10

HUGE Mistakes

Facilities Make in Boiler Operation

And How to Avoid Them

Thank you!

Hello, and thank you for downloading Clarity Water Technologies' exclusive eBook, the ***10 HUGE Mistakes Facilities Make in Boiler Operation and How to Avoid Them***! This eBook is a result of over 100 years of combined practical water treatment experience from expert water treatment professional throughout the United States.

Clarity Water Technologies was formed to provide superior cooling, process water and boiler water treatment products and services to customers in the industrial, commercial and manufacturing industries. Our company is based on one guiding principle:

> *Save our customers money by making their facility's mechanical and/or chemical processes the most efficient and effective they can be at the best possible price.*

To do this, we have committed to developing and utilizing the highest quality products available in the marketplace and recruiting only the most experienced and knowledgeable water treatment specialists in the industry. Today, we are considered by many to be the most elite team of water and energy specialists in North Atlantic Region.

As one of the most successful water treatment companies in the Northeast, we are constantly asked by facility managers and property owners what they can do to improve the operation of their heating and cooling equipment. This eBook will give you a good understanding of the top ten most typical mistakes that many facilities make when they are installing or operating their boiler systems.

We hope you will find this information useful, and if you downloaded this eBook looking for an answer that was not provided, please do hesitate to reach out to us ant time. As a company, we are extremely passionate about water and energy. Our water treatment professionals are highly knowledgeable and are always available to assist you in troubleshooting your water treatment related issues.

Good luck to you, and enjoy ***10 HUGE Mistakes Facilities Make in Boiler Operation and How to Avoid Them!***

clarity
water technologies llc

About the Authors

The topics contained in this eBook were written by, and are the opinion of, the following people:

Joshua Baty – Editor & Contributor

Joshua Baty is the Vice President of Business Development for Clarity Water Technologies, LLC. His background in facilities maintenance began in New York City in 1995 as Operations Manager of Equinox Health and Fitness Clubs. Josh holds a Bachelor of Fine Arts degree from Marymount Manhattan College and has over 10 years of Sales, Marketing and Business Development experience.

Christopher Scala – Contributor

Christopher J. Scala is a Regional Account Manager for Clarity Water Technologies, LLC servicing the Mid-Atlantic area. He began his career in the Petroleum Testing and Instrumentation Industry after graduating from Penn State University with degrees in Chemical and Environmental Engineering. He has since spent the past 13 years in various water treatment and energy management positions focusing on the manufacturing, food and beverage and health care industries. A member of NAPE, he resides in PA with his wife and three children, and services water treatment accounts throughout the NY, NJ, PA, MD and VA.

Dominick Tuzzo – Contributor

Dominick Tuzzo is a Regional Account Manager for Clarity Water Technologies, LLC. A former Chief Boiler Technician, Instructor, and Oil/Water Laboratory Supervisor for the United States Navy, Mr. Tuzzo has over 34 years of experience in maintaining and servicing marine, commercial, industrial, and cogeneration steam and high temperature hot water boiler systems. He holds an unlimited horsepower steam license, a B.S. from Regents College in Albany, NY, and is a member of AiCHE and ASHRAE.

Mike Weiland – Contributor

Mike Weiland is a Regional Manager for Clarity Water Technologies, LLC. He has been working in water treatment since 1994 servicing steam and hot water boilers, cooling towers, and closed loops. He holds multiple patents in water technologies and holds a B.S. in Agricultural Engineering from Penn State University and a degree in common sense that was earned working as a farmer in the great state of Pennsylvania.

Frank Vigliatura – Contributor

Frank Vigliatura is an Industrial Water Treatment Consultant and Regional Account Manager for Clarity Water Technologies, LLC. A 30 year professional in the industrial water treatment marketplace, Mr. Vigliatura holds B.S. Degree from Worcester State University, Worcester, MA which includes chemistry, metallurgical profiling, thermodynamics and global economics studies. Mr. Vigliatura's certification and expertise in industrial water management includes steam boiler and power generation (15 to 2200 psi), cooling water and refrigeration (50 to 10,000 tons), wastewater, waste minimization, water reuse, process systems, filtration and desalinization. Mr. Vigliatura also holds a certification in Six Sigma Methodology and has certification in the ISO 9000 series chemical production process. Most recent positions held include; Corporate Marketing and Technical Sales Manager, Global Corporate Accounts Manager, National Technical Sales Manager and is an active member of ASHRAE and the AWT.

Social Media

Clarity Water Technologies is committed to demystifying the science behind and necessity for good water treatment programs. In an effort to make information accessible, we regularly publish to various social media platforms. If you currently use Facebook, Twitter, Google+ or LinkedIn, we invite you to add us to your network, follow us, friend us, like us, re-tweet us - (whatever is appropriate). Also, to make sharing information super easy, we have provided easy-to-use Social Media Icons (like the ones below) throughout this eBook and we encourage you to use them to share this information with your own personal networks.

Follow Us

We publish great information every month; if you are a facilities manager, property owner or chief engineer, you may be interested in subscribing to our blog (via RSS or email) or joining us on your favorite social network. Please use these buttons to follow us on the web:

Share Our Content

Our content is free to share. (However, please do not re-label our hard work and research as your own... that's not nice.) Know someone that would like to see this information? Please use the following buttons to share this eBook with your networks:

About this eBook

The following ***10 HUGE Mistakes Facilities Make in Boiler Operation and How to Avoid Them*** are listed in no particular order. The list was compiled by interviewing and utilizing the experiences of top water treatment experts over the course of many years in the field. The topics that are covered, their importance to your facility, and how we recommend that you treat them are "in our opinion" as water treatment professionals. We do not recommend that you use any portion of this eBook to self-diagnose any mechanical or chemical issues that may exist within your facility. This eBook is merely a guide for facilities and operational personnel to use as a tool to understand what some of the mechanical and chemical problems that commonly plague boiler systems throughout the country may be.

IMPORTANT: Never attempt to fix a mechanical or chemical issue that you may believe you have unless you are trained and certified to do so. *Remember:* SAFETY FIRST. Always consult a specialist before starting any mechanical or chemical related projects.

And now, we humbly present, ***10 HUGE Mistakes Facilities Make in Boiler Operation and How to Avoid Them...***

Table of Contents

Mistake #1: No Water Softener

Hard water is a boiler's worst enemy. Hard water contains calcium and magnesium which, when cycled up in a boiler under heat and pressure, deposit out as scale. Scale in a boiler causes a reduction in heat transfer, which leads to increased fuel consumption. It could also lead to "hot spots" within the boiler which, if left alone, could eventually lead to a tube rupture. One of the most important things that a facility can do for their boiler system is to invest in a quality commercial grade water softener that will eliminate ALL calcium and magnesium for the system's makeup water. The removal of calcium and magnesium dramatically reduces the possibility of boiler scale formation.

