

Failure of Building Water Systems: How to Plan for Success and Manage Liability

Adam Green
Baker, Donelson, Bearman,
Caldwell & Berkowitz, PC
Robert J. Cunningham, P.E.
Arthur Freedman Associates, Inc.

Abstract

The premature failure of building water systems and mechanical equipment can result in large liabilities. In many instances, parties are wrongfully accused and forced to incur significant legal expense to prove their innocence. The resulting lawsuits reflect that the reasons for these failures are both common and, in many instances, avoidable. Some of the usual suspects include: (1) failure to clearly define scope of work and responsibilities; (2) failure to prepare and follow comprehensive job specifications; (3) failure to properly coordinate passivation and start-up; (4) not understanding responsibilities after turnover; and (5) lacking the documentation needed to defend yourself when wrongfully accused. This publication identifies common case scenarios with the objectives of planning for success and managing exposure.

Introduction

In recent years, there have been a large number of corrosion-based failures of system water piping associated with HVAC, Process Cooling, and Fire Water systems. Systems designed to provide long term service life are failing due to leaks and obstruction incident to severe pitting attack, corrosion and massive tuberculation in both galvanized and un-galvanized carbon steel and copper piping. It is not uncommon to encounter systems where complete penetration has occurred within a few years after initial commissioning. These events can occur even though an appropriate water treatment program is in place and no issues appear in the bulk waters being tested and treated on a monthly basis. These premature failures are now finding their way into the courtroom, where the assignment of responsibility and the calculation of damages rests in the hands of attorneys and laypeople, who are completely unfamiliar with industry standards and practices and the respective responsibilities in the design, construction and maintenance of such systems. Many attorneys and potential jurors are not well-versed in the scientific and technical aspects that are crucial to understanding and accurately determining the nature and cause of these failures.

Anyone involved in the design, construction, installation, commissioning, start-up and maintenance of these systems may find themselves in the crosshairs. Attempts to determine responsibility and to seek compensation for these failures, result in consider-



Robert J. Cunningham



Adam Green

able legal expense, as well as business disruption that may last for years. Moreover, the scope of a defendant's potential liability may far exceed the amount they were paid for their services, as it may include not only the damages incident to the repair and replacement of the water system and its attendant equipment, but also to any surrounding structures and improvements, the expenses incident to constructive eviction of the building tenants who are displaced while such repairs or replacements are performed, and, in some cases, the prevailing party's attorneys' fees and costs.

There is a high degree of inherent risk in defending complex, technical cases with significant damages to an inexperienced and unfamiliar audience. This publication presents common scenarios leading to system failure and the lawsuits resulting therefrom. Some of the usual suspects include: (1) failure to clearly define scope of work and responsibilities; (2) failure to prepare and follow comprehensive job specifications; (3) failure to properly coordinate passivation and start-up; (4) not understanding responsibilities after turnover; and (5) lacking documentation needed to defend yourself when wrongfully accused.

This publication identifies common case scenarios based upon actual building system failures and the corresponding lawsuits that followed with the objective of planning for success and managing exposure.

Failure To Provide And Follow Comprehensive Job Specifications

The root cause of system failures can result from the lack of clear, unequivocal, site-specific specifications delineating respective responsibilities for the various tasks involved in design, construction, commissioning, start-up, maintenance and water treatment for condenser water systems. Unfortunately, job specifications are frequently recycled, generic forms that are not tailored to the current project. Contractors commonly bid these specifications as written with a sense that all parties have an unwritten understanding that the specifications are a mere form document and therefore, there can be no reasonable expectation that they will be performed to the letter. They may likewise fear that if they do not simply bid the specifications as presented, that another contractor who is willing to do so will be awarded the work. As indicated by the case studies below, the failure to comply with specific items of otherwise generic

specifications can lead to costly litigation despite the fact that the lack of compliance had nothing to do with the system failure.

