FILMTEC Membranes

Troubleshooting: Symptoms of Trouble, Causes and Corrective Measures

Trouble with the performance of an RO/NF system normally means at least one of the following:

- Loss of normalized permeate flow rate; in practice this is normally seen as a feed pressure increase in order to maintain the permeate output.
- Increase in normalized solute passage; in RO this is typically associated with an increase in permeate conductivity.
- Increase in pressure drop: the difference between feed pressure and concentrate pressure at constant flow rate becomes larger.

From such symptoms, their location and kind of occurrence, the causes of the trouble can often be determined. In the following sections, the mentioned three main troubles are discussed systematically.

Low Flow

If the system suffers from loss of normalized permeate flow performance and the problem can be localized, the general rule is:

- First stage problem: deposition of particulate matter; initial biofouling
- Last stage problem: scaling
- Problem in all stages: advanced fouling

A low flow performance may be combined with a normal, a high or a low solute passage. Depending on this combination, conclusions as to the causes may be drawn.

Low Flow and Normal Solute Passage

Low permeate flow associated with normal solute passage can have the following causes:

a. Biofouling and Natural Organic Matter (NOM):

Biofouling of the membranes is indicated by the following changes in the operating parameters, predominantly at the front end of the system:

- Permeate flow decreases when operated at constant feed pressure and recovery.
- Recovery decreases when operated at constant feed pressure, in cases where biofouling is advanced to large biomasses.
- Feed pressure has to be increased if the permeate flow is to be maintained at constant recovery. Increasing the feed pressure is however self-defeating when done for a long time, since it increases the fouling, making it more difficult to clean later.
- Differential pressure increases sharply when the bacterial fouling is massive or when it is combined with silt fouling. Since pressure drop across the pressure vessels can be such a sensitive indicator of fouling, it is strongly recommended that provisions for installing differential pressure monitoring devices be included for each stage in a system.
- Solute passage remains normal or even low at the beginning, increasing when fouling becomes massive.

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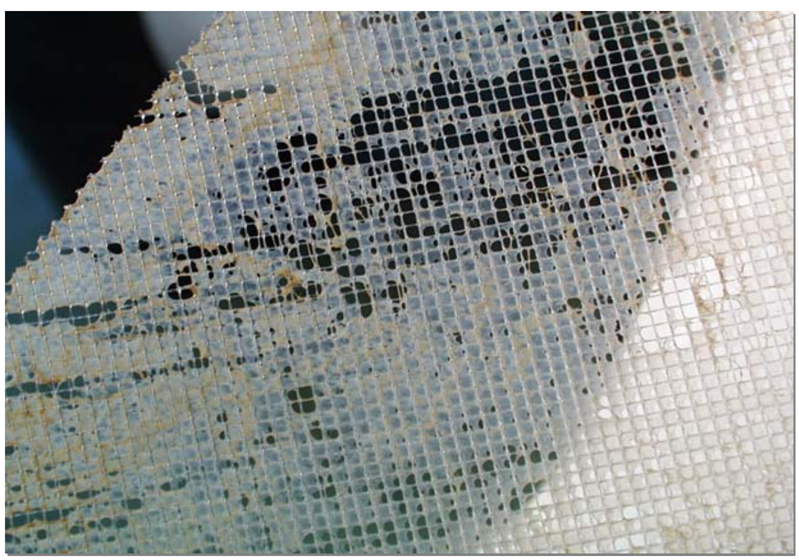
Low Flow (cont.)

- High counts of microorganisms in water samples taken from the feed, concentrate, or permeate stream indicate the beginning or the presence of biofouling. For proper microbiological monitoring see *Assessment of the Biological Fouling Potential (Section 2.6.2)*. When biofouling is suspected, the system should be checked according to the items described in *System Design Considerations to Control Microbiological Activity (Section 3.15)*.
- Biofilms feel slippery to the touch, often have a bad smell
- A quick test for biofouling is the burn test: a sample of biofilm is collected with a spatulum or the point of a knife and incinerated over the flame of a lighter. The smell of a burnt biofilm is like the smell of burnt hair. *(This is really just a quick test for an indication but not for a proof.)*

Figure 8.4 and Figure 8.5 are photos of a biofouled membrane and feed spacer, taken after element autopsy.

Figure 8.4 Picture of biofilm on membrane surface

Figure 8.5 Picture of feed spacer with biofilm



Low Flow (cont.)