Softeners are installed to pre-treat boiler makeup water prior to system entry. Most commercial water softeners operate by ion exchange, whereby a favorable sodium ion is exchanged for an unfavorable calcium and/or magnesium hardness ion in a one-to-one ratio. This happens inside the softener vessel and is a function of makeup water interacting with ion exchange resin beads that have been infused with sodium ions (by being submerged in a brine solution). Eventually, the softener's resin bed will be completely filled with as many unfavorable calcium and magnesium ions as it can hold and will need to be regenerated. At this point, the makeup water must stop following into the system, so that the resin bed has time to regenerate. Softener regeneration is a process whereby unfavorable hardness ions are rinsed off of the resin beads and out the drain, and then are replaced with new favorable sodium ions collected from a brine solution that is held in an adjoining brine tank. Once the softener has regenerated the resin bed is ready for service and fresh makeup water may be allowed to flow through it again.

There are many configurations and sizes of commercial grade water softeners available in the marketplace. This is by no means a “one size fits all” purchase. Besides the sizing requirements, there are many types of softener options available including:

- Single Vessel
- Twin Alternating
- Timer Regenerated
- Meter Regenerated
- Manually Regenerated
- Digital Head
- Mechanical Head

Since it is, by far, the most important piece of pre-treatment equipment that you will put on your boiler system, it is recommended that you consult a reputable water treatment company for guidance on sizing the correct softener for your system.

Mistake #2: No Deaerator

Elevated levels of dissolved gases in your boiler system's feedwater could easily wreak havoc on your boiler's internal metal surfaces. The two biggest culprits in this category are oxygen and carbon dioxide. Dissolved oxygen in boiler feedwater can cause extremely rapid, localized corrosion on boiler tubes; this is commonly referred to as "oxygen pitting," due to this type of corrosion's characteristic creation of small holes in the metal. Dissolved carbon dioxide in boiler feedwater will result in depressed pH levels and the inevitable production of carbonic acid. Carbon acid and low pH levels will cause an unyielding acid attack on the metal surfaces within your boiler system, resulting in a potentially catastrophic loss of metal.

Cleaver-Brooks SprayMaster DA

There are multiple solutions for controlling dissolved gases in boiler feedwater, including chemical options, however, the most efficient and economical way to remove them is through a mechanical process called deaeration. Deaeration works on the following two scientific principles of nature:

1. Gas dissolved in a solution becomes less soluble as the temperature of the solution increases. The hotter the solution gets, the less gas can stay in the solution.

2. Gas dissolved in a solution becomes less soluble as the gases' partial pressure above the solution decreases. A good example of this is when you open up a bottle of soda. The carbon dioxide starts to deplete faster once the pressure is released. This is why an opened bottle of soda goes flat.

Inside a deaerator, both of these principles of physics are employed, making it possible to remove almost all of the dissolved, non-condensable gases from the boiler feedwater including oxygen and carbon dioxide. A deaerator uses steam produced by the boiler system and can also be used to recapture condensate return. Most deaerators either spray a fine mist of makeup water directly into steam or drop it over a perforated deck to increase the surface area of the water and allow it to heat quickly allowing the gases to be liberated. Liberated gases are vented to atmosphere leaving behind deaerated hot water that is almost completely free of dissolved gases.

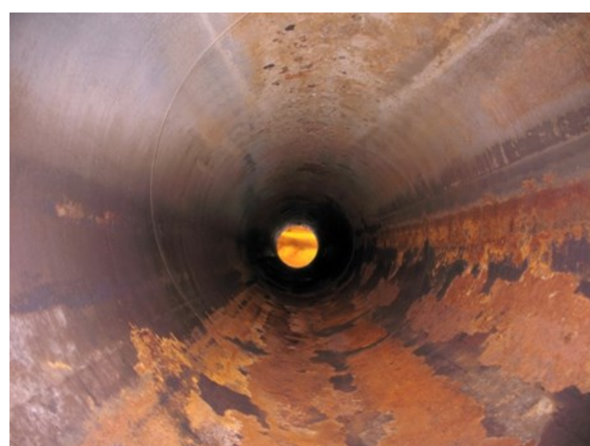
Although deaerators are capable of reducing oxygen and carbon dioxide to exceptionally low levels, the remaining minute amounts of dissolved gases are still significant and should be sequestered as they still pose a threat to the internal metal surfaces of the boiler. Therefore, a deaerator alone should not be considered a substitute for proper boiler water treatment. Additionally, a deaerator is not an alternative to proper softening and dealkalization of the make-up feedwater. A deaerator will, however, greatly diminish the amount of oxygen scavenging chemicals (such as sodium sulfite) which must be fed to maintain proper residuals with the boiler.

At Clarity Water Technologies, we promote a properly operated and well maintained deaerator alongside an effective chemical program to dramatically improve boiler lifespan and performance, as well as reduce operational and energy costs.

Mistake #3: No Condensate Treatment

Before we talk about why it is so important to treat your boiler system's condensate, we should probably first discuss what condensate is and why it is important. If you have a steam boiler, your boiler system produces steam. Steam leaves the boiler through piping to transfer heat to something; usually a heat exchanger or steam jacket. When the steam condenses in the pipe it is called condensate. This condensate water has very little impurities in it. In fact, condensate is practically pure, clean water… and it's very hot, which makes it the perfect fit for boiler feed water. That's why one of the best things that you can do at your facility is capture and return as much hot condensate water back to the boiler as possible. Returning the condensate back to the boiler saves water, but more importantly, it saves fuel. If condensate is not returned to the boiler, then the boiler needs to have fresh water introduced, which needs to be pre-heated, which burns fuel. The bottom line is, if you can return most of your condensate and keep it hot, you can save tons of money in energy.

There is, however, a dark side to this seemingly wonderful condensate. As mentioned earlier, condensate is almost pure water, and pure water is one of the most corrosive elements on the planet; especially when it comes in contact with steel and starts to cool. The problem is CO2. When water cools, carbon dioxide (CO2) easily dissolves in it. At the right pH, it starts to form carbonic acid and carbonic acid eats through steel.



So what needs to be done? It's a compound answer:

1. The system needs to be checked for leaks and failed steam traps.
2. The pipes and condensate receivers need to be properly insulated.
3. The steam needs to be treated chemically with a condensate treatment.