Form Over Substance. Parties who do not perform to the exact language of specifications are frequently targets of complex litigation. Unfortunately, innocent parties are often forced to incur significant legal expense to prove that their technical non-compliance was unrelated to the cause of the occurrence. Parties seeking recovery may deliberately confuse or conflate the difference between a "flaw" and a "defect." Flaws are imperfections in the performance of responsibilities that have no causal effect on the damages incurred. Defects are those errors, omissions or failures that actually cause or contribute to the harm at issue. Such form over substance litigation often places faultless parties in the unenviable and expensive position of proving their innocence. In a complex, technical lawsuit, these expenses can be significant.

Case Study:

The condenser water system for a 30-story high-rise luxury condominium suffered from corrosion and leaks less than five years from the date the system was commissioned. As a result, the Owner's Association filed a lawsuit for damages exceeding \$8 million. The evidence revealed that the HVAC mechanical subcontractor who constructed the system repeatedly introduced untreated water into the system for more than a year before contracting with the water treatment contractor. It was undisputed by all parties that this scenario created irreversible corrosion leading to complete system failure.

Nonetheless, the building owner sued 14 different entities, citing each and every instance wherein a party failed to comply with the exact verbiage of the generic specifications used for the project. For instance, it was alleged that the general contractor, the HVAC mechanical subcontractor and the water treater each failed to comply with the express requirement to "conduct a complete characterization analysis of the raw water supply." Each of the entities had worked in the geographic area for the ten years preceding the project and were highly familiar with the characteristics of the area water. Because the parties failed to conduct an independent characterization analysis specifically for this project, Plaintiff alleged that the elevated chloride and sulfate content of the raw water supply was not properly accounted for and caused microbially-influenced corrosion. This situation could have been avoided by performing a new water characterization study. Alternatively, a simple email confirming with the owner/developer that the most recent raw water characterization study was sufficient could have avoided the issue.

The water treatment contractor likewise did not fully comply with the form specifications by failing to: (1) provide written reports of each visit to the jobsite; (2) have a service branch office within 50 miles of the jobsite; (3) ensure the administration of the program was under the supervision of a full-time employee with a B.S. in Chemistry; (4) submit an affidavit from a corporate officer affirming prior performance of the type and scope of treatment program at issue; and (5) install corrosion coupons and conduct 30-day tests each month. In total, the water treatment contractor failed to comply with the exact language of the specifications in 11 different respects. As a result, the water treater, who was paid \$5,500 for a



The weight is over.

Introducing Oxi-King™
commercial water treatment system

Ironically, making water safe has long been a dangerous job, requiring lots of protective gear and a very strong back. Oxi-King just did for water treatment what Steve Jobs did for computers—made it way friendlier. No exposure to strong odors and accidental chemical spills. Everything is pre-filled and light weight. One 5 pound pac will treat up to 500,000 gallons with a 0.6 ppm residual and no load. Now the winner of the Occupational and Health Safety Magazine New Product of the Year Award in Hazmat Safety!

Think Safe • Think Simple • Oxi-King
Learn more at www.Oxi-King.com



year of treatment, was forced to endure three years of litigation and more than \$400,000 in legal expense to successfully prove that its lack of conformity to generic specifications was not the actual cause of the system breakdown. Ultimately, the water treatment contractor was dismissed because its failures to comply with the form specifications were determined to be flaws and not defects. In other words, none of the listed shortcomings were found to be an actual cause of the damages at issue.

Failing To Clearly Define Scope Of Work And Responsibilities

The design, construction, commissioning and maintenance of condenser water systems is a multi-party and multi-disciplinary practice. The lack of a clear understanding by and between the building owner and the various contractors about each discipline's scope of work and division of responsibilities frequently leads to litigation. To avoid being wrongfully implicated in a lawsuit arising from system failure, these entities are behooved to clearly define what is included in their scope of work to the exclusion of other responsibilities.

Vague Duties with Superlative Performance Standards. Generic descriptions of project responsibilities are not limited to loose job specifications. The contracts entered by and between the crafts on a project frequently have job duties that are not well-defined. To compound the issue, these contracts may simultaneously contain warranties that the vague job description will be performed to the highest possible standards. As provided below, this is a dangerous combination that can lead to the wrongful implication of innocent parties.