Causes for biofouling are mostly the combination of a biologically active feedwater and improper pretreatment.

The corrective measures are:

- Clean and sanitize the entire system, including the pretreatment section and the elements. See *Cleaning Procedure (Section 6.5)*. An incomplete cleaning and dis-infection will result in rapid re-contamination.
- High pH soak and rinse – see cleaning instructions for *Biofouling (Section 6.9.6)*.
- The installation or optimization of the pretreatment system to cope with the fouling potential of the raw water. See *Biological Fouling Prevention (Section 2.6*).
- Installation of Fouling Resistant (FR) elements.

b. Aged Preservation Solution

Elements or RO systems preserved in a bisulfite solution can also become biologically fouled, if the preservation solution is too old, too warm, or oxidized by oxygen. An alkaline cleaning usually helps to restore the permeate flow. Renew preservative solution if storing elements. Store in cool, dry, dark environment.

c. Incomplete Wetting

FILMTEC™ elements that have been allowed to dry out may have a reduced permeate flow, because the fine pores of the polysulfone layer are not wetted. The techniques to re-wet dry membranes are described in *Re-wetting of Dried Out Elements (Section 7.3.2)*.

Low Flow and High Solute Passage

Low flow associated with high solute passage is the most commonly occurring condition for plant failure. Possible causes are:

a. Colloidal Fouling

To identify colloidal fouling:

- Review recorded feedwater SDI's. The problem is sometimes due to infrequent excursions or pretreatment upsets.
- Analyze residue from SDI filter pads.
- Analyze accumulations on prefilter cartridges.
- Inspect and analyze deposits on feed scroll end of 1st stage lead elements.

The corrective measures are:

- Clean the elements depending on foulant (see *Cleaning Procedures for Specific Situations - Section 6.9.1*).
- Adjust, correct and/or modify the pretreatment.

b. Metal Oxide Fouling

Metal oxide fouling occurs predominantly in the first stage. The problem can more easily be localized when permeate flow meters have been installed in each array separately. Common sources are:

- Iron or aluminium in feedwater (see *Prevention of Iron and Manganese Fouling - Section 2.9*, and *Prevention of Aluminum Fouling - Section 2.10*).
- Hydrogen sulfide with air in feedwater results in metal sulfides and/or elemental sulfur (see *Treatment of Feed Water Containing Hydrogen Sulfide - Section 2.11*).
- Corrosion of piping, vessels or components upstream of membrane elements.

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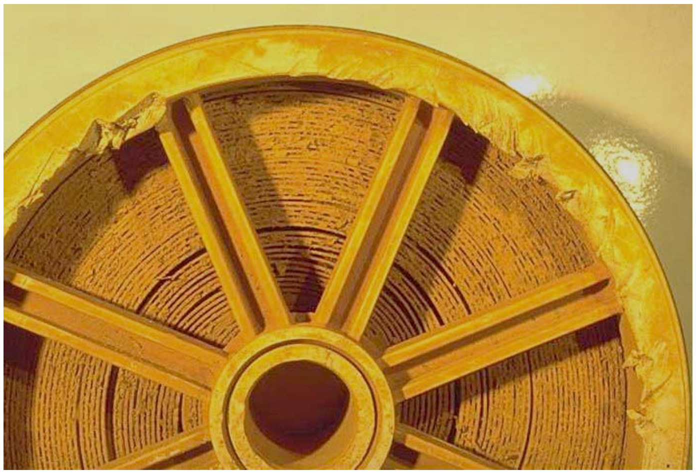
To identify metal oxide fouling:

- Analyze feedwater for iron and aluminium.
- Check system components for evidence of corrosion.

Iron fouling can easily be identified from the look of the element – see Figure 8.6 for example.

Figure 8.6 Picture of iron fouled feed side of an element with telescoping damage and signs of mechanical force



The corrective measures are

- Clean the membrane elements as appropriate (see *cleaning procedure - Section 6.5*).
- Adjust, correct and/or modify the pretreatment
- Retrofit piping or system components with appropriate materials.

c. Scaling

Scaling is a water chemistry problem originating from the precipitation and deposition of sparingly soluble salts. The typical scenario is a brackish water system operated at high recovery without proper pretreatment. Scaling usually starts in the last stage and then moves gradually to the upstream stages. Waters containing high concentrations of calcium, bicarbonate and/or sulfate can scale a membrane system within hours. Scaling with barium or with fluoride is typically very slow because of the low concentrations involved.