There are many types of condensate treatments, but the most common are amines. Amines fall into two major categories: filming and volatile. The volatile amines are completely soluble and therefore, can technically be fed in the boiler. They are considered volatile because they flash off and are carried with the steam into the rest of the system. These types of volatile amines are often referred to as short range, medium range and long range neutralizing amines, because of the distance they are able to travel "down pipe." Neutralizing amines are alkaline and, therefore, neutralize the acids that can form in the condensate by raising the pH. Neutralizing amines control corrosion in condensate applications by diminishing the effects of carbon dioxide and other acid forming compounds.

Neutralizing amines are used in boiler water treatment to control condensate return line corrosion. The amines do not have any adverse effects on copper or copper alloys under normal treatment conditions where pH is maintained between 7.5 to 9.0 and where only a few ppm of amine are continuously added to the boiler water. This has been confirmed by the long history of amine treatment in thousands of boiler water systems. However, at elevated concentrations, these neutralizing amines may be corrosive to copper and its alloys. To avoid this situation, amines should always be fed continuously in proportion to the feedwater by means of a chemical metering pump.

By contrast, filming amines are not completely soluble, and therefore, cannot be fed directly into a boiler. In fact, feeding this type of amine into a boiler could cause even worse problems than not treating the condensate at all. In order for a filming amine to work properly, it must be direct injected into the steam header. There are specially designed injection quills and pumps that are used to do this so that the filming amine is properly dispersed throughout the steam. When the steam condenses, this type of amine does not dissolve. Instead it coats the inside surfaces of the pipe with a microscopic layer of chemical that is almost oily in nature. When this material deposits on the inside of the pipe, liquid cannot penetrate it, preventing the condensate from coming in contact with the metal. The filming barrier protects the pipe from acid and oxygen pitting.

Amine feed should be examined and evaluated in any system such that:

1. The chemical feed pump should be activated only when the feedwater pump is running. At no time should chemical treatment be allowed into an idle feedwater line or boiler.

2. Treatment chemicals should be added over a 24-hour period of time. Slug-feed or shortening of daily feed duration may cause temporary high amine concentrations which may attack copper.

3. Treatment chemicals should be injected directly into the boiler if a separate chemical feed line is available. Chemical treatment can also be added to the feed water tank or storage tank of the deaerator. The large volume of water in the boiler or feedwater tank allows further mixing and dilution.

4. Amines should not be fed before a deaerator since passage through the deaerator will cause some loss of the amine.

5. In extremely long steam/condensate piping systems consideration should be given to supplemental amine feed directly to the steam lines in such quantities as are necessary to produce the desired condensate pH.

6. Amines should not be fed to boilers in which nitrite is used as a treatment compound since this combination may form nitrosamines which are known carcinogens.

Most amines are designed to work synergistically with oxygen scavenging, dispersion and other boiler treatment compounds, but the right mix of these chemistries and their proper administration should always be handled by an experienced water treatment expert.

Check with your water treatment provider to make sure that their line of condensate treatment chemicals available will fit your needs, especially if you have specialty applications including comfort heating of extremely large facilities or food processing.

Mistake #4: Improper or No Blowdown Control

Conductivity, or the total dissolved solids inside the boiler, is controlled only by the boiler surface blowdown valve. Improper control of the valve can lead to two issues:

1. The boiler is under-cycled. The blow down occurs too often, and does not allow the system to fully recycle the available water and chemicals to their fullest potential. This results in a waste of both water and chemical treatment product, thereby increasing the usage (and yearly cost) of both.

2. The boiler is over-cycled. The blow down does not occur enough and the boiler has a high amount of dissolved solids inside the system. This will result in hardness precipitating out of the water and onto the tubes forming a layer of insulating scale. This scale will force the boiler to increase its heating load to compensate, thereby increasing the likelihood of tubes overheating and ultimately failing. This is in conjunction with other problems caused by over-cycling such as under-deposit corrosion and sludge build-up.

Walchem Blowdown Controller

Many facilities make blowdown a regular part of the operators daily responsibilities, however, this can sometimes lead to a boiler not being blown down at the correct times or worse, not at all. Unless a facility has an operator taking hourly conductivity readings and making blowdown adjustments, we strongly recommend installing an automated surface blowdown controller. While there are many advantages, here are a few of the important ones:

- Save on water and fuel costs by eliminating excessive blow down
- Reduce time operators spend making adjustments
- Increase the reliability of the system to produce quality steam at high TDS levels
- Saves water and energy costs of blowing down the boiler to remove contamination

Mistake #5: Low Feedwater Temperature

Low feedwater temperatures during boiler operation have three major negative impacts:

1. Increase in fuel costs due to loss in efficiency. (It costs more money to heat cold water.)
2. Higher instances of corrosion, like oxygen pitting, due to increased dissolved gases in feedwater.
3. Higher chances of Thermal Shock (sometimes called Boiler Shock) which could lead to sudden pressure vessel failure, a potentially dangerous and catastrophic event.

In steam systems that return very little condensate, it is common to "make up" the lost water with incoming fresh water, sometimes referred to as "city water." The best practices for accepting this makeup water in a steam boiler is usually outlined in the boiler manufacturer guidelines and often includes some type of pre-treatment regime. Pretreatment of boiler makeup water often includes, but is not limited to, chemical treatment, softening and heating of the makeup water through a deaerator tank.

Important note: Throughout the water treatment industry it common to hear the terms "makeup water" and "feedwater" used interchangeably. However, at Clarity, we use terms to describe two separate situations. “Feedwater” is water that has been altered to become acceptable to introduce into a system. It may have been treated with a chemical, or heated, or softened, etc. “Makeup water” is water that comes into the facility from an outside source and is untreated for process use; makeup water is essentially tap water.

Loss in Efficiency

Common sense tells us that colder water takes longer to heat. Preheating makeup water is a critical step to maximizing the efficiency of many boiler designs. In the case of a conventional fire tube boiler, a steam sparger is often engineered into the condensate return tank to maximize efficiency by making sure that the boiler does not have to work harder to transform cold water into steam. This result is less fuel consumption.

Dissolved Gas Induced Corrosion

Dissolved gases love cold water. Elevated levels of dissolved gases in your boiler system’s feedwater could easily wreak havoc on your boiler’s internal metal surfaces. The two biggest culprits in this category are oxygen and carbon dioxide. Often referred to as oxygen pitting, dissolved oxygen in boiler feedwater can cause extremely rapid, localized corrosion on boiler tubes. Dissolved carbon dioxide in boiler feedwater will result in depressed pH levels and the inevitable production of carbonic acid. Carbonic acid and low pH levels will attack the metal surfaces inside the boiler.

