ENVIROGEN TECHNOLOGIES

A Lifecycle Performance Company

TECHNICAL BULLETIN - RO SYSTEM OPERATIONS

Operating and maintaining a Reverse Osmosis (RO) system can be a challenge. Proper pretreatment to prevent fouling, and identification of potential issues are critical steps, as well as knowing when and how to clean the membranes or replace them. This Technical Bulletin will offer guidance to help optimize RO system performance over time.

RO SYSTEM BASICS

RO systems are used to treat water and other aqueous solutions for a number of applications including boiler feed, process water, rinse water, wastewater, recycle water reclaim, product purification and in some cases concentration of the end product.

Osmosis is the natural process in which water diffuses through a semi-permeable membrane to dilute a more concentrated solution to equilibrium. Reverse Osmosis reverses the natural osmotic flow by applying pressure to the contaminant bearing water which forces less concentrated water (permeate) through the membrane concentrating the contaminants in the rejected stream. The amount of permeate generated is called flux. The feed water source typically determines the allowed flux of the membrane. The cleaner the source water the higher the flux rate allowed.

RO elements are typically spiral wound with an FRP outer wrap. The elements are designed to be cross flow with the feed water travelling parallel to the membrane surface across the feed channel spacer. The treated water, called product water or permeate, is collected in the product tube in the center of the membrane element and may exit through either end of the element. The water with concentrated contaminants, called reject or brine, exits the membrane element on the opposite end from the feed. The turbulence created by cross flow velocity and the feed channel spacer prevents buildup of contaminants on the membrane surface and is a critical factor in the design of the system to help prevent fouling.

RO Membrane elements are housed in pressure vessels. The number of pressure vessels required for the feed flow is referred to as a stage. RO Systems may consist of multiple stages. Each stage in a reverse osmosis system typically operates at 50% recovery with 50% of the feed exiting as permeate (product) and 50% as concentrate (reject). Feed flow is controlled by a flow control valve or by VFD control of the feed pump. Applied pressure to the membranes driving the permeate flow is controlled with the concentrate (reject) flow control valve.

MONITORING RO SYSTEM PERFORMANCE

RO Permeate Flow can be impacted by several factors including total dissolved solids in the feed water, age of the membrane, fouling and scaling of the membrane, pressure, and temperature. As the feed water changes, the permeate flow can increase or decrease, and sometimes competing factors can cancel each other out, masking a potential problem. Water temperature is particularly important, with cold water reducing flow and hotter water increasing flow based on the viscosity change of the water.

When operating an RO system, it is imperative to monitor and record pressures, flows, temperature, and conductivity at multiple points throughout the process. Also, make note of when the system is cleaned and/or elements replaced. A daily logbook is critical for troubleshooting. Some systems will have PLC data logging and trending software, but Envirogen recommends use of a logbook.

Monitoring should be conducted at the baseline and then daily. This will help identify both sudden and gradual changes occurring in the system and will help to troubleshoot the system. The gradual changes are the ones most easily overlooked.

Since operating conditions can change over time and affect the system, the data needs to be normalized. Basically, normalization is a calculation that factors out changes in the operating conditions, such as temperature and net driving pressure, to allow a clearer view of what is happening in the system. Membrane manufacturers offer software programs that take the monitored data and run the calculations to interpret the data compared to the baseline data. It is not uncommon to see steady product flow data, but declining normalized flow that is indicative of a problem.

When seeing a decline in product flow, some operators may be tempted to Increase feed pressure to maintain permeate flow. However, this is detrimental to the elements since higher pressures may cause compaction and mechanical damage to the membrane and exacerbate fouling issues at the surface. A better approach is to monitor normalized flow, and when a 10% drop in normalized flow is reached, membranes should be cleaned.

RO SYSTEM PROBLEMS

Fouling is the most common RO membrane issue. Fouling is the deposition of unwanted materials on the membrane surface. Membranes can be fouled with inorganics/scale minerals, organic materials, bacteria/biofilms, and/or with particulates/colloids.

Telltale signs that your RO membrane is fouled are:

- High differential pressure
- Reduced permeate (product) water output
- Increased cleaning frequency
- Increased energy usage
- Shorter membrane life
- Drop in permeate water quality
- Higher operating costs

Hardness is a particularly common type of scaling caused by the presence of calcium and magnesium in the feed water. Scaling typically occurs the most on the last element in a stage and in the second or last stage of the system. This happens as the salts concentrate to the point that they exceed the solubility of the compounds. Hardness scaling is particularly problematic as it can result in permanent flux decline.

Elements can also be mechanically (compaction, telescoping) or chemically (oxidation, hydrolysis) damaged, or fouled with oils, organics, or particulates (mud, silt, colloids). The key is to identify the source of the fouling or damage and to determine if it is reversable or permanent. A membrane autopsy may be required to identify the cause and extent of the fouling. Once the cause of the fouling or damage is determined, the most effective cleaning regimen can be selected. Most of the time fouling can be reversed, provided the best cleaning procedure is used. If there is a mechanical failure, such as pin hole leaks that cannot be reversed, the elements will need to be replaced.

MEMBRANE CLEANING

As a rule of thumb membranes should be cleaned when the normalized flux decreases by 10%. Note that when multiple foulants are in play, the method of cleaning and the order of cleaning matters greatly. Membrane cleaning methods include mechanical and chemical cleaning. Chemicals used include acids, alkalis, chelants, detergents, surfactants, and special formulations. Consult with Envirogen's technical staff for assistance in determining the best cleaning method for the specific membrane type/model, and for cleaning services.

FOULING PREVENTION

The best way to prevent membrane fouling is with proper pretreatment. Antiscalant or other chemical pretreatment is one option. For source water with hardness issues, a softener would be more effective and less expensive. Particle filtration is a must to prevent particulate fouling.

Typically, 5µ depth filters or sand filters are used upstream of the RO to reduce the silt density index (SDI). Knowing whether the feed water has a lot of colloidal particles is also important. The SDI may be low (<3 as measured with a 0.45µ membrane disc), but colloids (<0.2 u) will still foul the membranes. A good particle size distribution analysis may be required. Ultrafiltration systems have been used to prevent colloidal and biological fouling.

RO SYSTEM SERVICE

To ensure that an RO system maintains optimal performance, contracting the services of RO system experts should be considered.

During a typical monthly on-site system evaluation and service the Envirogen technician will inspect the system and analyze the operation data, monitor alarms, check for leaks or damage, adjust flow and pressure if necessary, change pre-filters, and vent air from the RO pump, etc.

Following each visit, Envirogen will prepare and issue a report that can be used to identify and mitigate any major issues. Once issues are known, planning and budgeting for necessary services to keep the RO system operating at its optimum level can be implemented. Annual service visits may also be desired, where the Envirogen technician will lube pumps, test controller function, and calibrate equipment.

During the service visit, the technician can also inspect and service other equipment that you might have on site such as pretreatment and posttreatment equipment (filtration, activated carbon systems, softeners or ion exchange systems) and replace consumables as needed (cartridge and bag filters, softener salt, IX resins, etc).

Envirogen also offers new RO membrane systems and replacement RO membranes for existing systems.

CONTACT US FOR ALL YOUR WATER TREATMENT SYSTEM NEEDS!

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