FILMTEC Membranes
How to Evaluate the Active Membrane Area of Seawater Reverse Osmosis Elements

Knowing the active membrane area of a reverse osmosis (RO) element is critical to reliable system design and performance. However, research shows that there are often significant discrepancies between the nominal (stated or implied) membrane area and the actual active membrane area in some competitive sea water RO elements. This Tech Fact bulletin will discuss:

- The importance of evaluating the nominal vs. actual active membrane area of an RO element
- Why RO elements constructed via automated methods offer a more accurate nominal membrane area
- How to measure the actual active area of an RO element

The Need for Accurate Measures

As OEMs, consultants and end users have gained experience in the operation of RO elements in various applications and locations, many now include in their specifications a limit on the average permeate flux (APF) – expressed as liters per square meter per hour (L/m^{2}h), or gallons per square foot per day (gfd) – at which systems may be designed and operated.

To accurately calculate the APF of any membrane system, it is necessary to know the actual area of useful membrane surface area in each type of element used. This “useful area” is known as the *active membrane area* and is defined as the available surface area of membrane within an individual element, or within a system, through which permeate can pass.

Active membrane area differs from *total membrane area* and *nominal membrane area*, as follows:

- **Total membrane area** is the area of the membrane actually used in the construction of an RO element and is not normally stated by the element manufacturer.
- **Nominal membrane area** is a value given or implied by the element manufacturer as the membrane area in any particular element type or configuration. The nominal area is a non-standardized measurement and does not always accurately reflect the active membrane area of an RO element.
- **Active membrane area** is the actual, measured area of useful membrane when an element is opened and the area is measured and calculated leaf by leaf. The difference between active and total membrane area is accounted for by the membrane area lost during the construction of an element – i.e., membrane covered by adhesives and other construction materials.

Form No. 609-00434-803

Element Construction Techniques Affect Accuracy of Nominal Membrane Areas

If the RO element has been manufactured in a precisely controlled and repeatable way, then the nominal and active membrane area values should be very close. If, however, the construction of the element is not precisely controlled, then the actual active area can be significantly different from the nominal membrane area claimed for a particular element – and can vary from element to element. Accurate representation of active membrane area results in accurate design guidelines, which in turn result in accurate design flux and efficient systems with fewer fouling problems and lower costs of operation.

The Automated Multi-leaf Element Cell (AMEC) construction technique – developed and used by FilmTec Corporation – produces FILMTEC™ RO elements of all types with an active membrane area that matches the nominal membrane area with a tolerance of plus or minus 2 percent. The AMEC construction technique allows for a level of accuracy and reproducibility that typically cannot be achieved by the manual or semi-automated techniques common to the construction of most competitive RO elements.

Figures 1 to 4 show the appearance of element leaves typically produced using the AMEC technique vs. conventional manual rolling technology (CMRT).

Figure 1. Automatic glue line (AMEC construction) (from far)

Figure 2. Manual glue line (CMRT construction) (from far)

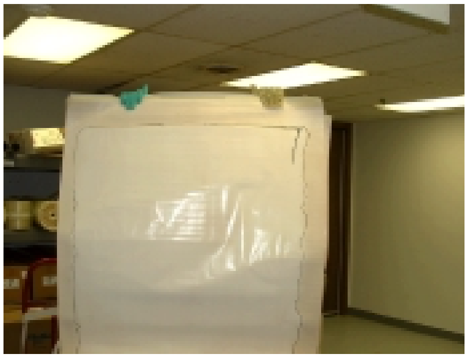


Figure 3. Automatic glue line (AMEC construction) (detail)

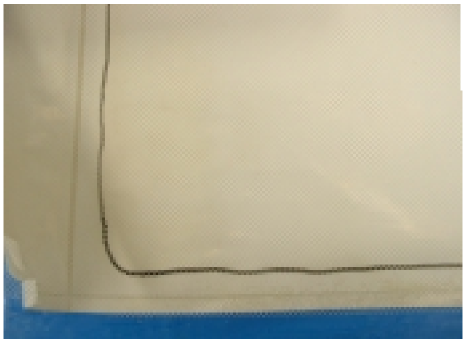
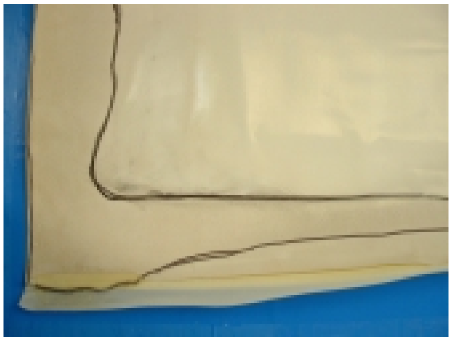


Figure 4. Manual glue line (CMRT construction) (detail)



Figures 1 to 4 clearly show that CMRT-produced glue lines are more variable and have a significantly larger width than glue lines produced by the AMEC technique. Note that a significant proportion of membrane area is lost due to the wider glue lines in CMRT-constructed membranes – area that in a FILMTEC element is available, making the element more productive.