Case Study:

Within two years from start-up, the open loop portion of a condenser water system in a large high-rise building experienced catastrophic failure incident to corrosion and leaks. The open loop system design employed was novel, untested and critically flawed. During deposition testimony, the design engineer admitted that the design was problematic and that an alternative design should have been implemented. After the leaks were discovered, the areas of the building serviced by the failed open loop were converted to a closed loop design. No further issues occurred after this change.

Despite the facts, the building owner filed a \$4,000,000 dollar lawsuit not only against the design engineer, but also the general contractor, the mechanical subcontractor who built the system, the pipe supplier, the construction phase water treater, and the ongoing monthly water treater. The lawsuit exploited the lack of clearly delineated roles while relying on contract superlatives used to describe the standard to which the work was to be performed. For instance, both the general contractor and the HVAC mechanical subcontractor warranted in their contracts that their responsibilities to coordinate the construction of the system shall be completed: (1) "in accordance with the Contract Documents, including those items reasonably inferable from the Contract Documents necessary to produce the indicated results" while also warranting that (2) the work would be "first class and in accordance with the highest standards of the construction industry." The building owner used these broad terms to argue that the "indicated result" was a functioning open loop system free from defects. The owner further alleged that to achieve this result in accordance with the highest standards of the construction industry, the contractors were required to not only coordinate with the design engineer but to challenge the design

choice. The owner charged these parties with failure to diagnose the poor design and warn the owner despite the fact that neither entity had design expertise.

The owner used similarly undefined terms to frame allegations against the water treatment contractors based upon general language in their contracts, providing that they would "check the systems" with "highest standards of attention to detail." Based upon these terms, the owner concocted a theory that in fulfillment of the duty to "check the systems," the water treaters were somehow required to perform periodic internal pipeline inspections throughout the property to somehow discover the corrosive problems that arose due to the poor design. There was no reference in any of the contract documents to internal pipeline inspections, how they were to be conducted (by borescope or otherwise), the frequency at which they were to occur, the associated expenses associated or who would pay for them. Both treaters properly testified that this was far beyond the scope of their limited monthly visits (wherein they would visit the designated mechanical rooms to take bulk water samples, perform maintenance on the chemical feed station, record the water chemistry readings and replenish chemicals) for which they were paid \$200.

Failing To Properly Coordinate Passivation And Start-Up

The failure to properly coordinate chemical treatment with the initial introduction of water can prove fatal to a system. Pressure to meet construction deadlines and a lack of understanding of the true impact of introducing untreated water to the inner wall of virgin pipe surfaces can lead to severe corrosion and costly litigation.

The Critical Passivation Period. After construction of the piping system is complete, the mechanical contractor who built the system will typically conduct one or more hydrostatic pressure tests during which the piping system is filled with water and pressurized to test for leaks before insulation is applied and surrounding sheetrock is installed. This is the point where the corrosion process should be addressed. A water treatment contractor should be contacted so that the water chemistry itself can be adjusted by the addition of a high level of chemical corrosion inhibitors during the entire testing process. Specifically, the exposed metal surface should be chemically "passivated," to ensure that the piping system metals have some reserve "corrosion resistance" to carry the protection forward. In the absence of proper corrosion and microbial control during this period, the addition of water jumpstarts the microbial proliferation and the ensuing corrosion acceleration.

Case Study:

The condenser water system for a 28-story commercial office building suffered from corrosion and leaks less than two and one-half years from the date of start-up. As a result, the building owner filed a lawsuit for damages exceeding \$6 million. The undisputed evidence revealed that the HVAC mechanical subcontractor constructed the system by lowering the system pipes by overhead crane for assembly five floors at a time. Once five floors were constructed, the pipes were fitted with end caps and then hydrostatically pressure tested. If the pipes did not leak, the water was left to sit stagnant in the pipes while the next five floors were constructed and the testing process repeated. This process occurred for six months before the water treatment contractor was retained. Plaintiff's metallurgical expert testified that this process was fatal to the system and that the corrosive process became irreversible within six weeks of untreated

water being introduced and left to sit stagnant in the unprotected pipes.

