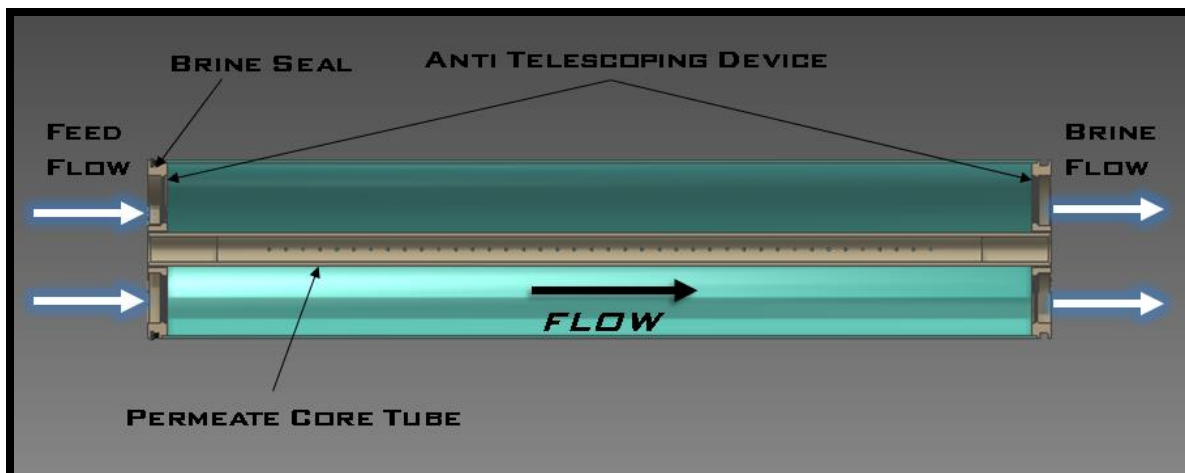


Figure 1 - Element Loading Direction

**Note:** The flow direction may not be the same for all vessels in a system.

**Caution:** Never put V-cup brine seals on both ends of an element.

**Caution:** RO elements are preserved with a solution containing 1% sodium bisulfite. Avoid direct contact with this solution.

5. Gently lubricate interconnector O-rings with thin layer of pure silicone lubricant (Molykote 111 / 7 or Parker Super O-Lube) or 100% glycerin and insert interconnector in permeate tube of first element.
6. Lubricate element brine seal with glycerin solution using brush or dauber.

7. Connect next element to interconnector and push both elements into pressure vessel up to three-quarters of the length of the element and again remove the plastic bag. **Caution:** Ensure the weight of the outboard element is not supported by the interconnector by supporting the element if necessary – Figure 2.

