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CONSULTANT'S UPDATE

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DO I HEAR RUNNING WATER?

By Douglas E. Jones, PE

I recently awoke in the middle of the night to the sound that sends shivers up the spine of central Florida homeowners – running water. I walked out to the garage hoping to see the comforting sight of the irrigation timer counting down the operation of one of the zones. Unfortunately, I spent the next half hour with my ear to floors and walls trying to locate the source of the noise. I finally located the source…water spewing out a pinhole leak in the copper tubing leading to the shower. I was well acquainted with this sound as a similar leak several years ago resulted in the plumber jack hammering the slab in the master closet. The plumber's comments from that first leak popped in my brain – *"Fix the first leak. When (not if) the second leak occurs, re-pipe the house."* So began a three-day effort to rid the house of copper plumbing.

Copper is easy to install, widely used in residential plumbing, and has a history of resistance to corrosion. However, in some areas of the country, corrosion of copper pipe and tubing is a significant cause of plumbing failure. Its prevalence is probably underestimated as the majority of fail-

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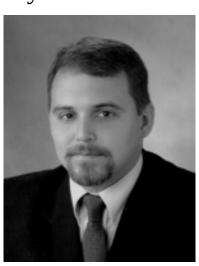
RADON: WHAT YOU NEED TO KNOW

By Wilson S. Bull, MPH



Radon is a colorless, odorless, and tasteless gas. It occurs naturally from the decay of radium, which is a byproduct of the decay of uranium, present in rocks, soil, groundwater, and materials derived from rocks. Some building materials such as concrete, brick, granite, and drywall can contain low amounts or uranium, but the decay of uranium in these materials has not been linked to elevated radon levels indoors. The Environmental Protection Agency's (EPA's) action level and units used for the measurement of radon gas are expressed in PicoCuries per liter of air (pCi/L). The EPA reports that radon is naturally present in the outside air we breathe at an average level of 0.4 pCi/L and that an average level of 1.3 pCi/L can be detected indoors.

According to the National Cancer Institute and the EPA, seven epidemiological studies of mining workers have linked exposure to elevated levels of radon with increased incidence of lung cancer in humans. The Florida Department of Health estimates that 21,000 lung cancer deaths in the United States are attributable to radon gas exposure. The Surgeon General of the United States has issued a warning that radon is the second leading cause of lung cancer in the United States.

Radon gas originates from underneath a building's foundation and travels upward. The gas becomes trapped underneath the foundation and the radon gas concentration

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DONATIONS

In looking for creative ways to recycle, Chastain-Skillman donates our shredded paper to the local SPCA. Long-cut shreds are used for animal bedding, especially for puppies. If your place of business would like to make a similar paper donation and be an SPCA "friend," please contact your local SPCA location.

Mr. Goodbar, courtesy of SPCA Inc.

Inside this issue:

UPPER PEACE RIVER HYDROLOGIC AREA FIELD TRIP

By Thomas E. Jackson, PG

A cherished tradition of the Southeastern Geological Society (SEGS) is conducting field trips to geologically interesting areas and providing a venue for public outreach, education, and networking. Recently, I organized a dinner meeting and field trip to the Upper Peace River Hydrologic Area (UPRHA) for more than 40 fellow members of the SEGS and the interested public to carry on that tradition. The Friday night (May 2, 2008) dinner meeting, held at Mike's Fine Food Restaurant in Bartow, featured PowerPoint presentations on historic Kissengen Spring and on the nearly-completed United States Geological Survey (USGS) study of the hydrogeology and stream losses to karst features in the UPRHA. The Saturday (May 3, 2008) field trip was an all-day excursion in 15-passenger vans to the UPRHA, the historic Kissengen Spring site, and to the Circle B Bar Reserve, located nearby on Lake Hancock.

