# BOILER TREATMENT – FACTS AND CONSIDERATIONS

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## ABSTRACT

As the boilers are the heart of any sugarcane mill, boiler water treatment chemicals are an important part of the effective operation of any mill. There are a number of options available to the mills when it comes to boiler water treatment chemicals; however, there are no "silver bullets". This paper provides a discussion of boiler water treatment chemicals currently available to sugar cane mills. The paper discusses the various chemistries that are and have been in use in the mills and the advantages and disadvantages of each. First and more importantly, the paper discusses the limitations of any boiler water treatment chemical program. It details other considerations and recommendations to help ensure the success of any program. These considerations are based on situations encountered routinely in the sugarcane mills in Louisiana and Florida.

## INTRODUCTION

Boilers are extremely critical to the operation of a canesugar mill. Loss of steam production can mean a slowdown or virtual shutdown of a mill. Because mills process a perishable commodity, this can cause loss of cane through deterioration or necessitate diversion of cane to another mill. This can affect overall mill efficiency and lead to higher final cost of product.

The operation of these systems can be difficult. Although high quality feed water can be obtained as a result of condensate return from the process, it can be contaminated by carry-over of sugar during the evaporation process, as well as natural water way or well water addition in the event that condensate storage quantities do not meet feed water demand. These upset conditions can cause damage to the boilers that can be serious and permanent. Proper reaction to upsets coupled with effective boiler water treatment can minimize or eliminate this damage.

No boiler treatment method is fail-safe and possibilities for potential failure will be discussed. Once these are understood, understanding the chemistries used and the limitations and benefits of those chemistries is paramount in maintaining boiler efficiency throughout the grinding season.

## RESULTS AND DISCUSSION

### BOILER WATER INTERNAL TREATMENT

The main purpose of any boiler water treatment program is to prevent deposition and corrosion. When these problems occur, boiler efficiency decreases, causing production slow-downs, as well as increased maintenance and energy costs. Deposition, commonly known as scale, can be especially dangerous in boiler systems. Widespread scale, even a thin layer, is enough to hinder heat transfer and affect steam production. Scaling can also lead to over-heating of boiler tubes and, in extreme cases, tube rupture due to over-heating. Once deposition has formed, the environment under the deposit is ideal for corrosion to occur. Metal loss from under deposit corrosion, usually in the form of pitting, can also shorten tube life. Corrosion by-products are likely to deposit elsewhere in the boiler causing the cycle to repeat itself.

There are a number of chemistries available to cane sugar mills which can effectively prevent these problems. Before they are discussed, there are numerous other factors to consider when implementing an effective boiler water treatment program. Although these are operational and mechanical in nature, you will find they can have an impact on the success or failure of any boiler water treatment program. Some of these factors include:

1. Feed-water hardness upsets
2. Improper blow-down
3. Sample points and sampling techniques
4. Program control
5. Excessive sugar shots
6. Chemical feed points
7. Mechanical problems/changes to boiler

The applicability of each factor is dependent on each mill. Some mills may see all of these factors; some may see none. This section will generally discuss these factors and recommend ways to help minimize or eliminate their affect on the success of any boiler water treatment program.

### Feedwater Hardness Upsets

When a mill is operating normally, there is an excess of high quality condensate to use for feedwater for the boilers. The impurity levels in this feedwater are well below the ASME guidelines shown below as Table 1.

**Table 1.** Feedwater quality guidelines for boilers operating at 0 – 300 psi.

| | |
|---|---|
| Total iron (Fe) | < 0.1 ppm |
| Total copper (Cu) | < 0.05 ppm |
| Total hardness (as $CaCO_3$) | < 0.3 ppm |

However, during start up, long mill shut-downs, or for other reasons this condensate is not available and make-up water must be used. This make-up water may come from wells, rivers, bayous or the city. The source of the water will determine the impurity level, but in any case, the level normally far exceeds the guidelines noted above.

The traditional way to handle this excess is to add additional boiler water treatment chemical in an attempt to either precipitate or transport the additional impurities. This approach works to a point, however truly excessive impurity amounts can make it virtually impossible or at least uneconomical to feed enough chemical. An example of this is shown in Figure 1.