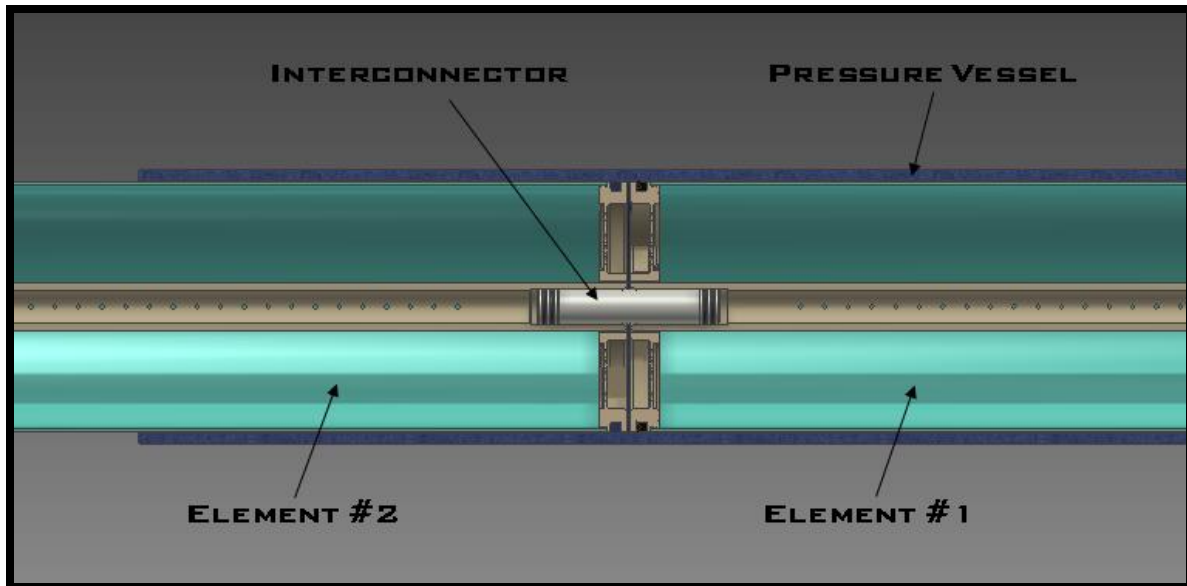


Figure 2 - Interconnector Configuration Between Two RO Elements

8. Repeat above steps with all other elements.
9. When installing last element, push the element stack completely inside the pressure vessel towards the brine end until the last element fully connects with end plate permeate adaptor on brine side of the pressure vessel. Avoid “slamming” the stack up against brine end as damage may occur.

**Caution:** It is extremely important to avoid pinch points where fingers and hands can be crushed while elements are moving into the vessels.

10. It is recommended to use an element pushing device, which is at least a 16 inch (400 mm) length of 6 inch (150 mm) diameter PVC pipe, which safely keeps workers hands outside of the vessel when loading the last element to avoid possibly crushing fingers and hands when using such force as used when pushing a stack of 6, 7 or 8 elements deep (Figure 3).
11. After loading all elements determine if shimming the vessel is necessary prior to installing the upstream end cap.

