FILMTEC Membranes

How to Improve Permeate Quality Using FilmTec's Interlocking Endcaps

The methods used for connecting reverse osmosis (RO) membrane elements in series have not kept pace with new advances in membrane performance. As a result, the permeate quality of today's state-of-the-art systems often relies upon a decades-old coupler technology that exhibits many shortcomings, resulting in lower permeate quality and higher costs. To eliminate these shortcomings and boost permeate quality, FilmTec will introduce new interlocking endcaps for connecting RO membrane elements. This Tech Fact bulletin will discuss:

- Shortcomings of current membrane element connection methods
- Benefits of FilmTec's patented interlocking endcap design
- Results from the new design's laboratory tests and field trials

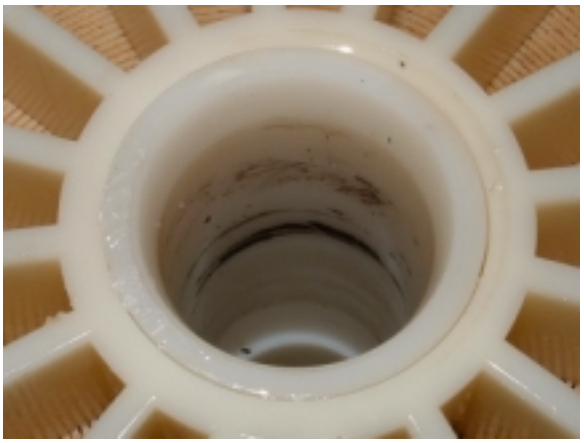
Shortcomings of Current Connection Methods

Current methods of connecting RO membrane elements incorporate a sliding coupler – comprised of a pipe segment with radially compressed o-rings at both ends – that is internally or externally connected to the adjacent product water tubes. The shortcomings of this "slip-fit" approach are well known to those who are responsible for the construction, start-up, operation, reliability, quality, maintenance or efficiency of an RO system. These shortcomings include:

- Potential leakage from o-rings pinched, rolled or twisted during element installation
- Leakage from o-rings abraded by the movement of elements inside the pressure vessel (see Figure 1)
- Increased flow resistance caused by the reduced inside diameter of the coupler, resulting in greater energy consumption

These shortcomings negatively affect system performance over time and can lead to higher costs or lower quality permeate, regardless of membrane performance.

Figure 1. Evidence of o-ring wear inside a product water tube due to insufficient lubrication of the sliding seal.



Benefits of FilmTec's Patented Interlocking Endcaps

Interlocking endcaps on FILMTEC™ elements consist of a single axially-compressed o-ring seal in combination with a rotational (vs. an axial or radial) mechanical connection (see Figure 2). Interlocking tabs around the periphery of each endcap provide a fixed mechanical connection between elements, compressing the o-ring upon installation and maintaining a tight seal thereafter. The injection-molded endcaps are made from ABS plastic, a material widely used for such parts (see Figure 3).

Figure 2. Representative examples of three methods of mechanical interconnection. (a) Axial; (b) Radial; (c) Rotational.

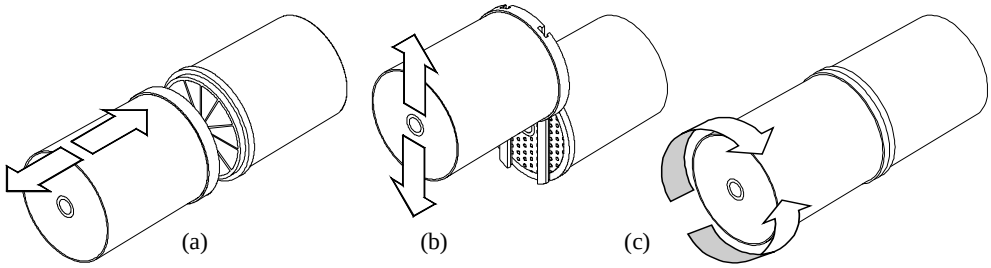
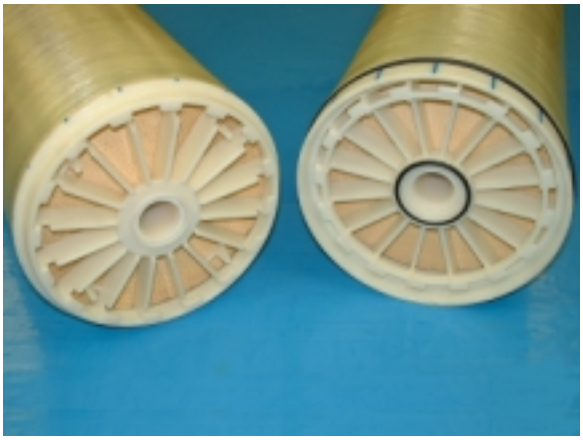


Figure 3. Interlocking endcaps with axially-compressed o-ring seal.



The patented design of the interlocking endcaps eliminates the shortcomings of the current "slip-fit" connection approach and offers the following benefits:

- **Long-term seal integrity** – The single, non-sliding seal greatly reduces the number of potential leak sites and eliminates the abrasion that can damage o-rings in a slip-fit connection. Seals are reliably and evenly compressed upon installation and the flow-induced compressive loads, rather than causing abrasion, provide additional sealing force during operation.
- **Leak-tight startup performance** – The new design eliminates the possibility of o-rings being rolled from their grooves or pinched and damaged during installation. The recessed sealing surfaces also ensure seals are protected from possible damage due to handling of the element.

