

# Water Chemistry Considerations When Installing an RO System to Treat Boiler Make-up Water Originally Only Sodium Zeolite Softened

## Introduction

The addition of a reverse osmosis (RO) system to a boiler plant which originally only sodium zeolite softened the make up water significantly improves the purity of the boiler feedwater. The lower dissolved solids water produced by the RO reduces the potential for boiler and steam system deposition and corrosion enabling our customers to reduce boiler blowdown, saving both energy and water treatment chemicals. In addition, because the alkalinity of the RO treated water is lowered carbon dioxide in the condensate is reduced and the potential for condensate system corrosion lowered.

The many potential benefits that can be derived by adding an RO to a softened water system can be fully realized only with a water chemistry program that takes into consideration the revised water characteristics and the operating requirements of the plant. The following discussion has been prepared to help formulate effective treatment recommendations so our customers receive the maximum benefit from their RO system.

## RO Permeate (Treated Water)

The RO permeate normally has less than 5% of the dissolved solids present in the RO feed stream, but the concentration of dissolved gases such as carbon dioxide is unchanged. Consequently, the pH of the RO permeate is lower than that of the influent water. For most waters, the pH of the RO permeate will be between 5.5 and 6.0. Figure 1 shows the ef-

fect of varying levels of carbon dioxide on RO permeate pH.

Providing it does not result in membrane fouling, a controlled feed of caustic to the RO feed stream can be used to convert a portion of the carbon dioxide to bicarbonate ion making it removable by the RO membrane. For each ppm of caustic fed, the carbon dioxide level will be reduced by 1.1 ppm.

Some systems feed acid to the RO feed stream to control membrane fouling. In this case for each ppm of sulfuric acid fed, the amount of carbon dioxide in the treated water will be increased by 0.9 ppm resulting in an even lower pH of the RO permeate.

In most instances, the carbon dioxide in the RO permeate can be removed by the deaerator. Any carbon steel equipment between the RO and the deaerator should be provided with a corrosion resistant lining or replaced with corrosion resistant materials such as stainless steel. If the water is from a well with a high carbon dioxide content or if acid is fed ahead of the RO to control scaling, the deaerator design should be checked to be sure that the materials of construction are suitable for handling the low pH stream and that the deaerator will remove the amount of carbon dioxide present.

In those instances where the carbon dioxide level is too high to be removed by the deaerator the carbon dioxide in the RO permeate can be removed by a decarbonator, reducing the corrosivity of the treated water.



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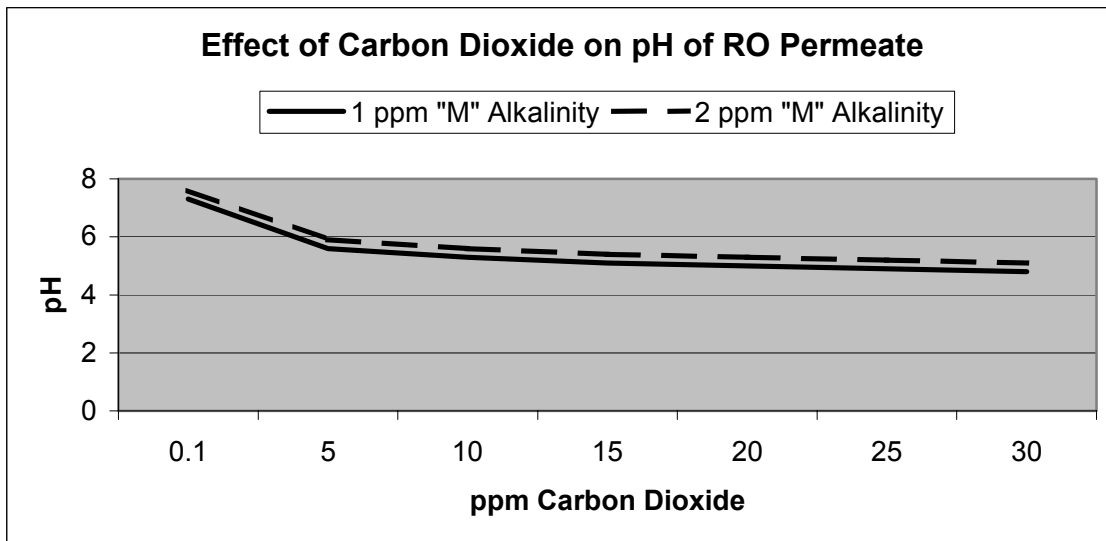


Figure 1: The pH of RO permeate decreases with increasing carbon dioxide content.