**Red arrows indicate Pinch Points, the edges of vessel ends to avoid with fingers and hands.**

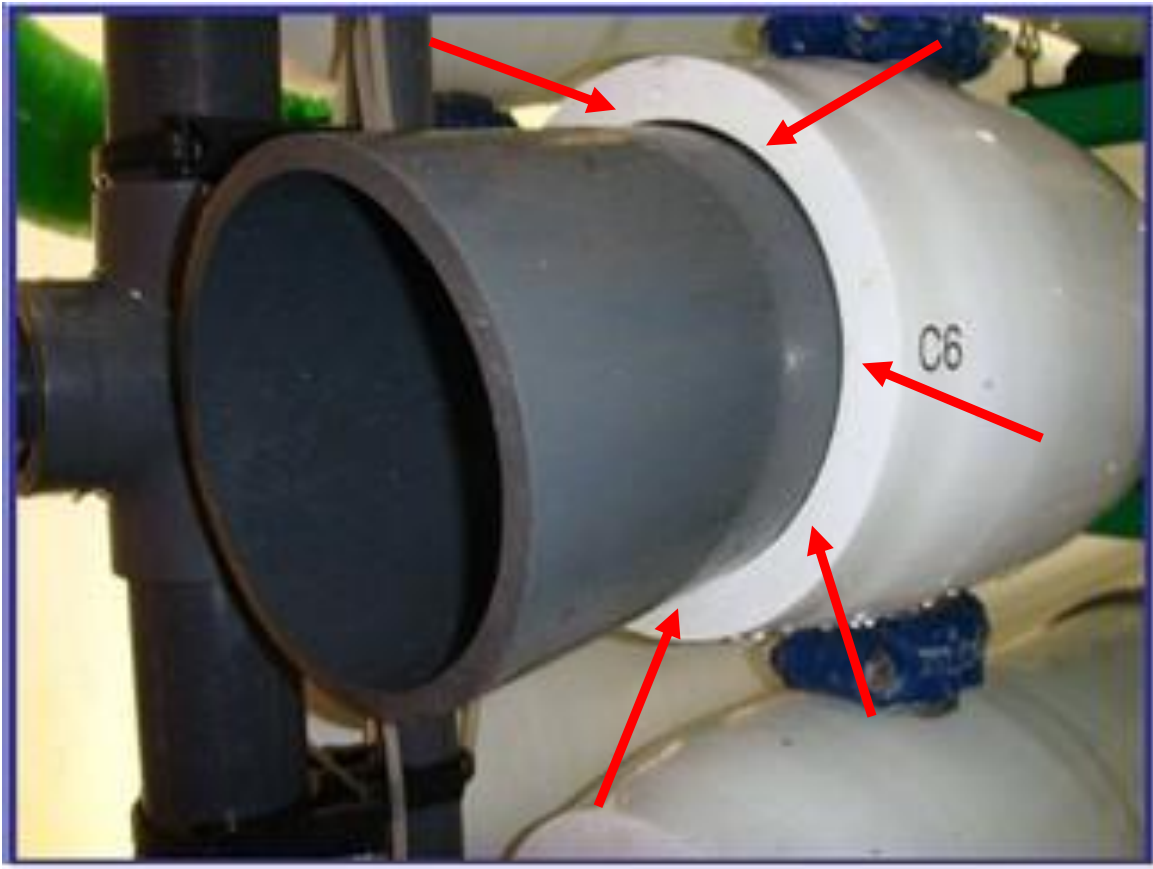


Figure 3 – Element Pushing Device

## Pressure Vessel Shimming

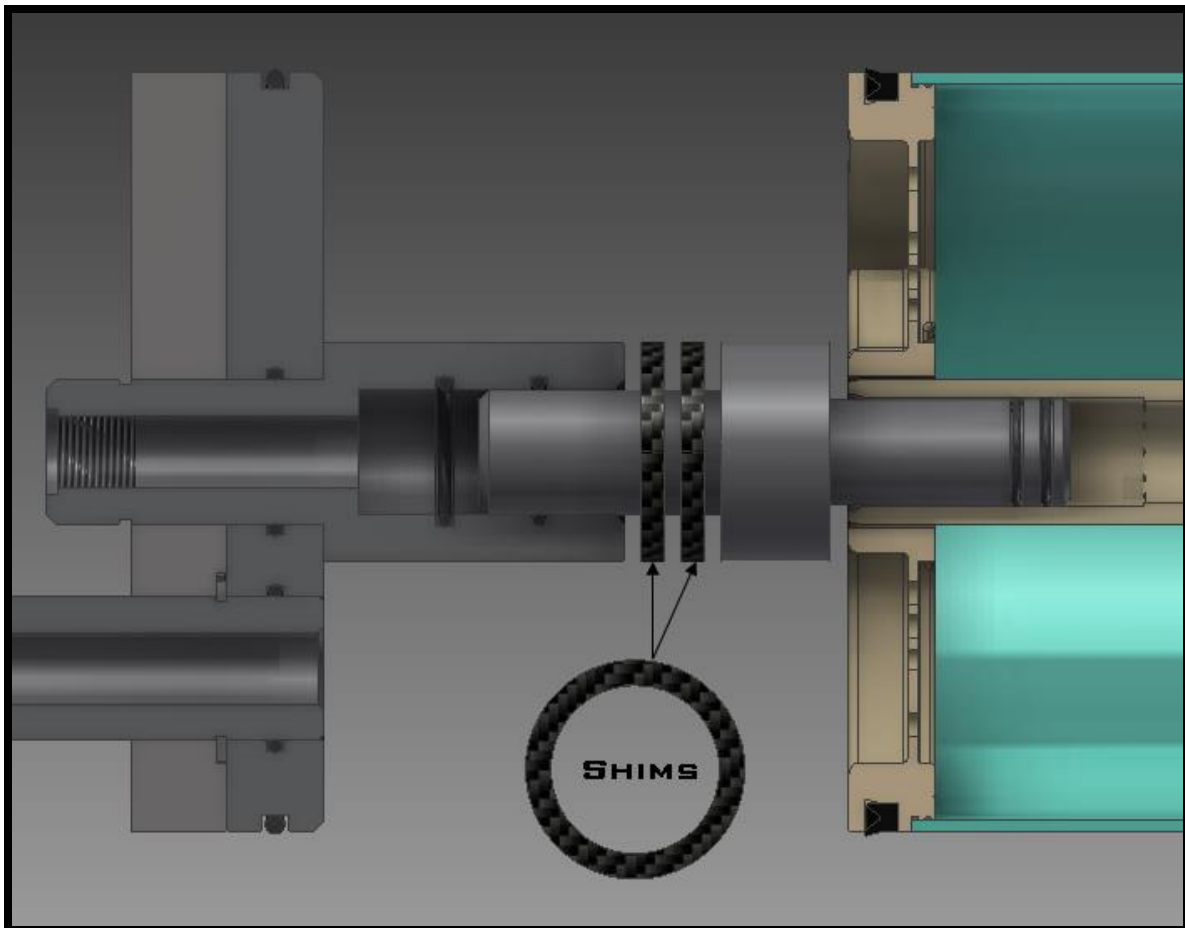
All pressure vessels are built with some tolerance in length to account for small differences in the length of the elements. Furthermore, the length of the pressure vessel also changes slightly due to expansion during operation. Therefore it is recommended to shim elements to take up free space in the vessel. This helps to prevent elements from moving when the system is shutting down and starting up. The appearance of leaks between elements is also minimized when the elements are shimmed and movement minimized. Insufficient shimming can lead to premature wear of interconnector and end plate adaptor O-rings or even to disconnections of elements from end plate adaptors. This will result in feed to permeate leaks and poor permeate quality.

