SYSTEM

TROUBLE-SHOOTING

Investigation of RO Element Performance Loss and Countermeasures

Lewabrane®

LANXESS
Energizing Chemistry

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1. Troubleshooting

1.1 Introduction

The problems typically encountered in RO systems are salt rejection decrease, product flow rate decrease and pressure drop increase. If the decrease or increase occurs moderately or slowly, this may indicate a normal fouling which can be handled by proper and regular cleaning. However, a sudden change in performance may be caused by a defect or mis-operation in the plant. It is essential that the proper countermeasures are taken as soon as possible because any delay decreases the chance of restoring the plant performance. The steps for troubleshooting are briefly summarised in Figure 1.1.

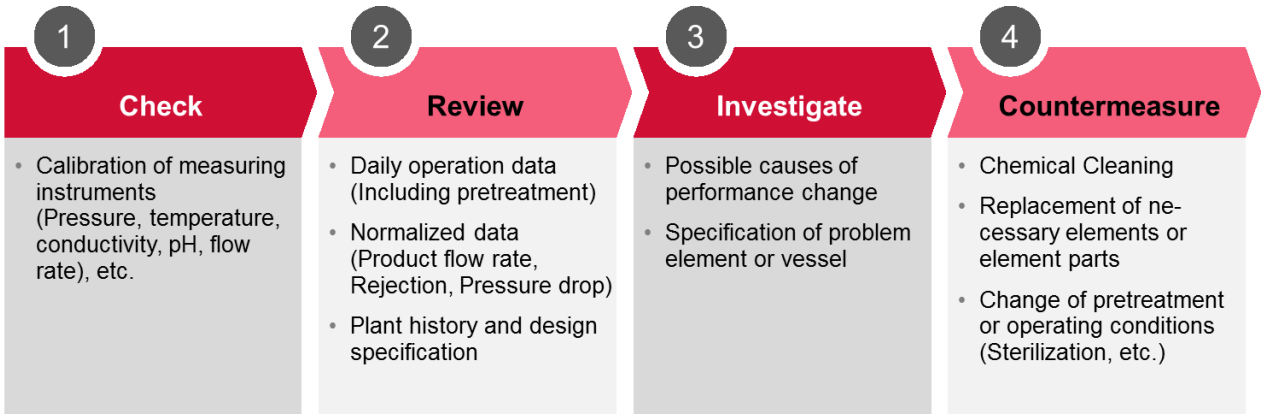


Figure 1.1: Steps for troubleshooting Under “4” above, Countermeasure, “Replacement of necessary elements OR element parts

1.2 Typical Performance Change

1.2.1 Rejection decrease case

In the RO system, the causes of salt rejection decrease are usually:

- changes in operating conditions (feed composition, temperature, pressure, recovery rate, etc.)
- chemical damage to the membrane (oxidation by oxidizing agent, hydrolysis by strong acid or base)
- fouling or scaling
- mechanical leakage (membrane de-lamination, membrane surface damage, defective element parts

If polyamide RO membrane elements are exposed to oxidizing chemicals, irreparable damage will happen to the membrane, normally followed by a decrease of salt rejection. In this case, the lead element is typically more affected than the downstream elements. And, heavy metal ions (Cu, Co, Mn, etc.) can accelerate the oxidation by catalysis.

Causes of mechanical leakage are usually:

- membrane de-lamination
- membrane surface damage (fracture, abrasion, scratch)
- glue line failure
- O-ring leak or brine seal leak
- interconnector or center pipe crack

Because mechanical leakage often results in the direct passage of feed or concentrate

water to the permeate (passing the membrane), the leakage greatly affects the RO system rejection.

1.2.2 Determination of the specific element with decreased rejection

To determine the specific element which has low rejection from mechanical leakage or the oxidation, a center pipe probing method is often used on site.

First, the suspected leakage vessels are specified by pressure vessel profile. In all vessels, TDS or conductivity or other relevant quality values are individually checked by comparing to baseline start-up data. If one vessel shows a significantly higher permeate conductivity than the other vessels of the same stage, the center pipe probing method is performed to this vessel. A flexible tube is inserted through the permeate port of the vessel to measure the permeate TDS or conductivity, or other relevant quality values at known intervals through the vessel. Figure 1.2 shows the conductivity profile from a center pipe probing method.

