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Using RO Permeate for Boiler Pretreatment: Benefits, Costs and Treatment Considerations

There are well documented advantages for the use of Reverse Osmosis permeate for boiler feedwater makeup. These include the following:

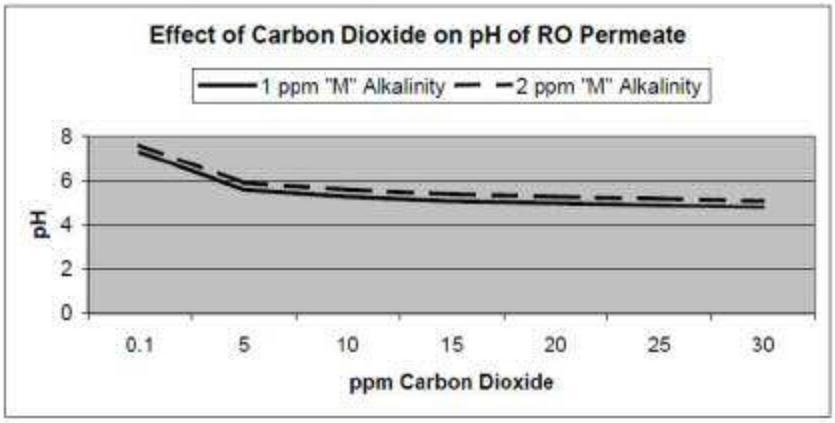
1. Energy Savings due to reduction in boiler blowdown. Reducing 95%+ of the dissolved solids in the makeup can increase cycles of concentration to as many as 50+ cycles. This reduces boiler blowdown Depending on current blowdown heat recovery systems and current percent condensate return the heat recovery can be significant. Reducing blowdown by an excess of over 70% is typical. Boilers using RO permeate as makeup typically have cleaner heat transfer surfaces and are more efficient than boilers using most other pretreatment equipment. One project showed actual boiler fuel reduction of 4.3% due to the use of RO for boiler pretreatment. (See project review)
2. Reduced chemical costs. The internal boiler treatment is reduced significantly due to better quality makeup, higher cycles of concentration and less makeup water required. The amount of chemical required to prevent condensate corrosion is much less due to alkalinity reduction in the boiler makeup water. One RO replacement project resulted in a total of 60% chemical treatment costs reduction. (See project review)
3. Improved steam quality. This is because the boiler water conductivity is normally less. Also alkalinity influenced carryover is lower in boilers using RO permeate for makeup .
4. Reduced condensate corrosion. Because of the reduction of carbon dioxide in condensate systems pH control and consequently condensate corrosion of process equipment, steam traps, condensate recovery systems and condensate return lines is much improved. This often results in reduced maintenance costs in many plants. If condensate system corrosion is causing lower condensate recovery RO treated boiler water can also impact energy savings by increasing condensate return.
5. Reduced regenerant costs. If softeners or demineralizers are used for boiler feedwater preparation , RO installation can reduce and sometimes eliminate salt, acid and caustic requirements. This often reduces waste treatment costs.
6. Water Savings or Cost is net of the following :
    a. Savings: Reduced Blowdown, Improved long term condensate return, Reduced Regenerant water usage, Possible use of RO Concentrate in other conservation projects, Possible other water conservation uses as RO feedwater
    b. Costs: Concentrate water , RO pretreatment losses including filter backwash, CIP water uses

The above benefits will often outweigh the costs of providing RO quality water for boiler feedwater. The cost-benefit analysis however should also include the following:

1. The cost of feedwater preparation prior to the RO system. This might include any pretreatment equipment and chemistry required. This may also include antiscalant, dechlorination or biocide requirements.
2. Electrical costs for operating high pressure RO feedwater pumps.
3. Capital costs for the RO equipment
4. Maintenance costs for the maintenance of the RO equipment. This may also include CIP (Clean in Place) costs.
5. Replacement costs for the replacement of RO elements.
6. Water Savings or Cost is net of the following:
    a. Savings: Reduced Blowdown, Improved long term condensate return, Reduced Regenerant water usage, Possible use of RO Concentrate in other conservation projects, Possible other water conservation uses as RO feedwater
    b. Costs: Concentrate water , RO pretreatment losses including filter backwash, CIP water uses

Reverse Osmosis Treatment Considerations in Boiler Feed Systems

1. Dissolved gases (notably carbon dioxide) in unbuffered RO permeate may lower boiler makeup pH to point where corrosion of preboiler or predeaerator feedwater may become an issue. (See attached graph) This especially may be an issue when acid is being used to is being fed to reduce RO fouling. Examples of ways to prevent this problem may include:
    a. Controlled feed of caustic to RO feedwater can convert some of carbon dioxide to bicarbonate making it removable at the RO.
    b. Controlled feed of caustic or neutralizing amine in the RO permeate to buffer permeate pH. Using caustic may increase the potential for carbon dioxide related condensate system corrosion.
    c. Using a decarbonator for carbon dioxide removal from the RO permeate. This is often preferred if the permeate carbon dioxide levels plus other dissolved gases exceed the capacity of the deaerator.
    d. Using corrosion resistant linings or corrosion resistant materials such as stainless steel in the equipment and piping between the RO and the deaerator.
2. Boiler feedwater pumps having carbon steel housings and bronze impellars that may not be suitable for handling high purity water produced by RO systems. The feedwater pump supplier should be consulted if a change in metallurgy is required.
3. If sulfite is used for an oxygen scavenger it is best to not use acidic sulfite solutions in the feedwater because the low buffering capacity of the RO permeate. Erythobate/sulfite solutions are effective because erythobate is a passivator as well as an oxygen scavenger. Catalyzed sulfite should be considered especially when the feedwater pH is low. Buffering feedwater pH may be necessary with either caustic or neutralizing amine to enhance the oxygen scavenging.
4. For RO feedwater polymer formulations can be used to control internal boiler deposits. Caustic can be used to buffer either the feedwater and or the boilerwater. Standard phosphate/polymer can be used but phosphate residuals are less important when hardness levels are low.
5. RO feedwater reduces the alkalinity and consequently makes buffering the condensate much easier. Maintaining condensate pH in the 8.5 to 9.0 with neutralizing amines is recommended. Adding DEHA as an oxygen scavenger and passivator is also an effective strategy to minimize condensate corrosion.



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Project Benefits Summary

Reverse Osmosis Installation - Boiler Feedwater Preparation

Savings Achieved

Date Installed: November 15, 2005
Energy Savings: 4.3% of Total boiler fuel costs
Chemical Saving: 60.2% of Total boiler treatment chemical costs
Payback: 19 months

Unique Features of this Project

1. Real Time Monitoring of Key Operational Parameters - Designed by KWT
2. Concentrate from RO System is being used as Condenser Makeup
3. Ongoing Operator Training to assure System Effectiveness and Membrane Life
4. Pretreatment - 2 stage Automatic Dechlorination - Designed by KWT
5. No System Downtime or loss of Membrane Efficiency in First Year of Operation

Additional Savings from Project

1. Improved Steam Quality
2. Improved Condensate Corrosion Control
3. System Sized for Plant Expansions
4. Project included Softening of Sanitation Hot Water System - Improved Sanitation Reliability

Prepared by: EBF Company : KWT	Notes RO Installation Features & Benefits	Customer: Project : RO Installation Date : Nov. 15, 2005