



HVAC WATER TREATMENT OVERVIEW

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Hot Water and Chilled Water Systems

Chilled water and hot water systems are “closed recirculating water” systems. For water treatment, closed systems have several advantages:

- There is no loss of water in the system (except when a leak occurs) and, thus, no need for make-up water. Therefore, deposition or scaling is not a problem.
- Once filled and entrained air removed, the closed system creates an anaerobic environment that eliminates biological fouling as a problem.
- Closed systems reduce corrosion problems because the water is not continuously saturated with oxygen (an oxidizer) as in open systems. The low temperatures common to HVAC systems further reduces the potential for corrosion.

Water treatment to reduce or even eliminate the potential for corrosion is required only when the water system is initially filled with water or when it is drained and re-filled due to maintenance, repair, or modification.

Corrosion in a closed system can occur due to oxygen pitting, galvanic action and/or crevice attack. To prevent these conditions, the “shot feed” method of chemical treatment is used. With this method, a bypass chemical feeder is used to add treatment chemicals to the system via a one-time “shot” just after the system is filled with water. For the steel and copper mixed metallurgy typical of HVAC water systems, a molybdate corrosion inhibitor is best, with treatment limits of 200-300 ppm recommended.

Condenser Water Systems

For “open” condenser water systems, the water treatment issue becomes much more involved and a specialized water treatment program is required to prevent or control deposition (scaling), corrosion, and microbiological fouling of cooling towers, condensers, and piping.

As a portion of the condenser water flow is lost by evaporation (approximately 0.1% of the flow rate per degree of temperature range) through the cooling tower, the concentration of dissolved solids increases since solids are left behind as the liquid evaporates. Make-up water, which is added to the condenser water system to offset the evaporation losses, will add dissolved minerals at a lower concentration level than the condenser water and, thus, some equilibrium concentration level will be maintained. However, if this equilibrium concentration level is high enough that can deposition occur, a program to control solids concentration at a lower level is required.

The concentration of dissolved solids can be reduced by adding more make-up water, which has a lower concentration, to the condenser water, which has a higher

concentration. However, to add water to the system, an equal amount must be removed from the system by *blowdown*, the intentional “dumping” of condenser water to drain.

For corrosion control, condenser water pH must be maintained between 4 and 10 and, in most cooling tower water treatment programs, the desirable range for pH is between 8 and 9 in order to water alkalinity to a reasonable level (400 ppm or less). However, in metal towers, a pH of 7.0-8.0 is preferred to help prevent white rust corrosion. Therefore, at least for most metal cooling towers, the ideal pH range is 7.5-8.5.

Water hardness and alkalinity is a function of the hardness and alkalinity of make-up water, the amount of evaporation and drift loss from the cooling tower operation, and the blowdown to proposed to yield the desirable pH to prevent both deposition and corrosion. The term *cycles of concentration* defines the ratio of the desired concentration of dissolved solids in the condenser water to the concentration of dissolved solids in the make-up water, as follows:

Cycles (of Concentration) =

Dissolved Solids (ppm) in Blowdown / Dissolved Solids (ppm) in Make-up

This relation can be express in terms of water flow by the following equation:

$$\text{Cycles (of Concentration)} = \text{MU} / \text{BD}$$

where

MU = total make-up water flow, which is the sum of evaporation + blowdown, gpm

BD = blowdown flow, gpm

MU in this equation can be replaced with the value (E + BD), where E is the evaporation rate, and rearranged to yield the following relationship:

$$\text{BD} = \text{E} / (\text{Cycles} - 1)$$

Since drift water loss is not included in these calculations, the actual required BD flow can be reduced by the amount of drift loss from the tower (about 0.5-1.0%)

There are two ways of controlling blowdown in an HVAC cooling tower system:

Constant blowdown with manual adjustment based on periodic water hardness analysis is the simplest method. However, since the amount of blowdown is constant, the loss in water and water treatment chemicals is high and this really represents the most expensive approach.

Controlled blowdown based on continuous monitoring of the water hardness as indicated by its conductivity. Automatic control minimizes the waste of water and water treatment chemicals and is the preferred method.