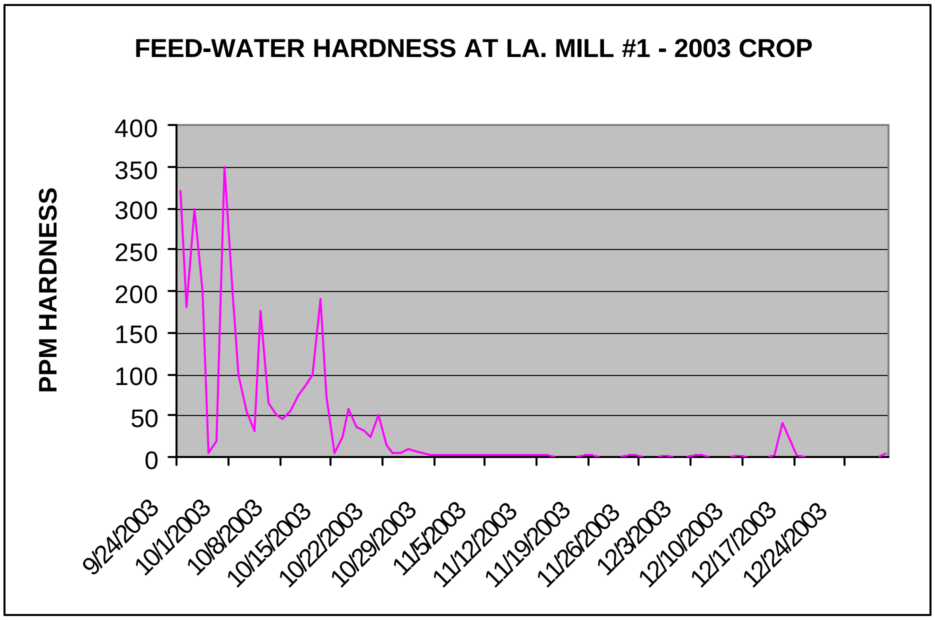


**Figure 1.** Graph of feed-water hardness.

Difficulties during start-up required the use of large amounts of well water at the beginning of the crop. Feed-water hardness levels exceeded 300 ppm on several occasions. With a mill feed-water flow of 350,000 pounds per hour, 300 ppm of hardness translates to 2,500 pounds of hardness per day entering the boilers. At an assumed required liquid chemical dosage of 10 ppm/ppm hardness, 25,000 pounds or approximately 2,700 gallons per day (at 9 pounds per gallon) of treatment chemical would be required. At most mills, feeding this amount of chemical would be impossible, and the result of the under-feed is scale formation in the boilers.

In fact, for the mill shown above, calculations show conservatively over 25,000 pounds of hardness were introduced into the boilers during the approximately 100 day crop. At the dosages noted above, 250,000 pounds or 27,000 gallons of liquid would have been required to treat the actual hardness levels. That is nearly 500, 55 gallon drums!

A second example of feed-water hardness is shown in Figure 2.

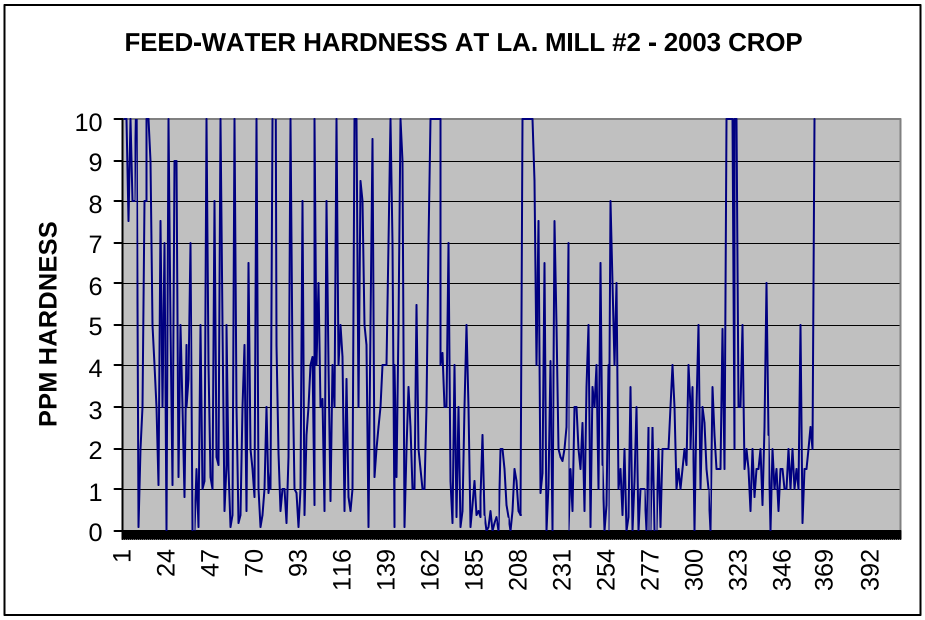


**Figure 2.** Graph of feed-water hardness.

This mill had numerous excursions throughout the year, although none as dramatic as mill #1. Even so, the actual amount of hardness introduced into the boilers was around 3,000 pounds. At the assumed dosage of 10 ppm liquid treatment chemical per ppm hardness this translates to 30,000 pounds or 3,300 gallons of chemical. Much better than the first example but still 60 drums of chemical in a 100 day crop, over ½ drum per day on average.