In recent years, the Upper Peace River sometimes has not been meeting Minimum Flow and Level (MFL) requirements, particularly during the Spring dry season. This area has received considerable attention and study in recent years, and hopefully solutions will be forthcoming to allow recovery while addressing critical water supply and environmental protection issues. We were fortunate to have great participation from members of the technical community familiar with the area. The trip provided a rare opportunity for members of the general public to interact directly with knowledgeable members of the technical community.

The field trip was scheduled for the "dry season" when the Peace River stage is typically low enough to expose many of the various karst features (i.e., sinkholes, swallets, and fractures) in the main river channel. Sections of the river within the UPRHA have gone completely dry during recent years as river flow is captured by the karst features. Thus, the group was able to visit Gator Sink (a large sinkhole with great exposures), Dover Sink, the Crevasses, and many other interesting karst features. Charles Cook, biologist and land manager with FDEP's Bureau of Mining and Mineral Regulation, provided great insight into the dynamic nature of the area and the recent timing of river stages, as well as the important relationship between hydrology and the health and nature of the plant communities and wildlife that are so dependent on sustainable water resources.

Gator Sink, courtesy of Ralph Craig

Patty Metz (USGS hydrologist) and Billy Lewelling (former USGS biologist now with SWFWMD), were among the highly talented group that participated. The USGS has been studying the UPRHA for quite a few years now, and Metz and Lewelling are now in the final stages of a SWFWMD-funded USGS study of the area. For excellent background information and a map showing the locations of many of the karst features in this area, USGS Fact Sheet 102-03 (Knochenmus, L.A, 2004) is available online at: http://pubs.usgs.gov/fs/2003/fs-102-03/

(Field Trip—Continued on page 4)

PLEASE JOIN US AS WE WELCOME OUR NEW ASSOCIATES

In Lakeland

Our Civil Engineering department has two new additions. **William "Bill" Conerly**, PE graduated from the University of Florida with a Bachelor's degree in Agriculture and Biological Engineering. Bill will be serving as a Senior Project Manager, working out of our Lakeland office. **David Molnar**, EI graduated from the University of Toledo with a Bachelor's degree in Civil Engineering. He will be filling the role of Engineering Intern. David has recently been notified that he passed his PE exam. As this newsletter was going to print, David was headed to San Francisco, CA to participate in the Escape from Alcatraz Triathlon. We look forward to David's results report in for the next newsletter.

Our Survey department welcomes **Richard "Mike" Benton**, PSM, and **Paul Ammermann**. If their names sound familiar, it's because both have previously worked for CSI. Mike is returning as a Project Manager, and Paul as a Survey Crew Supervisor. We also welcome **David Morris** as a survey crew member during his summer break from studies at the University of Central Florida. David is pursuing his Bachelor's degree in Civil Engineering. Finally, we welcome **Michelle Allman** to the department's administrative staff.

Liz Racette has come on board on a temporary basis as our File Records Clerk. Liz graduated in June from Auburn University with her Bachelor's degree in Biomedical Science and is currently enrolled in the graduate program at the University of South Florida.

In Tampa

Our Tampa office welcomes **Kathleen Fowler** to the office's administrative staff.

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ures are not likely reported to the local water utility. Often small leaks initially go undetected and the resulting wet conditions can provide a favorable environment for termites and mold. Consequently, repair of the plumbing and associated damage is often costly for the owner.

Regulation and Health Effects

The Environmental Protection Agency (EPA) has set the action level for copper at 1.3 parts per million for 90% of the first-draw samples collected at the tap. This action level is the lowest level to which utilities can reasonably be required to control copper levels at customers' taps. Exceeding this level is not a violation but may trigger other requirements such as additional monitoring or treatment. EPA believes that short-term exposure to copper above the action limit may lead to such health effects as gastroenteritis, nausea, and vomiting. Long-term exposure to elevated copper levels has been implicated in kidney and liver damage.

Types of Copper Corrosion

Copper corrosion is typically classified as either uniform or localized (pitting) based on visual inspection of the pipe. Uniform corrosion will demonstrate an even thinning of the pipe wall and is typically associated with elevated copper levels at the tap. Often the surface will be tarnished or covered with a powdery blue-green scale (Figure 1). Localized corrosion, as the name implies, describes specific areas of corrosion. Localized corrosion usually does not result in a significant increase in copper levels at the tap, as the amount of corrosion is often very low.

