FILMTEC Membranes

Why FILMTEC Thin-Film Composite RO Membranes Outperform Cellulose Acetate Membranes in Water Purification Service

When selecting reverse osmosis (RO) membranes for water purification systems, the decision process often involves choosing between two major membrane types...thin-film composite membranes such as the FILMTEC®, FT30 membrane and cellulose acetate (CA) membranes. Although CA technology predates other membrane types and remains relatively inexpensive to purchase and install, today use of cellulose acetate membranes has been largely displaced by thin-film composite membranes. Thin-film composite membranes offer superior operating performance, service life and overall economy.

To aid in the membrane selection process, this bulletin will describe the construction of both membrane types and compare their performance. The definitions for “thin-film composite” and “cellulose acetate” membranes follow.

Definition – Thin-Film Composite Membranes

The term “thin-film composite” describes the manner in which these reverse osmosis membranes are fabricated. Thin-film composite membranes usually consist of layers of dissimilar materials joined together to form a single membrane. This layered construction permits use of material combinations that optimize the performance and durability of the membrane.

For example, FILMTEC FT30 membrane features a thin aromatic polyamide barrier layer that provides high water flux, salt and silica rejection, and excellent chemical resistance. Beneath this outer layer is a thick microporous polysulfone sublayer that supports the barrier layer, offers necessary porosity and strength properties, and resists compaction under RO pressure conditions. The polysulfone layer is cast onto a nonwoven polyester inner web that contributes to overall structural strength. The barrier layer is then applied by interfacial polymerization. Figure 1 shows a cross-section of the FT30 membrane structure.

Although a variety of materials are used in the fabrication of other thin-film composite membranes, membranes utilizing an aromatic polyamide barrier layer over a polysulfone base have been shown to provide the best overall combination of productivity, performance, and durability. With this construction design, the membrane resists compaction, thereby providing high water quality for longer service life.

Definition – Cellulose Acetate Membranes

Cellulose acetate membranes are the oldest form of commercial RO membrane. They are available in diacetate and triacetate (CTA) grades, and in blends of these grades (CA/CTA). Cellulose acetate membranes get their name not from their structure, but from the material used in their fabrication. All commercial CA membranes are structurally classified as asymmetric membranes. The dense surface skin “membrane” and the thick, porous supporting underlayer have exactly the same polymer and chemical composition but are structurally dissimilar.

These membranes are fabricated in a one-step process by casting a film or spinning a fiber from a solution of cellulose acetate and solvent(s). The film or fiber is then coagulated in a water bath to form the asymmetric structure. This bath also removes the solvent(s) from the membrane. The thin surface skin formed by this process rejects salts and permits water permeation. The remainder of the structure provides physical strength to the surface skin while allowing water to permeate to the product water side. Figure 2 shows a cross-section of a CA membrane.

Although inexpensive to produce, effective CA membranes can be difficult to fabricate. The freshly cast film is water-swollen and must be “tightened” via a hot water annealing process. While annealing greatly improves the salt rejection performance of freshly cast CA films, it tends to thicken the surface skin and reduces water flux. Furthermore, asymmetric membranes tend to compact into increasingly dense structures under the continuous high feed pressures used in reverse osmosis systems.