The amount of make-up water is reduced significantly as the number of cycles is increased from 2 to 6. However, there is only a further 5% reduction in make-up water as the number of cycles is increased from 6 to 10, and only a further 2% reduction as it is increased to 20. *Therefore, in most cooling tower applications, cycles of concentration is maintained between 5 and 10 and deposition inhibitors are added as necessary.* While lower cycles represent loss of more water and treatment chemicals, the amount of treatment chemicals required tends to go down with cycles, and 5-10 cycles usually represents a good balance point.

In these cases, chemical treatment, i.e. the addition of deposition inhibitors to the water system, becomes necessary to augment blowdown. The most common scale inhibitors used in condenser water systems are *posphonates*, which are organic phosphate compounds, such as HEDP, which function by adsorption on the crystals as they form and prevent them from attaching to metal. Thus, these crystals precipitate out of solution, usually in the tower basin.

Metal corrosion occurs as a result of *galvanic action* at a negatively charged “pole” or site on the metal surface. Both *anodes*, negatively charged sites, and *cathodes*, positively charged sites, can be created on the metal due to impurities in the metal, localized stress, metal grain size or composition differences, or even scratches on the metal surface. Due to the differences in charges, there is an electrical potential between the anode and cathode and an electrical current (electrons) flows from anodes to cathodes, using the surrounding water as a conductor or *electrolyte*.

Corrosion is the loss of metal; it literally “dissolves”. Corrosion can exhibit two characteristics depending on the underlying reason for the anodic and cathodic sites. *General corrosion* is wide spread and is caused, usually, by impurities in the metal or characteristics of the metal or its environment that results in an overall fouling of the metal surface. *Localized corrosion* results, mostly, from scratches, stress, or localized environment and the most common reason for “metal failure”. If dissimilar metals with different electrical potentials are used in a condenser water system, galvanic corrosion is enhanced and the metals simply corrode faster, particularly at and near the point(s) of contact between the metals.

The first step in corrosion control is to minimize the contact between water and mild steel materials. **All primary wetted surfaces...wet decks for induced draft towers and tower basins... should be constructed of stainless steel.** This typically increases tower costs, but it is generally a worthwhile investment. Use plastics or fiberglass for the tower casing, wet deck covers, intake louvers, drift eliminators, and fill. Finally, if mild steel is used for the tower structural frame, it should be galvanized *and coated with an epoxy or polymer final protective coating.*

Piping in most condenser water systems is carbon steel and must be protected from corrosion. This accomplished by using one or more treatment programs, as follows:

Passivating (Anodic) Inhibitors: These chemicals form a protective oxide film on the metal surface which is not only tough, but, when damaged, quickly repairs itself. *Othophosphates, a common passivating inhibitor, should not be used in condenser water systems containing stainless steel since it will make the metal brittle over time.*

Precipitating Inhibitors: Precipitating inhibitors form complexes that are insoluble at the higher pH and, thus, precipitate out of the water. Zinc is good precipitating inhibitor. Molybdate will also act as a precipitating inhibitor and, thus, can serve as a corrosion inhibitor using two mechanisms.

Adsorption Inhibitors: These are organic compounds containing nitrogen, such as amines, or sulfur or hydroxyl groups. Due to the shape, size, orientation, and electrical charge of the molecule, they will attach to the surface of the metal, preventing corrosion. Their drawback is that they form thick, oily surface films that reduce heat transfer capability.

Biological fouling results from bacteria, fungi, zooplankton, and phytoplankton or algae introduced through make-up water or filtered from the air passing through an HVAC cooling tower. “Fouling” results when these microorganisms grow in open systems rich in oxygen (an aerobic process) and form slime on the surfaces of the tower, piping, and heat transfer surfaces of the condenser water system. Slime is an aggregate of both biological and non-biological materials. The biological component, called the *biofilm*, consists of microbial cells and their byproducts. The non-biological components consist of organic and/or inorganic debris in the water that has become adsorbed or imbedded in the biofilm layer.

The number one method of controlling biological fouling is to keep cooling towers clean. At least twice during the cooling season, the tower should be drained, scrub cleaned and allowed to fully dry before refilling. Then, the use of chemical treatment will complete the control chore.

There are two kinds of antimicrobial chemicals or *biocides* used in cooling tower water treatment programs to control biological fouling: oxidizing and nonoxidizing.