Figure 1: Corrosion resulting in blue-green scale

The mechanisms of copper corrosion are not well understood. Numerous causes of corrosion have been suggested, including water quality, microbial activity, material imperfections, workmanship, soldering flux, and stray currents. Corrosion is also accelerated by high velocity and turbulence. Uniform corrosion is most commonly associated with low pH, high alkalinity water.

Localized or pitting corrosion is by far the most common type observed in central Florida. It is characterized by small areas of increased corrosion that can eventually lead to perforation of the pipe resulting in pinhole leaks. Pinhole leaks often occur at fittings and bends (Figure 2). This form of corrosion is often the most damaging as the leaks may go unnoticed for months.

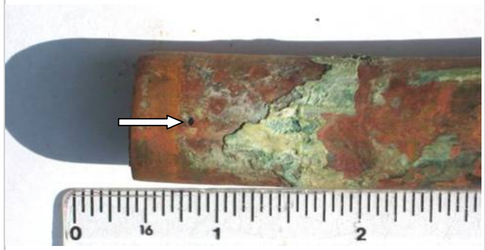

Figure 2: Localized (pitting) corrosion resulting in pinhole leak near a soldered joint

This type of corrosion may appear to occur randomly, striking some houses while neighboring homes are unaffected. This has led to speculation that localized corrosion is the result of multiple factors such as water quality, use patterns, and construction quality.

Localized corrosion is further divided into three subtypes:

1. Type I (Cold Water Pitting) – This is typically seen in horizontal runs of cold water pipes with hard well water, pH 7.0-7.8, high sulfide, and high alkalinity. This type appears to be the most common.

2. Type II (Hot Water Pitting) – Occurs with hot water often with pH below 7.2 and/or high chlorine residuals.

3. Type III (Soft Water Pitting) – Occurs with soft water often with pH above 8.0 and low alkalinity.

What's a Homeowner to Do - Treatment or Replacement?

Successful case studies have been reported in literature where copper corrosion was mitigated by the water utility through treatment of the water supply. In cases where the water supply is the definite cause, corrosion can sometimes be reduced or prevented by adding corrosion inhibitors to the water or adjusting the pH. However, utilities are sometimes reluctant to take action for fear of liability.

When the cause of copper corrosion is unclear, it is the homeowner who must decide what to do. An Internet search shows a number of companies and technologies that advertise solutions. Many of these "solutions" are questionable at best. I have had neighbors tell me that they were not concerned because they were sold water softeners to prevent copper corrosion. The Water Quality Association states that ion exchange water softening neither causes nor controls corrosion. Calcium carbonate scale on the inside of piping often forms a protective layer against corrosion. Water softeners can dissolve this layer and subject the pipe to corrosion.

Localized corrosion is usually discovered only after the first leak. By this time there are likely multiple points of corrosion within the plumbing. It is uncertain whether any form of mitigation or treatment will prevent continued propagation of these pits. This leaves the homeowner with two choices – fix the leak or replace the copper plumbing. Based on discussions with plumbers and experience with my house, I believe it is only a matter of time before the second, third, or fourth leak occurs.

The decision to replace the copper plumbing is an individual choice. I chose to take the advice of my plumber - *"Fix the first leak. When (not if) the second leak occurs, re-pipe the house."*

Bite the Bullet and Re-pipe

While the Florida Plumbing Code allows several pipe materials to be installed (including copper), the overwhelming choice of local plumbers is Copper Tube Size (CTS) Chlorinated Polyvinyl Chloride (CPVC). The pipe should meet NSF61 standards and conform to ASTM D2846 rated for continuous service to at least 100 psi and 180°F. CPVC has a long history of dependable and safe service for drinking water uses.

