The Rest Of The Story: You Have Treated Your Cooling Tower - What Can Go Wrong?

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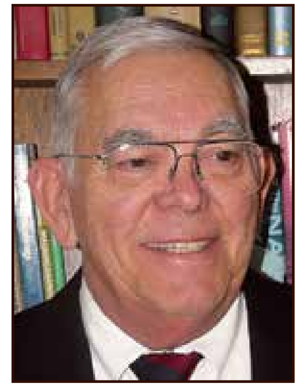

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Abstract

Open and closed cooling systems are subject to the very real constant threat of corrosion, scale, and microbiological fouling. While water treatment is the science of minimizing these conditions, water treatment alone may not avail a system. What is the universe of factors that affect a cooling system and how do they affect successful long- term maximization of system performance and minimization of deterioration and premature failure? It is helpful to group these factors into the following non-exclusive list of general considerations: (1) Mechanical Factors; (2) Operational Factors; (3) Environmental Factors; (4) Microbiological Factors; and (5) Chemical Factors. This publication will address these factors with case studies in an effort to minimize risk of loss.

Introduction

Despite the fact that a cooling tower is being properly treated, there are a variety of mechanical, operating, chemical, and microbiological factors that may defeat a sound treatment program. Detective work including a comprehensive monitoring program with routine checks for certain conditions may be the only thing that can avail a system from imminent perils. These undertakings extend beyond the reasonable scope (and pay) for ordinary and normal water treatment and routine services. It is a reasonable expectation that the owner who has continuous access to the system should routinely investigate its system for symptoms and material issues; however, reality dictates that this is not often the case and those with primary access and responsibility frequently shirk the same in favor of blaming the periodic service visits of the water treating company.

Frequently, the water treater is the most technically sophisticated and comprehensively insured party with any role or responsibility relating to the building water system. Accordingly, the water treating company, providing these routine services can become a primary target of misdirected litigation regardless of the merits of the claim.

While a good defense attorney may be able to successfully defend you in court, it is much less expensive to operate with simple contracts which clearly define the scope of the water treater's roles and responsibilities. Thus, water treating companies are increasingly documenting not only the extent of their work but also expressly disclaiming those duties not undertaken to provide protection from baseless litigation. With routinely small profit margins for water treatment service, even a successful defense can disproportionately impact a risk reward analysis.

A myopic focus on water treatment alone fails to recognize that even the best chemical treatment and control efforts are just one of the many efforts that have to be routinely monitored and actively managed in order to have a truly successful outcome. Those who assume that chemicals alone will avail the system may do so at the peril and the possibility of serious financial expense.

What defines the universe of factors that affect a cooling system and how do they affect successful long-term maximization of system performance and minimization of deterioration and possibility of premature failure? It is helpful to group these factors into the following non-exclusive list of general considerations: (1) Mechanical Factors; (2) Operational Factors; (3) Environmental Factors; (4) Microbiological Factors; and (5) Chemical Factors.

Mechanical Factors

Mechanical factors include over-all system design and construction, as well as the design and construction of each component in the system. Too often, attention is focused on the cooling tower, evaporative condenser, or closed-circuit cooler, while the overall system, that employs various types of heat exchangers, pumps, piping, valves, fittings, sensors, and controllers is overlooked. Each of these components have been supposedly designed, fabricated, selected, and deployed in the cooling system with specific and limiting parameters. These include material selection, design process and coolant fluid flow characteristics as well as routine optimum operating ranges and operating range limits for factors such as temperature, mechanical stress, and chemical tolerance specifications. Compatibility considerations such as coupling requirements when coupled with dissimilar metals can also be critical.

Redundancy is also an important design consideration for specific system components. For example, if the system incorporates redundant cooling towers, pumps, and exchangers, which is often a necessary indispensable system reliability consideration, then it is necessary to consider how this additional redundant equipment is to be operated, as well as protected from deterioration during idle or lay-up periods. Finally, consideration needs to be given to proper insulation of some components to prevent undesirable coolant temperature changes in the system due to environmental changes.

Case Study (Mechanical Factors):

A large university cooling system was renovated. Specifically, all of the comfort heating and cooling equipment was removed, the building was upgraded structurally to incorporate the latest seismic design refinements, and all of the piping, pumps, and equipment were replaced. The plans and specifications were provided by a very experienced team including an architectural firm, a large general contractor, and well known sub-contractors and suppliers.

