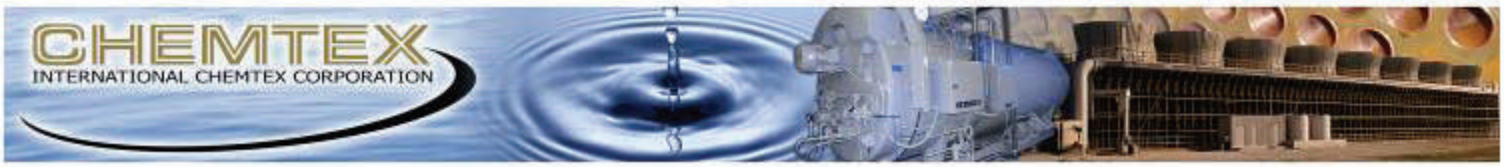

WATER TREATMENT NEWS

Keep Your Softener Working at Full Capacity

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In an idyllic setting along a state highway in northwestern Wisconsin, a billboard conveys an effective sales message from a company that sells water softeners. The sign simply states, "You can live without soft water, but it's hard." This statement cleverly suggests that homeowners' lives would be easier if they purchased one of the company's softeners for their home water supply.

As true as that might be, the sales message would perhaps be even more apt if it were directed at facilities engineers who operate steam boiler systems. Operating a boiler system efficiently using hard make-up water is not only hard, it's expensive as well.

Hard water – what is it and what makes it so difficult to live with? The answer is not in what it is, rather in what it does. The term itself is a misnomer the way many people conceive of it. Hard water is not physically harder than soft water.

Years ago, certain water supplies – those that contain high levels of calcium and magnesium salts – were described as "hard to wash with." The calcium and magnesium (hardness) react with alkalinity in soap, preventing the soap from lathering and forming instead a sticky precipitate – the familiar bathtub ring.

The effect of hard water in a steam boiler is much more problematic than the nuisance of having to scrub the soap scum out of your bathtub. In a boiler, anions such as bicarbonate, sulfate, phosphate and others react with hardness to precipitate and form a hard scale on boiler tubes. The scale acts as insulation, impeding the transfer of heat through the tubes, resulting in increased fuel use. The insulating effect of the scale also causes long-term overheating of the boiler tubes, which can lead to tube failure.

Both effects are costly. The loss of heat transfer due to scale can increase boiler fuel use by 25% or more – a substantial amount when you consider that a typical fuel bill for a 500 horsepower (HP) boiler firing natural gas at $7.00/thousand cubic feet (mcf) can approach $1,000,000 per year. Repair or replacement of a failed boiler tube can cost tens of thousands of dollars. The cost of hard water in a boiler system can break a facility's operating budget.

Fortunately, a cost-effective, reliable solution to hard water problems exists – the water softener. Water softeners use the principle of ion exchange to remove hardness from boiler make-up water. A properly operating softener system reduces the hardness in boiler make-up water to less than one part per million (ppm), regardless of the incoming hardness level. Under these conditions, the boiler water chemical treatment program can efficiently and cost effectively keep boiler waterside heat transfer surfaces completely free of scale.

A softener is simply a tank containing a bed of small styrene resin beads that serve as the ion exchange media. The resin beads are covered with exchange sites, each of which has a negative electrical charge. The resin bed is prepared for use in a procedure called regeneration, during which a concentrated sodium chloride brine solution is passed through the bed, causing the positively charged sodium ions from the

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brine solution to attach to the negative sites on the beads. When hard water passes through the bed, the resin beads, having a stronger affinity for the calcium and magnesium ions, release the sodium ions and exchange them for calcium and magnesium ions. This process continues until all the sodium ions are exchanged for calcium and magnesium. At this point, the resin bed is said to be exhausted and needs to be regenerated.

A system for softening boiler make-up water should include twin resin tanks or exchange columns, a brine tank and automatic controls that include a water meter to measure the flow of water through the system. A properly designed system has sufficient ion exchange capacity to provide a continuous supply of soft water to the boiler. The facility manager should consult a well-qualified water treatment professional to determine capacity requirements when buying a new softener system or to determine if his current system has sufficient capacity and that it is achieving its maximum softening potential.

Once the total capacity of the softener system is determined, it is critical to assure that the softeners continuously operate at or near that capacity. This requires a good softener maintenance program.