Oxidizing chemicals include chlorine, bromine, and ozone that *oxidize* or accept electrons from other chemical compounds. (**Warning!** *Oxidizing chemicals, particularly chlorine, can react with steel, including stainless steel, and cause rapid corrosion. To prevent this, concentrations of these chemicals must be kept low, ideally to less than 0.7 ppm. Oxidizing chemicals must be introduced into the condenser water system in a way to be rapidly dispersed to prevent localized high concentrations.*)

Nonoxidizing antimicrobials attack cells and damage the cell membrane or the biochemical production or use of energy by the cell, resulting in its death, and are sometimes referred to as “surface-active” biocides. Typical nonoxidizing biocides include isothiazolines, gluteraldehyde, MBT, and polyquat.

Microbials in condenser water systems can become resistant to a single method of attack, or some microbials may be more or less immune to one type of attack. Therefore, it is recommended that both types of treatment chemicals be used (oxidizing and nonoxidizing), either blended together or in alternating treatment patterns, as indicated by periodic water testing results. *The key to a successful biological treatment program is maintaining adequate chemical treatment levels at all times via continuous feed of antimicrobials into the condenser water system.*

HVAC cooling towers are excellent “air washers”. Pollen, dust, microbes, leaves, and other debris in the air is readily trapped and removed by the water and deposited in the basin to form “sludge”, which can foul heat transfer surfaces. In the majority of cases, regular basin cleaning will control the problem, but in many urban and/or industrial areas, the amount of sludge formed during normal tower operation may be so great that specific control measures must be installed.

The most common general fouling control method is the use of *side-steam filtration*. Here, a portion of the condenser water flow is diverted through a filter for removal of dirt and suspended solids. Typically, filters are sized so that the entire water volume is filtered each hour. Thus, it necessary to determine the total system water volume contained in the tower basin and wet deck, condenser water piping, condenser(s), etc. and divide that volume, in gallons, by 60 minutes to establish the required filter flow rate, in gpm.

The most common (an economical) type of sidestream filter is a sand filter with backwash, much as used for swimming pool applications. These filters will remove suspended solids of 50 micron and larger particle size.

Ozone is a condenser water antimicrobial that eliminates the need for chemical treatment for microbiological fouling. Ozone (O_3) is an unstable form of oxygen (O_2) that has a relatively short half-life, usually less than 10 minutes. Ozone is a powerful biocide and virus deactivant and will oxidize many organic and inorganic compounds. Ozone treatment cannot be used with water with excessive hardness (500 ppm or higher calcium carbonate) or with sulfates greater than 100 ppm. Also, because of its short life, ozone should not be used in large systems or systems that have long piping runs that would required long residence times to get complete coverage.

Every few years, salesmen make the rounds to tower owners and designers and talk about the “wonders” of magnetic treatment for deposition control in condenser water systems. Their product consists of strap-on magnets installed around condenser water piping. Promoters of these devices claim that dissolved solids, which dissociate into charged ionic salts in solution, can be easily removed by allowing them to pass through a magnetic field. *Tests by independent sources have proved conclusively that magnetic treatment typically has no effect on deposition rates in condenser water systems.* (See [engineering report on magnetic water treatment](#).)

There are three special issues relative to cooling towers that must be addressed by a combination of routine cooling tower maintenance and water treatment:

White Rust: Since the late 1970's, there has been a significant increase in the use of galvanized steel cooling towers in lieu of wooden towers, particularly in the HVAC market. With the advent of new cooling tower water treatment polymers and corrosion inhibitors, most condenser water treatment programs are now utilize little or no acid addition and operating pH levels have increased from 6.5-7.5 to as high as 9.5 (with the new alkaline polymer approach). As the technology of the water treatment industry has changed, the corrosion of galvanized steel has now become a major concern.

The term *white rust* refers to the premature, rapid loss of galvanized coating on cooling tower metal surfaces. White rust is evidenced by a white, waxy, non-protective zinc corrosion deposit on wetted galvanized surfaces. This rapid loss of the galvanizing

results in the corrosion of the underlying steel and, instead of tower systems that will last 20 to 25 years, equipment will have drastically shortened life spans.