Three years after the renovation, recirculating piping in the basement began to leak, and severe corrosion and tuberculation of steel pipe was found. All parties were sued in the university's zeal to recover substantial direct and indirect repair and replacement costs. The defendants included two water treatment suppliers, each of whom had successively enjoyed the business briefly after start-up.

During the litigation, it was discovered that some remote sections of pipe had not been replaced, and that the old piping had been isolated from the start-up hydro-testing, cleaning, and passivation. It was also eventually discovered that the property had been shut down for an extended time after piping, hydro-testing, cleaning, and passivation, and neither treater was informed that old pipe was re-connected into the system after the start- up process was completed. The new system was found to have experienced severe MIC (Microbially Induced Corrosion) during this process, and the old, unremediated piping was also found to be severely corroded and full of MIC. The lawsuit started as a misdirected case of treater negligence and was later resolved in a settlement with the mechanical parties.

Operational Factors

The breadth of factors to be considered in the operation of a water cooling system and its components can vary widely. Operators need to be aware of the previously discussed mechanical factors that are involved in the system and component design to allow long- term trouble-free use of the physical plant components. Generally, operation involves all maintenance functions required to result in the expected system reliability and service life.

For day-to-day operations, the engineers who prepare the operating specifications and operating manuals for the facility must consider all of the above mechanical factors to ensure the system is operated in a manner consistent with the system and component design considerations. It is the responsibility, however, of the operators to follow these operating manuals and to perform all of the required performance and control sampling and testing required to ensure that the operation is compatible with both design and service life expectations. Frequently, the periodic water treater is accused of having operational responsibilities despite their limited access and correspondingly limited pay. Water treaters are typically on-site for a defined service period (either monthly or weekly in most cases) and limited scope /purpose, other than performing routine wet chemistry checks. They do not own the system, nor do they have the final say in operational decisions that can easily defeat sound water treatment.

Case Study (Operational Factors):

A 20-story commercial building in a seasonal climate was equipped with a hydronic system that could be used for heating or cooling. The configuration included an open cooling tower system with a closed condenser loop and a hot water loop. These separate loops would mix at all times between valve exercise and mode operation. Accordingly, at any given time the water chemistry would be shared among all of the systems.

During the warmer summer months, the hot water loop would be "laid up" for at least 120 days. As opposed to draining, drying and cleaning the surface before start-up in the fall, the building maintenance crew would leave the hot water loop partially filled and isolated. Ultimately, the system and its attendant equipment failed. The Owner and property manager blamed the monthly water treater citing elevated bacterial levels in the water as the purported root cause of failure. It was discovered in litigation that because the hot water system was not completely drained, and dried, or otherwise properly laid up, microbial colonies flourished during the stagnant period. This water contaminated the rest of the system.

Despite the fact that the property manager had full access to the premises 365 days a year, the infrequently visiting water treater was promptly blamed for the failure to drain and repassivate. This was the case although the equipment manufacturer's written standards advised that "Proper cleaning and surface preparation must be completed prior to system start-up." Notably, the Owner's contract with the water treater specifically provided that the "Owner will not be liable for any charges other than those described and expressly authorized." The authorized acts were limited to a single monthly service visit for the stated purpose of treatment of the systems and water analysis. For that task, the treater was paid a gross sum of $300 per month. The agreement contained no provisions regarding any shutdowns, cleaning, flushing, or passivation.

Nonetheless, the owner opted not to turn to its property manager that was charging in excess of $20,000 per year. Instead, it opted to target the $300 per month water treater whose contract limited it to a single monthly visit that lasted no more than an hour each month with the chief task of water analysis. When asked where these duties appeared within its contract, the Owner stated, "We hired you guys to take care of the system. You're the experts."

It was successfully argued that the task of re-passivation was beyond the scope of the limited duties to be completed during the once per month visit of the water treater. Further evidence revealed that the hot water loop could not be independently shut down, cleaned and drained, and the chemical treater did not have the autonomy or discretion to do so.

Although a successful legal defense was secured, there were no contingent fee defendants and the cost of defense overwhelmed the relatively small profits for the water treater. While the contractual language providing that the "owner will not be liable for any charges other than those described and expressly authorized" was helpful in the defense, the water treater would have been well served to include a specific scope of work with a one-line disclaimer providing that all duties not expressly listed were otherwise disavowed.

