HYDRANAUTICS
High Performance Membrane Products
A NITTO DENKO CORPORATION

Troubleshooting Your RO

Summary: There can be many reasons why a RO system suffers a loss in performance, and is unable to produce the proper quantity and/or quality of permeate water. Similar to a doctor attempting to make a diagnosis, you must identify as many symptoms as possible before you can derive an educated guess as to what the disease is.

INTRODUCTION

The focus of this paper is how to troubleshoot a RO system on-site. Many of the techniques assume the equipment has been designed with instrumentation and sampling points to allow troubleshooting and for on-site cleanings, which is common for "industrial quality" systems, but not necessarily for "residential or light commercial" equipment. The capital cost for small RO to include troubleshooting instruments and sample valves is prohibitive for their market niches, relative to the minimal cost of replacing RO elements on a more frequent basis. As RO systems reach a certain size (say 15 gpm or larger), the cost of replacing RO elements on a frequent basis becomes prohibitive versus the initial capital cost of adding instruments, sample valves and on-site cleaning equipment.

HOW TO AVOID TROUBLE

The best way to stay out of trouble with a RO system is to avoid it initially. A few RO design tips are:

- Design the RO system with access to a complete water analysis. If there are seasonal variations (which are common for surface sources) or varying sources (which are common with municipal sources), get all the analyses you can and be sure they are recent.

- Perform 15 minute SDI (Silt Density Index) tests. This on-site testing helps to determine the potential for colloidal silt fouling. Refer to TSB113.
- Invest in the appropriate pretreatment. If you want to sleep well at night, make sure the system design has adequate pretreatment to the RO.
- Design the RO system flux rate conservatively, especially if the potential for fouling exists. A RO with a clean well water source can be designed more aggressively than one for a surface water source. A reduced rate of permeate water flow for a given area of membrane reduces the convective deposition of foulants at the membrane surface. Fluxes for surface waters should range from 8 to 14 gfd (gallons per square foot of membrane area per day) and 14 to 18 gfd for well sources.
- Design the RO recovery rate conservatively. A conservative per cent recovery of the feed water minimizes the concentration of foulants.
- Maximize the cross flow velocity in the elements. A conservative design maximizes the cross-flow velocity of the feed and concentrate streams. A higher cross-flow velocity reduces the concentration of salts and foulants at the membrane surface by increasing their diffusion back into bulk feed stream above the membrane surface.
- Select the right membrane for the application. Sometimes a neutrally charged CAB (cellulose acetate blend) or LFC (Low Fouling Composite) RO element is a better choice than a negatively charged CPA (Composite PolyAmide) RO element for difficult surface or waste water sources.

IDENTIFYING A PROBLEM

Verify that you really have RO system fouling. Changes in system operating parameters do have an effect on performance. For instance, an increase in feed TDS (total dissolved solids) will increase feed pressure requirements by approximately 1 psig for every 100 ppm TDS increase due to increased osmotic pressure and it will also increase permeate conductivity since the RO will always reject a fixed percentage of the salts. A 10^{o} F increase in feed water temperature will decrease the feed pump pressure requirement by 15%. An increase in the per cent recovery of the system will increase the reject TDS which in turn will increase permeate conductivity. (Concentrate TDS due to concentration of the feed water is 2 times higher at 50% recovery, 4 times higher at 75% recovery and 10 times higher at 90% recovery). Finally, a reduction in the permeate flow will result in higher conductivity if the same recovery is maintained because the passage of salts through the membrane is independent of the passage of water through the membrane, which results in less permeate water to dilute the salts that have passed through.

It is recommended that you "normalize" your logged operating data to determine if you have a problem with your system. "Normalization" computer programs, such as RODATA, graphically represent normalized permeate flow, per cent salt rejection and feed-to-reject pressure drop. These normalized parameters are calculated by comparing a particular day's operations to the first day of operation. Adjustments are made for changes in major operating variables such as temperature, feed TDS, recovery, and pressures. In this way, performance declines unrelated to operating parameters can be identified and treated.

Questions to ask yourself…

Loss in performance is generally divided into two categories: loss of flow, and loss of rejection. The following lists of questions help to identify possible root causes for either of these problems.

<u>Loss of Flow</u>

Attributable to fouling, these questions can help pinpoint the problem. Certain foulants impact the front end of the system while others impact the back end of the system. Use the RO Troubleshooting Matrix (at the end of this document) to help determine the nature of the foulant.