More troubling was the fact that the proposed water treatment contract required the water treater to provide chemical treatment upon "the initial introduction of water." Unbeknownst to the water treater, this event had already occurred, making the contract impossible to perform on the day it was signed. When asked about the failed sequence, the mechanical contractor who built the system testified that it was under immense pressure from the owner and general contractor to expedite the construction schedule. Specifically, the general contractor advised that sheetrock installation was imminent and as a result, the hydrostatic pressure testing of the pipes was expedited. It was also apparent that the mechanical contractor regarded the water treatment portion of the process as a low-level, line item maintenance expense and a relative "speck of dust on an elephant." Despite its many years of experience, the mechanical contractor never developed an accurate understanding about the need for chemical passivation. Specifically, the foreman testified that he believed only the water used for the initial fill immediately preceding start-up needed passivation chemicals. He mistakenly believed that water introduced for hydrostatic pressure testing would not have a corrosive effect on the pipe interior. The mechanical contractor was proven to be liable for the damages.

Detecting the Undetectable. The failure to discover the presence of hidden under deposit corrosion often leads to water treaters being implicated for failing to detect the undetectable. Commonly, the evidence of this corrosive process is concealed from the bulk waters to which the treater has access for testing and treatment. It is commercially impracticable for a water treater to disassemble or otherwise probe the entirety of an existing system to the degree necessary to adequately ascertain its condition prior to treatment. Nonetheless, despite their limited functions, pay and access to the property, water treatment contractors can be wrongfully regarded as guarantors of system maintenance and performance.

Case study:

The condenser water pipes in a luxury hotel experience failure due to corrosion and leaks. The evidence reveals that the system was not properly passivated and under deposit corrosion began to form before the first water treatment chemicals were introduced into the system. Specifically, the evidence reflected that precipitated corrosion products (such as iron oxide) and microbiological depositions (such as iron and sulfate reducing bacteria which imbed themselves into iron deposits) formed on the inner wall of the pipe surface. These deposits formed a concrete-like concealing layer that rendered subsequent attempts to introduce corrosion inhibitor ineffective. Once this layer was formed, inhibitors could no longer make physical contact with the inner wall of the pipe they were meant to protect, and corrosion products were hermetically sealed off from the bulk water supply, rendering them inaccessible to subsequent testing or treatment of the bulk waters.

The monthly water treatment contractor was not hired until 16 months after the corrosive process began. Consistent with its contract, treatment entailed monthly site visits by the water treatment representative to collect water samples and review tests of the treated waters that are actually flowing through the system. These tests included monthly readings for conductivity, alkalinity, pH and other factors, but only for the accessible waters flowing through the pipes.

Accordingly, the issues within the system were not discovered until leaks occurred when the corrosion breached the other side of the pipe.

Plaintiff alleged that the water treater should have detected this under deposit corrosion and somehow "reversed or retarded the corrosive process." The Field Service Reports reflected that the levels for all relevant metrics were well within the designated control levels and that the corrosive process was not evident in the accessible waters. Despite these facts, Plaintiff alleged that the treater had extra-contractual responsibilities to perform internal inspections of the system piping (as with a borescope), external inspections of the system piping for signs of leaks and environmental inspections throughout the building to affirmatively find signs of leaks (such as rust stains on insulation or the floor). This case ultimately resolved short of trial.

Understanding Responsibilities After Turnover

The lack of a clear understanding of mechanical, operational and maintenance responsibilities after turnover is a frequent source of litigation. Despite having full time maintenance personnel on the premises, building owners frequently allege that the General Contractor and HVAC Mechanical Contractor retain responsibilities after turnover. Owners also frequently allege that the monthly water treatment contractor has day-to-day mechanical and operational responsibilities ranging from mechanical cleanings of condenser water system equipment to building-wide inspections for signs of degradation or leaks.

Who Maintains the System? A clear understanding of maintenance responsibilities of the condenser water system after turnover is critical. The transition of responsibilities from the contractors who built and commissioned the system to the building maintenance team is a common source of legal contention.