Benefits of FilmTec's Patented Interlocking Endcaps (continued)

- **Lubricant-free operation** – Omission of o-ring lubricant to preserve permeate quality, such as in ultra pure water applications, will not compromise sealing performance.
- **Backward compatibility** – Compatibility with existing hardware is maintained. The smooth inner bore located at each end of the permeate collection tube is unchanged, permitting insertion of sliding couplers and existing vessel adapters. The net length of the elements, when connected, remains 40 inches, allowing them to fit inside current vessels.
- **Immediate feedback** – Four radially deflected tabs on the downstream endcap snap over protrusions on the upstream endcap to provide tactile and audible verification that a leak-tight connection between adjacent elements has been achieved upon installation. Rotational alignment markings on the rim of each endcap provide visual verification.
- **Reduced permeate pressure drop** – Internal couplers and vessel adapters account for more than 70 percent of the permeate-tube pressure drop in some systems. The interlocking endcap design eliminates these restrictions, imposing less permeate backpressure.
- **Robust mechanical design** – Tests have shown that the interlocking endcap connection can withstand almost three times the bending moment imposed by a wet element supported in a cantilever situation during installation (see Figure 4) and does not leak as a result of deflections induced by a sagging pressure vessel (see Figure 5). The endcaps are permanently welded to the permeate collection tubes and will not loosen with rough handling. Accelerated life-cycle testing has demonstrated high durability through repeated installation cycles. The integrity of the connection at high pressure has also been tested, ensuring that the connection withstands feed pressures exceeding maximum element pressures by a factor of two or more.
- **Easy loading and unloading** – Element loading and unloading requires no increase in time or personnel with interlocking endcaps. In addition, the effort required by an individual to connect the elements, one to the next, is equal to or less than that required with current connection methods.

Figure 4. Element temporarily supported in cantilever mode during installation.

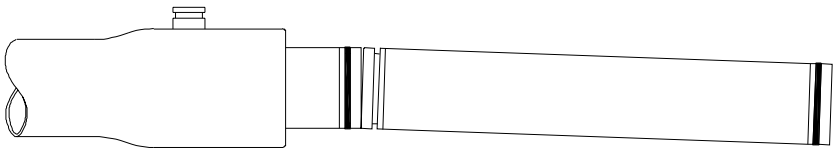
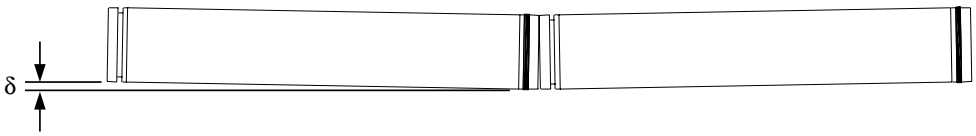


Figure 5. Bending condition imposed upon coupled elements inside a sagging pressure vessel.



Laboratory Tests and Field Trials Confirm Benefits

Each of the benefits described above has been documented in extensive laboratory evaluations. Detailed results from these evaluations are available in the technical paper, "Say 'Good-Bye' to the Weakest Link: Introducing a New Method for Coupling Membrane Elements," available online at www.filmtec.com/sw (Form No. 609-00447).

In addition, further study of the interlocking endcap is ongoing at three field trial sites involving the conversion of sea water for potable use and the treatment of surface water for industrial feed.

- Six interlocking elements were installed into a plant in Freeport, Texas, that produces high-quality industrial feed water from a high-fouling surface source. The plant is owned and operated by USFilter, a subsidiary of Veolia Environment. The elements were put into service in March 2002. They reside in the first stage of a two-stage system operating at 130 to 240 psi (17 bar), depending upon feed temperature. The system is shut down, and the elements removed, three to four times per year for off-site cleaning. An ongoing comparison between the vessel permeate conductivities for the interlocking elements and six control elements has shown no leaks among either group.
- Twelve interlocking elements were installed into a municipal seawater RO system in San Pedro, Belize, in April 2002. The system is owned and operated by the Consolidated Water Company Ltd. of the Cayman Islands. The elements were placed in two side-by-side vessels within a single-stage array operating at a feed pressure of approximately 870 psi (60 bar). The system is typically shut down twice per day. Periodic probing of the vessels has revealed no leaks among the interlocking connections.
- A third installation, involving two vessels containing 12 interlocking seawater elements, was carried out in March 2003 at the INALSA water treatment on the island of Lanzarote, Spain. The vessels are located in both the first and second stages of a plant operating at approximately 930 psi (64 bar). The elements continue to operate successfully.
- A fourth installation was carried out in May, 2003, at a semiconductor plant in Freising, Germany. A pair of vessels in the second stage of that 4 by 2 array were retrofitted with interlocking and standard versions, respectively, of the FILMTEC SG30-400 element. The array comprised the first pass of a system for producing ultra-pure process water. A well-water feed was introduced at pressure of 290 psi (20 bar). Both vessels exhibited excellent hydrocarbon rinse-down performance. No increase in system permeate TOC (total organic carbon) was observed upon startup, even though the rinsing of the new elements was limited to a brief, 15-minute flush upon installation. The interlocking elements continue to perform.

Distributed By:
APPLIED MEMBRANES INC.®
2450 Business Park Dr. Vista, CA 92081 ☎ (760) 727-3711 🖷 (760) 727-4427
🌐www.appliedmembranes.com ✉ sales@appliedmembranes.com