Environmental Factors

Environmental factors include indoor and outdoor environmental temperatures, humidity, air quality, the physical location of equipment, and any expected or possible plant process contamination. Additional environmental factors include quality, quantity, and availability of the make-up water and the availability of proper disposal facilities for tower blowdown and larger volumes of system cooling water if the system requires draining, flushing, and refilling.

The regulatory environment must also be considered, as well as any client-imposed limits including limits on the water treatment chemistry, water consumption, or any other aspect in the use of the water cooling equipment. Some questions to ask include:

(1) Is the cooling tower sited so that the exit air stream is in close proximity to facility inlet air ducts, open building windows, or entrances? (2) Is the tower sited in close proximity to utility stack discharges, fly ash handling facilities, coke plant discharges, paint booths? (3) Will exchanger leaks result in contamination of the cooling water with process gasses/fluids, or solids? (4) Will exchanger or piping leaks be likely to contaminate product with cooling water?

Case Study (Environmental Factors):

A very prominent technology firm was looking for a technical breakthrough to reduce the cost of their cooling tower water treatment programs in an effort to appease their stockholders that they were reducing their "chemical footprint". With these client- imposed restrictions, a water treater recommended the use of a water softener on the cooling tower make-up at the new campus headquarters. The treatment vendor advised that the client shut-off the tower blowdown and depend on drift to limit cycles of concentration.

The water softener removed calcium and magnesium and was regenerated with sodium chloride. As a result of softening the make-up water, the treater recommended shutting off the blowdown. As a result, the chloride in the make-up water cycled up causing excessive chloride concentration in the recirculating water. Within 18 months, the client experienced highly aggravated pitting in the 304 stainless steel cooling towers. In addition, they experienced a rash of complaints concerning water spotting of automobile paint, etching of window glass, and discoloration of building siding. The client incurred substantial damages relating to these self-imposed environmental restrictions.

Micobiological Factors

Microbiological Factors include consideration of the types of organisms that are locally found in the air and water available at the plant site, as well as the human population that is expected to use the facility or those that may be reasonably expected to be in the potential exposure pathway. For instance, will only young, healthy people frequent this location or is the facility a nursing home with a regular populace of older, immuno- compromised or otherwise unhealthy people? Is the cooling system design and metallurgy compatible with the use of relatively high levels of oxidants for cooling water microbial control? Is the treatment program designed and applied in a manner that discourages microbial proliferation? Are side stream filters, basin sweepers, and routine system cleaning and disinfection employed at the site? Can expected use concentrations of oxidants be discharged to the receiving stream without oxidant removal/destruction? Can high levels of demonstrably effective non-oxidizers be routinely employed and safely/legally discharged? Is the facility located in close proximity to agricultural sites where routine or periodic high levels of airborne organisms, nutrients, or bio-mass forming airborne contaminants are present?

For the past century, water treatment has been intended to promote system efficiency through the minimization of piping and equipment corrosion, scale formation, the accumulation of alluvial deposits, system wide microbial fouling and microbial induced corrosion. The sole purpose and scope of minimizing these factors has been to aid in preservation of asset value, minimization of energy and water consumption, reduction of maintenance costs and to achieve optimal heat transfer.

The cooling technology industry is facing a perpetual challenge with respect to the minimization of legionellosis risk. Cooling tower recirculating water is usually within the envelope of temperatures where Legionella thrives, and the water is often loaded with nutrients. The collective responses to Legionella related illness and proposed methods of control are continuing to evolve in terms of science, law and standards.

Whether due to increased rate of incidence or improved medical methodology, confirmed cases of legionellosis are on the rise. This has occurred in the context of traditional water treatment chemicals being restricted or banned based on environmental regulations due to the negative impact (real or perceived) on public health and environmental degradation. The water treatment industry has been forced to trade a biostatic control regimen for one that substitutes carbon, nitrogen, phosphate, and sulfur (also known as "bug food") and then employs the new chemistry at a pH control range that cripples the effectiveness of the remaining highly regulated and discharge limited oxidant chemistry. While research reveals no studies, the question must be asked whether the prohibition of the most effective water treatment chemicals and the subsequent rise of legionellosis cases is causative or coincidental.

Allegations of a legal duty to control a bacterium universally recognized to exist in all aquatic environments (including tap water) represent a significant challenge to the traditional practice or purpose of standard water treatment. Plaintiffs' experts are now attempting to create legal duties beyond those based upon system efficiency and useful life. We are entering a new world where lawyers are asserting that those with any involvement with a cooling water system have legal duties to protect the public from an organism with no known safe level that may infect only certain members of the populace who are merely present in the exposure pathway.