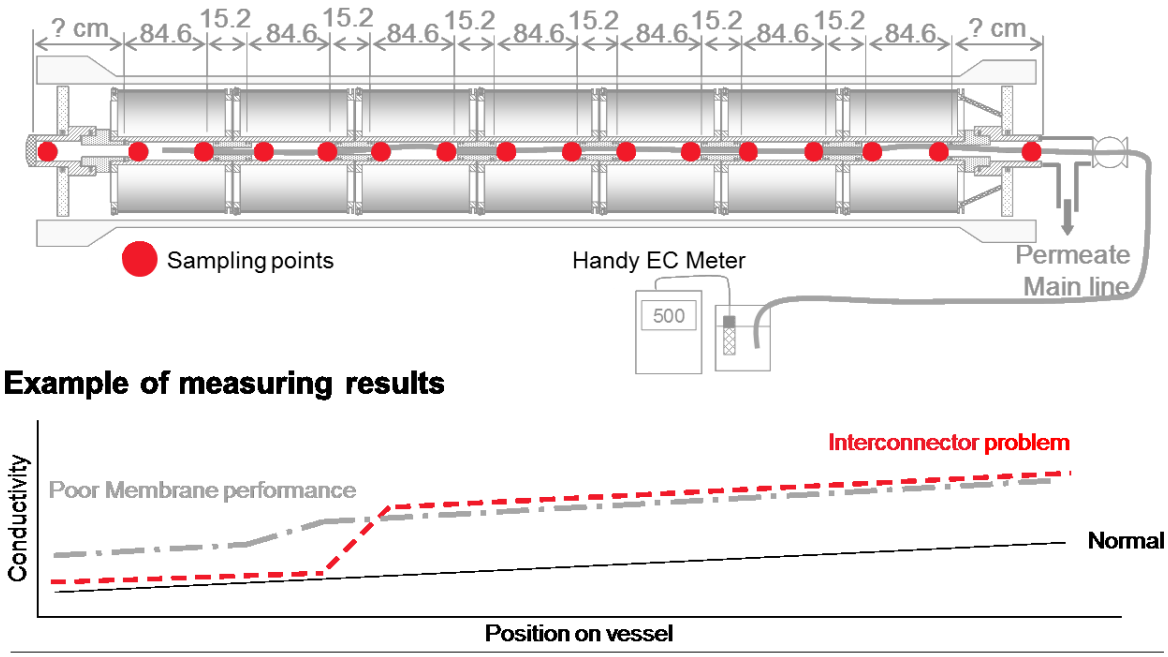


Figure 1.2 Conductivity profile from a center pipe probing method

1.2.3 Permeate flow rate decrease case

In the RO system, the causes of permeate flow rate decrease are usually:

- changes in operating conditions (feed composition, temperature, pressure, recovery rate etc.)
- membrane fouling (insoluble solids, microbiological fouling, chemical fouling)
- membrane scaling

Membrane fouling and membrane scaling are described in more detail in a separate Technical Service Bulletin available on our Lewabrane® web site. Once permeate flow

rate decreases, operating pressure should be increased to maintain a constant permeate flow rate. When the operating pressure increases, any foulants are pressurized, and pressed into the pore of the membrane typically resulting in temporary lead element flux increases. But this means that the foulant will be more difficult to remove, and that membrane fouling will be accelerated. If the permeate flow rate of the element is too low and cannot be restored by cleaning, the element should be replaced.

To characterize fouling or scaling, the below indications are typical:

- Fouling is often found in lead element of first stage, while scaling occurs in end element of last stage.
- A gel like structure is a strong indication for biofouling.
- White crystal structure is a strong indication for scaling.

It is important to remember that a final conclusion regarding fouling and scaling is often confirmed by autopsy of the RO element.

1.2.4 Pressure drop increase case

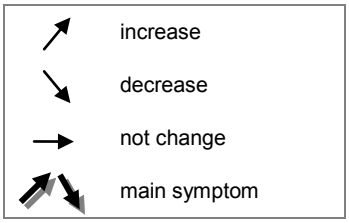
Pressure drop increase has the same cause as permeate flow rate decrease that is usually plugging of the feed or concentrate channel with the fouling or scaling materials. As the pressure drop increases, the thrust force may damage the RO element (transformation of the element; telescoping, etc.). Additionally, as described earlier, the higher operational pressure will accelerate the fouling process.