The above examples would see some help from increased blow-down, but if the same upset which caused the use of make-up water also caused the operators to fire the boilers on gas, there would be a substantial increase in the overall operating costs. For mills where condensate is a problem then, what is the solution?

<u>Solutions</u>

1. The ultimate solution is to minimize downtime so as not to run out of condensate. Obviously this is often times uncontrollable.
2. Condensate storage capacity could be increased by converting tanks or adding tanks.
3. Alternate make-up water sources could be investigated to find the best quality make-up water.
4. Pretreatment equipment could be used to remove the impurities in the make-up water. If equipment purchase is cost prohibitive, lease options are now available.

**Blow-down**

Blow-down is necessary to control solids in the boiler to prevent treatment chemical failure leading to deposition forming in tubes and on drum walls. There are two types of blow-down available in most boilers, continuous or surface blow-down and bottom blow-down. The continuous blow-down is used mainly to control total dissolved solids (TDS), and the bottom blow-down is used to remove suspended solids or particulate.

Continuous blow-down

The first consideration of continuous blow-down is the configuration and location of the continuous blow-down line. This line should be located in the steam drum over the down-comer section of the drum where circulation in the drum is flowing downward. It should extend the length of the drum and be configured with ports at various intervals. The size and the spacing of the ports should be such that flow into the line is even across the length of the line. It also is important to check the ports to make sure they are not blocked. The end of the line should not be open. This will allow for even solids removal across the drum. The line should be located 4-8” below the normal operating water level in the drum. The highest dissolved solids level in the boiler is at the steam release surface where pure water is being released and impurities are being left behind. Removing the water from this area will allow for the greatest impurity or TDS removal for a given volume of water and therefore result in the least waste and greatest boiler efficiencies. The ports on the blow-down line should point straight up as shown in Figure 3, again for maximum TDS removal.

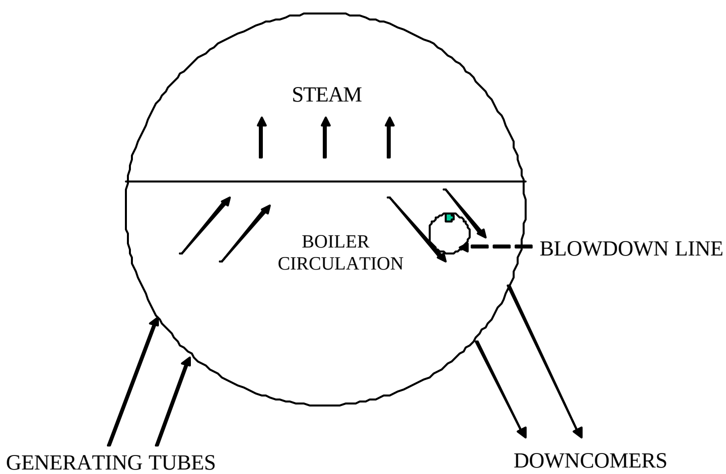


**Figure 3.** Correct blowdown line placement.

Another consideration is the position of the continuous blow-down line in relation to the feed-water line. The feed-water line should not be pointing toward the continuous blow-down line. This could cause short circuiting of the feed-water into the blow-down. This will result in poor solids removal and possibly high levels of solids building up in other areas of the boiler.

Bottom Blow-down

With phosphate chemistry, bottom blow-down is critical, as it removes the calcium phosphate sludge or "mud" which is produced. It is from this that the mud drum got it's name. With newer polymer programs, bottom blow-down is necessary only to remove any particulate that enters the boiler or flakes off the internals. Therefore bottom blow-down can be substantially reduced on these programs, although it should never be eliminated in a sugar mill boiler.

