NEW LOGIC INTERNATIONAL, INC.

Application Note

Boiler Feed Water Treatment for Industrial Boilers & Power Plants

A cost-effective and environmentally-sound solution

Background

In the steam boiler industry, high purity feed water is required to ensure proper operation of steam generation systems. High purity feed water reduces the use of boiler chemicals due to less frequent blowdown requirements (reducing blowdown frequency by as much as a factor of 10). Lower blowdown frequency also results in lower fuel costs. Scale buildup is reduced due to a smaller concentration of impurities in the boiler feed water to foul heat transfer surfaces. The lower level of impurities also reduces corrosion rates in the boiler. When boiler is used to run a steam turbine, turbine blade erosion is reduced due to higher purity steam generated.

The use of reverse osmosis in feed water purification systems reduces chemical costs by reducing the frequency of ion exchanger regeneration. A complete system, which includes reverse osmosis and ion exchange, typically results in a more cost effective system when compared to systems that do not use reverse osmosis. However, the use of conventional reverse osmosis requires substantial use of pretreatment unit operations which also adds costs.

Silicate and colloidal deposits decrease boiler efficiency and also result in premature failure of turbines. Ultrafiltration can remove greater than 99% of colloidal silica, as well as precipitated iron and aluminum. The reduction in particulate matter, suspended solids and total organic carbon also enhance turbine and boiler efficiency. However, the use of conventional membrane technologies has faced substantial membrane fouling problems.

Objective

To meet the requirements of both ecology and economy, the filtration of boiler feed water streams allows an industrial boiler or power plant to meet the stringent requirements for more efficient boiler performance. The treatment of the boiler feed water is required for preventing excessive heat transfer equipment fouling and the erosion of turbine blades.

Solution

Technological advances in membrane filtration systems have created an opportunity for industrial boilers and steam power plants to treat boiler feed water streams in order to meet stricter system performance. The “Vibratory Shear Enhanced Processing” or VSEP™, developed by New Logic International makes it possible to filter influent water or effluent wastewater streams without the fouling problems exhibited by conventional membrane systems. The VSEP membrane system will significantly reduce TDS, TSS, color bodies, silica and hardness from influent streams originated from city water, well water, and river/surface waters, thus minimizing treatment cost.

The VSEP treatment system uses ultrafiltration or nanofiltration/reverse osmosis membrane modules to treat the influent water in order to generate a permeate stream that meets the boiler feed water criteria regarding concentrations of suspended and dissolved solids, silica, and hardness. After final polishing by ion exchange resins, the clear permeate can then be used as boiler feed water. Reverse osmosis filtration can be used if dissolved solids are an issue. In summary, the VSEP treatment system can be used to treat boiler feed water with only minor final polishing by ion exchange resins. -VSEP will eliminate the pretreatment requirements and can substantially reduce chemical usage for regeneration thus reducing disposal of spent regenerant and the associated costs.

Figure 1
Power Plant Water Cycle

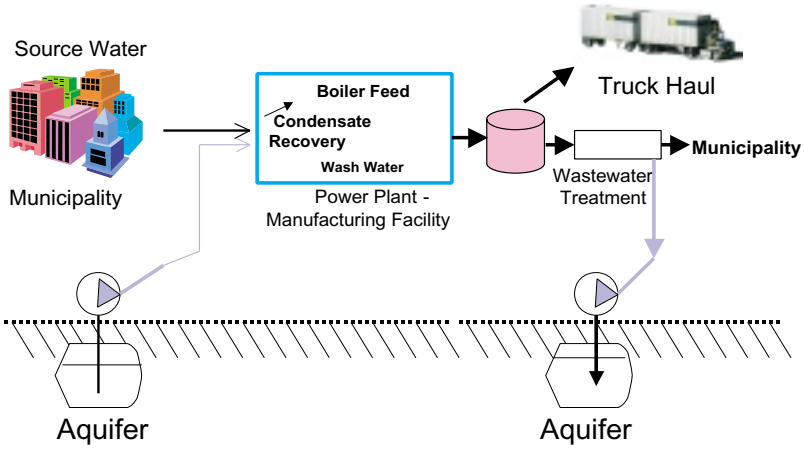
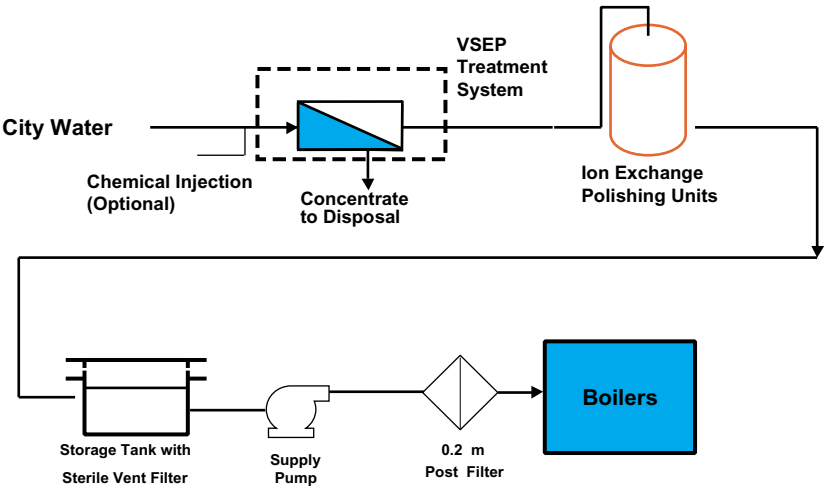