1.3 Causes of Performance Change, and Countermeasures

Specific performance changes in the permeate flow rate, the salt rejection and the pressure drop can usually be related to specific causes. Although, the symptoms of different causes may overlap, typically there is one main symptom causing the majority of the trouble. In Table 1.1, an overview of the causes in RO system performance changes are shown, their possible causes, typical tendency of performance change, and its countermeasures are given.

Causes	Performance Changes			Countermeasure
	Product Flow Rate	Rejection	Differential Pressure	
Leak from element parts (O-Ring, brine seal, center pipe)	↗	↘	→	Replace the parts
Membrane leak (back pressure, abrasion)	↗	↘	→	Replace the element
Degradation of separating membrane (Oxidation)	↗	↘	→	Replace the element
Degradation of support membrane (Solvent)	⇗	↘	→	Replace the element
Scaling	↘	↘	↗	Cleaning, Improve pretreatment (scale control)
Biofouling	↘	→	⇗	Cleaning, Disinfection, Improve treatment
Particle fouling or Colloidal fouling	↘	↘	↗	Cleaning, Improve treatment
Chemical fouling (Adsorption)	↘	→	→	Cleaning, Replace the element, Improve pretreatment

Table 1.1: Typical tendency of RO system performance changes and its countermeasures



1.4 Evaluation Steps during Troubleshooting

1.4.1 Evaluation of system performance and operation

If the plant performance is not satisfactory, the first step is to calibrate the measuring instruments. Then, the next step is to evaluate the performance and the operation of the entire system. This is done on the basis of normalized plant data (permeate flow rate, rejection and pressure drop), usually calculated by a normalization program. When the actual normalized plant performance is compared against the performance at start-up, any significant RO performance deterioration can be directly identified, and subsequently investigated.

1.4.2 Element performance test on site

In case of a change in RO plant performance, a single element performance test on site could be conducted to investigate the situation (assuming measuring equipment exists on site). The tests usually consist of:

- Visual inspection of the exterior of the RO element
- Measuring the weight of the RO element
- Measuring RO element performance, such as flow and rejection at standard conditions
- Comparing the change in RO element performance before/ after cleaning

When measuring the weight of RO elements, the element should be kept standing vertically for 30 minutes (to drain water) before measuring the weight. A new RO element weight is about 15-16 kg in usual wet conditions. Measuring the RO element weight will help to understand the fouling or scaling tendency in the pressure vessel.

Figure 1.3 shows an example of weight changes of fouled elements in a pressure vessel.

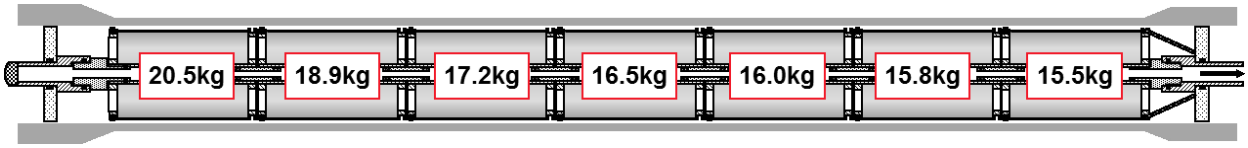


Figure1.3: Example weight measurement

1.4.3 Returned element inspection

When the causes of a plant performance change are not known, or when they should be confirmed, one or more elements of the system should be returned to the membrane manufacturer (LANXESS) for individual element analysis. Inspection items of returned element are usually:

1. Visual inspection - outlook, photograph, weight
2. Standard element performance measurement - salt rejection, permeate flow rate, pressure drop
3. Element autopsy
4. Standard performance measurement of autopsied membrane - salt rejection, permeate flux
5. Analysis of foulant or scale - weight, water content, rate of ash, inorganic or organic analysis
6. Observation of physical damage - dye test, photography of membrane surface
7. Judgement of chlorine contact - Fujiwara test etc.
8. Dipping test (of autopsied membrane) - in cleaning solution, then performance measured
9. Cleaning test (element)
10. Inspection report

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CONTACT

LANXESS Deutschland GmbH
Business Unit Ion Exchange Resins
Chempark Leverkusen
51369 Leverkusen, Germany
Email: lewabrane@lanxess.com

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