Autopsies of CMRT- and AMEC-constructed elements show that in CMRT-constructed elements, there is typically a greater spread of glue from the side of each leaf. Manual glue lines are usually about 2 in. (5.1 cm) wide but can be as wide as 4 in. (10.2 cm). Conversely, elements manufactured with AMEC precision construction have glue lines that are only 0.7 in. to 1 in. (1.7 cm to 2.5 cm) wide. This difference in glue line width means that the active membrane area of an AMEC-constructed element is about 12.5 percent larger on average than a CMRT-constructed element of equivalent nominal and total area.

Evaluating the Accuracy of Nominal vs. Actual Active Areas in Various RO Elements

Table 1 shows a comparison of active, nominal and total membrane areas for some current commercially available FILMTEC and competitive seawater RO elements.

Table 1. Comparison of nominal and actual active membrane areas for various seawater elements

Brand	Number of autopsies	Nominal flow, gpd (m^3/d)	Nominal rejection, %	Nominal area, ft^2 (m^2)	Measured active area, average, ft^2 (m^2)	Active vs. nominal, (%)
FILMTEC SW30HR-380	2	6,000 (23)	99.70	380 (35.3)	377 (35.0)	-0.9
FILMTEC SW30HR-320	3	5,000 (19)	99.70	320 (29.7)	315 (29.2)	-1.6
Brand A – Product 1	3	5,900 (22)	99.70	370 (34.3)	318 (29.5)	-14.1
Brand A – Product 2	3	5,500 (21)	99.80	370 (34.3)	308 (28.6)	-16.7
Brand B	1	6,000 (23)	99.75	370 (34.3)	313 (29.0)	-15.4

Some element types (Brand A and Brand B) appear to show significantly lower actual active area vs. specified nominal area. These differences lead to systematic inconsistencies when calculating the total active membrane area or the average permeate flux of a membrane system.

With these differences in active vs. nominal area, it should be expected that many membrane systems in the field are actually operating at 15 percent to 20 percent higher average permeate fluxes than calculated from the nominal membrane area. This means that a system using products with inconsistent area specifications, designed for an APF of 14 L/m^2h (8.2 gfd), would in reality operate at 16 L/m^2h (9.4 gfd) – a significant difference. Such differences may have implications for the reliable design and operation of systems – for example, on concentration polarization and fouling behavior.

FilmTec recommends gaining further understanding of the active area of your membrane system by measuring the active membrane area yourself. The method we are recommending for the measurement of active area is included in the following section.

How to Measure Actual Active Area of RO Membrane Elements

The most difficult part in measuring active membrane area is opening the outer epoxy shell of a membrane element. Once the appropriate tools for opening the element are available and the element is open, measuring and calculating the active area is easy. The necessary tools can be readily purchased. Contact your FILMTEC representative if you would like further advice or support in performing an active area measurement on any FILMTEC or competitive element.

Instruments Needed

- Vibration saw
- Knife
- Ruler

Procedure

- Remove outer wrap and end caps from element

  Prior to autopsy, the element should be rinsed to remove biocides and/or other hazardous materials and then drained in a vertical position for about 30 minutes to remove excess water. To remove the hard shell, it is advisable to wear ample eye and face protection as well as long-sleeved garments to avoid skin contamination with fiberglass particles. We recommend the use of a vibration saw (such as model Astxe 638 or Msxe 636 from C. & E. Fein GmbH & Co, Stuttgart, Germany), along with ear protection.

  Figure 5. Vibration saw

- Count total number of leaves

  A single leaf is defined as a rectangular sheet of tricot sandwiched between two layers of membrane and adhered around three edges by an adhesive.