The low temperature of makeup water allows the gases to stay dissolved. (Think cold club soda versus hot club soda.) Heating the makeup water to its boiling point helps to liberate most of the dissolved gases. The gas that remains can be further liberated with the addition of chemicals. This process often takes place in a deaerator tank.

Thermal Shock

Thermal shock is a phenomenon that can happen when there is a rapid temperature change in the boiler or uneven temperature changes to boiler vessel. Parts of boiler expanding (or contracting) more rapidly than other parts can cause continuous "flexing" of metal components against unyielding parts. This can result in leaking tubes, cracked tube sheets or cracked sections in cast iron boilers. Anyone that has ever accidentally poured cold water into a heated glass or ceramic dish has seen this process in action when the dish exploded into fragments.

Thermal shock is caused by the return of cold water to a hot boiler. An example of this is when system piping in building cools down overnight , yet the boiler is kept hot, or when secondary pumps over pump primary pumps. Also, failing to bring a cold boiler up to temperature slowly could lead to thermal shock. A cold boiler should stay at low fire until it is up to operating temperature for 30 minutes. It is important to note that it is also bad to introduce extremely hot water to a cold boiler; for example, in the case where a cold secondary boiler is started after being completely isolated from system flow.

Rule of Thumb

While each different type of boiler has its own optimal operating guidelines, it is a generally acceptable practice to keep incoming boiler feedwater at a temperature of 200 degrees Fahrenheit or higher. For a feedwater tank, 200 degrees and above is ideal. For a deaerator, the rule of thumb is (212 degrees) + (2 times the Tank Pressure). For example, if the pressure of a deaerator is 6psi, then the ideal temp should be 224 degrees Fahrenheit or greater.

Always consult with your boiler manufacture before making any changes to your existing boiler water treatment program.

Mistake #6: Improper Boiler Cycling

As mentioned in Mistake #4, conductivity, or the total dissolved solids inside the boiler, is controlled only by the blowdown rate. Unless an operator, who takes hourly conductivity readings on the boilers, closely monitors the system one of two things can happen:

1. The boiler is under-cycled, resulting in a waste of both water and chemical treatment product, thereby increasing the usage (and yearly cost) of both, or

2. The boiler is over-cycled, resulting in hardness precipitating out of the water and onto the tubes forming a layer of insulating scale. This scale will force the boiler to increase its heating load to compensate, thereby increasing the likelihood of tubes overheating and ultimately failing.

One of the biggest goals of any successful boiler water treatment program is to fully optimize the cycles of concentration a facility's boiler runs at. The term "cycles of concentration" simply refers to the amount of times water is recycled a boiler before blowing it down. It is calculated by using the following formula:

Cycles of Concentration = **<u>Conductivity of the Boiler Water</u>** divided by **Conductivity of the Feedwater**

The amount of cycles that can be run in a boiler depends on many factors; the most important being feedwater quality. The amount of iron, silica, hardness, alkalinity, chlorides and other dissolved solids are all limiting factors that will determine the amount of cycles that can be run. It is up to a qualified water treatment specialist to perform a complete water analysis of the system's feedwater and determine the saturation limit of each analyte before making a determination of actual cycles.

Once a limit is determined, the best way to fully ensure control over the optimum amount of cycles that can be run in a boiler is by investing in an automatic blow down controller. The advantages are as follows:

- Save on water and fuel costs by eliminating excessive blow down
- Reduce time operators spend making adjustments
- Increase the reliability of the system to produce quality steam at high TDS levels
- Saves water and energy costs of blowing down the boiler to remove contamination

The automatic blow down system Clarity recommends is a programmable boiler controller. The system consists of three parts:

1. The Boiler Controller keeps boiler water conductivity in the correct range by automatically blowing down water at high solids levels so it can be replaced with low conductivity make-up water. The controller can be set up for either intermittent or continuous sampling. In conjunction with blow down control

this inhibits corrosion, solids precipitation and scale build up. Programming is simple and is accomplished by using only three keys. Conductivity levels are displayed on a single-line backlit LCD display. LED’s provide visual indication of operating conditions and alarms.

2. The motorized blow down valve is connected to the conductivity controller, which opens or closes the valve in order to maintain the desired level of dissolved solids in the boiler. The high torque actuator mounts directly on the valve (no brackets). This eliminates misalignment, reduces wear and provides longer life for the actuator and valve.

3. The durable, forged steel flow control valve is used to regulate the blow down rate. A built-in dial and indicator makes flow rate adjustments easy.

This simple investment can return thousands of dollars back to a facility when you factor in fuel, water, chemical and labor costs.

Mistake #7: Poor Steam Trap Maintenance

Would the owners of your company be happy if you took $50,000 of their money and set it on fire? I know it seems like a silly question – because of course they would! Yet every day, in thousands of facilities across the United States, failing steam traps go unchecked and the dollars in lost energy just pile up. Failing steam traps are a major cause of energy loss in a steam system and can easily equate to serious dollars going right down the drain. Think about it this way: Let's assume, for the purpose of this example, that it costs $5 to produce every 1000 pounds of steam at 100 psi (depending on your system's efficiency it could be much more) and that, at 100 psi, just one failed steam trap could potentially allow over 800,000 pounds of steam to escape your system every month. That means that every month your facility could be losing over $4000 in energy! One failed steam trap could quickly equate to over $50k per year right out the window.

So what makes a steam trap so important?

Well first, let's quickly review the purpose and function of a steam trap. When steam condenses in a pipe the resulting pure water produced is called condensate. Condensate acts as a heat transfer barrier to the remaining steam in the system and so it must be removed to maintain maximum efficiency. To do this most steam systems have multiple steam traps plumbed in throughout the piping system. These steam traps were installed to remove the liquid condensate and


Spirax Sarco Steam Trap

air from the pipe so that pipe stays filled with “dry” steam. As the trap allows the dry steam to pass, it redirects the hot liquid condensate to a condensate receiver where it can be reused in the boiler. This also helps maintain the steam system’s overall efficiency by recapturing the resulting heated water to make new steam with less energy and with less water treatment chemicals than would be required if the water was straight make up from cool city supply.

