Pretreatment
Iron, Manganese & Transition Metals

The following are general recommendations for controlling high levels of iron, manganese and other transition metals in systems using reverse osmosis (RO) and nanofiltration (NF) elements. For additional information on cleaning elements, please see MANN+HUMMEL Water & Fluid Solutions' various Cleaning Guides or contact MANN+HUMMEL Water & Fluid Solutions Technical Service.

INTRODUCTION

Iron and manganese may be found in water in two different states: either in a reduced state which tends to be soluble, or in an oxidized state which tends to be insoluble. Of the two metals, iron is usually the most prevalent in naturally occurring water sources. Iron may be heavily prevalent in a well water source, especially if the pump is starting to rust. Black iron or carbon steel used for piping, tanks or tank internals may also contribute to the iron concentration in the feed water.

If the iron or manganese concentration is greater than 0.05 mg/L in the feed water, its removal is highly recommended. If the iron or manganese is in the reduced (soluble) state, it may not cause any fouling problems with the element system. However, if air enters the system or if any oxidizing agents are introduced, the iron or manganese will oxidize into their insoluble states and may foul the membrane elements. In their insoluble state, iron and manganese may also catalyze the oxidative effects of residual oxidizing agents and lead to membrane degradation.

SOURCES OF FOULING

Iron fouling occurs more frequently than manganese fouling because iron oxidizes at a much lower pH. Typical sources of iron fouling include:

- Anoxic waters (waters that are depleted of oxygen) typically contain soluble divalent iron or manganese, or both. If water containing iron or manganese has come into contact with more than 5 mg/L of oxygen or has been chlorinated, the metals convert from their soluble, reduced state (i.e. ferrous, Fe^{2+}) to an insoluble oxidized state (i.e. ferric, Fe^{3+}). As a result, hydroxide flocs (oxidized iron and/or manganese) form, which in turn may foul the RO/NF membranes. The oxidation of iron and manganese is given by:

  $$4\ Fe(HCO_3)_2 + O_2 + 2\ H_2O \rightarrow 4\ Fe(OH)_3 + 8\ CO_2$$
  $$4\ Mn(HCO_3)_2 + O_2 + 2\ H_2O \rightarrow 4\ Mn(OH)_3 + 8\ CO_2$$

  If an anoxic process is used, it is highly recommended to avoid the following to prevent iron fouling:
  - Oxygen leakage into the feed water,
  - Reaction of iron with silica to form insoluble iron silicate,
  - Oxidation by iron-reducing bacteria. This may result in the acceleration of biofilm growth and iron deposit on the membrane surface.
  - Blending water containing ferrous iron with water containing hydrogen sulfide (H_2S). This mixture may lead to the formation of an insoluble black ferrous sulfide, FeS.

  Regular cleaning may be necessary for an anoxic process to restore membrane performance. An alternative method of handling anoxic waters includes oxidation-filtration.

- Natural organic matter (NOM) containing iron complexes.
- Hydroxide flocs from coagulation process.
- Corrosion products from piping materials used for the feed water. When pipes or other pieces of equipment begin to corrode, the concentration of iron and other transition metals in the feed water increases. As a result, the potential for iron fouling increases.
- Silicates containing iron.

PRETREATMENT

Iron fouling is very common. Fortunately, iron fouling can be cleaned fairly easily, but there are some pretreatment methods that may help prevent fouling from occurring:

- Oxidation with filtration. Manganese greensand or oxidizing agent injection oxidizes the transition metal to an insoluble state. Once contaminants are oxidized to their insoluble states, the greensand acts as an excellent filter to remove them prior to the RO/NF systems. Media filters that include greensand are able to remove iron, manganese or hydrogen sulfide down to concentrations as low as 0.01 mg/L.
- Prevent oxidation and precipitation of iron and manganese by keeping the feed water in a reduced state. To do so, it is recommended to prevent exposure of the water to air or to any oxidizing agents (i.e. chlorine).

OPERATIONAL CONSIDERATIONS

pH

A low pH is favorable in attempt to slow Fe^{2+} oxidation. Optimal conditions to keep iron in solution include a pH less than 6 and oxygen concentrations less than 0.5 mg/L.

Permeate Flush

The membrane elements should be flushed for a minimum of 3 minutes with permeate water each time that the membrane system shuts down. This will flush out the highly concentrated water in the tail-end of the system which will prohibit precipitation during this stagnant flow period.

CLEANING PROCEDURE

A customized cleaning procedure must be implemented on a scheduled maintenance basis. This will ensure removal of any iron or manganese fouling.

Please refer to MANN+HUMMEL Water & Fluid Solutions' **Membrane Cleaning Guide – Water Application Elements** (TSG-C-001) for cleaning recommendations using alkaline cleaners TriClean™ 214TF or TriClean™ 212TF (for thin-film composite RO and NF membranes).

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