- Select three leaves to make measurements

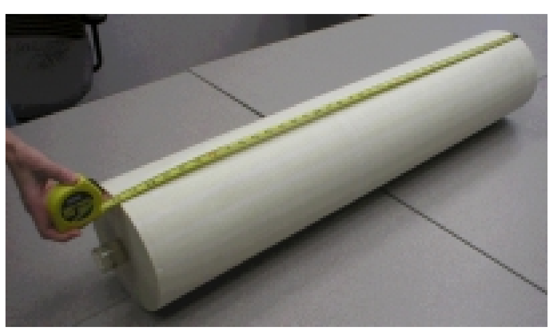
  Leaves selected should be the most evenly spaced leaves in the element.

- Make and record measurements

  Use the accompanying datasheets to record your measurements.

  1. Measure and record trim width. (trim width illustrated in Figure 6)

  Figure 6. Trim width

How to Measure Actual Active Area of RO Membrane Elements (continued)

2. Measure and record right side glue line width in two places – maximum value and minimum value (measurements must be made at places no less than 5 in. (12.7 cm) from permeate collection tube).
3. Measure and record left side glue line width in two places – maximum value and minimum value (measurements must be made at places no less than 5 in. (12.7 cm) from permeate collection tube).
4. Measure and record the distance from the end of the leaf to the inside edge of the bottom glue line on both sides of the leaf. Frequently this distance is different on each side of the leaf.
5. Measure and record the width of the bottom glue line at the center of three randomly spaced leafs.
6. Measure and record total leaf length (continuous membrane length from end of one leaf to end of next leaf).
7. Measure and record the width of any crease protection.

- Calculate active area
  Use the accompanying datasheets to calculate active and total membrane area.

Number of Leaves, Trim Width and Glue Line Width Datasheet

Measure	Parameter	Proc.	Data
Number of leaves	NL	B	
Trim width	WT	D1	
Right side maximum glue line width – Leaf 1	GLR1min	D2	
Right side minimum glue line width – Leaf 1	GLR1max	D2	
Left side maximum glue line width – Leaf 1	GLL1min	D3	
Left side minimum glue line width – Leaf 1	GLL1max	D3	
Bottom glue line width – Leaf 1	GLB1	D4	
Right side maximum glue line width – Leaf 2	GLR2min	D2	
Right side minimum glue line width – Leaf 2	GLR2max	D2	
Left side maximum glue line width – Leaf 2	GLL2min	D3	
Left side minimum glue line width – Leaf 2	GLL2max	D3	
Bottom glue line width – Leaf 2	GLB2	D4	
Right side maximum glue line width – Leaf 3	GLR3min	D2	
Right side minimum glue line width – Leaf 3	GLR3max	D2	
Left side maximum glue line width – Leaf 3	GLL3min	D3	
Left side minimum glue line width – Leaf 3	GLL3max	D3	
Bottom glue line width – Leaf 3	GLB3	D4	

Leaf Length Datasheet

Measure	Parameter	Proc.	Data
Membrane leaf length – Leaf 1	LLM1	D6	
End of leaf to inside of bottom glue line – Leaf 1	LIBG1a	D5	
End of leaf to inside of bottom glue line – Leaf 1	LIBG1b	D5	
Membrane leaf length – Leaf 2	LLM2	D6	
End of leaf to inside of bottom glue line – Leaf 2	LIBG2a	D5	
End of leaf to inside of bottom glue line – Leaf 2	LIBG2b	D5	
Membrane leaf length – Leaf 3	LLM3	D6	
End of leaf to inside of bottom glue line – Leaf 3	LIBG3a	D5	
End of leaf to inside of bottom glue line – Leaf 3	LIBG3b	D5	
Membrane crease protection width	CPM	D7	

Active Area Calculation Datasheet

Measure	Parameter	Calculation
Right side average glue line width	GLRave	Average(GLR1min, GLR1max, GLR2min, GLR2max, GLR3min, GLR3max)
Left side average glue line width	GLLave	Average(GLL1min, GLL1max, GLL2min, GLL2max, GLL3min, GLL3max)
Bottom glue line average	GLBave	Average(GLB1, GLB2, GLB3)
Average active leaf length	LLave	Average(LLM1, LLM2, LLM3) – Average(LIBG1a, LIBG2a, LIBG3a) – Average(LIBG1b, LIBG2b, LIBG3b)
Active area	**AA**	**NL × (WT – GLRave – GLLave) × (LLave – CPM) / 144**

FILMTEC Membranes
For more information about FILMTEC membranes, call the Dow Liquid Separations business:

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Notice: The use of this product in and of itself does not necessarily guarantee the removal of cysts and pathogens from water. Effective cyst and pathogen reduction is dependent on the complete system design and on the operation and maintenance of the system.

Form No. 609-00434-803