Many believe that the change to the dry kettle method of galvanizing continuous sheet steel has had an effect on the increased formation of white rust. Initial research has shown that the levels of aluminum and lead in the galvanizing have changed. With the wet kettle method, lead levels were 0.60% to 1.0% and aluminum levels were .005%. Levels of lead have dropped to .05% and levels of aluminum have increased to .40% since going to the continuous sheet galvanizing. This increase in aluminum and decrease in lead is believed to help increase the brightness of the metal surfaces; making a better-looking product. The higher aluminum percentage also improves bonding of the zinc coating to the steel.

Cooling tower manufacturers do not believe that changes in the galvanizing process or in the lead and aluminum levels deposited are responsible for the increase of white rust. The industry has stated that aluminum levels have not changed and that the galvanized coating is actually more than twice as thick (2.35 oz. of zinc per square foot of steel sheet) as they were 20 years ago.

However, it can be documented that cooling water programs operated with a pH range of 8.0 to 8.5 for many years without having white rust problems. It can also be documented that new towers added to existing systems, using the same make-up water, chemical treatment and controls have developed white rust, while the original units have not. Therefore, white rust does not appear to be a water quality and or water treatment problem.

So while the argument continues, and based on current information, it is well established that white rust may form if the following conditions exist:

- The galvanized coating is not properly “passivated” when the tower is placed in service. (Passivation is a process that allows the zinc coating to develop a natural nonporous surface of basic zinc carbonate. This chemical barrier prevents rapid corrosion of the zinc coating from the environment, as well as from normal cooling tower operation. The basic zinc carbonate barrier will form on galvanized surfaces within eight (8) weeks of tower operation with water of neutral pH (6.5-8.0), calcium hardness of 100-300 ppm, and alkalinity of 100-300 ppm.)
- Condenser water is maintained at pH above 8.0.
- High condenser water alkalinity (above 300 ppm).
- Low condenser water calcium hardness level (below 100 ppm).
- The lack of phosphate-based corrosion inhibitor in the condenser water treatment program.

For most galvanized metal HVAC cooling towers, white rust will occur if not prevented by the following steps:

- Provide a secondary barrier coating on all wetted surfaces, such as epoxy or

polymer finish for a new tower or coaltar (bitumen) on an existing tower. An even better approach is to specify new towers to have wetted surfaces such as basins and wet decks to be constructed of stainless steel.

- Run the cooling water treatment program at a pH between 7.0 and 8.0, which may require pH control.
- Make sure the galvanized tower is properly passivated upon system start-up. Where white rust has occurred, the metal can be “re-passivated” by treating the surface with a 5% sodium dichromate 0.1% sulfuric acid, brushing with a stiff wire brush for at least 30 seconds, then rinsing with thoroughly.
- Incorporate a phosphate-based product into the water treatment program, along proper dispersants.

Legionella: In 1976, 34 attendees at an America Legion Convention in Philadelphia died from a pneumonia-like disease that was later traced to the then-unknown bacteria that we now call *Legionella*. Since this initial outbreak (which was really preceded by earlier events in Austin, MN in 1957 and Washington, DC in 1964), the recognition of *Legionella* as a serious problem has grown significantly. According to the U.S. Centers for Disease Control (CDC), Legionnaires’ Disease infects approximately 25,000 people in the U.S. each year and 10 to 15 percent of these cases are typically fatal. *This equates to 3,000-7,000 deaths attributable each year to Legionella.*

Legionella is a bacteria that is common in surface waters, including lakes, rivers, etc. The bacteria survive routine water treatment and low concentrations are introduced into most potable water supplies. *Legionella* thrives in water temperatures between 68 °F and 122 °F, with optimal growth occurring between 95 °F and 115 °F. Low pH and high levels of aquatic growth (microbiota, amoebae, algal slime, etc.) enhance bacteria growth. Water temperatures above 135-140 °F kill the bacteria.

At these temperatures, the ideal habitats for *Legionella* include cooling towers and evaporative condenser systems, where temperatures typically range from 85-100 °F. (Other potential breeding grounds for *Legionella* include domestic hot water systems in schools and hospitals, humidifiers, spas or whirlpools, and even vegetable misters in supermarkets.)