**Note: Always shim vessels from feed end side. Shimming from brine end side can lead to telescoping of the elements.**

The following procedure is recommended to shim the pressure vessel:

1. Remove O-rings from permeate adapter (element side) and head seal from 1 feed end cap Head assembly. Use this as the Test Head assembly for all feed side endcaps for vessels to be tested.
2. Remove adapter from head assembly and gently lubricate adapter seal with silicone lubricant (Molykote 111 / 7 or Parker Super O-Lube) or 100% glycerin.
3. Insert adapter into permeate port of the Test Head assembly, but do not slide them flush together, leave enough space for shims.
4. Gently install Test Head assembly into place until the bearing plate is seated properly up to the retaining ring groove on the pressure vessel, this minimizes, but does not completely close the gap between adapter and permeate port.
5. Gently remove Test Head assembly from pressure vessel and measure the remaining gap between adapter and permeate port (Figure 4).
6. Insert required quantity of shims over adaptor to completely fill the gap and insert the adapter back into the Test Head assembly permeate port.
7. Ensure that the Test Head assembly will now seat squarely into the vessel end up to the retaining ring groove and be retained properly.
8. Once the required quantity of shims are determined for the 1<sup>st</sup> tested vessel, repeat this step with the Test Head assembly on all or a selected few to ensure that the quantities are the same for those vessels.
9. For all the end cap heads, install the required amount of shims.
10. Install O-rings and head seals and lubricate them gently with pure silicone lubricant (Molykote 111 / 7 or Parker Super O-Lube) or 100% glycerin.
11. Install all end cap assemblies.
12. Finally install all end cap retaining devices (segmented ring or spiral lock ring).
13. Re-install all connecting pipes.

**Note:** A gap of 2 mm between the end plate and the shims will not cause problems in performance.



**Figure 4 - Shimming**

14. Slowly fill the system with water at low pressure to prevent hydraulic shock (water hammer) at start-up. When all air is purged from the system, slowly bring the system up to design pressure and flow. Hydranautics recommends that the RO system be pressurized at no more than 10 psi (0.69 bar) per second to ensure no damage is done to the membrane element.