There are many different types of steam traps, and they are often chosen because they fit a very specific function in the overall steam system design. The four most common steam trap designs are:

1. **Mechanical** – In these traps a volume of condensate will move a float to open the trap and allow the condensate to move out of the main pipe.
2. **Fixed** – These traps are also called fixed orifice traps because they have a preset hole in the orifice plate that allows condensate to drain from the main pipe whenever it is present. These When condensate is not present, these types of traps will usually have a small amount of dry steam escaping from them.
3. **Thermostatic** – The difference between the temperature of the condensate and the temperature of the steam is what actuates this type of trap to open and allow the condensate to drain from the main pipe.
4. **Thermodynamic** – These traps operate by pressure. The pressure difference between the cooler condensate and the hot steam cause a disc to open to allow condensate to drain from the main pipe. When there is less condensate, the pressure changes and the disc moves to the closed position allowing dry steam to move through the main without escaping.

Every steam system is different and some steam trap designs fit certain applications better than others. Choosing the correct type of steam trap can make a big difference to your overall steam system efficiency, and therefore, it is always recommended to seek the advice of a mechanical engineering professional when making changes to your steam system piping.

So what can you do to avoid steam trap failure?

Traps can fail for all types of reasons. Corrosion from poor water treatment, damage from water hammer, and metallurgical issues from extreme temper changes can all affect a steam traps performance. Sometimes it is easy to determine that a trap has failed. There could be steam blowing in to the condensate receiver; there could be steam flashing issues, or severe pump cavitation – which could all be indicators of a failed steam trap. Smart facilities avoid these things altogether by having a proactive steam trap maintenance program in place. Depending on the size of your facility's steam system, hiring a professional steam trap maintenance firm could literally be worth its weight in gold. These companies specialize in yearly steam trap maintenance and trouble shooting and their cost is usually far outweighed by their benefits.

Just remember: Choosing the right steam trap maintenance firm is like anything else; do your homework and get referrals! Ask your water treatment provider for help if you need it and stop senseless steam loss today!

Mistake #8: Improper Seasonal Boiler Lay Up

If your steam boiler only gets seasonal use then this topic is for you. We will assume that during heating season, your boiler water treatment levels are maintained within specific operating ranges to optimally inhibit corrosion and prevent scale. However, during the non-operating months, even the best chemical treatment program must be supplemented to prevent corrosion. When a boiler is taken off-line and allowed to cool down for extended periods of time, a boiler layup program is highly recommended, to offset the increased levels of oxygen in the boiler. Oxygen can quickly produce pits in tube sheets and boiler tubes. Once oxygen pitting starts, it can easily corrode through a boiler tube in a very short period of time. When it is time to start your boiler back up in the fall, you first have to make a call to a mechanical contractor to plug or replace tubes. Not good for your boiler and very expensive.

So what should you do to make sure your boiler operates as designed when restarted in the fall?

When a boiler is taken out of service, the boiler should be cooled until the water is below the atmospheric boiling point, but not below 180 °F, and then the boiler should be emptied and flushed out. An inspection should be made to determine what repair work is necessary and what cleaning should be done. A decision should then be made on whether to employ dry or wet storage techniques.

DRY STORAGE

This procedure is preferable for boilers out of service for extended periods of time or in locations where freezing temperatures may be expected during standby. It is generally preferable for reheaters.

1. The cleaned boiler should be thoroughly dried, since any moisture left on the metal surface would cause corrosion. Precautions should be taken to preclude entry of moisture in any form from steam lines, feed lines or air.

2. A moisture absorbing material, such as quicklime (2 lb. per 30 cu. ft.) or silica gel (5 lb. per 30 cu. ft. of boiler volume) may be placed on trays inside the drums to absorb moisture from the air. The manhole should be then closed and all connections on the boiler should be tightly blanked. The effectiveness of the materials for such purposes and the need for their renewal may be determined through regular boiler inspections. This should be done every three months. If there is high humidity, this should be done more frequently. If quick lime or a non-indicating silica gel is used, desiccant plates with indicating dye should be placed on each tray with the absorbing material as a quick indicator. These plates will change from cobalt blue color to pale pink if the absorbing material is exhausted and loses its effectiveness.

3. Alternatively, air dried externally to the boiler may be circulated through it. The distribution should be carefully checked to be sure the air flows over all surfaces.

WET STORAGE

A wet procedure may be used for a boiler to be placed in standby condition. Wet storage is particularly useful if the standby boiler may be required for service at short notice or if it is impractical to employ a dry storage procedure. The method is not generally employed for reheaters or for boilers, which may be subjected to freezing temperatures. Several alternative procedures have been employed:

1. The clean empty boiler should be closed and filled to the top with water, conditioned chemically to minimize corrosion during standby. Water pressure greater than atmosphere should be maintained within the boiler during the storage period. A head tank may be connected to the highest vent of the boiler to maintain pressure above that of the atmosphere.
    a. For short storage periods, caustic soda and sulfite should be added until their levels in the boiler water reach 450 ppm total alkalinity and 200 ppm sulfite. If the superheater is of the drainable type, it can also be filled with the same treated water by over flowing from the boiler.
    b. If the superheater is non-drainable, it should be filled only with condensate or demineralized water containing a minimum of dissolved solids, not more than 1 ppm. Before introducing the water into the superheater, mix in uniformly about 200 ppm of hydrazine and sufficient volatile alkali, such as ammonia, cyclohexylamine or morpholine to produce a pH of 10. The treated water may be introduced into the superheater through an outlet headed drain until the water over-flows into the boiler. When the superheater is filled, close the drains and vents. The boiler can now be filled through the feedwater or other filling line with condensate, feedwater or clean service water treated as described, with hydrazine and additional volatile alkali. If the storage

period is expected to exceed three months, the concentration of hydrazine should be doubled.

c. If preferred, the boiler may be filled using feedwater or condensate treated with caustic soda and sodium sulfite as described in (1) after first filling the superheater with condensate treated with hydrazine and additional volatile alkali.

2. As an alternative, the boiler may be stored with water at normal operating level in the drum and nitrogen maintained at greater than atmospheric pressure in all vapor spaces. To prevent in-leakage of air, it is necessary to supply nitrogen at the vents before the boiler pressure falls to zero as the boiler is coming off the line. If boiler pressure falls to zero, the boiler should be fired to re-establish pressure and superheaters and reheaters thoroughly vented to remove air before nitrogen is admitted. All partly filled steam drums and superheater and reheater headers should be connected in parallel to the nitrogen supply. If nitrogen is supplied only to the steam drum, nitrogen pressure should be greater than the hydrostatic head of the longest vertical column of condensate that could be produced in the superheater.

3. Rather than maintain the water in the boiler at normal operating level with the nitrogen cap, it is sometimes preferred to drain the boiler completely, applying nitrogen continuously during the draining operation and maintain a pressure of nitrogen greater than atmospheric throughout the draining and subsequent storage.