Bottom blow-down ports are in the bottom of the mud drum, usually only one or two in each boiler. Many boilers have an angle iron which runs the length of the drum over these ports to help with solids removal. Bottom blow should be minimized as it is hard on the boiler. It opens the mud drum to atmospheric pressure, and if left open, can actually affect the circulation of the boiler possibly stopping flow in tubes and causing overheating. Therefore bottom blow-down duration should always be kept at a minimum. For most effective particulate removal, the blow-down should be "bumped", that is opened and closed several times. This gives solids time to settle between blow-downs and allows more solids to be removed. Please remember that bottom blow-down is a very inefficient way to control TDS and should only be used to do so in an emergency, such as during a sugar shot.

<u>Solutions</u>

1. Make sure continuous blow-down lines are configured and oriented as recommended above.
2. Use continuous blow-down to control TDS ranges recommended by your water treatment consultant.
3. Make sure feed-water is not short circuiting into the blow-down.
4. Minimize bottom blow-down and "bump" when blowing down.
5. Make sure all blow-down ports are clear.

**Sample Points and Sampling Techniques**

Boiler water sample points should always be taken off a properly oriented and configured continuous blow-down line for the most representative sample. Any other sample location is unacceptable, and if the blow-down line is not set up correctly, it is probably unacceptable. For example, a sample taken off a sight glass line will contain mainly condensate, and therefore, actual boiler TDS could be running considerably higher than thought. This could lead to scaling and carryover problems in the boiler. Also, if the feedwater line is short circuiting into the blow-down, some feed-water will be sampled, giving lower readings than are actually present in the boiler leading to the same problems.

Feed-water sample points are best taken after the feed-water pumps. This leaves no chance for sample contamination and gives the most representative sample of what is actually going to the boilers.

Poor sampling techniques also can lead to poor test results and give an erroneous picture of what is actually happening in the boiler leading to treatment failure. In some boilers, if the blow-down line is high in the boiler, running the sample too hard can cause steam to be sucked into the blow-down line and therefore into the sample. Once again, test results will show much lower levels than those actually being carried in the boiler. This can lead to program failure and deposition in the tubes and on the drums.

Not letting samples run long enough is another potential problem. This will lead to the testing of stale sample which is not representative of what is currently in the boiler. Samples should always be run until the water is hot.

Another sampling problem is leaks in the sample cooler. Depending on the piping configuration, this can cause cooling water to contaminate the sample, once again giving low readings compared to what is really in the boiler.

Solutions

1. Make sure all boiler water samples come off the continuous blow-down lines.
2. Make sure there is no chance of feed-water short circuiting into the blow-down.
3. Sample feed-water after the feed-water pumps.
4. Always run samples until they are hot, then reduce flow to minimize chances of pulling steam into sample.
5. Check sample coolers to make sure cooling water is not leaking into sample.

**Program Control**

This is fairly self-explanatory. For any chemical treatment program to work, you must control boiler parameters within set guidelines. These guidelines are typically recommended by your water treatment consultant. As a bare minimum, there are five parameters that must be kept in control to ensure the success of the program in a sugar mill. These five parameters are:

1. Sulfite/oxygen scavenger residual – Ensures oxygen corrosion is not occurring.
2. Boiler conductivity/TDS – Ensures scale/carryover risks are minimized while not wasting water and energy through excess blow-down.
3. Boiler water O alkalinity – Ensures acid corrosion is not occurring in the boilers and also sufficient alkalinity is present for internal treatment to work. Phosphate programs typically need a minimum 200 ppm of OH alkalinity to work effectively, and polymer programs need a minimum of 50 ppm. At lower alkalinities, the reactions may be incomplete, and poor scale protection and poor passivation may result.
4. Chemical level in feed-water or chemical residual in boiler – Ensures there is enough internal treatment to handle impurities.
5. Feed-water hardness – Ensures hardness levels are not exceeding internal treatment capabilities.

If these five parameters are controlled within the recommended limits, discounting other factors, there is a high degree of probability of success for any of the treatment programs discussed.

How can these parameters be kept within limits? Automation is a possibility but normally not in use in cane sugar mills. So, manual control is the rule. To make any control effective, training is critical. The personnel running the tests must be trained in all test procedures. Even more importantly, the personnel interpreting the test results and making necessary adjustments must fully understand the basics of boiler water treatment. This is critical for them to make the correct adjustments to maintain control. For example, they must understand that all parameters track the TDS, so if chemical levels are low and TDS is low, the adjustment is to decrease blow-down first, NOT to increase chemical feed.