After operating for a few hours to a few days, stop the plant and inspect the end adaptor insertion. It is possible that the membranes shift during initial operation. See figure 5 and 6 below.



Figure 4. End Adaptor –Correct Position

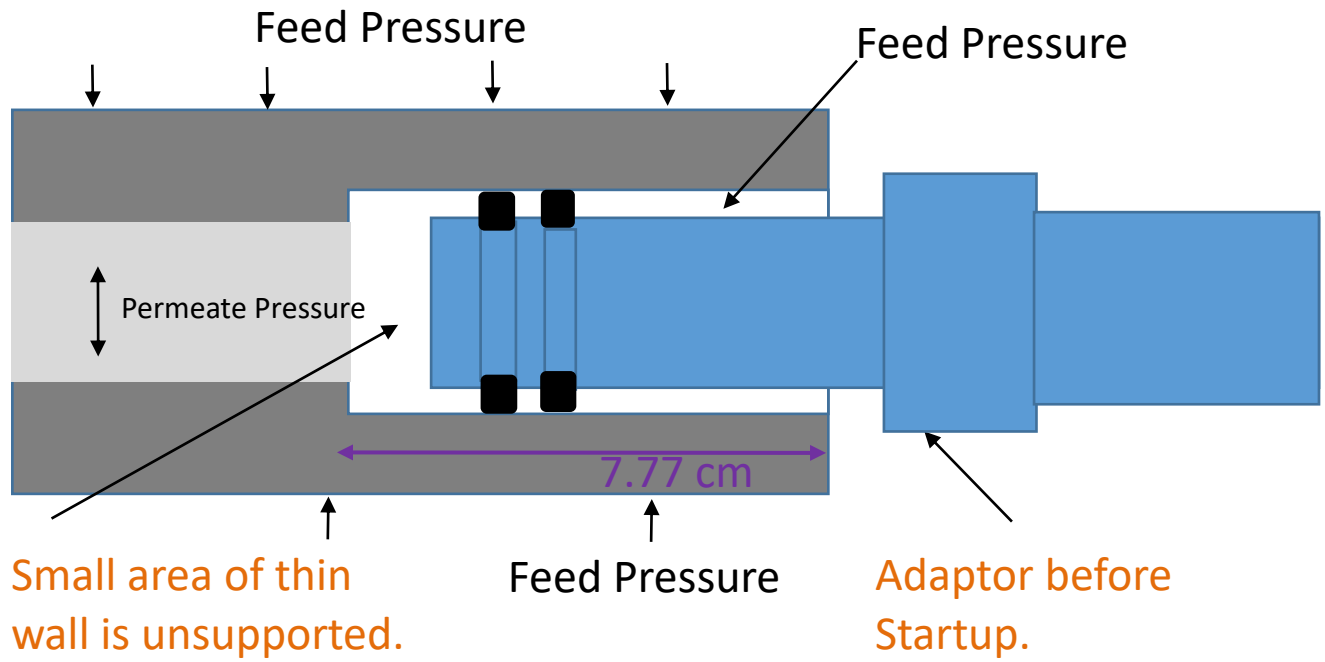
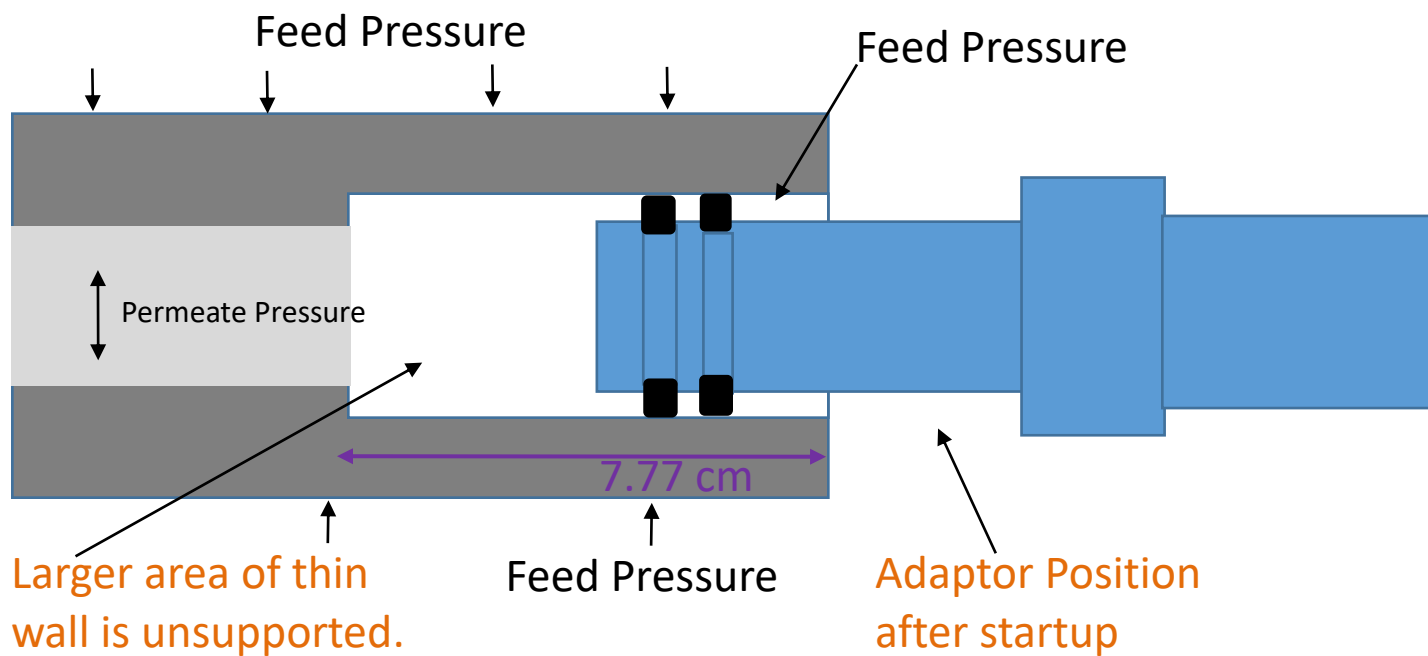