Mistake #9: Improper Boiler Commissioning and Initial Startup Procedure

Every boiler is unique. Even when they are the same exact models, they are still unique from each other. Metal thickness, skin temperatures, heat tolerances are all evidence of this. One of the most important steps in boiler's lifetime (regardless of make, model or serial number) is when it goes through its initial startup and commissioning process. When done properly, it sets the tone for the how the boiler will operate during optimum conditions. When done poorly, or not at all, it could lead to immediate and profound problems. While there are multiple checkpoints that must be verified and tested during startup, this article will focus on the ones regarding water treatment.

When a new boiler is installed, the pressure vessel will most likely have mill oils, grease, protective coatings and other foreign matter that collect there during manufacturing. Not to mention, there will be additional oils and grease, as well as welding slag (iron and cutting oils), which accumulates during fabrication and installation inside the new piping system. Unless a boiler is constructed with stainless steel or aluminum heat transfer surfaces, an alkaline boil out must be performed in order to remove these oils, greases and other protective coatings (i.e. cosmoline) from the waterside heat transfer surfaces.

(**IMPORTANT NOTE**: Alkaline products should NOT be used in boilers containing either stainless steel or aluminum. High alkalinity in can destroy aluminum and cause stainless steel to become brittle and develop stress fractures. Specialized products must be used to commission these types of boilers.)

All steel boilers, including mild steel, molybdenum steel, and even cast iron, will benefit from an alkaline boil out of their waterside surfaces. This process is performed during start up and commissioning in order to prevent premature failure due to localized overheating which occurs when boiler water is insulated from carrying away the heat of combustion due to deposition, oil, grease, etc. This phenomenon is sometimes referred to as a “hot spot,” or a place where foreign material adhered to the metal heat transfer surface in the boiler and therefore lends itself to overheating due to localized insulation.

In addition to metallurgical issues that can be caused by improper start up, many plants have steam purity requirements which will not be able to be met if a proper boil out program is not conducted. For example, a cooked vegetable processing plant that uses direct steam in their process to cook and/or peel vegetables could experience severe contamination of their product if they do not conduct a proper boil out on their new (or recently maintained) boilers. This could result in huge losses in production and, if not caught, could lead to potential consumer health related liabilities.

Another example is in a commercial laundry facility, where direct steam is often used at the steam press. Any mill oils present in the system will most likely transfer to the fabric being pressed, and thereby destroy it.

Common chemicals used during the boil out process include, but are not limited to, combinations of: Trisodium phosphate (Na3PO4, 12H2O), Caustic soda (NaOH), and/or Soda Ash (Na2CO3). It is of extreme importance to always follow the boiler manufacturer’s recommendation(s) in chemical selection, dosage rates, procedures, and time under fire whenever performing the boil out. For example, if your boiler water column gauge glass contains mica, the manufacturer will typically recommend you to either valve-off or install a temporary glass during the boil out evolution in order to prevent damaging the mica. Boilers using round glass water columns usually have no such requirements. Because alkaline boil out chemicals are so highly corrosive and present such a personnel hazard, it is often best practice to leave the alkaline boil out evolution to a competent water treatment vendor which has the appropriate products, procedures and personnel available to perform such specialized services to meet a wide range of manufacturer and customer needs.

The importance of a proper alkaline boil out is not only restricted to newly installed boilers, but is equally important for boilers which have been re-tubed in the field. Failing to properly chemically commission a new or re-tubed boiler typically results in one or more of the following detrimental conditions to varying levels of severity:

- Carryover of contaminants into the steam system causing loss of productivity, failure of steam traps, steam purity issues, discoloration of products, etc.
- Increased boiler and water column turbidity and discoloration
- Loss of boiler gauge glass and water column
- Loss or failure of boiler water level control systems, water columns, and/or low water shut downs
- Loss of heat transfer efficiency resulting in increased fuel consumption
- Localized overheating
- Tube pitting and/or under-deposit corrosion

- Departure from nucleate boiling (the inability of the boiler water to generate steam and thus carry heat away from the generating tube as a result of the contaminate insulating the water from the heat source)
- Limited or non-effectiveness of boiler water treatment program to reach the metal surfaces
- Baking on of oils, greases, contaminants as the boiler is continually fired
- Decreased boiler longevity
- Premature boiler failure

Mistake #10: Incorrect Water Treatment Program

Every boiler room in the world is as unique and diverse as the people responsible for maintaining them. The boiler design, output, demand, fuel, layout, metallurgy, makeup and feedwater quality, run schedule, load, and what the steam comes into contact with will have its own degree of originality and thereby will require its own specific handling and needs. So, why would anyone then assume the water treatment would be the same across the board? With the thousands of possible combinations of oxygen scavengers, scale inhibitors, amines, multi-functional one drum treatments and alkalinity supplements that could be used in any given boiler water treatment program, is your facility getting one that meets its individual and unique needs? Also, with advancements in polymers in water treatment chemistry over the years could your facility be running an outdated program that is not utilizing the latest innovations in energy and water conservation technology?

Let us first look at scale inhibitor technology. There are many families of scale inhibitors each designed to inhibit the formation of scale in different ways depending on the boiler design and feedwater quality. For instance, "all-polymer" technology has been much more attractive over the past decade or so due to the cleanliness of the boiler internals and the ability to run it safely at high cycles, but if your feedwater routinely experiences upsets in iron and hardness the polymer can become stressed and these particulates will drop out of solution and form deposits. It cannot do the job it is required to do based on feedwater quality issues. In these cases, an older method of treatment, like precipitating phosphate scale inhibitor chemistry, is better designed to handle these types of upsets without causing scaling conditions. Conversely, if your plant rarely has hardness and iron upsets and you are still running a phosphate based scale inhibitor program, then you are almost certainly losing money every year in fuel and water by not optimizing the cycles you can run in your boiler.

Another example is condensate treatment. Neutralizing amines are commonly used for condensate corrosion prevention. Neutralizing amines are volatile and flash out with the steam in the boiler. They buffer the condensate to ensure a pH that is noncorrosive. Most amine products are normally blended as a mixture of amines that are of short, medium and long range effectiveness. A facility that sends steam through hundreds and thousands of feet of piping would be better served with a long range amine technology while a plant that is much smaller in size would be benefit from a short and/or medium range amine for the most effective condensate treatment. Your facility may in fact require a short and long range blend based on your particular needs. In addition, there are some industries that require that no contaminants be in their steam since it comes in direct contact with food or other people; in these cases, neutralizing amines are not allowed in any form. Some scale inhibitors and multi-functional products contain small amounts of amines blended into them, and therefore, may unintentionally be in violation of these facility mandates.