Figure 1. Cross-section of a Thin-film Composite Reverse Osmosis Membrane

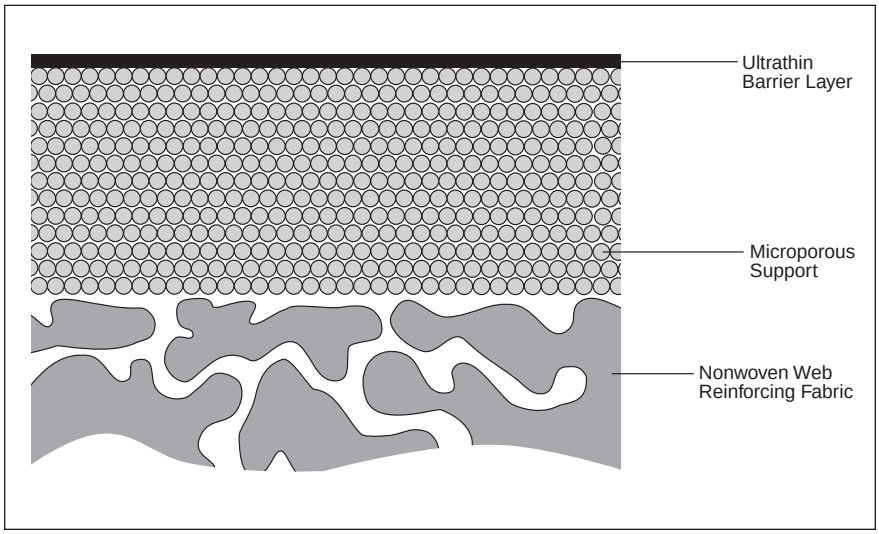
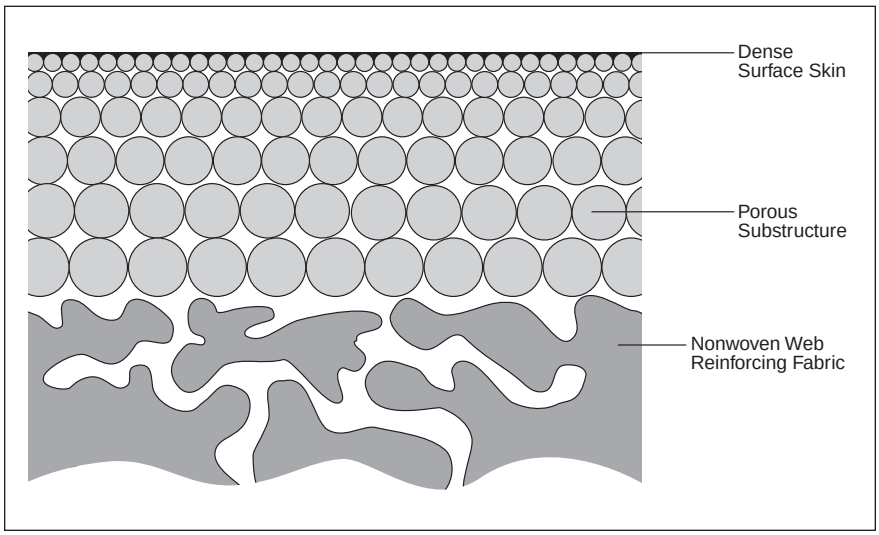


Figure 2. Cross-section of a Cellulose Acetate (asymmetric) Membrane



Overview Comparison of Thin-film Composite Membranes vs. Cellulose Acetate Membranes

Thin-film Composite Membranes

Advantages:

- Excellent hydrolytic resistance for greater membrane stability and longer life.
- Superior rejection of salts for higher quality product water.
- Superior organics rejection for higher water purity.
- Strong/resilient membrane structure for greater durability.
- Excellent membrane flux for higher productivity and lower operating pressures.
- Compaction-resistant sublayers stand up to pressurized operation, and contribute to longer service life.
- Superior mechanical durability (due to the toughness of the barrier layer), for abrasion resistance and extended service life.
- Wide operating pH range for produced water (pH 2-11).
- Broad operating temperature range for produced water (0°C to 45°C).

Disadvantages:

- Limited tolerance to chlorine... continuous chlorination causes an attack on the aromatic polyamide structure of the barrier layer. *However, FILMTEC FT30 membrane offers better tolerance than most other polyamide membranes. (Because chlorine is easily eliminated from feedwater through sodium metabisulfite addition or by using activated carbon prefilters, the limited tolerance of composite membranes to chlorine is not a major drawback.)*

Cellulose Acetate Membranes

Advantages:

- Relatively low purchase cost.
- Tolerant of chlorine in feedwater.

Disadvantages:

- Hydrolysis by acids and alkalies can lead to deterioration of the membrane structure (Cellulose Triacetate – or CTA – membranes offer better hydrolysis resistance than diacetate grades).
- Membrane susceptibility to biodegradation means continuous chlorine disinfectant protection is often required.
- Inferior salt rejection characteristics result in lower purity product water (CTA membranes offer slightly better salt rejection than diacetate grades).
- Narrow pH range tolerance (pH 4-8 for continuous operation and pH 3-9 for cleaning) reduces operating flexibility and greatly restricts cleaning capabilities.
- Narrow temperature limits (0°C to 35°C) make strict control of operating conditions essential, may limit the speed and effectiveness of cleaning operations.
- Membranes are subject to structural compaction under normal RO feedwater pressures, resulting in abbreviated service life.

- Forty to fifty percent lower membrane permeability means operating pressures required to achieve desired productivity and salt rejection levels are nearly doubled, so energy costs are significantly higher.

Table 1. Comparison of Typical Salt Passage Data for Cellulose Acetate and FT30 Membranes

Salt	CA	FT30
NaCl	5%	2%
$NaHCO_3$	5%	3%
$MgSO_4$	2%	<1%
$CaSO_4$	2%	<1%
$NaNO_3$	15%	8%
SiO_2†	15%	2%

†Dissolved reactive silica

Specific Performance Comparisions

Following are comparisions of the salt rejection, organics rejection, pH, and temperature performance of cellulose acetate membranes vs. FILMTEC FT30 thin-film composite membrane.