The major mechanism for infection by *Legionella* is via inhalation of aerosolized water droplets or particles containing the bacteria. Cooling towers or evaporative condenser sprays introduce aerosolized water droplets and, therefore, represent prime mechanisms for infecting humans. There is no evidence that drinking water with the bacteria in it will cause disease, nor can the disease be passed by human-to-human contact.

There are two types of disease caused by *Legionella*: “Legionnaires’ Disease” is a severe form of pneumonia, while “Pontiac Fever” is a nonfatal flu-like illness. Legionnaires’ Disease symptoms can vary from a cough and low fever to rapidly progressive pneumonia, coma, and death. Symptoms occur typically within 3-9 days after exposure.

To monitor and control *Legionella*, the following steps are recommended:

- Test for *Legionella* in cooling tower water. While there is an academic debate over the cost-vs-benefit of routinely testing for *Legionella*, it is dumb (from both an ethical and a liability point of view) to ignore any potentially life-threatening condition at a facility. Testing must be specific for *Legionella*: “total bacteria” tests promoted by some water treatment companies are inadequate since there is no correlation between total bacteria and *Legionella* concentrations.
- If *Legionella* is found, reduce or eliminate the bacteria concentration. Cooling towers (and evaporative condensers) can be decontaminated by slug chlorination with 50 ppm of free residual chlorine, along with a dispersant. Then maintain 10 ppm of free residual chlorine for a least 24 hours, while maintaining the water pH at 7.5-8.0. Finally, drain the system and repeat the process.
- Cooling tower systems should be drained and flushed twice each year. All surfaces should be cleaned and allowed to air dry before reuse. Continuous-feed water treatment systems for biocides are required to maintain consistent concentration levels.
- Keep up with the latest information on *Legionella*. ASHRAE has published Guideline 12, *Minimizing the Risk of Legionellosis Associated with Building Water Systems*, and CTI has also published a guideline specifically addressing cooling towers.

Microbiologically Induced Corrosion (MIC): MIC is caused by sulfate-reducing bacteria (SRB) in the water and is usually evidenced by reddish or yellowish nodules on metal surfaces. When these nodules are broken, black corrosion by-products are exposed and a bright silver pit is left in the metal. A “rotten egg” smell when the nodule is broken is also evidence of SRB corrosion.

SRB’s obtain their energy from the anaerobic reduction of sulfates that are available in most water. The bacteria contains an enzyme that enables it to use hydrogen generated at a cathodic site to reduce sulfate to hydrogen sulfate and act like a cathodic “depolarizing agent”. *Iron corrosion by this process is very rapid and, unlike rusting, is not self-limiting.*

Once SRB’s begin to grow in a system, they are very difficult to eliminate. Thus, a *preventative program* is far more effective than a clean-up program:

- Keep the system clean through sidestream filtration and regular cleaning.
- Prevent contamination by oils and/or grease. Even very small amounts can cause problems.
- Eliminate potential bacteria sources (such as bathroom and kitchen vents, diesel exhaust, etc.) near cooling towers.
- Run the condenser water pump as much as possible. Do not allow stagnant conditions to exist.

The condenser water system should be regularly tested for SRB's in accordance with ASTM Standard D4412 *Standard Test Methods for Sulfate-Reducing Bacteria in Water and Water-Formed Deposits*. Normally, control of SRB's can be accomplished with the housekeeping measures outlined above, coupled with the use of an oxidizing antimicrobial. *However, if SRB's do become established in the system, biocides are no longer effective and a special clean-out program must be designed for each system.*

Steam Systems

Poor water treatment can cause a wide range of boiler system failures, including:

Poor heat transfer and/or overheating and rupture due to deposits on tubes.

Corrosion failures due to oxygen pitting, chelant corrosion due to excess concentration of sodium salt over a period of time, caustic attack due to tube deposits in phosphate treated boilers caused by caustic dissolving magnetite film, and/or acid attack due to poor pH control.

To avoid these potential problems in steam boiler systems, water treatment systems and programs must be implemented, as follows:

Make-up water pretreatment:

- Softening, via ion exchange or reverse osmosis methods, to reduce dissolved solids.
- Deaeration to reduce dissolved oxygen.

