Creating fresh water around the world

Valves play important role in sea water reverse osmosis industry

Rapidly expanding populations, along with worldwide industrial expansion, are creating a demand for fresh water that, in many areas, has already exceeded existing supplies. In the future, it will be increasingly difficult to satisfy the increased demand of populations in the Middle East, China and the Mediterranean with traditional fresh water generation methods. Prolonged drought conditions in certain parts of the world, including Australia, have caused immediate needs for alternate sources of fresh water. Methods of producing fresh water, such as the desalination of salt water, have been evolving to meet the growing needs of these populations. However, several of these methods involve increased pressures and corrosiveness, which results in challenging operating environments for equipment. Valve technologies are being developed to meet these increased demands, allowing users to save time and money on installation and maintenance.

By Ben Lee, Product Manager, Flowserve Flow Control Division

Desalination technologies

Prevailing desalination technologies are divided into two primary categories; thermal processes, including multi-stage flash and multiple effect distillation, and osmosis processes.

Osmosis processes are currently favored in the desalination industry due to lower capital costs and reduced overall energy requirements when compared to thermal processes. Whilst requiring lower initial investment, these plants readily incorporate energy recovery systems, which reduce energy consumption by reusing waste energy to power the osmosis process.

Osmosis is the movement of water across a selectively permeable membrane caused by a difference in the concentration of dissolved salts, such as chlorides, on the two sides of the membrane. The selectively permeable membranes allow passage of water, but not of the solute particles. The natural tendency of the water is to move from the side of higher concentration of dissolved salts to the side of lower concentration. However, the direction of the water's

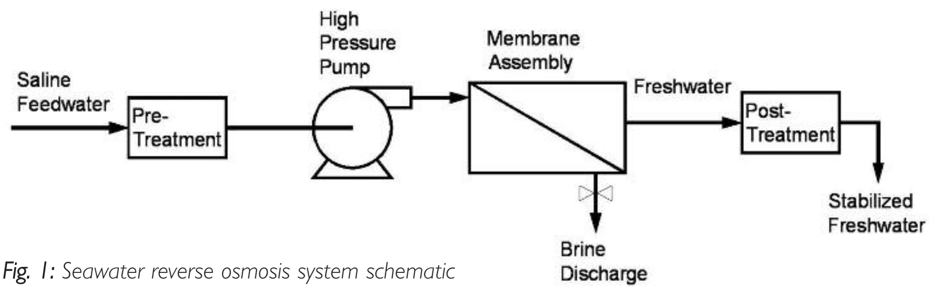


Fig. 1: Seawater reverse osmosis system schematic

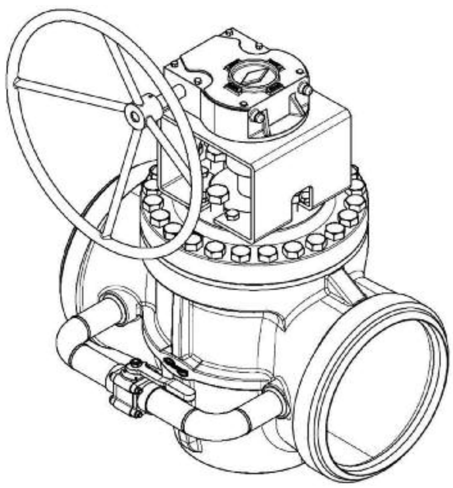


Fig. 2: Bypass valve system

natural movement can be reversed by applying hydrostatic pressure to the highly concentrated solution, a process called reverse osmosis.
There are two types of reverse osmosis processes: brackish water reverse osmosis (BWRO) and seawater reverse osmosis (SWRO). The International Desalination Association reported in 2008 that 54 percent of the world's desalinated water is currently being produced by reverse osmosis.
The United States has predominantly used BWRO technology in its dry southern states due to its relatively low cost. However, in most parts of the world, including Australia, North Africa, and the Middle East, the amount of available brackish water is not adequate to meet fresh water demands. In contrast, SWRO can tap the nearly limitless supply of feed water available in the oceans of the world.
Due to the increased salinity of seawater relative to brackish water, SWRO involves higher pressures to affect the reverse osmosis process. This requires the process components, including pumps and valves, to be rated for the increased pressures. The material requirements for all equipment used in the SWRO process are more stringent due to the increased corrosiveness of seawater.