Where it is impractical to line or replace the carbon steel equipment between the RO and the deaerator, the pH of the RO permeate can be adjusted by the addition of neutralizing amine or caustic to protect the carbon steel equipment between the RO unit and the deaerator. When economically practical, neutralizing amine is preferred for this purpose, as most of the carbon dioxide will be vented from the system by the deaerator reducing the potential for condensate system corrosion. In addition, nearly all of the amine added for this purpose will stay in the system providing protection for the feedwater and condensate systems.

When caustic feed is used for RO permeate pH control, only a small amount of the carbon dioxide will be vented in the deaerator. Most of the carbon dioxide neutralized by the caustic will be released to the steam by the decomposition of bicarbonate and carbonate ions in the boiler water. The corrosion potential will be less than it was with softened make up water, but much greater than if the carbon dioxide is nearly all vented in the deaerator or reduced with a decarbonator.

When the RO permeate will flow through equipment previously used for lime softening, the equipment should be mechanically cleaned to remove the large amounts of scale formed during operation. Filters that will remain in the system should also be cleaned. Betz Dearborn IEC2 can be used for this purpose. Following mechanical cleaning the units should be rinsed with RO permeate to achieve an

“acceptable level” of effluent hardness before placing in service. Hardness levels of 5 to 10 ppm can be expected for several weeks. If the lime softener cannot be mechanically cleaned, high levels of hardness (up to 100 ppm) can be expected for several months.

## Boiler Feedwater Pumps

Many systems with softened boiler feedwater have pumps with carbon steel housings and carbon steel or bronze impellers. These materials of construction may not be suitable for handling the higher purity water produced by the RO. The customer's feedwater pump supplier should be consulted to determine if a change in pump metallurgy will be required.

## Oxygen scavenger

Catalyzed sulfite is normally recommended for the control of dissolved oxygen corrosion when sodium zeolite softened make up water is used. With the use of higher purity RO make up water the application of Control OS products, which both scavenge oxygen and help passivate the metal surface without adding solids to the boiler water, often proves beneficial. If a change in oxygen scavenger is contemplated be sure to consider any regulatory requirements such as those in plants where steam contacts food.

Where preferred, sulfite can still be used for most systems that do not use feedwater as a source of steam attemperating water. For systems without deaerators or with a history of poor deaerator performance, catalyzed sulfite is recommended for boilers operating at pressures up to 900 psig pressure. However, an alkaline sulfite product should be used as the more popular acidic sulfite products will depress the pH of the lightly buffered boiler feedwater and increase the potential for corrosion. An acidic sulfite product can be used as long as care is taken to maintain an adequate feedwater pH. The feedwater pH should be maintained above 8.5 for effective oxygen scavenging and it is often beneficial to maintain a pH of 9.0 or greater to minimize feed-line corrosion as discussed in the "Condensate and Boiler Feedwater Treatment" section of this document.

## Internal Treatment

Most reverse osmosis make up systems will have boiler feedwater hardness levels of 0.5 ppm or less. Lower levels are attainable, if required, through multi-staging and/or combination with other unit operations. Also, feedwater iron levels of less than 0.050 ppm are expected as low alkalinity make up water allows highly effective, economical treatment of the condensate and feedwater systems. The application of all-polymer treatments, OptiSpense\* AP products, can be very effective in maintaining clean boiler heat transfer surfaces. These easy to apply and control treatments will protect against unscheduled outages due to equipment damage and help boost boiler efficiency by maintaining clean heat transfer surfaces. Minimum boiler water "P" alkalinity of 75 ppm is recommended.

Although many polymer applications are successfully fed to the boiler feedwater, the preferred point of boiler polymer addition is to the boiler steam drum. This will reduce the pick up of iron from the boiler feedwater lines and economizer. Where the feed of polymer to the feedwater line is required, an Optisperse product is preferred to limit the amount of feedwater system iron transported into the boiler. An exception to this recommendation should be considered when high feedwater iron levels cannot be avoided. In this instance, an Optisperse HTP product is preferred.