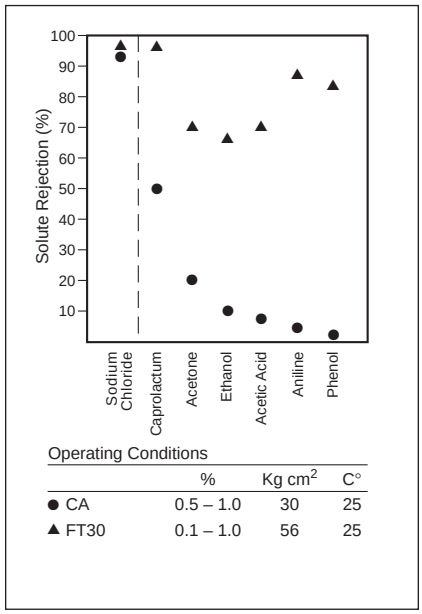
Comparative Salt Rejection

Table 1 shows that, for most of the common inorganic salts in naturally occurring water, the FILMTEC FT30 thin-film composite membrane passes 50 percent less salt than a cellulose acetate membrane.

Comparative Organic Solute Rejection

Figure 3 shows that, while cellulose acetate membranes exhibit very low organic solute rejections, the FILMTEC FT30 membrane provides consistently higher rejection performance.

Figure 3. Organic Solute Rejections Comparison, FILMTEC FT30 Membrane vs. Cellulose Acetate Membrane

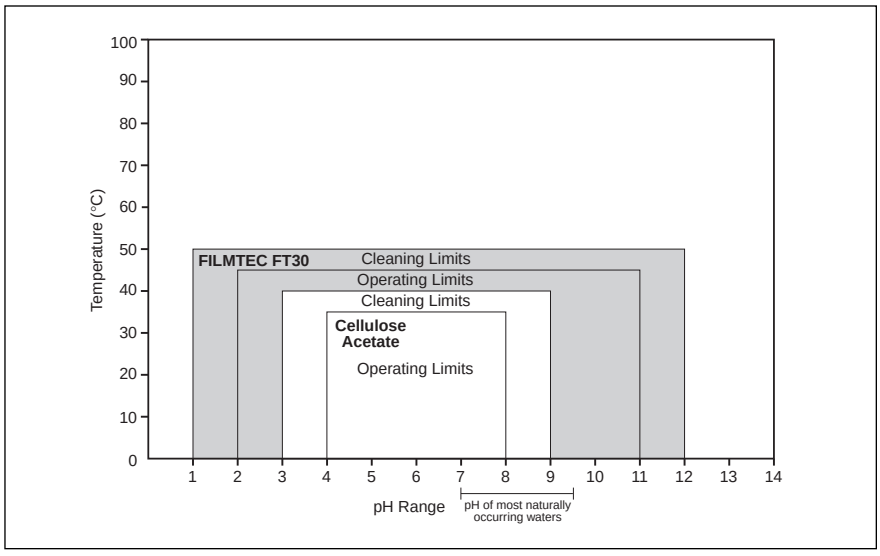


Comparative pH and Temperature Performance

Figure 4 shows that the operating and cleaning parameters of cellulose acetate membranes are very limited compared to the parameters for FILMTEC FT30 membrane. While CA membranes can be continuously operated between pH 4 and 8, FT30 membrane performs between pH 2 and 11, providing greater operating latitude. FT30 membrane also operates at higher temperatures than CA membranes (0°C to 45°C, compared to 0°C to 35°C for CA membranes).

The cleaning pH and temperature limits of FT30 membrane are significantly greater than those for CA membranes. This means stronger, faster, and more effective cleaning processes can be used to clean FT30 membrane, reducing maintenance downtime and increasing system productivity.

Figure 4. Comparison of Operating and Cleaning Parameters of FT30 and CA Membranes



FILMTEC Membranes

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Thin-film Composite Membranes – The Right Choice for Highest Water Purity and Longest Membrane Service Life

The data in this bulletin shows that thin-film composite membranes offer better salt and organics rejection than CA membranes, resulting in more highly purified water. What's more, composite membranes produce purified water at lower feed pressures. They are also more durable and easier to operate and maintain. All of these features make thin-film composite membranes the clear choice for reverse osmosis water purification systems.

To Learn More...

Call 1-800-447-4369 for additional information about the advantages of thin-film composite membranes in RO water purification service. Also, learn more about FILMTEC thin-film composite membranes, the world's leading membrane for water purification systems. To date, more than 1,000,000 FILMTEC membranes have been installed worldwide. Find out why today.

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