Second, the tests should be easy to run. The number of tests run should be kept to a bare minimum (five as noted) and the easier the tests are to run, the more accurate and repeatable the results. Also, in most sugar factories, the personnel controlling the boiler water parameters have many other responsibilities. Therefore, the less time the testing takes, the more likely personnel are to run them when they get busy. The number of times the boilers are tested each day is dependent on the individual mill. Some mills may maintain control effectively by testing only twice per day. Other mills may run up to six or eight times per day.

Another way to ensure control is to neat feed liquid products using a drawdown gauge to check actual feed rate daily. This takes away the guesswork of mixing chemicals. Unless a pump fails, this is typically an effective way to consistently maintain control of desired chemical levels.

Also, log sheets should be set up in a manner that allows personnel to see trends. This helps control to be proactive. Some mills have even begun using trending software to produce actual charts.

Solutions

1. Keep number of tests per set to a minimum.
2. Keep test procedures as simple as possible.
3. Automate where possible.
4. Train all personnel responsible for testing and control, including blow-down control.
5. Neat feed where possible.
6. Utilize log sheets or charts which allow trends to be monitored.

**Excessive Sugar Shots**

Introducing excess sugar into the boilers through contamination of the condensate causes a two-fold problem. The first is simply the increased level of impurities raising the risk of scale deposition in the boilers. The second and more important problem is the sometimes extreme suppression of pH which the sugar shot causes, as sugar breaks down into an organic acid in the boilers. This suppressed pH will cause corrosion of the boiler internals which could in cases be severe, especially in higher pressure boilers. A secondary concern caused by this problem is that, while pH is being raised by adding caustic, precipitation of the soluble corrosion products occurs. This can deposit on the boiler tubes and adhere as scale.

The problem is best controlled by not allowing sugar to enter the boilers. Condensates which are more susceptible to sugar contamination should not be returned to the boilers at all if possible and not directly returned if not possible. This includes juice heater condensate and third and fourth body condensates. If it is necessary to use this condensate, it should be monitored with an on-line monitor, such as a conductivity monitor with an automatic dump set up to ditch condensate when sugar is detected. Many mills are setting up these monitors on any stream which has the potential for contamination. The susceptible condensate also can be routed through a separate tank which is routinely monitored and can be taken off line if sugar is detected. This decreases the chance of contamination of the main condensate return.

If large amounts of sugar enter the boilers and pH suppression is severe, the recommendation is to shut down and drain the boilers. This is normally not practical in the cane sugar mills. Therefore, if sugar does enter the boilers, the most important first step is to find and eliminate the source. Blow-down should be increased to maximum to remove the sugar from the boilers as soon as possible. Continuous blow-downs should be wide open, and bottom blows should be conducted as frequently as is safe and practical. Control of pH is normally regained as mentioned through the addition of caustic. This addition should be carefully controlled so as not to overshoot, minimizing the chance and/or amount of deposition which could form. It is also a good idea to feed additional iron dispersant chemical while raising the pH with caustic. This too will minimize the risk of deposition as scale on the boiler internals.

<u>Solutions</u>

1. Where possible, do not return juice heater or third or fourth body condensates to the boilers at all. If it must be returned, return it to a separate tank so as not contaminate the main condensate stream should contamination occur. Or, set up a monitor and dump as noted below.
2. Monitor any condensate stream susceptible to sugar contamination with a conductivity or similar monitor. Set it up to dump automatically when detected.
3. If sugar does enter the boilers, take the following steps:
    a) Find and eliminate the source ASAP.
    b) Open blow-downs wide open and start frequent bottom blows.
    c) Begin additional iron dispersant feed.
    d) Add caustic carefully to raise pH. Anti-foam also will be necessary to maintain level control.

**Chemical Feed Points**

If any of the treatment programs discussed are not fed at the correct point in the system, program results could suffer. These points should be reviewed and determined by your water treatment consultant, but following are some guidelines:

1. Oxygen scavenger feed should be to the de-aerator storage section, beneath the water line. In fact, optimally the feed should be split and introduced at both ends of the tank for the most complete mixing. Feeding in this location protects the internals of the storage

tank from corrosion, but also ensures complete oxygen removal prior to internal treatment addition.

2. Internal treatment feed should be to the de-aerator drop leg. This is after complete oxygen removal and also before the feed-water pumps which act to mix the chemical in the feed-water.
3. Caustic feed should be to the de-aerator storage section also. Raising the pH in the de-aerator allows the oxygen scavenger to work more efficiently.