To identify scaling:

- Check feedwater analysis for the scaling potential at prevailing system recovery.
- Analyze the concentrate for levels of calcium, barium, strontium, sulfate, fluoride, silicate, pH and Langelier Saturation Index (Stiff & Davis Saturation Index for seawater). Try to calculate the mass balance for those salts, analyzing also feed water and permeate.
- Inspect concentrate side of system for scaling.
- Weigh a tail element: scaled elements are heavy.
- Autopsy tail element and analyze the membrane for scaling: the crystalline structure of the deposits can be observed under the microscope. A foaming reaction with acid indicates carbonate scaling. The type of scaling is identified by a chemical analysis, EDXRF or ICP analysis.
- Scaling is hard and rough to the touch – like sand paper. Cannot be wiped off.

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Low Flow (cont.)

Photographs of scaled membranes are shown in Figure 8.7.

Figure 8.7 Picture of scaled membrane surface with imprints from the feed spacer

The corrective measures are:

- Cleaning with acid and/or an alkaline EDTA solution (see *cleaning procedure - Section 6.5*). An analysis of the spent solution may help to verify the cleaning effect.
- Optimize cleaning depending on scaling salts present.
- Carbonate scaling: lower pH, adjust antiscalant dosage.
- Sulfate scaling: lower recovery, adjust antiscalant dosage and type.
- Fluoride scaling: lower recovery, adjust antiscalant dosage or type.

Low Flow and Low Solute Passage

a. Compaction and Intrusion

Membrane compaction and intrusion is typically associated with low permeate flow and improved salt rejection. Compaction is the result of applied pressure and temperature compressing the membrane which may result in a decline in flux and salt passage. Intrusion is the plastic deformation of the membrane when pressed against the permeate channel spacer under excessive forces and/or temperatures. The pattern of the permeate spacer is visibly imprinted on the membrane. Intrusion is typically associated with low flow. In practice, compaction and intrusion may occur simultaneously and are difficult to distinguish from each other. Although the FILMTEC membrane shows little compaction and intrusion when operated properly, significant compaction and intrusion might occur under the following conditions:

- high feed pressure
- high temperature
- water hammer

Water hammer can occur when the high pressure pump is started with air in the system.

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Low Flow (cont.)

Damaged elements must be replaced, or new elements must be added to the system to compensate for the flux loss. If new elements are installed together with used elements, the new elements should be loaded into the tail positions of a system to protect them from too high flux operation. New elements should be distributed evenly into parallel positions. It should be avoided to have vessels loaded exclusively with new elements installed in parallel with other vessels containing exclusively used elements. This would cause an uneven flow distribution and recovery of the individual vessels.

For example, if six elements of a 4(6):2(6) system are to be replaced, the new elements should go into position 4, 5 and 6 of each of the two vessels of the 2nd stage. Likewise, if six elements are to be added, they should go into positions 5 and 6 of the 3 vessels of the 2nd stage of an enlarged 4(6):3(6) system. If for some reason this is not possible, at least positions 1 and 2 of the first stage should not be loaded with brand new elements.

b. Organic Fouling

The adsorption of organic matter present in the feed water on the membrane surface causes flux loss, especially in the first stage. In many cases, the adsorption layer acts as an additional barrier for dissolved salts, or plugs pinholes of the membrane, resulting in a lower salt passage. Organics with a high molecular mass and with hydrophobic or cationic groups can produce such an effect. Examples are oil traces or cationic polyelectrolytes, which are sometimes used in the pretreatment. Organics are very difficult to remove from the membrane surface.

To identify organic fouling:

- Analyze deposits from filter cartridges and SDI filter pads.
- Analyse the incoming water for oil and grease, as well as for organic contaminants in general.
- Check pretreatment coagulants and filter aids, especially cationic polyelectrolytes.
- Check cleaning detergents and surfactants.

The corrective measures are:

- Clean for organics (see *organic fouling - Section 6.9.5*). Some organics can be cleaned successfully, some cannot (e.g. heating oil).
- Correct pretreatment: use minimal coagulant dosages; monitor feedwater changes to avoid overdosing.
- Modify pretreatment, i.e. oil/water separators.

FILMTEC Membranes
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