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## Using Reverse Osmosis for Boiler Pretreatment

*By James McDonald, P.E., CWI and Dave Chustophersen, CWI*

There are numerous makeup water pretreatment strategies for boiler systems including softeners, dealkalizers, demineralizers, and reverse osmosis. Factors such as makeup water characteristics, economics, manpower, system familiarity, boiler requirements, space requirements, and so forth, will determine which pretreatment strategy is used. Reverse osmosis (RO) has come of age in the past decade as a real, economical alternative for boiler pretreatment. RO pretreatment produces a higher quality water than many other pretreatment strategies, but can come with some operational trade-offs. These trade-offs may be positive or negative depending upon the situation.

In order to gain a better, practical understanding of using RO for boiler pretreatment, it is helpful to compare a typical soft water pretreatment program to that of an RO pretreatment program. Advantages of RO over a softener boiler pretreatment program include:

- 90 to 99.9% removal of dissolved solids to allow boiler to operator at much higher cycles of concentration (up to 100 cycles).
- Removal of more than just hardness (calcium & magnesium).

- Lower boiler makeup and blowdown rates.
- Lower fuel usage.
- Less internal boiler treatment chemicals required.
- Less alkalinity resulting in less neutralizing amine demand.
- Cleaner boilers.
- Reject may be of good enough quality for cooling tower makeup or wash water.
- If using softeners with RO, the regeneration costs (including salt and water) may decrease depending upon the current condensate return and blowdown rate.
- No regenerant chemicals.
- For the right waters, lower manpower requirements may be realized.

Disadvantages of RO as compared to a softener boiler pretreatment program include:

- Increased electrical costs.
- If acid pretreatment is used, acid handling will be required.
- Product water flow rate is pretty much fixed while ion exchange can manage variable flows.
- An antiscalant may be necessary upstream of the RO.
- With polyamide (PA) membranes, chlorine must be removed upstream of the RO.

- Increased monitoring responsibilities including RO normalized permeate flow, percent salt passage, pressure drops, SDIs, conductivity, temperatures, etc.
- Commonly 25 % of water into an RO comes out as reject. If this water has no other uses, it is sent down the drain.
- Membranes must be cleaned and replaced periodically.
- Microbiological fouling can be an issue.
- Flow is temperature sensitive.
- May need additional pretreatment equipment.
- In some waters, higher manpower requirements are seen.

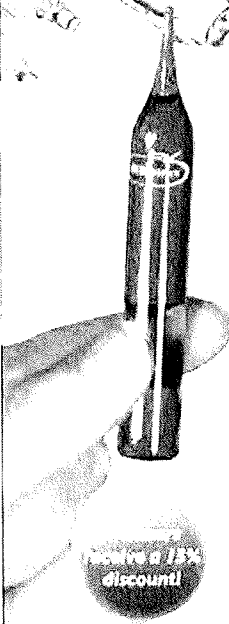
Similar advantages and disadvantages apply when comparing RO to other boiler pretreatment systems as well. Table 1 outlines the additional advantages and disadvantages of RO as compared to dealkalizing and demineralizing.

Table 1: Reverse Osmosis Comparisons

| Pretreatment Strategy       | RO Advantages  | RO Disadvantages  |
|-----------------------------|--|---|
| Anion Exchange Dealkalizing | <ul style="list-style-type: none"> <li>• Does not add chlorides</li> <li>• Removes more than just alkalinity</li> </ul>  | <ul style="list-style-type: none"> <li>• Higher capital cost</li> </ul>   |
| Demineralizing              | <ul style="list-style-type: none"> <li>• No acid or caustic regenerants</li> <li>• RO can be less expensive than demineralization for moderate or higher TDS levels</li> </ul> | <ul style="list-style-type: none"> <li>• Produces high purity water, but possibly not as high purity as some demineralizer quality water. For higher purity water, two-pass RO may be required or other polishing systems.</li> </ul> |

RO units generally remove 90 to 99.9% of all dissolved solids in a water source. Dissolved gases, however, pass through an RO membrane. Having a good understanding of which impurities are removed by which boiler pretreatment system can facilitate making the correct choice for your boiler system. Table 2 is a general list of impurity removal capabilities.

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Table 2: Pretreatment Impurity Removal Systems

| Impurity                | Reverse Osmosis | Softener | Softener + Dealkalizer | Demineralizer Train |
|-------------------------|-----------------|----------|------------------------|---------------------|
| Total Dissolved Solids  | Yes (90-99.9 %) | No       | No                     | Yes (>99 %)         |
| Hardness                | Yes             | Yes      | Yes                    | Yes                 |
| Alkalinity              | Yes             | No       | Yes (up to 90 %)       | Yes                 |
| Silica                  | Yes             | No       | No                     | Yes                 |
| Carbon Dioxide & Oxygen | No              | No       | No                     | Yes                 |

### Conclusion

The big picture for a properly applied RO pretreatment system in an ideal situation is: lower water costs, lower sewer costs, lower fuel costs, lower treatment chemical costs, lower or elimination of regenerant chemical costs, higher boiler reliability, and higher steam purity. As discussed, exceptions to this big picture do exist, and how an RO boiler pretreatment system fits into each unique situation must be carefully considered.

**Certification Quiz Paper, Titled Using Reverse Osmosis for Boiler Pretreatment in Analyst, 2012 Summer by James McDonald**

1. Which of the following is boiler makeup water treatment strategy:
  - A. Acid Feed
  - B. De-chlorination
  - C. Reverse Osmosis
  - D. Condensate Recovery
2. Which of the following is NOT a factor in determining pretreatment strategy?
  - A. Makeup characteristics
  - B. Space requirement
  - C. Economics
  - D. Boiler feed water temperature
3. What pretreatment strategy produces highest water quality:
  - A. Carbon filtration
  - B. Sodium zeolite softening
  - C. Ion exchange dealkalization
  - D. Reverse osmosis filtration
4. R O pretreatment strategy always presents a negative trade-off:
  - A. True
  - B. False
5. How many advantages of using RO over softener pretreatment?
  - A. None
  - B. Five
  - C. Ten
  - D. Eleven
6. The reason that RO pretreatment strategy can increase higher cycles than softener strategy is:
  - A. It also removes iron
  - B. It does not require salt regeneration
  - C. It also removes silica
  - D. It removes 90 to 99.9% of dissolved solids
7. If using RO with softeners, the regeneration costs may decrease depending on the current amount of condensate return.
  - A. True
  - B. False

8. Which of the following is an disadvantage in using RO pretreatment when compared to softener :
- A. No brine tank needed
  - B. Less alkalinity in the effluent
  - C. Higher electricity cost
  - D. Reject may be of good enough quality for cooling towers
9. Commonly what percentage of water entering RO comes out as reject?
- A. 15
  - B. 25
  - C. 33
10. What impurities pass through RO membranes?
- A. Anions
  - B. Virus
  - C. Trace metals.
  - D. Dissolved gases

ANSWERS ARE HIGHLIGHTED.