Case study:

The hydronic water system in a commercial high-rise development experiences catastrophic failure causing more than \$3 million damages. One cause of the occurrence is discovered to be inadequate water flow throughout the system including areas where the system was end capped because no tenants had yet occupied the space to be serviced by that portion of the system. The mechanical contractor testified that after the building was turned over to the owner that the owner was responsible for ensuring that there was adequate flow in the system. When asked, the maintenance supervisor testified that none of the maintenance personnel had experience or training with regard to managing flow in the system. Maintenance personnel knew nothing of measuring flow, how to adjust bleed valves, how to spot potential areas of low circulation or dead legs. With respect to the subject jobsite, maintenance personnel was also not made aware of any issue with the piping that serviced the unoccupied tenant space sitting idle with no load.

The owner filed a lawsuit alleging that the General Contractor and HVAC Mechanical Contractor were responsible for educating the owner about quality control as it related to the management of water flow even for the spaces that were not yet built-out or occupied. The subject contracts were silent as to these responsibilities. The owner likewise alleged that the monthly water treater was responsible for the management of water flow on a day-to-day basis despite the fact that it was allowed access to the premises for only 12 days of the year.

Defending Yourself Through Documentation

Missing or incomplete documentation relating to the construction and maintenance of the condenser water system may wrongfully result in exposure for events wholly beyond the knowledge or control of a given defendant, and substantially increase the cost of any subsequent litigation.

No Daily Logs. The events giving rise to the occurrence frequently occur many years before the lawsuit is filed. As time passes, important dates and significant events can be forgotten or confused if not memorialized. The lack of affirmative evidence that important events did occur can leave parties open to substantial risk and expense.

Case Study:

The condenser water system for a 22-story building failed within four years of start-up causing \$2.2 million in damages. Despite the fact that the HVAC mechanical contractor who constructed and commissioned the system was paid more than \$32 million for this project, it failed to keep any daily logs showing its activity. When asked, the foreman stated, "we are builders – not secretaries."

By the time the mechanical contractor testified, more than seven years had elapsed since it completed its work on the project. Having constructed numerous other systems since that time, the foreman had little memory of the details of the project. He could not attest to the date water was introduced, the date hydrostatic pressure testing was complete, the date of passivation or the date that the water treatment contractor was advised that water was being introduced.

He testified that it was standard practice to call the water treater before water was first introduced but had no documents or independent recollection that this occurred. The water treatment contractor testified that it was not contacted to provide initial water treatment services until weeks after water had been introduced. The conflicting testimony created an issue of fact that had to be decided by a jury after years of litigation and corresponding expense.

Failure to Document Customer Refusals. Contractors frequently make recommendations or offer services that are declined by the customer for a myriad of reasons. Many companies are not in the business of documenting failed sales attempts and only make a record of the recommended services that are accepted. As illustrated below, the failure to document the full recommendation so that it may be compared with the services provided can prove to be a costly omission for entities ranging from the design engineer to the monthly water treatment provider.

Case Study:

Two 15-story twin commercial buildings are constructed with open loop condenser water systems and rooftop cooling towers. The developer solicited only bids for an open loop design citing the desire for "free cooling." In light of its concern about possible microbiological fouling and corrosion control incident to the open nature of the system for this particular geographical area, the design engineer met with the developer's lead representative to suggest a more expensive closed loop alternative. This suggestion was declined and the open loop system design was implemented. Within six years, the open loop system experienced catastrophic failure due to excessive



RESEARCH POWERED SOLUTIONS

Series **ES** & Series **ESP**



EVAPTECH, INC.
A WHOLLY OWNED
SUBSIDIARY OF EVAPCO, INC.
8331 NIEMAN ROAD
LENEXA, KS 66214
913.322.5165
MARKETING@EVAPTECH.COM
WWW.EVAPTECH.COM



EVAPTECH ASIA PACIFIC, SDN. BHD.
B-6-1, 101 BOULEVARD
JALAN KENARI 5,
BANDAR PUCHONG JAYA
47170 PUCHONG
SELANGOR DARUL EHSAN
MALAYSIA
PHONE: (60-3) 8070-7255
FAX: (60-3) 8070-5731
MARKETING-AP@EVAPTECH.COM
WWW.EVAPTECH.COM

SINGLE & MULTI-CELL FIELD ERECTED, FIRE-RETARDANT COUNTERFLOW COOLING TOWERS

- **Reliability of Operations**
- **Hardened to Survive** - SafeWall™ casing technology resists damage from airborne debris.
- **Cost Effective** – Cost comparable to fire protection systems.
- **Customizable Fill Components** – High performance low-fouling fills.
- **Low Drift Rates** – as low as 0.0005%.
- **Air Inlet Treatments** – Optional cellular PVC or wide-spaced louvers available.
- **Product Quality is a Given** – Quality audits of all combustible components by FM Approvals.
- **Avoid Thermal Redundancy** – Extra or over-sized cells not required.