Many mills have a "charge tank" set up to dose directly to individual boilers. This typically has a high pressure feed pump to pump against the boiler pressure and a manifold system to allow feed to individual boilers. This allows for adjustment of chemical levels in individual boilers if necessary. However, if feed points are set up as outlined above and feed-water is properly treated, this should normally not be necessary.

Many mills also have a separate system or some other means to feed caustic in the event of a sugar shot. This may be to the feed-water or to individual boilers.

<u>Solutions</u>

1. Follow the guidelines above for chemical feed points, but let your water treatment consultant make the final recommendations on where to feed.

**Mechanical Problems/Changes to Boilers**

Anytime a mechanical change is made to the original design of a boiler, the circulation in the boiler could potentially be altered in certain areas or tubes, making them more susceptible to deposition and scaling. Changes could include adding or modifying steam separating equipment, adding or removing baffles, or others. Any changes should be thought through before being made.

Changes to feed-water line orientation also can cause deposition in certain areas. Right before the feed-water hits the boiler, it is typically at around 320-325º F and at a pH of 8.0 – 9.0. Upon entering the boiler, the temperature and pH immediately increase. This would cause any impurities in the feed-water to deposit as scale. Therefore it is important that the feed-water mix thoroughly with the boiler water in the steam drum before it is introduced into the tubes. Any orientation of the feed-water line which allows this and does not allow short circuiting of the feed-water into the blow-down is acceptable. It has even been determined that the feed-water line ports pointing straight up is acceptable. It was once thought this could disrupt the surface of the water and cause carryover, but cameras placed in the drums of running boilers have shown this to not be true.

Another change to the boilers which can affect the effectiveness of any internal treatment program is over-firing. As mills push to grow, many times boilers are operated over their design capacity. This can affect temperatures and circulation in the boiler and once again lead to internal treatment failure resulting in deposition in the tubes.

Solutions

1. Thoroughly review any potential change considered being made to a boiler. Discuss possible changes with your water treatment consultant.
2. Check feed-water line orientations in all boilers.
3. Avoid over-firing boilers substantially where possible.

## BOILER WATER INTERNAL TREATMENT PROGRAMS

Now that the mechanical and operational factors that can affect any program are understood, the actual chemistries will be discussed.

There are numerous types of scale caused by hardness and other minerals inherent in water. The mechanism for the prevention of these can be very different. Understanding the different types of treatment chemistries commonly used today and the mechanisms by which they function will be helpful in choosing a program to maintain boiler efficiency throughout the grinding season.

### I. Residual Phosphate Treatment

Residual phosphate boiler programs minimize scale in boilers by controlled precipitation. The mechanism for this is as follows:

1. Phosphate is added to boiler water with sufficient alkalinity levels, calcium is precipitated as hydroxyapatite – $Ca_{10}(OH)_2(PO_4)_6$.

2. The hydroxide alkalinity will precipitate magnesium as brucite – $Mg(OH)_2$.

3. The hydroxyapatite and brucite precipitates form a sludge.

4. Synthetic organic polymers in the program condition the sludge.

5. Well-conditioned sludge is not sticky and will be removed in blow down.

Some residual phosphate programs use a blend of polymers for conditioning. These alter the crystalline structure of the sludge and this facilitates the dispersion of the reaction products.

**Advantages and Disadvantages of Residual Phosphate Programs**

| **Advantages** | **Disadvantages** |
| --- | --- |
| 1. Feed-water hardness up to 60 ppm. | 1. Precipitates can deposit resulting in scale, loss of steam production, tube overheating and failure. |
| 2. Well understood and accepted by industry. | 2. Increased solids mean increased blow-down, loss of steam production. |
| 3. Carry large residuals, so there is room for feed-water quality excursions. | 3. Precipitates can contribute to carryover and affect steam quality. |
| 4. Residual phosphate is non-corrosive. | 4. Typically not effective in dispersing particulates, such as iron. |
| 5. Cost per pound is relatively inexpensive. | 5. Causes suspended solids, therefore supplemental dispersant is necessary. |
| 6. FDA approved. | |

**II. Chelate and Chelate/Polymer Treatment**

Metal ions possess reactive sites at which the activity of the metal is centered. Normally, water molecules will occupy these sites. When materials are added that interact more strongly or compete more effectively for the reaction site, the sheath of water molecules is displaced as in Figure 4, and the metal ion acquires a new set of properties (e.g. could become less soluble).

