Drinking Water from the Sea

Changing climatic conditions, population growth, and the resulting development of existing limited natural supplies all build up pressure on the supply of clean drinking water. Reverse osmosis is an established method of turning seawater into drinking water. A new approach to this technology has led to a marked reduction in supply costs. Sulzer Pumps has played a key role in the successful development and commissioning of the groundbreaking Ashkelon (IL) desalination plant, the world’s largest reverse osmosis installation.

In solutions, molecules move naturally from regions of higher concentration to regions of lower concentration. Osmosis is a special case of diffusion where the solvent moves across a semipermeable membrane from lower to higher concentration. It can be slowed, stopped, or even reversed if sufficient pressure is applied to the membrane from the concentrated side. When water is forced across the membrane against the concentration gradient, from higher concentration to lower concentration, the process is called reverse osmosis (RO) (Fig. 1). Reverse osmosis—a very fine form of filtration—allows the removal of particles as small as ions from a solution. The diameter of ions is in the magnitude of 0.2 nm or, for example, about 1/100 of that of viruses. Depending on the salt concentration, the pressure on the raw-water side of the semipermeable membrane is raised to 60–70 bar and it forces the purified fluid through the membrane whereas most particles are rejected.
Reverse Osmosis

1 Reverse Osmosis is often used to remove salts from water in order to make it suitable and safe for drinking. Sulzer pumps work in the world’s largest desalination plant that uses this process.

Energy Recovery

Usually, pumps provide the pressure to drive the process. The energy necessary to drive the pumps is the highest cost item over time. Historically, the rejected high-pressure brine passes through an energy recovery device such as a Pelton turbine or a reverse-running pump to reduce the energy requirements of the primary driver. The efficiency of the pressure recovery has to be high in order to reduce running costs as the plants typically operate continuously. As the rejected brine is highly corrosive due to concentration of dissolved salts, the materials of construction of the pump require particular attention, as high internal velocities can lead to rapid corrosion of critical components.

Currently, only about 30 percent of the worldwide desalination installed capacity involves reverse osmosis, but membranes developed in recent years have made the process much more economical and popular up to the point that it represents around half of the new annual construction. Furthermore, the new technology for energy recovery, which uses the isobaric chamber principle, is even more efficient than Pelton turbines (Fig. 2). Sulzer Pumps is able to deliver equipment suitable for either turbine or pressure exchange recovery.

The World’s Largest Plant

Once fully operational, the Ashkelon plant will be the largest RO plant in the world, producing 110 million m³/year of drinking water, which roughly amounts to the average annual consumption of around 850,000 persons in a typical eastern Mediterranean country. Two stand-alone blocks, which take their raw feed from the Mediterranean Sea, will each produce 55 million m³ annually.

The most innovative process feature is the so-called Three Center Design, which comprises a pressure center, a membrane rack center, and an energy recovery center (Fig. 3). These three arrangements provide significant flexibility and reduce the overall water cost.

Sulzer Pumps Drive the Process

A small number of large high-pressure pumps (three off 14×14×19A MSD-D/two-stage pumps plus one in stand-by per plant) form a pressure center, which supplies seawater to all the membrane racks via a common header. The energy recovery center consists of 20 isobaric chambers of reciprocating type (Fig. 4). The pressure center is designed for operation at maximum efficiency with minimum maintenance. The energy recovery center is capable of changing its pumping flow independently of the high-pressure pumps. The membrane racks (including the novel concept of eight membranes per tube) are designed especially to ease cleaning and, consequently, to provide high availability.

Special Control Program

The problem of equal distribution of feed flow to the membrane racks and proportional collection of brine represented a challenge to system designers (Fig. 5). As there is a certain degree of mixing of seawater and brine in the isobaric chambers, the feed flow coming from the isobaric chambers is slightly more salty than the feed flow coming from the high-pressure pumps, thus exposing the membrane racks located near the energy recovery center to higher salinity. The pressure drop in the distribution and collection lines could cause unevenness in the flow shared between the membrane racks; future fouling and cleaning will also cause asymmetry in the hydraulic resistance of the membranes. A special control program was developed to overcome all those problems and is another essential element in optimizing plant operation.

Long-Term Guarantees

Pump selection was so critical to the success of the project that submissions were assessed for operating cost over 25 years, perform-
ance curve characteristics that closely matched process needs, and a guarantee of efficiency after 5 years in operation. So critical were these aspects to the project that Sulzer engineers designed tailor-made hydraulics for several of the applications to ensure an optimum solution. After order placement, Sulzer carried out a detailed review of the pipe work layout for the main pumps and developed stage machine pumps to help ensure successful operation on start-up of the pumps.

**Resistant Materials**

Of equal importance was the selection of materials to ensure long life of the pumps and prevent the possibility of any damage to the membranes. Sulzer’s long experience in both RO and arduous offshore oil production applications led to the selection of proven grades of duplex stainless steels for all wet parts. Of further benefit to the customer was the ability of Sulzer Pumps to provide the full range of pumps needed on the project, sourced from plants in Brazil, Finland, and South Africa. A single-point contact based in the UK, where also the main high-pressure pumps were manufactured, provided the project management.

Sulzer Pumps supplied in all 47 pumps absorbing more than 50 MW. These include the critical services of seawater intake (five off BS 650) and main high-pressure feed (eight off MSD-D 14x14x19/two stage). The first phase of the plant was successfully commissioned in August 2005 and is operating at planned capacity. The second phase is due on stream in February 2006. Site checks show that all the pumps are performing well and within the guaranteed efficiency values. Overall pumping power requirements are lower than the guarantee levels, which reduces the operating costs for the operating utility.

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