Deposition control to reduce scale that crystallizes directly onto surfaces and sludge deposits precipitated and deposited on surfaces (by moving water):

- Reduce make-up water hardness and alkalinity via water softening
- Chemical treatment by phosphate or phosphate/polymer, chelant, or chelant/polymer additives

Corrosion control:

- pH control (8.5-12.7 maximum range)
- Oxygen control (5-7 ppb) via deaeration and/or oxygen scavenging chemicals

Condensate corrosion treatment

Fireside fouling control

Make-up Water Pretreatment: The most common method of reducing water hardness and alkalinity is to “soften” the incoming make-water to reduce the concentration levels

of dissolved sodium salts via a *zeolite water softening process*. This is an *ion exchange process* that uses “strong acid cation” resin to exchange calcium and magnesium ions for sodium ions. Regeneration of resin is done by treating with sodium chloride solution, then rinsing.

Duration, the next step in pretreatment, is designed to remove dissolved oxygen from make-up water produces localized corrosion (pitting) in piping and boiler tubes.

Dissolved gases can be removed by lowering the pressure in the atmosphere contacting the liquid by “vacuum deaeration”. However, this process is relatively inefficient so “pressure deaeration” is normally used for boiler feedwater pretreatment. With this process, feedwater is sprayed into a low pressure (typically 5 psig) steam chamber where contact with steam heats it to within just a few degrees of the saturation (flash) temperature. As feedwater temperature is elevated, the oxygen solubility is reduced by 97-98% and the dissolved oxygen dissociates. Oxygen and a small amount of steam are vented to the atmosphere. Deaeration is normally required when more than 15% make-up is required (i.e., less than 85% condensate recovery). Most units are rated at 0.005 cm³/l (7 ppb) of oxygen in feedwater. However, periodic feedwater testing should be done to ensure proper DA operation (2-4 times per year).

Deposition Control: Just as for cooling towers, *blowdown* is the primary method of deposition control for boilers. The amount of blowdown is a function of the quantity and quality (hardness) of make-up water.

The blowdown requirement is determined by measuring boiler water electrical “conductance”, a measure of the amount of conductive solids in the water (pure water has zero conductance). The recommended boiler water conductance is 3500 mega-mho/cm or less (where, electrically, a “mho” is the conductive equivalent to an “ohm” of resistance).

Two methods are used for boiler blowdown:

Manual “bottom” blowdown consists of opening blowdown valves in accordance with an operating schedule dictated by periodic boiler water testing. This method removes both dissolved solids and sludge, but to be effective, frequent short blowdown periods are required. The boiler operator must monitor boiler water level during blowdown to prevent boiler operating problems.

Automatic “top” blowdown can be intermittent or continuous, as determined by conductance monitoring and the water treatment control system. With this method, blowdown is taken from the highest water level, where dissolved solids concentrations tend to be higher, resulting in a more efficient process. Heat recovery from the wasted boiler water is possible and is recommended. Note that with automatic blowdown, some manual blowdown may still be required for sludge removal.

The amount of boiler blowdown required is computed as follows:

$$\text{Required Blowdown (\%)} = 100 \times (A/B)$$

where

A = actual dissolved solids concentration in the feedwater (mix of make-up and condensate)

B = desired dissolved solids concentration in the boiler water, recommended as follows:

Boiler Operating Pressure (psig)	Total Dissolved Solids, TSD (ppm)	Total Alkalinity (ppm)
0-50	2500	500
51-300	3500	700
301-45	3000	600

Additional deposition control can be provided with chemical treatment by phosphate or phosphate/polymer, chelant, or chelant/polymer additives if blowdown fails to provide the required levels of TDS and/or alkalinity in the boiler water.

Corrosion Control: Corrosion in boiler systems occurs as the result of following:

- Galvanic corrosion occurs when a metal is coupled with another metal of different electrical potential (valence). This condition induces an electrical current and loss of electrons at the anode. Galvanic corrosion can be caused by metallic scale deposits, surface pitting or scratches, etc. exposing different materials within the metal. This process is accelerated when two different metals are used, such as steel and copper.
- Caustic corrosion occurs in the presence of a concentration of caustic (such as NaOH) due to steam blanketing that allows salts to concentrate on surfaces and/or localized boiling caused by porous deposits on tube surfaces. The caustic dissolves the protective magnetite layer, causing a loss of the underlying metal.
- Acidic corrosion is caused by low feedwater pH and results in metal “thinning” (general corrosion) and/or local corrosion at bolts and other stress points.