Table 1
Benefits of VSEP when Comparing with Competitive Technologies

Technology	Benefits of VSEP
Chemical Addition/Clarifier Systems	• **The main advantage of VSEP over a clarifier system is that the settling that a clarifier requires is a great deal of time which leads to clarifiers with a great hold-up volume and thus large space required and cloudy overflow.** • VSEP can handle wide variations in feed concentrations • VSEP generates a permeate quality with 0 ppm suspended solids versus about 500 ppm from a clarifier treatment process • VSEP is a one step process where as the clarifier treatment process generally requires pre and post treatment • VSEP can obtain higher quality permeate, typically 10 to 20 mg/L of hardness and less than 1 mg/L of Silica when RO membrane is used • VSEP offers smaller foot print, thus much lower building/facility costs • The chemical consumption for clarifiers is usually high and significant overdose is required for proper control of the clarifier effluent.
Cross-flow Filtration/ Spirals	• **Product recovery is poor with cross flow systems, with cross flow at e.g. 60% to 75% versus 80 to 90% typical for VSEP** • **Cross flow filtration normally requires substantial pretreatment** • **VSEP offers higher end point concentrate stream** • Frequent membrane replacement for the cross flow system can become expensive • Cross flow membranes will plug up with higher solid streams • Hold-up volume of cross flow system is high • Need larger feed/working tank with cross flow filtration • Larger piping is required for cross flow filtration • VSEP offers 2 to 3 times higher flux • VSEP offers one pass operation • VSEP can handle wide variations in feed concentrations • VSEP can obtain higher quality permeate, typically 10 to 20 mg/L of hardness and less than 1 mg/L of Silica when RO membrane is used • VSEP offers much lower power requirement. • VSEP offers smaller foot print, thus much lower facility cost

Figure 2
V✧SEP Nano/RO Filtration
For Boiler Feed Water Treatment



Several technologies are currently being used for boiler feed water treatment. Table 1 presents a summary of the benefits of VSEP when compared to selected competitive technologies such as chemical addition/clarifier systems and cross flow filtration/ spiral membranes. VSEP offers significant advantages over these technologies, as presented in Table 1.

For the industrial boilers and power plant systems, as well as the cogeneration industry, VSEP membrane systems can now be utilized where traditional cross-flow membrane technologies faced substantial membrane fouling problems in the past. The VSEP is an attractive alternative to conventional filtration methods due to its vibrational, shear-enhanced design.

Process Conditions

Figure 1 presents a schematic of a power plant water cycle. The influent water to a power plant may come from a groundwater well (aquifer), surface waters, or a municipality. The influent water would have to be treated to meet the requirements for boiler feed water criteria. Within the boundaries of a power plant, treatment of boiler condensate and its recovery, and the treatment of waste water generated from flue gas treatment scrubbers are additional important water treatment challenges. For boiler feed water treatment, depending on its requirements, a number of processes can be utilized which include chemical treatment/lime softening, dual media filtration, carbon adsorption, conventional reverse osmosis membranes, and final ion exchange resin polishing. Significant waste is generated from these unit operations, including spent carbon and spent regenerant chemicals from the ion exchange resins.