Figure 5. End Adaptor –Incorrect Position



## Storage of new elements in pressure vessels

Once the spiral elements are de-bagged and placed in the clean pressure vessel (PV) and shimmed, the PV should be closed and sealed from outside contamination. The elements will still have some SBS preservative in them, but this will be minimal and will not effectively prevent microbiological growth. Hydranautics thus highly recommends that the elements be flushed with in-spec feedwater, clean permeate or other comparable water within 30 days after de-bagging. Once the elements are flushed, further care should follow TSB118, TSB110 and TSB108 guidelines.

<https://membranes.com/wp-content/uploads/Documents/TSB/TSB118.pdf>

<https://membranes.com/wp-content/uploads/Documents/TSB/TSB110.pdf>

<https://membranes.com/wp-content/uploads/Documents/TSB/TSB108.pdf>

## Unloading of elements

There are 2 kinds of unloading, complete and partial. Complete extractions get all old membranes out of all vessels on the unit. Some of these membranes may or may not be re-used, therefore care should be taken to not break interconnectors, not crack FRP outer shells, or not destroy them.

Partial extractions entail removing perhaps one section or stage, while the other section or stage remains intact, therefore it is important to flush the unit with as low salinity flush water as possible, therefore it is preferable to use permeate as the unit may be off line for numerous days and with potentially opened vessels to air and low vessel water levels, this could potentially accelerate fouling or scaling.

Also, it is always good practice (also mentioned below) to provide a clean environment to place membranes for re-use on plastic or someplace clean, void of standing water, and covered to avoid debris, colloidal, and airborne material from contaminating them.