The absurdity of allegations of legal duty on behalf of a chemical water treater to protect the general public from a rapid recolonization bacterium is underscored by their limited access and pay. Most chemical water treaters are granted access to a particular system for a single site visit once or twice per month for which they are paid around $300 to $500 per visit. Despite these limitations, assertions of great responsibility for disease prevention are now being leveled. These accusations are being made despite the fact that there is no standard training, certification, compensation or clear standards by which the water treater is to bejudged. This is akin to conscripting plumbers to be trauma surgeons with no guidance, training, protocols, or pay.

Allegations that a chemical water treater has a legal duty to protect the public from a commonly occurring bacterium with no known safe level effectively charges the treater with being the conscience of the cooling industry in an environment where the owners are under no clear-cut requirements to comply with no legitimized road map to show them how to do so. The financial repercussions for defending a Legionella lawsuit are invariably grossly disproportionate to the payment received for water treatment services rendered. In this litigious context, it is highly advised that treaters do not undertake any Legionella related obligations and expressly disclaim the same.

Case Study (Microbiological Factors):

Five Plaintiffs alleged that they contracted Legionnaire's Disease while guests of a small hotel. They claimed they inhaled bacteria-laden mist emanating from the hotel's rooftop cooling tower. Two of the Plaintiffs died as a result. The surviving Plaintiffs and the families of the decedents filed a wrongful death lawsuit implicating the hotel owner and the chemical water treater.

There was no written contract between the treater and hotel owner. The parties had a personal relationship and entered a handshake deal. During the initial meeting, the water treater recommended a corrosion inhibitor and dual biocide (oxidizing and non-oxidizing) program. Testimony reflected that the owner opted not to purchase the oxidizing biocide citing leftover chemical inventory from a prior treater. There was no documentation to reflect that the oxidizer had been offered or refused.

Pursuant to their verbal agreement, the chemical water treater provided monthly service for over 6 years prior to the outbreak. At no point during the initial meeting or throughout the tenure of the water treater's service, did the owner and treater discuss *Legionella* or the prevention of legionellosis. During this time, the treater provided Field Service Reports for each of the months during the 6-year period preceding the outbreak.

After the outbreak, the hotel owner blamed the chemical water treater asserting that the hotel "followed every one of their recommendations to the letter" and that "we trusted them to handle our system because they're the experts." In absence of a written contract delineating the treater's duties, the conduct of the parties proved significant.

The pre-suit conducts of both the owner and treater consistently reflected that the hotel did not hire, request, or pay the treater to test for or to prevent *Legionella*. The evidence reflected that the water treater was hired by the hotel only to support a routine water treatment plan, which according to the testimony of the water treatment experts in the case, involved only recommending and selling chemicals that would accomplish the tasks of keeping the heat transfer surfaces of the equipment free of scale, corrosion, and biofilm. The experts' interpretation of the treater's job responsibilities was consistent with the widely accepted view of the industry that "most water treatment programs are designed to minimize scale, corrosion and bio-fouling and not to control *Legionella*."[1]

Furthermore, the charges by the treater and payments made by the hotel did not reflect service beyond those relating to system efficiency. For its standard monthly service, the treater was paid $190 per month. During the relevant time frame, charges relating to *Legionella* testing were $460 per test by CDC approved labs. In addition to the lack of charges for any Legionella related service, none of the 6 years of Field Service Reports made any mention of *Legionell*a or test results. Despite receiving these reports every month, the hotel owner never inquired about the status of *Legionella* in the system or any tests to that effect.

In addition, testimony reflected that the hotel never contacted the water treater to complain or to otherwise inquire about the ineffectiveness of any expected treatment after learning of the *Legionella* outbreak at the hotel. Instead, the owner first mentioned the outbreak to the treater in passing when the treater was on the premises for his normal monthly visit.

In light of the conduct of the parties, the Court found no evidence that the treater had assumed any duties with respect to *Legionella* at the hotel.