**TECHNOLOGY FOR THE FUTURE,
AVAILABLE TODAY!**



fouling, tuberculation and aggressive corrosion. The closed loop system for the building had no issues.

The owner/developer filed a \$3 million lawsuit against the design engineer citing the choice to use an open loop system design without any alternative. During the lawsuit, the design engineer conceded that the open loop design employed was the design option that was most susceptible to fouling and corrosion related failure. The developer's lead representative who attended the meeting regarding the alternative closed loop design option left his position with the developer five years before the lawsuit was filed and could not be located. The design engineer had no writings reflecting his concerns over the open loop design option and no writings proposing any alternative designs.

Failure to Document Prior Conditions. While building owners and post-turnover contractors will not likely be able to discover concealed issues like under-deposit corrosion, these parties are well-served to communicate about system issues that have been discovered. Contractors are especially behooved to document apparent system issues upon arrival to avoid later allegations that they somehow caused those conditions and the damages resulting therefrom.

Case Study:

In a 20-story commercial building, multiple heat exchangers experience failures incident to corrosion and degradation of the aluminum surfaces. The initial water treatment contractor failed to keep the pH levels within the range appropriate for the system. In June 2009, the owner solicits and awards the bid for the 2010 water treatment year with a start date of January 1, 2010. Two months before the new treater will begin its program, the heat exchangers experi-

ence complete failure. These units are replaced the week prior to the new treater's tenure, without the system being cleaned and flushed.

The owner did not disclose to the new water treater that the system at issue had encountered substantial problems and that the heat exchangers had been replaced. The new units fail within 30 days. The owner then filed a lawsuit against the subsequent treater for the new failed exchangers citing poor water treatment incident to high levels of pH and low levels of nitrites.

Conclusion

There is an ongoing need to balance business relationships and the risk of litigation with business partners. While the scenarios described in this publication underscore the need to avoid risk and manage exposure, it is both unreasonable and impractical to require exhaustive legal disclaimers and disavowals at every instance. Most business relationships are based upon trust. Business realities demand a certain allowance for what steps can reasonably be taken to manage project risk without tarnishing relationships through "over lawyering the deal" and losing the business to less demanding competitors.

The purpose of this publication is to educate the reader about possible risks and expenses incident thereto. While each scenario is different and no measure can guarantee that litigation will not occur, there are some basic measures that can possibly reduce the risk of innocent parties being wrongfully accused or expedite litigation defense.

Bidders are well-served to read the portion of the specification that they are bidding thoroughly and note the portions that are generic and do not apply to their work on the project. For those items that

FRP Panels for Cooling Tower Industry

Resolite Fiberglass Casing & Louvers

Since 1951, RESOLITE has provided high strength and corrosion resistant panels for the cooling tower industry. Designed to withstand the extremely corrosive environments often associated with cooling tower markets, Resolite panels are engineered specifically for use as louvers, stair enclosures and exterior casing.

FEATURES

- › Fire Retardant, with UL Fire Rating Classification
- › Corrosion Resistant
- › Outstanding Resistance to Weathering

BENEFITS

- › Unmatched, Long-Lasting Performance



Resolite

A DIVISION OF STABILIT AMERICA

285 Industrial Drive
Moscow, TN 38057
ph. 888-737-6548
fx. 901-877-1388
email. sales@resolite.com



do not apply or for which you are seeking a waiver or exception, a quick note in plain language to that effect in the bid submission may help you avoid involvement in litigation. These excepted items are typically inconsequential to the project and noting that your bid is subject to your notes may save you from being wrongfully accused.