Any successful boiler water treatment program needs a thorough examination of its mechanical systems (pre-treatment systems, steam traps, deaerator vs feedwater tank, etc), operational systems (blowdown schedule, boiler load runs, deaerator performance, operator testing) and chemical systems (water quality of makeup, condensate quality, chemical treatment program) to ensure long capital equipment life and energy efficiency. While some facilities may prefer to adopt an “if it’s not broke, don’t fix it” approach to their water treatment program, advances in technology, as well as changes to their surroundings, both external (changes to water source) and internal (deterioration of piping, changing load demands), may be costing them time and money in terms of efficiency, energy conservation and unnecessary maintenance.

Mistake #11: Underfeeding Water Treatment Chemical

You just got out of a meeting with your boss, and he just explained that he is slashing your budgets for the upcoming year by 20%! How are you going to make ends meet?

As you get back to your office your chemical rep is sitting there, waiting to go over his results with you from his service work that morning. You break the news to him, that you will be cutting your chemical purchases by 20% from last year, whether he likes it or not… and your equipment better be running clean and efficient, or else! Or else what?

So, can you cut your chemical use by 20% and still expect good results? After all, if using the correct amount of boiler chemicals protects the boiler, won't feeding a little less boiler chemical still be ok? It can't be that bad, right?

Well, not exactly. When it comes to industrial water treatment chemistry, there is very little ambiguity. Every boiler chemical that is fed to a steam system is fed for an explicit reason. The following is a list of the major chemical components to a typical steam boiler treatment program, what each chemical is designed to do and what could happen if you under feed them.

Oxygen Scavenger

Oxygen scavengers are chemicals that are fed to consume any remaining oxygen that did not get eliminated from mechanical deaeration of the feed water. Sufficient feed of these chemicals are essential in order to consume the oxygen in the feed water before it can cause oxygen pitting corrosion in the feed water and boiler systems. Sulfite is measured as a residual (or what has not been consumed by the oxygen removal process) in the boiler. In many systems, most of the sulfite fed is what is used to build the residual level that you can accurately test for. In other systems where the mechanical deaeration is less that desirable, a great portion of the chemical fed is used to eliminate the oxygen and only a small percentage is used to build the residual which is measured in the boiler.

Typically, for a well-run boiler system with good mechanical deaeration, the goal of oxygen scavenger feeding is to have at least 1 PPM (parts per million) residual per cycle of concentration in the boiler or at least 30 PPM, which ever number is greater. This calculation certifies (at least mathematically) that there is at least 1 PPM of sulfite residual at all times in the feed water. This ensures that your feed water system is protected and the transfer of iron to the boiler (as a byproduct of the corrosion process) is minimal.

So, reducing oxygen scavenger feed jeopardizes the protection of the feed water system. If you are running a polymer program, this transfer of iron to the boiler system will then INCREASE the polymer demand in the boiler!

Internal Treatment

Inadequate feeding of internal treatment chemistry (polymer) can result in both iron and calcium deposition on the heat exchange surfaces. This scale will impede heat transfer and will increase your fuel costs. Scale is also very detrimental to the projected lifespan of the heat exchange equipment. Scale does not form uniformly and, as a result, stress caused by temperature extremes will accumulate between the insulated (from scale) portions and the clean portions. This process can quickly fatigue system metal and ultimately cause system failure.

Alkalinity Booster

Inadequate pH (alkalinity) in the feed water will result in corrosion of the feed water system and ultimately transport the iron byproducts of corrosion to the boiler which increases the polymer demand.

Neutralizing Amines

Neutralizing amines are fed to increase the pH of the returning condensate to between 8.3 and 9.0. Without amine feed, the pH of condensate is normally driven downwards during steam production due to the formation of carbonic acid in the condensate due to the breakdown of alkalinity in the boiler water. Neutralizing amines counteract the acidity due to the formation of carbonic acid. Under feeding amines will result in increased corrosion rates, and ultimately the transfer of iron byproducts of corrosion back to the boiler which (you guessed it) increases polymer demand.

Summary

If overfeeding boiler treatment chemicals causes issues with carryover, then underfeeding boiler treatment chemicals causes issues with scale and corrosion. Cutting back on water treatment chemistry is often pennywise and pound foolish. An appropriate water treatment program will benefit the performance and efficiency of any boiler system, but in a steam boiler system it is even more serious. Problems in a steam boiler system that are caused by underfeeding boiler chemicals can escalate very quickly, and if no corrective measures are taken, these issues can lead to long interruptions of service and expensive repairs.

Under feeding boiler chemicals in steam system can eventually lead to boiler tube failure. In the case of a rupture under pressure, consequences could be catastrophic. For these reasons, always be sure to consult with your boiler system manufacturer and get the advice of a reputable water treatment company before making any changes.

Mistake #12: Overfeeding Water Treatment Chemical

So, if boiler chemicals help protect the boiler, feeding more chemical than that which is recommended is better, yes? Well, at least it can't hurt, right?

Well, not exactly. Each boiler chemical that is fed to a steam system is fed for a specific reason. Here is a list of the major chemical components to a typical steam boiler treatment program, what each chemical is designed to do and what could happen if you over feed them.

Oxygen Scavenger

Oxygen scavengers are chemicals that are fed to consume any remaining oxygen that did not get eliminated from mechanical deaeration of the feed water. Adequate chemical feed is required to consume the oxygen in the feed water before it can damage (pitting corrosion) the feed water and boiler systems. For low pressure steam systems, there are two primary choices that are typically used, acidified sulfite and neutral pH sulfite. Acidified sulfite is of a higher concentration, and is typically more cost effective to use. However, excess feeding of acidified sulfite will suppress the pH of the feed water. This pH suppression causes two different problems that can wreck a boiler water chemistry program and ultimately damage the system you are trying to protect.

First, feed water pH should always be greater than (>) 8.3. Depressing the feed water pH can cause corrosion of the feed water piping which can ultimately cause system failure. Secondly, when this happens, the corrosion byproducts of this process are transported into the steam boiler. These byproducts of the corrosion process (iron) can then form a tenacious scale that insulates the boiler heat transfer surfaces. If the internal treatment program is a polymer based dispersion program, this increased loading of iron can consume a great deal of the available polymer which reduces the amount available for the dispersion of calcium leak through from the pretreatment system. If you are still using a phosphate based internal treatment program, any iron dispersency is negligible and iron phosphate scale can form.