If the boiler feedwater is of sufficient purity, (typically, zero hardness and less than 0.1 ppm sodium), which can be attained by an RO/mixed bed or RO/EDI system, a coordinated phosphate-pH treatment program should be considered for those plants operating at pressures greater than 600 psig. Lower pressure boilers may also use coordinated phosphate-pH treatment, however, it is recommended that a minimum pH of 10 be maintained to minimize any potential for erosion-corrosion (flow accelerated corrosion).

## Condensate and Boiler Feedwater Treatment

The effective treatment of condensate and feedwater systems requires the application of volatile amines to maintain an alkaline pH throughout the system. Heitmann, et. al. (Figure 2) showed that at typical condensate system conditions the corrosion of low carbon steel is greatly reduced as the pH is elevated beyond 8.5 toward 9.5.

Plants using sodium zeolite softened make up water usually do not have optimum protection of their condensate systems because they under feed the amine due to chemical cost concerns. With reverse osmosis treated water, it is usually economically attractive to optimize the condensate and feedwater treatment protection by boosting the condensate and feedwater pH to 9.0 or above. Maintaining a condensate pH of 9 or greater reduces both the potential for ferrous alloy equipment failure and the return of iron corrosion products to the boiler.

For those systems with copper alloys, it is recommended that the pH be maintained below 9.2, with a pH control range of 8.8 to 9.2 considered a good compromise for the protection of both carbon steel and copper alloys.

In addition to neutralizing amines, hydroxylamine passivation of the system metal will help assure equipment reliability resulting in reduced maintenance costs and lower boiler feedwater iron and copper levels. The application of Steamate\* PAS products provides this added benefit compared to neutralizing amine only.

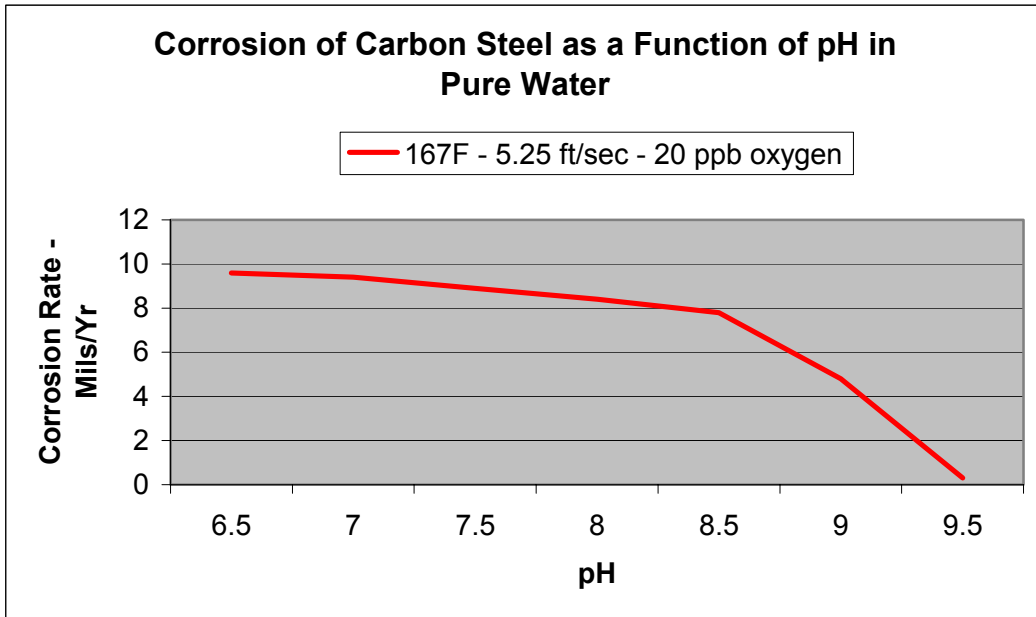


Figure 2 – The corrosion rate of carbon steel decreases rapidly as pH increases above 8.5. (Heitmann, H.G., Kastner, W., "Erosion-Corrosion in Water-Steam Cycles Causes and Counter Measures," VGB Kraft Works Technik 62, No. 3, March, 1982)

## Assistance

For assistance in developing a water treatment program that is best for you contact your local GE Water & Process Technologies representative.