Contractual language with vague job descriptions should be approached with caution. Job responsibilities that are ambiguous are subject to multiple interpretations and may result in allegations that your job responsibilities far exceed their actual scope. To the extent possible, state your responsibilities simply and include a provision stating that the contract is the complete agreement between the parties and any expansion of your duties must come through a change order.

Despite best efforts to specify your scope of work in specifications and contracts, litigation may be unavoidable. When possible, document significant events so that you are able to swiftly prove your innocence. Keep daily logs of important dates and events. Follow up phone calls with simple emails so there is a record of what occurred and you are not being tasked to remember specific dates from years ago during cross-examination.

While lengthy, self-serving disclaimers are off-putting, simple emails or letters can achieve the same purpose. For instance, write your full recommendations to the client. If they later choose to only partially accept the services recommended, an easy comparison can be made from the recommendation to the work accepted and invoiced.

The potential risks facing businesses involved in building water systems are frequently nuanced and complex. When in doubt, confer with counsel to educate you as to your risks so that you may determine which risks are acceptable and which need to be managed.

Illustrations

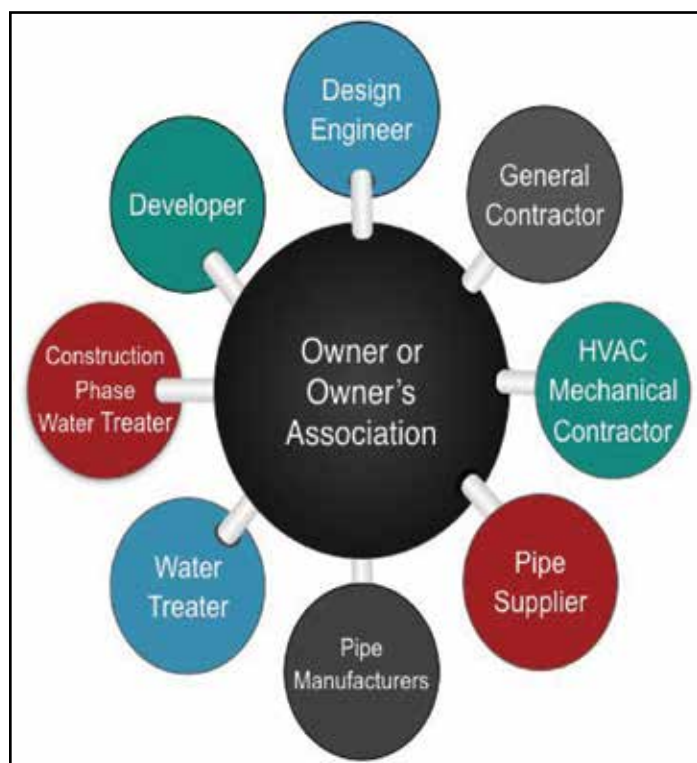


Figure 1. Common Building Water System Litigants



Figure 2. Classic example of pitting under deposits

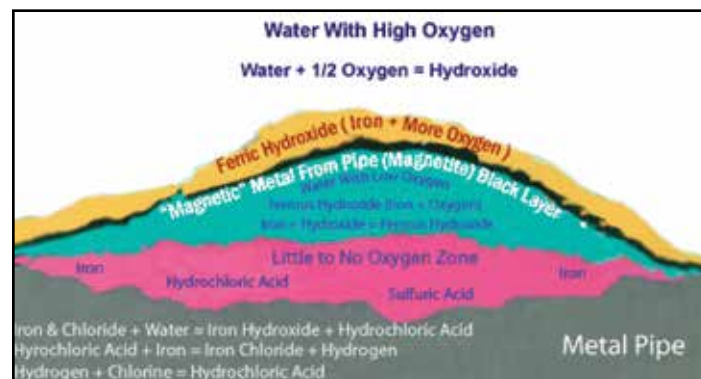


Figure 3. Diagram of under deposit corrosion mechanism



Figure 4. Corrosion product accumulation with subsequent pitting and MIC secondary to low or no flow (top of pipe section appears on the bottom of this photo – note heavier accumulation on the bottom)