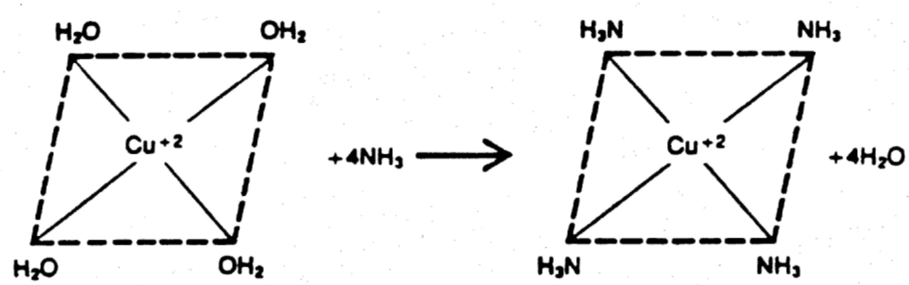


**Figure 4.** Diagram of copper ions with ammonia.

Chelating agents displace the molecules in these reactive sites with molecules made up of amine groups connected by an ethylene bridge. This incorporates the metal ion, such as calcium or magnesium, into a stable ring type structure as in Figure 5. The resulting complex is quite soluble and will not permit hardness metals, calcium and magnesium, to precipitate in the boiler as carbonates or sulfates. Although this complex is quite stable, strong competing ions such as $PO_4$, $SiO_2$ and $OH^-$ can form insoluble precipitates with the hardness in the presence of chelates.

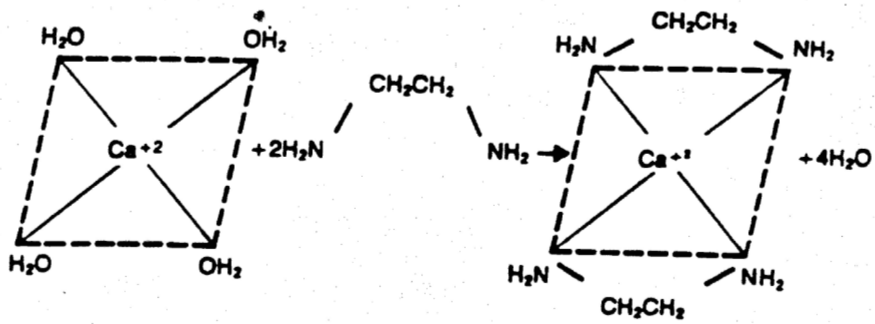


**Figure 5.** Diagram of calcium ions with ethylene diamine.

**Advantages and Disadvantages of Chelate Treatment**

**Advantages**

1. No precipitates are formed, so heat transfer surfaces are cleaner, blow-down is reduced resulting in higher steam Production, and tube life can be extended.

**Disadvantages**

1. They carry low residuals, so feedwater quality must be strictly controlled.

2. The control test is complicated, causing greater possibility for error.

3. Excessive residuals are very corrosive causing extensive boiler damage.

4. They offer poor magnesium transport.

**III. Traditional All Polymer Treatment**

True, all polymer programs contain no traditional chelates, phosphates, or phosphonates and require no supplemental dispersant to be effective. They function via a solubilization mechanism for calcium and magnesium and via a dispersion mechanism for iron and other particulates.

The solubilization mechanism involves complexation of hardness by the carboxylate functionality of the polymer. The reaction can be simply expressed as shown in Figure 6.

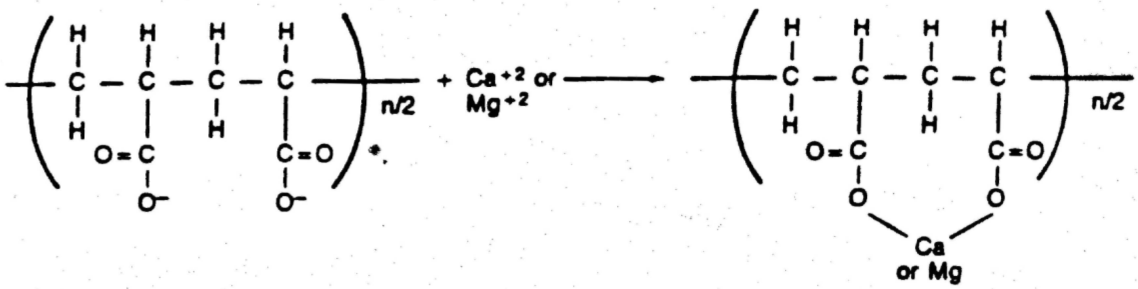


**Figure 6.** Diagram of solubilization mechanism.

The high charge density of the polymers strongly favors complexation reactions. Maintaining highly charged complexes keeps hardness ions in solution. The dispersion mechanism involves the adsorption of the polymer on the electrically charged sites of the particulate. This modification of the surface charge increases the repulsion energy of the particulates so that they remain suspended. Also, because of the large size of the polymers, a barrier is formed that further separates the particles, thereby reducing the possibility of agglomeration and scale formation.