First, always flush the RO unit, preferably with permeate where possible, if not standard feed water is suffice, however flush long enough to bring the salinity down. Take the RO unit off line, use the control / SCADA system to keep it out of service to prevent accidental starting, lock out and tag out the high pressure pump drive, close the necessary valves for feed, concentrate, and total permeate in order to isolate this unit, then check to make sure there is no flow. Depressurize and drain the unit.

1. A pipe joint flange or grooved connector fitting may have to be taken apart in order to drain some units, otherwise CIP headers and connections may suffice.
2. Remove supports and permeate piping to vessel ends. It is recommended to label or write on piping, endcaps, and fittings for their respective vessel position so that they may be assembled back to their original place, especially for custom fabricated fittings.
3. Remove endcaps, retainer rings, fasteners, hardware, permeate adapters, shims, thrust cones/blocks, and all small parts and keep them organized for each section of the RO unit. For example, 1<sup>st</sup> Stage feed side, 1<sup>st</sup> Stage concentrate

side, 2<sup>nd</sup> Stage feed side, and 2<sup>nd</sup> Stage concentrate side assemblies should stay in their respective groups to ensure they go back to the section they came from.

4. It is suggested to lay all endcap components on cardboard, sheet plastic, or plywood to keep off bare ground to keep clean. Place hardware, fasteners, and small parts in buckets to keep organized and accounted.
5. Inspect and observe for any broken pieces, missing, damaged hardware, worn seals, gaskets both external and internal of the vessel end components and replace as necessary.
6. Not a part of unloading, but vessel end components should be cleaned with soap, water, rags, light brush, and bleach to disinfect where applicable as in potable systems, where further inspection on cleaned pieces may show cracks and other imperfections.

Actual removal of old membrane elements inside of vessels can be done in several ways, the two covered here is the mechanical pull/push and hydraulic extraction methods. The pull/push is labor intensive and is suggested to have multiple workers in order to lift, pull, push, and carry the membranes out. The hydraulic method uses one of the vessel head assemblies that is modified to accept a hose of plant service water, and make a confined space for water pressure to push the old membrane stack out each vessel's opposite end.

1. Mechanical pull/push method:

- a. After opening vessels, using pliers, grab one of the fins of the ATD of the membrane face and carefully lift over the retainer ring groove of the vessel end and remove the old membrane from each open vessel.
- b. If the membranes are not to be reused, a tool can be made with all thread rods of various lengths with a small "T" handle on one end and a lag screw on the other to "stab and twist" into the membrane face to pull to the vessel end to grab and remove.
- c. Rods of 40+ inches (102+ cm) and 80+ inches (204+ cm) or longer can be made to reach the 2<sup>nd</sup> and possibly the 3<sup>rd</sup> membrane deep inside the vessel. If there is enough space on the opposite end of the unit, then 2-3 membranes can be removed from each end, that's 4 to 6 membranes.
- d. With 7M or 8M vessels, there will be 1, 2, 3, or even 4 membranes in the middle of the vessel that may not be able to be reached with this lag screw puller, so using lengths of PVC piping, preferably 1 ½ inch (38 mm) diameter or larger for rigidity, attach enough lengths to push the remaining elements from the middle to the reachable end, then continue removal.

- e. If membranes are to be reused, pushing membranes out with lengths of PVC piping may work better with workers on the opposite ends lifting and carrying them out.
  - f. Also, If membranes are to be reused, carefully separate the old inter-connectors from each membrane as they reach the vessel end as these may be brittle and could break off inside the core tube.
2. Hydraulic extraction:
- a. Using an extra vessel head or an existing one, install fittings and a control valve in order to connect service water from the plant through hoses to the extraction head (Figure 7).