For a typical single-story, two-bath house, the re-plumbing work should require 2½ to 3 days to complete. The first two days involve installing the distribution and service lines. This can be performed while the water service to house remains active. On the third day, the individual fixtures (toilet, shower, etc.) are disconnected from the copper lines and connected to the new service lines.

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(Field Trip—Continued from page 2)

During the lunch break, the group visited the historic site of Kissengen Spring and the adjacent "old picnic area." These were both enjoyed for many generations before flow at the spring waned and eventually ceased flow due to overpumpage of the underlying aquifer system. Kissengen Spring served as an important social and recreational facility for local residents and visitors from afar for many generations before it ceased continuous flow in February 1950. Thomas Edison visited the spring in 1887. Florida Governors Spessard Holland and Lawton Chiles also once frolicked in this spring, as did countless others. Recent data provide some hope that with the right management strategies, unplugging of the spring vent, and public commitment to water conservation and land stewardship, flow at this historic site might be restored once again.

Dover Sink, courtesy of Ralph Craig

After lunch, the group visited the 1,267-acre Circle B Bar Reserve, located on the northwest side of Lake Hancock. Polk County Natural Resources Director Jeff Spence graciously met the group and discussed ongoing plans for management and public use of this magnificent property. An impressive new environmental education center, now under construction at the site, is scheduled to open this October. The group visited wildlife-rich restored wetlands used to filter stormwater runoff from the Lakeland area before it reaches Lake Hancock, and enjoyed a scenic vista of Lake Hancock before returning to Bartow. The reserve plays an important role in the SWFWMD's ongoing Lake Hancock lake level restoration and wetlands treatment project, which is being designed to help meet MFL requirements and improve water quality in the Upper Peace River. Proposed management strategies include the dry-season release of stored water from lakes and reservoirs, and plugging and/or berming of some of the UPRHA karst features in the river channel to prevent losses to the underlying aquifers.

One of the most rewarding aspects of organizing field trips is receiving positive feedback from participants - particularly from the general public. The SEGS typically conducts two or more field trips per calendar year and welcomes participation by non-members including the interested public. Plans are now being finalized for a field trip later this summer to Silver Spring (Marion County). To learn more about the SEGS, and for updated information on activities and future field trips, visit the SEGS website at www.segs.org.

Tom Jackson is the current Vice President of the Southeastern Geological Society and is a Senior Project Manager/Professional Geologist in Chastain-Skillman's Lakeland Office. His work focuses primarily on water use permitting, water resources and geologic/hydrogeologic projects. Tom attended the University of Florida, and received his Bachelor and Master of Science degrees in Geology, and Certificate of Advanced Studies in Hydrogeology from the University of South Florida. He can be reached at (863) 646-1402 or tjackson@chastainskillman.com.

(Radon—Continued from page 1)

increases. Most new commercial grade heating, ventilation, and air conditioning (HVAC) systems are designed to keep a positive pressure on the interior spaces of the building, therefore preventing air outside the building from being drawn in. However, if an HVAC system does not maintain positive pressure, or if a negative pressure occurs inside a building, a vacuum can be created by the pressure differential drawing radon and other gases into the interior space of the building through cracks, gaps, joints, cavities, and openings.

Florida Statute 404.056 requires mandatory radon testing for state licensed and regulated 24-hour care facilities, public and private schools (kindergarten through 12th grade), foster homes, and state licensed day care centers in certain counties. A current list of counties subject to mandatory testing requirements can be found at the Florida Department of Health Radon Program website (http://www.doh.state.fl.us/Environment/community/radon/). Previous radon sample results by zip code can also be obtained through this site.

Radon testing can be performed by either a short-term (48 to 96 hours) or long-term test method (greater than 90 days) using a testing device approved by the Environmental Health Association and/or the National Radon Safety Board. If an initial result exceeds the EPA action level of 4.0 pCi/L, then a follow up test should be conducted to determine if the average of the two tests exceeds 4.0 pCi/L. Depending on the average result of the tests, radon mitigation activities performed by a Florida Certified Mitigation Business may be necessary. It is required by Florida Administrative Code 64 E-5, Parts X and XII that the facility or radon measurement business performing radon testing report the measurement results, location, and building information to the Florida Department of Health Radon Program office. It should be noted that reporting of results is required by the above mentioned code for all radon tests, regardless of whether the site is under mandatory testing requirements.