In the setting of a power plant, the Vibratory Shear Enhanced Processing (VSEP) has two major applications. The first is the processing of boiler water influent. To avoid scale in their boilers, power plants usually utilize a multistep process to remove the hardness of the incoming water, including either chemical treatment or ion exchange and several less advanced methods such as multimedia filtration. These multi-step processes can be replaced by a single pass VSEP machine that will purify the influent in one step.

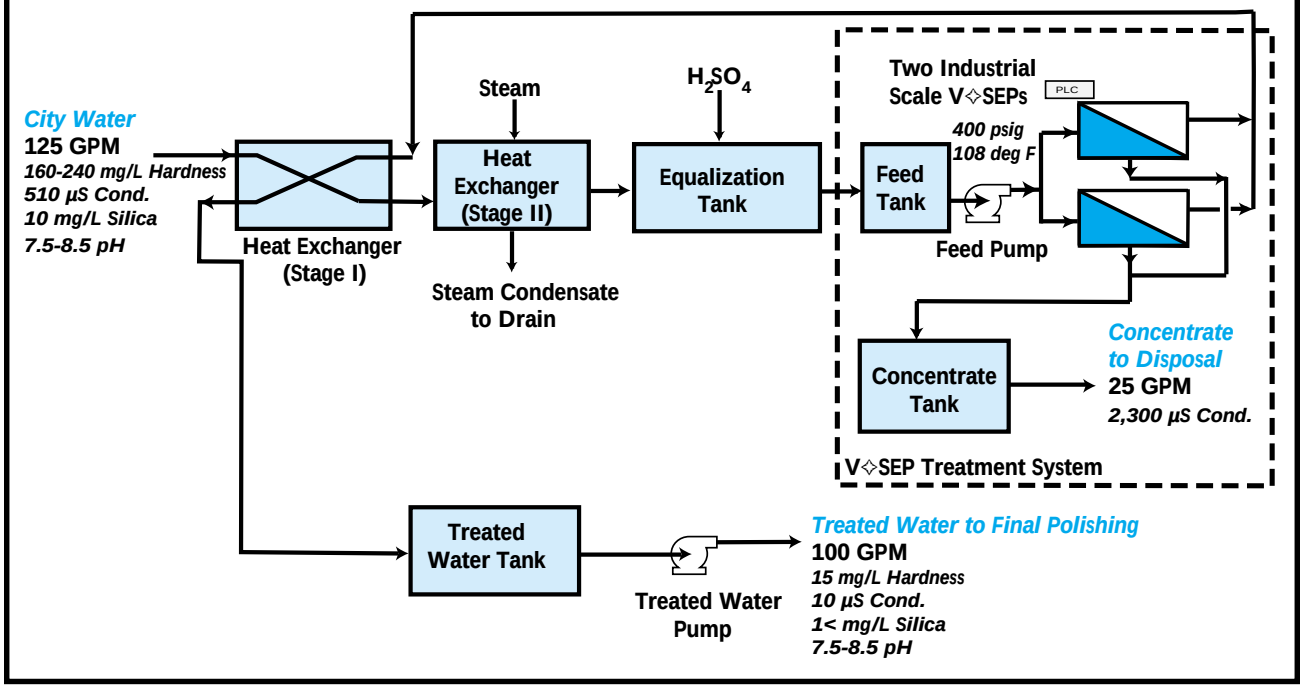
Another issue for power plants is the disposal of waste streams such as scrubber effluent. Of course, several methods already exist that can perform all of the above functions. Again, a multistep process is often employed. A typical wastewater treatment process might include chemical addition, then a clarifier, then a filter press, and finally ion exchange. VSEP technology is unique in that it rolls the whole operation into one machine. All of the systems mentioned could be replaced using a single VSEP machine equipped with nonporous membranes, which would remove everything from the large ash particles to the individual gypsum molecules. The resultant water quality would be as high as that produced by multi-stage filtration and chemical addition.

A process schematic for treatment of boiler feed water using a VSEP treatment system is presented in Figure 2. This system is using nano or reverse osmosis membrane filtration system to replace the entire pretreatment step that would be usually required, i.e. lime or cation softening, dual media filters, carbon adsorbers, and conventional reverse osmosis units. City water is treated in a single step VSEP treatment system followed by a final ion exchange polishing unit. The treated boiler feed water is then fed to the boiler via a supply pump.

Figure 3 is a process block flow diagram showing the integration of VSEP with boiler feed water treatment at an industrial manufacturing facility. This diagram also includes the overall material balance for the water treatment process and illustrates its performance.

