4-11. System Components

High Pressure Pump

The high pressure pump must provide smooth and continuous flow to the RO membrane elements and also be sized to provide the necessary flow rate at the desired pressure. Its energy consumption is one of the major expenses of RO system operation. There are two types of high pressure pumps, centrifugal pumps and piston pumps. Centrifugal pumps, which operate by spinning the fluid with the pump impellers are more energy-efficient than piston pumps, which use various numbers of mechanical plungers to create pressure. The centrifugal pumps provide more smooth and continuous flow than the piston pump, and are controlled by a throttling valve on the discharge line. The piston pump cannot be throttled, so pressure is controlled by a back pressure valve installed in a by pass line from the pump discharge to the pump suction. The pressure from piston pumps tends to pulsate, creating surges, which could damage RO membrane elements and therefore should be controlled using a damper (accumulator).

Pressure Vessel

Pressure vessel (membrane element housing) is designed for specific pressure applications. Most pressure vessels are overdesigned for safety reasons to withstand a pressure at 1.5 times the rated operating pressure. The vessel materials are usually FRP (fiber glass reinforced plastic) and sometimes stainless steel (316L) for special applications such as very high pressure applications (>800psig).

Pressure vessels are available with different diameters, lengths, and pressure ratings. The smaller vessels with diameters in the range of 1.5 to 2.5 inch are usually supplied by Payne. All other vessels with diameter in the range of 2.5 to 8 inch and the pressure rating up to 1000psig are manufactured by Advanced Structures Inc.

Alarms and Shutdowns

There is always the possibility of a malfunction in the RO system or with the pretreatment. Instruments can be used to monitor the quality of the RO feed water as well as the performance of the RO system. The instruments such as flow meters, pressure gauges, pH meters and conductivity meters can be connected with an audible alarm that will sound if some parameter is not within design specifications. Furthermore, if the parameter is significantly out of the specifications to damage the high pressure pumps and the RO elements or to produce an unacceptable permeate water, then the alarm should warrant automatic shutdown of the RO system. Suggested alarms and shutdowns are shown

below :

- Low inlet pressure damaging the high pressure pump
- Too high feed pressure damaging the RO elements
- High feed temperature damaging the RO elements
- High permeate pressure damaging the RO elements
- Too high concentration of colloidal matter or sparingly soluble salts in the feed damaging the RO elements
- Oxidizing agents in the feed damaging the RO elements
- Low concentrate flow fouling the RO membranes
- Oil in the feed fouling the RO membranes

Instruments, Valves, and Equipment

As mentioned above, instruments and valves are necessary not only to detect a malfunction in the RO system, but also to ensure proper routine operation of the system. The necessary instruments, valves, and other equipment are listed below in more details.

Pressure gauges to measure the pressure drop across the cartridge filter, the pressure on the pump inlet line and discharge line, the feed pressure to the membrane element(s), the pressure drop between feed and concentrate of each array, and eventually the pressure in the permeate line. Liquid-filled gauges should contain membrane compatible fluids such as water or glycerin in place of oils or other water immiscible liquids.

Flow meters to measure feed, concentrate and total permeate flow rate, also permeate flow rate of each array. pH meter in the feed line after acidification to control carbonate scaling potential. Conductivity meters in the feed line, in the brine line, and in the permeate line to determine permeate quality and salt rejection. Sample ports on the feed, concentrate and permeate line (total permeate and permeate of each array) to be able to evaluate system performance. A sample port on each pressure vessel permeate outlet is recommended to facilitate troubleshooting.

Feed inlet valve to shut down the plant for maintenance and preservation. Valve on the pump discharge line or pump bypass line to control feed pressure during operation and feed pressure increase rate during start-up. Check valve on pump discharge line. Check valve and atmospheric drain valve on permeate line to prevent the permeate pressure from exceeding the feed pressure. Flow control valve on the concentrate line to set the recovery (Caution: back-pressure valve must not be used). Valve in the permeate line to provide permeate drain during cleaning and start-up. Valves in the feed and concentrate line (and between arrays) to connect a cleaning circuit.

A small draw-back tank is necessary in the permeate line to provide enough volume for osmosis

backflow when a seawater system shuts down. Without the tank, air could be sucked into the membrane elements to dry the membrane (flux loss) and to contaminate the permeate side by airborne bacteria and fungi.

A shut down flush system flushes the feed-concentrate line with pretreated feed water or with permeate water after shut own, especially when scale inhibitors are used, and also in the case of a seawater system.

Materials of System Construction

The materials of system construction including the RO elements, pumps, pressure vessels, pipes, valves and instruments should be compatible with the pressures, vibrations, and temperatures during the RO system operation. The materials must also be resistant to the potential corrosion attacks caused by the high chloride content of the feed water and the concentrate stream, and the chemicals used for membrane cleaning.

Non-metalic materials such as plastics and fiberglass are widely used not only for economic reasons (e.g. pressure vessels and pipes), but also for preventing corrosion and chemical attacks, usually in the low pressure (<10 bar) applications.

However, it is usually necessary to use metals for the high-pressure (10-70 bar/ 200 - 1,000 psig) parts such as pumps, piping and valves. Carbon and low alloy steels do not have sufficient corrosion resistance, and their corrosion products can foul the membranes.

Stainless steel type AISI 316L with <0.03 % C is recommended for the pipe system for RO plants with concentrate stream TDS below 7000 ppm. For TDS higher than 7000 ppm, stainless steel type 904L is preferred for pipes and bends for welding and stainless steel type 254 SMO should be used for flange connections, valves, and pumps where crevices occur.