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Engineering aspects of reverse osmosis module design

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ABSTRACT

During the half century of development from a laboratory discovery to plants capable of producing up to half a million tons of desalinated seawater per day, reverse osmosis (RO) technology has undergone rapid transition. This transition process has caused signification transformation and consolidation in membrane chemistry, module design, and RO plant configuration and operation. From the early days, when cellulose acetate membranes were used in hollow fiber module configuration, technology has transitioned to thin film composite polyamide flat-sheet membranes in a spiral wound configuration. Early elements — about 4 inch in diameter during the early 70s — displayed flow rates approaching 250 L/h and sodium chloride rejection of about 98.5%. One of today's 16-inch diameter elements is capable of delivering 15–30 times more permeate (4000–8000 L/h) with 5–8 times less salt passage (hence a rejection rate of 99.7% or higher). This paper focuses on the transition process in RO module configuration, and how it helped to achieve these performance improvements. An introduction is provided to the two main module configurations present in the early days, hollow fiber and spiral wound and the convergence to spiral wound designs is described as well. The development and current state of the art of the spiral wound element is then reviewed in more detail, focusing on membrane properties (briefly), membrane sheet placement (sheet length and quantity), the changes in materials used (e.g. feed and permeate spacers), element size (most notably diameter), element connection systems (interconnectors versus interlocking systems). The paper concludes with some future perspectives, describing areas for further improvement.

Keywords: Thin film composite; Spiral wound; Reverse osmosis; Hollow fiber; Feed spacer; Permeate spacer; Permeate tube; Endcap; Interconnector; Interlocking endcap; Large diameter; 16 inch

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