As presented in Figure 3, city water is preheated in the Stage I heat exchanger with clean permeate water from VSEP and is then further heated with a steam-

Figure 3
Integration of V✧SEP with Boiler Feedwater Treatment



heated exchanger to a temperature of 42° C (108° F). The higher feed temperature improves permeate flux through the VSEP treatment unit and provides the energy drive for the first exchanger. The preheated water is introduced into the equalization tank where sulfuric acid may be added for pH adjustment. Other chemicals such as alum and polymer can also be injected at this point as needed to help coagulation. The equalization tank effluent is then transferred to the feed storage tank where it is fed to the VSEP units at a rate of 125 gpm. Two industrial scale VSEP units process the preheated city water.

VSEP generates a permeate stream of about 100 gpm which is sent to the heat recovery exchanger and then stored in the treated water tank for further processing (final ion exchange polishing followed by use as boiler feed water) at the manufacturing facility. The VSEP produces a concentrated waste stream at a flow rate of 25 gpm, which is routed to the holding ponds and then the sewer.

Two industrial VSEP treatment units, with a nano filtration/reverse osmosis membrane module, are provided. The raw city water has a concentration of 160 to 240 mg/L of hardness, ~10 mg/L of silica, and ~510 µS of conductivity. The permeate concentration is reduced to <15 mg/L of hardness, <1 mg/L of silica, and ~10 µS of conductivity, all well below the designed water quality limits.

Using a nanofiltration or a reverse osmosis module in the VSEP system is a commercially viable option for treatment of boiler feed water at industrial boilers and power plants. Nearly 80% of the influent water is recovered as treated water suitable for final polishing at a boiler facility, while less than 20% is disposed as concentrate.

Membrane selection is based on material compatibility, flux rates (capacity) and concentration requirements (hardness, silica, TDS, conductivity). In this example, the hardness reduction is over 90% and TDS and conductivity are also reduced by a similar amount. The permeate quality from the VSEP can be controlled though laboratory selection of membrane materials available to fit the application parameters.

Successful pilot tests have been conducted at New Logic for boiler feed water treatment. A commercial project is also under consideration for treatment of an industrial boiler feed water on the west coast of the United States. Depending on influent water concentration levels, process temperatures, membrane selection and the requirement for reduction of

hardness, silica, and conductivity from the influent streams, the permeate flux rate in the VSEP can range from 20 to over 70 gallons per day per square foot (GFD). The concentration level out of the VSEP unit is controlled by an automatic timed control valve. This valve is set such that the concentration of the solids is held at the desired level. A multi-stage feed pump supplies the VSEP unit at a pressure suitable for the membrane used. A variable frequency electronic drive is used to set feed pressure through P.I.D. (Proportional-Integral-Derivative) control loop. This kind of drive acts to control the rotational speed of the pump, thus controlling the flow rate.

Economic Value

New Logic's VSEP system provides an alternative approach for boiler feed water treatment applications. In a single operation step, VSEP will reduce hardness, TSS, TDS, and conductivity to provide a high quality boiler feed water stream for industrial boilers and power plants. In many applications, the addition of VSEP will eliminate conventional treatment process requirements and technologies without chemical treatment demands. The justification for the use of VSEP treatment system in your process is determined through analysis of the system cost and benefits including:

- Reduction of hardness, TSS, TDS, and conductivity for the plant influent stream.
- Provision of high quality water for introduction into the boilers or process.
- Reduce or offset fresh water demands and pretreatment cost.
- Retain heat in recycled process water as a possible method to reduce energy requirements.
- Elimination of biological growth, and odor in effluent.
- Reduction of effluent discharge volume and associated treatment cost.
- Simplify influent or effluent treatment with a compact, low energy system.

Summary

New Logic International has supplied VSEP separation technology successfully into many industrial processes. The industrial boilers and power plants as well as the cogeneration industries' effort to meet system performance criteria and environmental regulations will be enhanced with the utilization of membrane filtration combined with "Vibratory Shear Enhanced Processing". The development towards applications for industrial boilers and power plants, along with the availability of new membrane materials and VSEP technology, make it possible to treat the more difficult streams with very successful, economic results.

Contact a New Logic representative to develop an economic analysis and justification for the VSEP in your system. For additional information and potential application of this technology to your process, visit New Logic's Website @ www.vsep.com or contact:

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