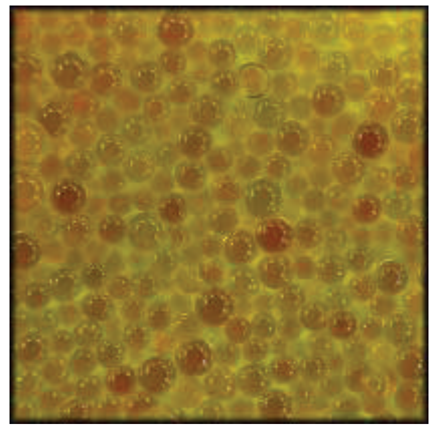
The first step is an evaluation of the condition of the resin. This necessitates a complete resin analysis by a qualified water treatment support laboratory. The analysis starts with proper collection of a resin sample, which requires opening the manway or handhole at the top of the softener column. If the softener doesn't have such an opening, the head must be removed. Next, open the softener drain to lower the water level so that it just covers the resin bed. Using a length of conduit or copper tube, push the tube carefully down through the bed until the support media beneath the bed is reached. Cap the tube, capturing a sample of resin, retract the tube and empty the sample, including the water, into a sample bottle. Before sending the sample in for laboratory analysis, make certain that the resin is completely covered with water in the sample bottle.

Resin is often lost from a softener during regeneration and normal operation. After collecting the sample, use the tube to measure the bed depth. Reinsert the tube all the way to the resin bed support media. Retract the tube and measure the length that is wet – this is the bed depth. Calculate the volume of resin according to the following formula:

$v = 3.1416 \times r^2 \times b$ where:
v = volume of resin, cu. ft.
r = ½ the diameter of softener, ft.
b = bed depth, ft.

Compare the bed volume to the specifications for the softener. If a significant amount of resin has been lost, the amount lost should be replaced.

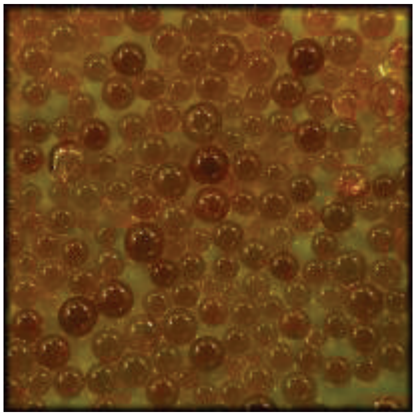
A complete laboratory resin analysis includes a microscopic examination of the resin to determine it's physical condition, the degree of iron fouling, the per cent moisture content and the ion exchange capacity of the resin after it has been thoroughly cleaned.



Clean resin in good condition. Approximately 3x magnification.

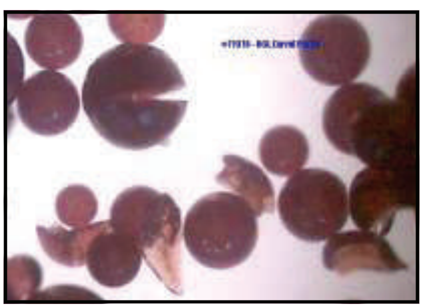
With this information, the facility manager, in consultation with the water treatment professional, can make intelligent decisions on whether the resin needs to be cleaned, replaced, or that no action is required.

If the analysis shows the resin to be iron fouled, the bed should be cleaned with a quality resin cleaner. Best results are obtained by cleaning the resin off-line. The water treater can provide the specific procedures required. The resin cleaner can also be applied during the softener regeneration procedure by adding the cleaner to the brine tank, but badly fouled resin is not cleaned as thoroughly using this method.



Iron-Fouled Resin. Approximately 3x magnification.

When the resin has been thoroughly cleaned, it is recommended that resin cleaner be added during regeneration on a periodic basis to prevent fouling and maintain the resin in good condition. The frequency of online resin cleaning is dependent on the iron content in the make-up water. Resin cleaner should be added with every regeneration to systems having high iron make-up water.



This photomicrograph shows cracked and fractured beads under approximately 5x magnification

When the resin is clean and determined to be in good condition, the softener operator should verify that the unit is producing a volume of soft water at or near its theoretical capacity. The theoretical capacity varies based on the amount of salt used per cubic foot of resin in regeneration (salt rate). The following table shows resin softening capacities at various salt rates:

Salt Rate	Softening Capacity
6 lb/cu. ft.	20,000 gr/cu. ft.
12 lb/cu. ft.	25,000 gr/cu. ft.
15 lb/cu. ft.	30,000 gr/cu. ft.

A common salt rate is about 10 lb/cubic foot, which provides about 24,000 grains of hardness removal per cubic foot of resin in the softener. The softener industry has traditionally used grains as the unit of measurement of water hardness; they express water hardness concentration in grains per gallon (gr/gal). To convert this measurement to the more commonly used parts per million, multiply by 17.1. For example, a water with 10 gr/gal hardness would have 10 X 17.1, or 171 ppm hardness.