Internal Treatment

Excessive feeding of internal treatment chemistry can cause boiler water "priming" or "carry over". These problems are attributed to increased concentrations of boiler solids which can cause the production of "wet steam". Wet steam does NOT carry the BTUs that dry steam does and can cause water hammer in the steam/return piping. Difficulty in maintaining water level control in the boilers is usually a result. A "bouncing" sight glass is a good indicator that carryover is occurring.

Alkalinity Booster

In some systems, depending upon makeup water characteristics and the level of mechanical deaeration available, additional alkalinity may be needed to increase the pH of the feed water to above 8.3 to counteract the effects of excessive acidified sulfite feed. Excessive alkalinity feed can cause boiler water priming or carryover as well.

Neutralizing Amines

Neutralizing amines are fed to increase the pH of the returning condensate to between 8.3 and 9.0. Without amine feed, the pH of condensate is normally driven downwards during steam production due to the formation of carbonic acid in the condensate due to the breakdown of alkalinity in the boiler water. Neutralizing amines counteract the acidity due to the formation of carbonic acid. There are strict limits on the amount of neutralizing amine that can be fed, as this chemistry is potentially hazardous at excessive feed rates. Excessive feeding of neutralizing amines can cause a potentially hazardous situation to develop.

Overfeeding in General

All chemicals, when added to water, eventually add dissolved solids to the boiler water. Excessive feeding of boiler chemicals add excessive levels of dissolved solids which may cause the need to operate at lower cycles of concentration. This increases fuel consumption of the system and ultimately increases system operating costs.

Summary

Using the right chemicals in the wrong quantities can result in major damage to your overall steam system; and therefore, facilities must monitor water treatment programs carefully. If no remedial action is taken, this issue can lead to downtime and costly repairs. Having a proper water treatment program will help the performance of any boiler system, but if your facility operates a steam boiler system it is even more critical. A steam system has more advanced needs than a hot water system, and tolerances for mistakes are generally lower. Overfeeding boiler chemicals in steam system could potentially lead to boiler tube failure and present multiple safety issues. As always, make sure you consult with your boiler system manufacturer and a reputable water treatment firm before making any changes.

Mistake #13: Incorrect Chemical Feed Location

As water treatment consultants, we have to work within the confines of the situation presented to us, which varies from location to location. Obviously not all boiler rooms are alike, and we often find ourselves walking into a new site wishing we had the capability of waving a magic wand to have every piece of equipment (whether it be pumps, controllers, injection quills, etc) installed in the most optimal location. Unfortunately due to limitations with space, cost and access we are forced to manage with the options available. Sometimes this requires us to feed boiler treatment chemistry in areas that are not ideal as per ASME guidelines, but still effective. However, there are many situations where the locations of equipment are not ideal or effective, and the water treatment chemistry that you think is protecting your boilers is, in fact, having no effect at all. In these cases, it is crucial that we go back to drawing board and make the necessary physical changes to the boiler room layout, so that the chemical program will work properly. Often we can solve major problems by moving the chemical feed location. Here are some examples of common feed location mistakes:

Small Systems

For small boiler systems that consist of one or two boilers (combined HP usually under 400HP) and that utilize a common feedwater tank, the typical water treatment program will consist of a multi-functional, one-drum product that will provide oxygen scavenging, scale inhibition and steam treatment; commonly referred to as an “all-in-one” product. The WORST place you can feed this all-in-one product would be directly into the feedwater line instead of the feedwater tank itself. In this situation, the boiler remains protected against corrosion and scale, while the feedwater tank is completely vulnerable to oxygen pitting attack due to the lack of an oxygen scavenger (or any treatment) being fed into the tank. Since feedwater tanks have no mechanical oxygen scavenging ability like a deaerator would, and do not operate at the same high temperature of a deaerator (over 220F), most untreated tanks tend to have a great deal of dissolved oxygen concentrated in the feedwater. When heated, the dissolved oxygen flashes off and becomes extremely corrosive to the metal shell of the feedwater tank. So while a facility may be investing in a water treatment program designed to protect their boiler systems, they end up doing extensive damage to the system preceding the boiler by simply feeding it in the wrong location.

Large Systems

As the size of the boiler system gets larger, it becomes more and more likely that the water treatment chemistry program will become more sophisticated and specialized. Separate feeds, used specifically for an oxygen scavenger product, a scale inhibitor product, a steam treatment product and sometimes an alkalinity booster, are all required to meet the needs of larger, more diverse boiler systems. While there can be more than one location to feed each product, there are more likely several locations where certain products CANNOT be fed, or else run the risk of ineffectiveness (best case) or long-term damage to boiler steam system equipment (worse case).

Here are a few examples:

1. Neutralizing amines, if fed above the water line of a deaerator, can lose up to 75% of their effectiveness by having the volatile product vent out through the DA orifice via the steam sparge before it even reaches any type of feedwater.

2. Highly concentrated caustic supplements that are fed into small piping areas of low water volume could cause rapid caustic corrosion. It's easy to over-feed corrosive chemicals in these locations due to the lack of water to buffer them.

3. Due to their viscous nature, certain polymer scale inhibitors can cause the boiler feedwater pump internals to clog if fed prior to the pump suction from a deaerator/feedwater tank.

4. Filming amines are not volatile (i.e. will not carry over with the steam) and therefore, will not reach its intended target if it is fed in the boiler or feedwater tank.

Based upon the layout and accessibility of your plant, there may be limitation inhibiting you from feeding your treatment chemistry in the "ideal" location. However, as the examples above demonstrate, you must, at the very least, make sure that where you are feeding your chemical is not doing more damage than not feeding chemical at all!

Disclaimer

Statements and suggestions contained herein are based upon the best information and practices known to Clarity Water Technologies, LLC, however, it should not be assumed either that information is complete on the subjects covered or that all possible circumstances, issues, safety measures, precautions, etcetera have been included. These statements and suggestions are not intended to reflect any provincial, municipal national safety codes or insurance requirements; where applicable, those sources must be considered directly.

Since the conditions of use are far beyond our control, Clarity Water Technologies, LLC makes no guarantee of results and assumes no liability in connection with the information contained herein. As with any water treatment related issue, always consult the manufacturer of your equipment and/or your water treatment service provider before making any changes.

permissions@claritywatertech.com

Clarity Water Technologies, LLC

50 North Harrison Avenue, Suite #10

Congers, NY 10920

www.ClarityWaterTech.com

Tel: (888) 616-3545

Fax: (888) 754-4304