Chemical Factors

Chemical Factors include the adequacy of the treatment program to function optimally during any expected control malfunctions or during any periodic anticipated low flow or high temperature events. They also include the ability of the chemical treatment program to adequately function to protect the metallic components during expected operational variation. The chemical control specifications need to be considered to ensure that the individual control limits are appropriate for the expected operation, including variations in flow, temperature, water quality, air quality, and probable process leaks and air contamination. The control limits must be designed to ensure reliable operation with acceptable corrosion, deposition, and microbial activity given the expected environmental, process, and personnel contamination considerations that will be encountered. Chemical control recommendations should include cooling water sampling and testing that is adequate to ensure the presence of the proper treatment ingredients at the proper concentrations for the correct times and duration. For example: Is the owner willing to provide sufficient numbers of properly trained and supervised personnel to routinely conduct all of the proper sampling and testing to confirm continuous reliable operation? Are the expected make-up water quality variation excursions and frequency minimal enough to ensure that the sampling and testing program will detect and correct for such make-up water quality variation? Does the chemical feed and control system that is installed use a proxy for control of one or more program ingredients? Does that proxy insure that the intended ingredient is actually present at the correct level, or does it merely detect the presence of the tracer? Can the ingredient level vary from the tracer level?

While smart controllers have been a great aid to the establishment of tight control, they are not designed and fabricated to provide long term reliable control in the absence of routine specific control testing and calibration to verify that the ingredient or parameter of interest is being reliably controlled by the device. This responsibility logically relates back to those with regular daily access to the system (the owner or property manager). The chemical supplier should not be relegated to staking its reputation and account profitability on the controller alone without sufficient reliance on the owner who should follow proper control sampling, testing, logging and review parameters. Treaters may be forced to ask whether the account revenue justifies the acceptance of additional responsibility for reliable control and routine sampling and testing in the event the owner shirks these responsibilities.

Case Study (Chemical Factors):

A water treatment service company was providing a routine treatment program for the office building cooling towers belonging to a large iron and steel manufacturer. The towers appeared in all measured aspects to be well treated and free of any significant indication of scale, corrosion, and fouling. The cooling water and the cooling tower appeared clean and free of any microbiological fouling. The treatment program incorporated the use of two different non-oxidizing microbicides fed on an alternating basis weekly. The weekly aerobic dip slides and the monthly tests for sulfate reducers, iron bacteria, slime formers, and algae showed aerobic bacteria and anaerobic organisms at or below $1(10)^3$, and $<(10)^1$ respectively.

The building owner, out of an abundance of caution, requested that *Legionella* testing be performed. Duplicate samples showed $1(10)^3$ cfu/ml *Legionella Pneumophila* Serogroup 1. Subsequent investigation demonstrated that while the microbial control program was working well on the populations of interest, it was ineffective with regard to the control of *Legionella*.

A change in the program to incorporate products and dosages known to be effective for *Legionella* control resulted in a reduction in Legionella counts to $<(10)^1$ cfu/ml. Repeat testing over time verified that the *Legionella* count remained below detectable levels. No further issues resulted.

Conclusion

The foregoing list of issues and case studies is a non-comprehensive list of examples of mechanical, operating, environmental, microbiological, and chemical factors that may give rise to system failures despite a sound water treatment program. It is important to reiterate that duties to investigate, monitor, or "catch" these issues extend beyond that of a routine water treatment program. It is important that the water treater's roles are clearly defined and that no legal duty is undertaken by the chemical treater without adequate client consultation, proper documentation, assessment of the risks and adequate compensation.

Specifically, it is critical that in the course of educating the client about certain risks that the water treater has clearly defined its scope of work to the exclusion of all other responsibilities. Absent clearly defined roles, the water treater may be targeted in litigation based on the owner's convenient assumption that any ill that befalls the system is the treater's responsibility.

Water treaters would be well served to discuss potential issues that may arise despite proper water treatment and to accordingly educate customers. A well-documented water treatment service program will narrowly define the duties undertaken commensurate with the corresponding pay. In the event the treater is hired to provide extra-contractual services to address the issues identified in this publication, consideration should be given to the amount of service time required for a particular account based on the revenue originally anticipated from standard water treatment. It is highly preferable that this decision is deliberately made by the water treater and that additional service is not assigned to the water treater based on the owner's assumption. Regardless of the business at issue, those providing service should be compensated relative to their commensurate risk. Water treaters are no exception and should be adequately compensated.

Depending upon the circumstances and the risks identified, the treater may wish to present itself as an advisor with a limited investigatory role and not a party responsible for remediating the identified contingencies.

[1] Ashrae Position Document On Legionellosis 7 (Ashrae 1998) (2012)