- <u>Did you shut down the RO system properly</u>? In some instances, the reject water from the Service operation should be flushed out of the system upon shutdown. If not, inorganic foulants can precipitate onto the surface of the membrane. The best flush water source is RO permeate.
- <u>Did you store the RO system properly</u>? Improperly stored systems (especially under warm conditions) can produce a severe biofilm problem. (Refer to TSB's 101, 103, 108, and 110 for more information).
- <u>If you acidify to lower feed pH or add scale inhibitor (SI) for the control of calcium carbonate (lime) scale, are you meeting your target pH or SI concentration</u>? If not, you may need to do an acid clean. (TSB's 100, 102, 107)

- Has your pressure drop between the feed and reject lines increased greater than 15%? Increasing pressure drop indicates that fouling of the feed path and a restriction of flow over the membrane surface is occurring. Monitoring pressure drops across stages gives you the advantage of determining if the fouling is limited to a particular stage, which can help identify the potential foulant.
- In seawater systems, are you flushing with permeate water at shut-down? Flushing removes high concentrations of ions that could precipitate out of solution. At a minimum, feedwater can be used, but it is recommended to use permeate water for the flush.
- Are the cartridge filters fouling? Inspect the RO feed cartridge filter for foulants as this is relatively easy.

Loss of Rejection

Loss of rejection displays itself as a higher permeate conductivity. It may be due either to fouling, degradation of the membrane surface, or an o-ring leak. The following questions can help you pinpoint the source of this problem. Verify that the permeate conductivity has not increased greater than 15%.

- Do all the vessels in a stage have nearly the same conductivity permeate? Measure permeate quality by stage and by pressure vessel if possible. One vessel having a significantly higher permeate conductivity probably has a faulty o-ring, a disconnect, or a damaged membrane. (See TSB's related to vessel shimming (TSB 109) and vessel probing (TSB 114) to determine the point of the leak).
- Have your composite membranes been exposed to chlorine or any other strong oxidant? The exposure may have damaged the membranes.
- Have your cellulose acetate (CAB) membranes been exposed to pH extremes? The exposure may have damaged the membranes. Likely causes of pH extremes are faulty metering pumps, acid tanks that have gone dry, loss of prime to the metering pump, or flushing/storage in non-acidified water.
- Is the instrumentation accurate? Verify that all of your instruments are calibrated properly.

- Do the elements look discolored or damaged? Inspect the RO elements for foulants or physical damage.
- How do the actual conductivity and temperature of the feedwater compare to the design criteria? If the actual feedwater has higher TDS or is warmer than the design, this may account for the discrepancy. Sample and obtain detailed water analyses of the RO feed, concentrate and permeate. Compare the results of the analyses to the RO design projections of the element manufacturer.
- Can there be times when the permeate pressure exceeds the feed pressure? If the permeate is pumped to an elevated position, and there are no check valves on the permeate lines, at shut down, the permeate pressure can exceed the feed pressure. This can cause the membrane envelopes to expand and rupture.
- Are your o-rings in good condition? O-rings can flatten or crack with age. The result is that leaks can develop. Replacement of o-rings periodically is a good, cost-effective preventive maintenance step. Alternatively, vessels may be probed (TSB 114) to find faulty o-rings.

IF you still think there is a problem…

- Once you have ruled out any mechanical failures as the source of your RO problem, then you need to determine what your suspected foulant or foulants are and perform a cleaning or series of cleanings.
- The cleaning solution can be collected and analyzed for the foulants removed, color change or pH change. The effectiveness of the cleaning can be verified by placing the RO back into Service.
- If you don't know what your foulants are and don't want to experiment on site as to what cleaning solution(s) are required and what the proper cleaning procedures should be, their are companies who specialize in the supply of proprietary cleaning chemicals and off-site evaluations of RO elements. These services can be invaluable, especially the first time around in cleaning a RO.
- If all else fails in determining what fouled the RO element, a destructive autopsy can be performed. The RO element is cut open and unrolled with analytical tests run on the membrane and the foulant to determine the problem.

Hydranautics can perform analytical testing of foulants at our labs, as well as perform Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray analysis to help determine the cause of fouling. TSB 116, Returned Goods Authorization (RGA) Procedure, provides a list of services and costs.

Summary

This list of questions should help in troubleshooting most RO problems. Attached is a table to help determine some of the most common problems from the given systems.

If further assistance is required, contact the Technical Service Group at Hydranautics by e:mail or at 1-800-CPA-PURE (1-800-272-7873)

RO Troubleshooting Matrix

Possible Cause	Possible Location	Normalized Pressure Drop	Normalized Permeate Flow	Normalized Salt Passage
Metal Oxide	**1st stage**	**Normal to Increased**	**Decreased**	**Normal to Increased**
Colloidal Fouling	**1st stage**	**Normal to Increased**	**Decreased**	**Normal to Increased**
Scaling	**Last stage**	**Increased**	**Decreased**	**Increased**
Biological Fouling	**Any stage**	**Normal to Increased**	**Decreased**	**Normal to Increased**
Organic Fouling	**All stages**	**Normal**	**Decreased**	**Decreased or Increased**
Oxidant (e.g. Cl_2)	**1st stage most severe**	**Normal to Decreased**	**Increased**	**Increased**
Abrasion (carbon, silt)	**1st stage most severe**	**Normal**	**Increased**	**Increased**
O-ring or glue leaks	**Random**	**Normal to decreased**	**Normal to Increased**	**Increased**
Recovery too high	**All stages**	**Decreased**	**Normal to Decreased**	**Increased**