Corrosion in boiler systems is generally controlled by a combination of pH control (8.5-12.7 maximum range) and oxygen control (5-7 ppb) via deaeration and/or oxygen scavenging chemicals.

Condensate System Corrosion: Corrosion in condensate piping occurs due to two conditions:

- Oxygen “pitting”, which results in localized loss of steel, occurs due to contact with air in atmospheric pressure pumped return systems. This problem can be treated by injection of an oxygen scavenger chemical into the condensate, but is a difficult and expensive method of treatment.
- Acid corrosion occurs when carbon dioxide in air reacts with water to form carbonic acid that attacks steel. This corrosion is enhanced by

decomposition of feedwater alkalinity that produces carbon dioxide. This problem can be treated by adding amines to feedwater to neutralize acids. Amines are introduced into the boiler water and “carry-over” into the condensate system with the steam.

Boiler Fireside Problems:

- Deposition occurs as deposits of fuel ash components on surfaces and may require treatment by fuel additives to dilute deposits.
- Corrosive fuel ash components (such as sodium sulfate, sodium vanadyl vanadate, etc.) may deposit on the boiler surfaces. These deposits have low melting points and, when in a liquid state, attack metal surfaces. Treatment additives to boiler fuels can raise melting points of deposits (but make deposits harder to remove). The best way to avoid this problem is to burn “clean” fuels (natural gas, light oils, low-sulfur/low ash heavy oils).

Water Treatment Program Contracting

The following are the recommended minimum standards that should be applied to the selection of a water treatment service company:

- To be considered, a water treatment service company should be an established company with full service capabilities. The company should have been in business at least five years, have corporate staff with sufficient expertise and experience to competently address all aspects of water related issues, and be capable of providing a reasonable list of references for whom they have provided service for a minimum of two years. *Call and verify the listed references.*
- The local service personnel should have sufficient expertise and experience to competently address all aspects of water related issues. After all, it is the local service technician who will actually provide the day-to-day service, not a “water expert” at the corporate office. Ask for a detailed resume for the service technician. Further, check into the company’s service technician turnover rate. If the local technician is constantly changing, the quality of service provided by this company will be uneven.
- The proposed approach to water treatment should incorporate proven technology. This does not mean totally excluding “new” technologies, products, or methods, but it does mean that the water treatment service company must demonstrate that their proposed technology has been successfully applied at other locations with similar water treatment conditions and needs. *Ask for a list of these locations and call them.*
- Ensure the program performance and its cost. Even with the most reputable water service companies, there are many instances where the water treatment program performance and/or cost did not meet promises. Therefore, develop detailed and rigid performance and cost standards and

include them in the contract with the service company, including penalties if the standards are not met.

As a basis of comparing alternative water treatment programs by different service companies, prepare a detailed "request for proposals (RFP)" that defines requirements and standards and send it to several service companies who potentially meet the standards outlined above. Thus, there will be several different proposals that will have a common basis for comparison. For larger systems, it may be necessary to retain an independent consultant to develop the RFP and/or evaluate the vendor proposals. Costs incurred for the consultant will be more than offset by the proper selection of a cost-effective water treatment program.

Initial water service treatment contracts should be for a two-year period. This gives the service company ample opportunity to address all of the problems that may be in the system and meet the cost and performance goals that have been established. After this initial period, contracts should be for one year.

As a part of the contract, require and evaluate regular, frequent reports by the water treatment contractor or staff, first to ensure that regular water treatment is being done and, second, to "track" the various treatment parameters pH, total dissolved solids (TDS), chemical types and quantities used, etc.

At least twice each year, send water samples to an independent laboratory for analysis and compare the results with the most recent monthly reports provided by the water service contractor or staff.

Finally, during shutdown periods, inspect cooling towers, boilers, and as much piping as possible for deposition, fouling, and/or corrosion that is being inadequately addressed by the water treatment program. Adjust the program accordingly.