Traditional all-polymer programs contain a combination of polymers in such a ratio that both solubilization and dispersion effects are maximized. The polymers are less aggressive toward complexing $Fe^{+2}$ and $Fe^{+3}$ than chelating programs, such as those using EDTA, NTA, HEDTA and phosphonate, reducing the likelihood of attack on boiler internals and boiler feed water equipment.

**Advantages and Disadvantages of Traditional All Polymer Treatment**

**Advantages**

1. As no solids are produced and particulate is dispersed, they are the cleanest treatment of all.
2. Less solids means blow-down is reduced, increasing boiler efficiency and steam production.
3. They can transport 100% of hardness through the boiler.
4. Tests for boiler water hardness can be run in the field, unlike phosphate or chelate treatment
5. They offer excellent iron and sludge dispersion to maintain clean heat transfer surfaces.

**Disadvantages**

1. Feedwater quality must be good. Recommended for systems with high condensate return or pretreated make-up.
2. Gross over-feed can cause corrosion.
3. Not tolerant to hardness upsets.
   - Calcium acrylate formation in severe underdosed conditions.
   - Product dosage based on “upper control limit” for hardness and iron.
   - Treatment can become costly during periods of high BFW hardness. A supplemental phosphate feed is usually implemented.

6. The programs are non-volatile, so they are safe for turbine operations.

7. They are less corrosive to boiler internals than other treatments.

8. They can provide excellent passivation properties (magnetite layer) to help reduce corrosion potential, even during lay-up.

9. They can be used in nearly any boiler up to 1000 psig.

10. FDA approved products are available.

4. Can lose activity in the presence oxygen.

5. Analytical tests are subjective.

**IV. Advanced Polymer Treatment Program**

The advanced internal treatment technology functions in much the same way as the traditional all-polymer treatment described above. There are, however, two important improvements over the traditional all-polymer treatment.

The first improvement of the advanced polymer is based on a new blend of copolymers. This change builds on the success of the traditional all-polymer treatment with three new major benefits:

1. Hardness upsets are handled much better by the advanced technology, and there is no danger of calcium acrylate formation or deposition.
2. Oxygen stability is improved, meaning polymer remains much more active in the presence of oxygen.
3. Thermal stability is improved, meaning polymer remains active much longer at the pressures and temperatures seen in the boiler.

The second improvement is the addition of fluorescence technology, which leads to dramatically improved control, more precise dosing, and numerous diagnostic capabilities previously not available to sugar mill operations. Listed below are the advantages and disadvantages of this boiler water treatment program:

**Advantages and Disadvantages of Advanced Polymer Treatment**

**Advantages**

1. As no solids are produced and particulate is dispersed, they are the cleanest treatment of all.

2. Less solids means blow down is reduced,

**Disadvantages**

1. Feedwater quality must be good. Recommended for systems with high condensate return or pretreated make-up.

2. Gross over-feed can cause corrosion.

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3. They can transport 100% of hardness through the boiler.

4. Tests for boiler water hardness can be run in the field, unlike phosphate or chelate treatment.

5. They offer excellent iron and sludge dispersion to maintain clean heat transfer surfaces.

6. The programs are non-volatile, so they are safe for turbine operations.

7. They can provide excellent passivation properties (magnetite layer) to help reduce corrosion potential, even during lay-up.

8. Improved oxygen and thermal stability over traditional all-polymer treatment programs.

9. Fluorescent technology provides for easier monitoring and advanced diagnostic capabilities.

10. They can be used in nearly any boiler up to 1000 psig.

11. FDA approved products are available.

3. Product dosage based on “upper control limit” for hardness.

4. Treatment can become costly during feedwater upsets. Supplemental phosphate is normally necessary.

## CONCLUSIONS

Control of deposition and corrosion in boiler tubes is critical to the efficiency and reliability of boilers in a cane sugar mill. There are many boiler water treatment programs available to the mills today to effectively control these problems. However, there are many other factors to consider and control before any of the programs can be effective.

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