The SWRO process explained

The SWRO desalination process is composed of three main steps (see Figure 1): pre-treatment, membrane assembly area and post-treatment of the fresh water stream.

Pre-treatment

First, all solids such as silt, sand and organic materials are removed from raw seawater, which has a high content of dissolved chlorides. The water is then chemically treated to prevent damage to the expensive and sensitive reverse osmosis membranes.
Pretreatment in the SWRO desalination process consists of passing seawater through a series of sand and cartridge filters. In this stage of the process, the seawater is at a low pressure but its chloride content makes it highly corrosive. A large number of butterfly valves are used to control the flow of the water through the pretreatment process. The valves range in sizes from 75 to 2500 millimeters, depending on the size of the SWRO desalination plant. Many of these valves are rubber-seated, with disc material ranging from super duplex stainless steel to ductile iron with coatings of Halar, Hypalon, PFA, PTFE and various other elastomers and plastic materials.

Membrane assembly area

After pretreatment, the treated water moves to the membrane assembly, where it is pushed through the reverse osmosis membranes at high pressure. This stage of the process requires the highest pressures, where pressures are frequently in the range of 60 to 70 bar.
The most commonly used isolation valves are ASME Class 600 plug valves. At this stage, filters have removed all of the sand and other solids from the raw seawater. However, the water still has high chloride content, necessitating the use of super duplex stainless steel for all wetted parts of the valve.
Typically, these valves are butt-welded, rather than flanged, which allows users to save money on expensive ASME Class 600 super duplex SS flanges on both the valve and the piping mating to the valves.
Repairing plug valves can be difficult; typical plug valves require usage of an expensive sleeve that is solidly locked into place in the body of the valve.

Butterfly valves are often used to control the flow of the water through the SWRO pretreatment process.

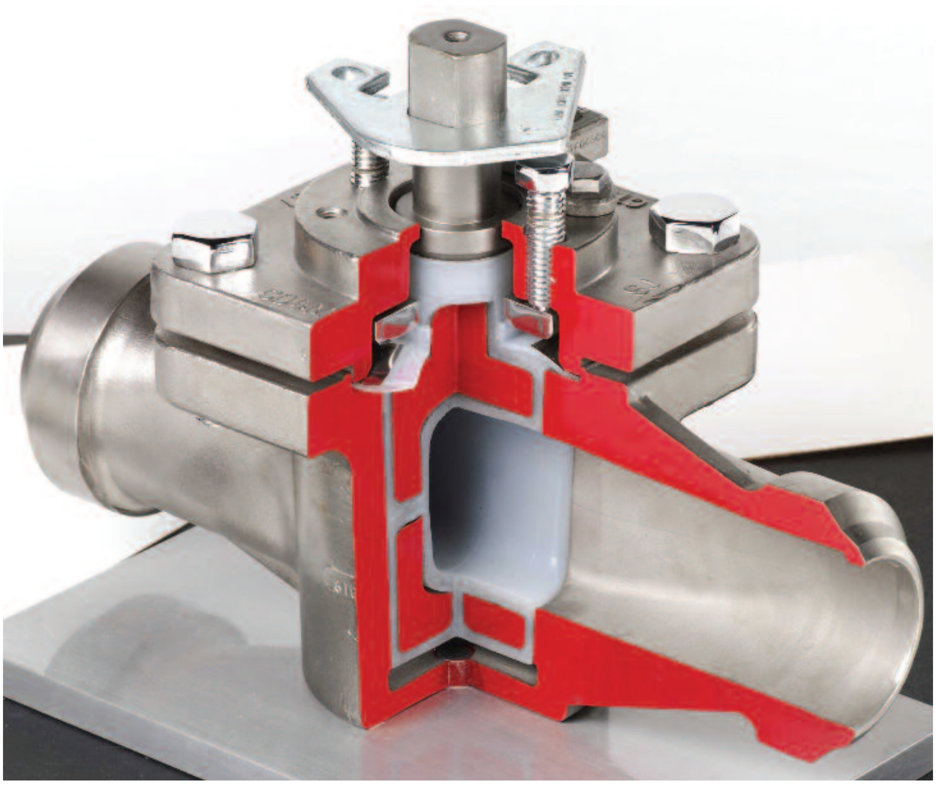
Replacement of this sleeve requires a hydraulic press and special tooling to force the sleeve into position. The sleeve can be damaged if not installed properly by a qualified technician.

