Highly efficient energy-saving seawater desalination to produce high-quality fresh water.

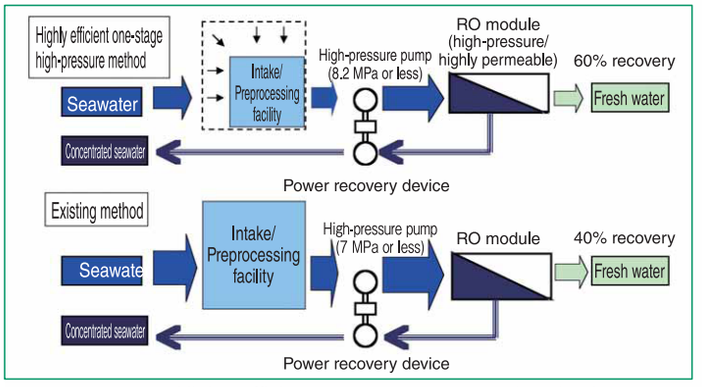
Hollow Fiber Reverse Osmosis Membrane for Seawater Desalination

Features

- Reduces energy required for desalination to 10% or less, compared with the evaporation method.
- The world's only one hollow fiber reverse osmosis membrane enables one-stage high-recovery operations, and reduces the quantity of required treatment chemicals to 2/3 of that required by conventional reverse osmosis membranes.
- Ensures high durability and reliability that attract customers in the Middle East and other regions of the world.

■ Comparison in seawater desalination energy

Separation process	Energy required for processing (converted to calories) (kcal/m^3)
Ideal value	616
Reverse osmosis (40% recovery)	4,500
Refrigeration	8,000
Solvent extraction	22,000
Electrodialysis	27,692
Evaporation (multistage flash)	53,300

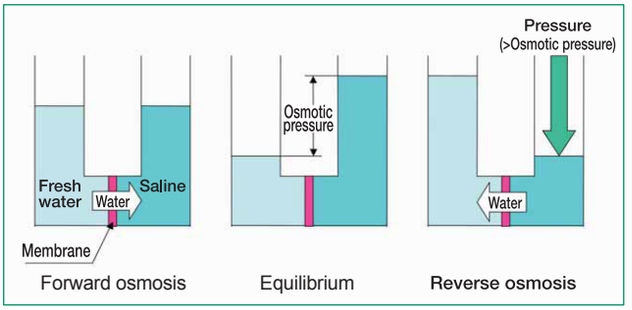


Highly efficient one-stage seawater desalination system

Overview (Technical principles, actions, etc.)

1. Reserve Osmosis Method

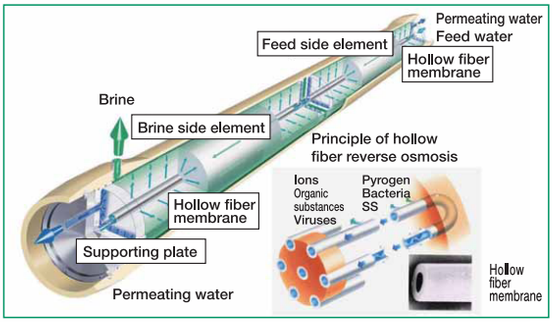
When a pressure in excess of the osmotic pressure of seawater is imposed on the seawater side of the semi-permeable membrane, desalinated water will move from the seawater side to the freshwater side. This phenomenon is called reverse osmosis, which enables direct desalination without any phase change, thus resulting in a significant reduction of energy consumption compared with the evaporation method.



Reverse osmosis (RO) method principle

2. Hollow Fiber Membrane and Membrane Module

Toyobo's reverse osmosis membrane is of hollow fiber type. Freshwater will permeate into the centrum when pressure is imposed on the seawater on the external side of the hollow fiber. Practically, a number of hollow fiber reverse osmosis membranes are used to construct the structure of a membrane module. The following illustration shows an example of a pressure vessel equipped with two membrane modules. Seawater applied to the membrane modules are guided to the hollow fiber membranes in the radial direction from the central part, and desalinated water passes through the hollow fiber membranes. The membranes are made of cellulose triacetate, which highly resist chlorine used as a disinfectant. Therefore, the system is free from trouble caused by microbes, the most serious problem in seawater desalination.



Hollow fiber reverse osmosis membrane module

Introductory Track Record

■ **Many large-scale seawater desalination plants, mostly in Middle Eastern countries, have been using hollow fiber reverse osmosis membrane modules. Examples of the customers are shown below.**

Plant/Region	Country	Production capacity(m^3/day)	Start-up year
① Ras Al Khair	Saudi Arabia	345,000	2014
② Jeddah 3	Saudi Arabia	260,000	2013
③ Shuqaiq Ⅱ	Saudi Arabia	240,000	2010
④ Rabigh	Saudi Arabia	218,000	2008
⑤ Yanbu	Saudi Arabia	128,000	1998
⑥ Jeddah 1,2	Saudi Arabia	113,600	1994
⑦ Rabigh 2	Saudi Arabia	109,000	2015
⑧ Jubail	Saudi Arabia	85,000	2007
⑨ Marafiq Yanbu	Saudi Arabia	50,400	2005
⑩ Fukuoka	Japan	50,000	2005

Effects

◎**The energy consumption of modules in the case of seawater desalination can be reduced to at least 1/10 of that required in the evaporation method.**

4,500/53,300 = 1/11.8 ≤ 1/10

Premises: Energy required for freshwater to be produced

Evaporation method (multistage flash): 53,300 kcal/m^3

(Source: Takahata, et al., P. 19 KHI Technical Review Vol. 88, May 1985)

Reverse osmosis method (40% recovery): 4,500 kcal/m^3

(Source: Yamazato, New Membrane Technology Symposium 2004)

◎**Improved recovery (40% to 60%) results in reducing the quantity of chemicals as well as the quantity of seawater necessary for pretreatment to 2/3.**

1.67/2.5 = 2/3

Condition: Seawater supplied to produce 1m^3 of freshwater

Recovery rate of 40%: 2.5 m^3 (1/0.4 = 2.5)

Recovery rate of 60%: 1.67 m^3 (1/0/6 = 1.67)

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