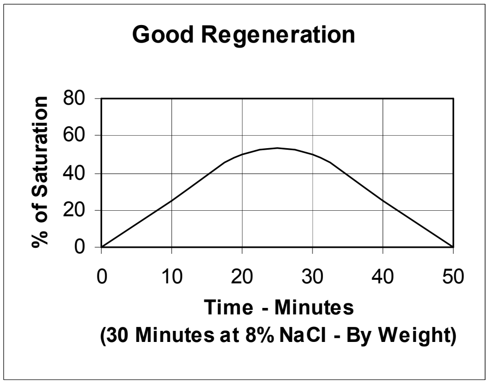
Calculate the total softening capacity of a softener, then, by multiplying the cubic feet of resin times the softening capacity from the table above, and dividing that total by the grains of hardness in the raw water. If the soft throughput is substantially less than the calculated total capacity, there is likely a problem with the regeneration procedure.

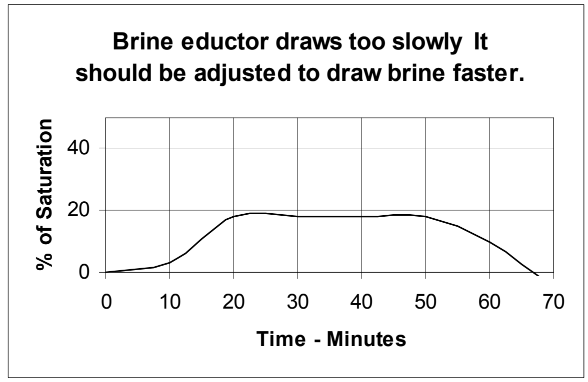
A qualified water treatment professional can determine if the regeneration procedure is correct or if it needs adjustment by conducting a softener brine elution study. The regeneration procedure consists of four steps: backwash, brine draw, slow rinse and fast or final rinse. During each of these phases, water and brine flow must fall within certain specifications for rate and time for the regeneration procedure to be successful in completely replacing calcium and magnesium ions with sodium ions on the bead surfaces and for the softener column to achieve full potential softening capacity when it is returned to service. If flow rates or timing of any of the phases is out of spec, regeneration will be incomplete and the softener will not achieve full capacity.

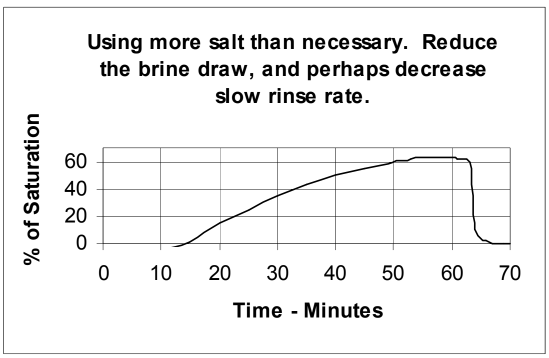
In an elution study, the water treatment technician measures flow rates and the timing of each regeneration phase, tests and records the concentration of brine passing through the softener at two or three minute intervals throughout the regeneration procedure, and plots the brine concentration readings on a graph. The shape of this graph, along with the other information gathered during the study, tells the technician whether the regeneration procedure is correct or, if not, what flow rates or times need to be adjusted to make the softener perform up to capacity.

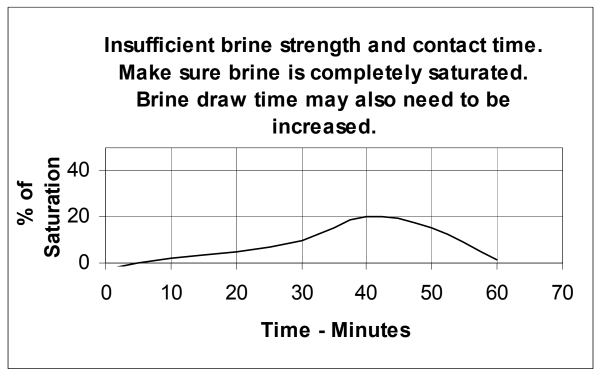
Brine elution studies need not be conducted on a regular basis, rather, only if a problem with softener hardness removal performance or capacity occurs. Once the softener performance is optimized, the ongoing mainte-

Some typical brine elution curves. The water treater can diagnose and fix regeneration problems by correctly interpreting the curve.









nance program should include regular monitoring of metered soft water throughput to assure that softening capacity is being maintained, and regular use of a good resin cleaner to keep the resin bed clean, prolong its service life and optimize its softening performance. The brine tank should also be inspected regularly and cleaned when necessary to remove dirt and other debris that can accumulate and plug up the brine distribution line.

If this simple maintenance program is followed, a softener should provide years of trouble-free service and produce a continuous supply of soft make-up water to the boiler system, helping assure that the boiler operates at maximum possible efficiency. A properly operating softener system arguably provides the highest return on investment of any piece of equipment in the boiler room. For the boiler engineer, you can live without soft water, but it's *really* hard.

Ask your Chemtex Representative about maximizing the efficiency of your softener system!