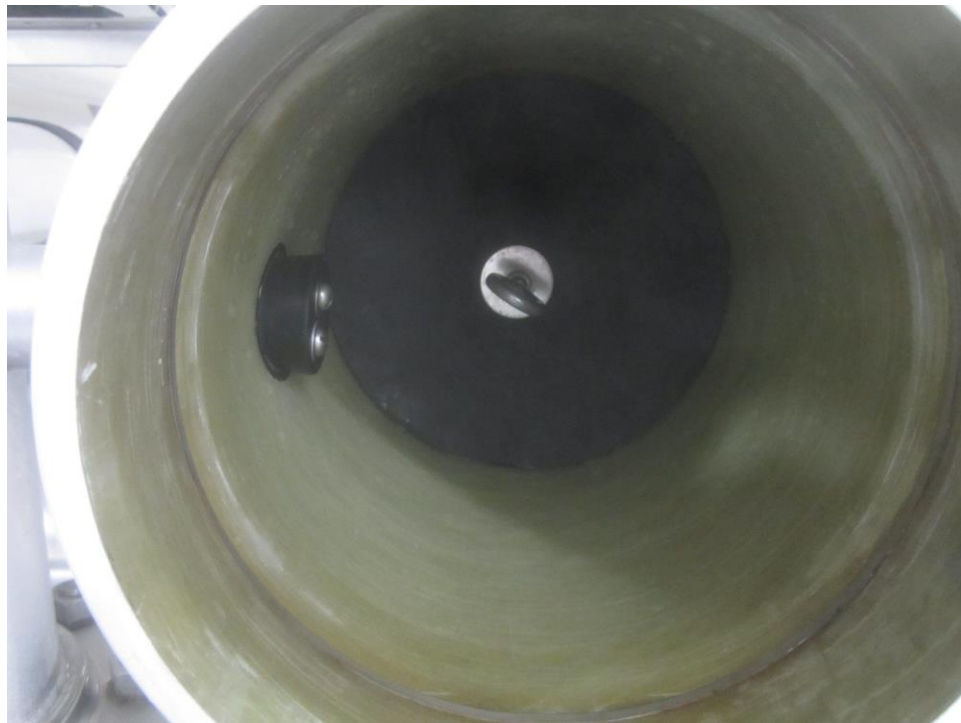


**Figure 7 – Extraction Head**

- b. Recommended fitting size and inlet valve should be 1 inch (25 mm), but  $\frac{3}{4}$  inch (19 mm) can work with plant finished water from a hose bib if that's all that's available. Service water should have a minimum of 50-60 psi (3.4-4.1 bar). Using fire hose that's somewhat flexible is helpful and stay with 1  $\frac{1}{2}$  inch (38 mm) or smaller as it will get cumbersome to handle if any larger. That goes for the 1 inch (25 mm) valve too.
- c. Using rubber or semi flexible material cut an 8 inch (200 mm) diameter circle and attach to a modified interconnector to make a flapper to insert into the lead element core tube that covers the spiral's face to stop majority of the flow through the membrane.



- d. Using rubber stoppers, plug into the feed side of the vessel's side port(s).



- e. With stoppers plugging side port(s), flapper covering the lead element as centered with the modified interconnector, and extractor head retained into the vessel end, slowly open the inlet valve on the extractor head to flow

water into that confined space and water pressure and volume will push the stack of membranes out the opposite open ended vessel.

- f. The small flow going around the outside annular space of the membrane stack will also help to lubricate the ID of the vessel, while helping to clean off some of the residue that may be present.
- g. When the entire stack of 6, 7, or 8 membranes are removed, pull the 8 inch (200 mm) diameter flapper off the lead membrane and repeat the process for subsequent vessels.

At the end of extracting old membranes out of the vessels, inspect and observe for any residue, scaling, or anything obvious in the way of damage or build up that needs to be addressed.

**Personal Safety Note:**

Element loading and unloading can require extended and repetitive physical motion. Simple stretching exercises before, during, and after loading/unloading multiple elements may help to reduce tightening and fatigue of joints and muscle groups used repeatedly during this type of work. So, if you begin to experience muscle tightness and/or joint fatigue, take a break and S-T-R-E-T-C-H.