Post-treatment of the fresh water stream

After the membrane, the fresh water moves into a post-treatment process to finish the conversion into stabilized fresh water, while the brine sludge is removed for disposal.
Butterfly valves are used to control flow in the fresh water stream after the water is purified by the membranes. The material demands of the fresh water stream are less stringent due to the absence of the dissolved salts and chemicals.

Valve installation and startup

The SWRO industry has experimented with various materials, such as aluminum bronze, 904 SS, 254SMO and duplex stainless steels. Alloys are required to have a PREN number exceeding 40 to reduce the possibility of pitting corrosion. In general, the SWRO industry uses different variations of super duplex stainless steel as it has the greatest resistance to highly corrosive seawater.
One potential source of difficulty for butt-welded plug valves occurs when the valves are welded into the piping



Late in 2008, Flowserve Corporation introduced a plug valve designed for high-pressure applications in the seawater reverse osmosis (SWRO) desalination industry.

About the author

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during installation. Because plug valves contain soft parts such as the PTFE sleeve, the welding interpass temperature of the body of the valve should be kept at 250°F (120°C) or lower in order to ensure that the sleeve does not become distorted, requiring replacement.

During startup, it is not uncommon for debris from the construction process to damage the valve's sleeve if not handled properly. Pressure increases in the system must be closely controlled to avoid damage to the expensive reverse osmosis membranes.

Pressures up to 70 bar (1000 psi) are required in order to push the seawater through the membranes. However, the membranes cannot be exposed to rapid pressure increases without incurring damage. Industry standards dictate that the system should increase gradually from ambient to full-process pressure in about two minutes. This gradual increase in pressure can be achieved by either variable speed drive (VSD) pumps or through the use of a valve downstream from a traditional pump.

VSD pumps allow for a controlled increase in pressure but are expensive, so some plants use plug valves with characterized ports downstream of the pump. During startup, when the valve is only slightly open, part of the seat can be exposed to the high-velocity flow resulting in damage. To avoid this problem, plug valves are designed with a bypass line containing a smaller valve (see Figure 2). The smaller valve uses a seat capable of withstanding the high pressure drop experienced on system startup.

At time of startup, the main valve is closed and the bypass valve is opened. This bypass valve is sized to ensure that the system pressure is increased at the recommended rate. Once the system reaches full-operating pressure, the main valve is opened to allow for full-flow capacity.

Plug valve advancements decrease maintenance costs

Recently, a new type of super duplex stainless steel plug valve has been designed to be easily repairable in-line. The valves have no discrete seat; instead the plug is lined with PFA material. The inner bowl of the body is machined so that the PFA-encapsulated plug rides directly on the body. The valves can be easily repaired by removing the plug, even while the valve is welded in-line, which reduces maintenance and installation costs.

The improved valve design gives the installer the option of removing the PFA-lined plug from the body before welding, thereby eliminating damage to the seat. Care must still be taken to ensure that the temperature of the body does not exceed 350°F (177°C) as excessive heat can change the chemical nature of the super duplex stainless steel material, reducing its chemical resistance. After welding is complete, the valves are re-assembled in the body and pressure tested prior to startup.

As the worldwide demand for potable water continues to increase and more desalination plants are built, valve technologies will continue to evolve to withstand the harshest operating environments while reducing the installation and maintenance costs for the SWRO desalination industry, helping to bring fresh water to populations around the world.