If you have any questions or concerns regarding radon, please contact Chastain-Skillman, Inc. for more information.

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The hot and cold distribution lines are routed into the attic rather than under the slab. Individual service lines are dropped vertically through inside walls to the fixtures. The horizontal lines in the attic should be attached to the roof trusses at a height sufficient to be readily visible above the insulation and not create a trip hazard. The lines should be routed to minimize conflicts with future maintenance such as air conditioning repairs.

It is important to consider expansion when installing the pipe, as attics in Florida can easily reach 140°F in the summer. For example, a 50-foot straight length of CPVC pipe will expand by approximately 2 inches when the attic and water temperature increases from 50°F to 140°F. In addition, the pipe needs to be well supported as CPVC becomes more flexible at higher temperatures and will sag. To reduce pipe expansion and prevent excessive heating of the cold water line, the homeowner should install foam insulation around the pipes (Figure 3).

Figure 3: Insulated CPVC lines

It is important that the new distribution and service lines be pressurized to check for leaks prior to turning the water on. Most plumbing contractors will perform the pressure test with air.

Selecting the right plumber is critical to making the process as painless as possible. Time is not on your side once there is a leak. Fortunately your house is probably not the first in your neighborhood to be re-plumbed. Neighbors can be good sources of information for selecting your plumber.

Some tips to consider are:

- Contact at least two or three plumbing contractors for estimates as prices can vary significantly.
- Do not select a plumbing contractor solely on price. Ask about their experience with re-plumbing houses and contact references. Experience is important in minimizing damage to drywall and bathroom tile. An experienced contractor should be able to install the service lines with minimal to no damage.
- Do not accept a price quote without a contract. The contract should include a detailed description of the work, materials, testing, schedule, and warranty.

Insist on having the new lines pressure tested for leaks.

The Results

- Most homeowners will notice improved pressure over copper due to slightly larger inside pipe diameter and less friction.
- Some people report a slight change in taste (I did not notice any difference).
- Exercise caution when using the water during the summer. The water (both the cold and hot water lines) may be very hot when first turning on a faucet. The heat buildup can be reduced by insulating the lines in the attic.

Depending on the quality of installation, the service lines in the walls may creak slightly when water is flowing through them.

While prices can vary significantly, the typical cost for re-plumbing a typical single-story, two-bath house in central Florida is $4,500 - $5,000. This price is actually favorable when compared to the costs incurred with repairing leaks and subsequent damage. Imagine a leak under your hardwood flooring!

Doug Jones is a Senior Project Manager in the Environmental Engineering department of Chastain-Skillman's Tampa office. Doug has Master of Science degrees in both environmental engineering and microbiology from the University of South Florida. He can be reached at (813) 621-9229 or djones@chastainskillman.com.

RECENT PROJECTS AND CONTRACTS OF INTEREST

- Chastain-Skillman has recently been awarded two new continuing contracts to provide general engineering services for the City of Winter Garden, and for Hardee County, Florida. We look forward to this new opportunity to serve Winter Garden, and to the "renewed" contract with Hardee County.
- For those driving the "Bartow Highway" between Lakeland and Bartow, you'll notice the new Highlands City Town Center, Publix-based shopping plaza has now opened. Chastain-Skillman provided the civil site engineering, surveying, and construction observation for the site and the associated roadway improvements.
- Our Health & Safety/ Industrial Hygiene group is performing projects for the Hillsborough County School Board. Additionally they have been invited by the University of South Florida, College of Public Health to participate in community awareness training/programs through the Univeristy's $1.2 million grant from the National Institute for Occupational Safety and Health (NIOSH).
- The Health & Safety group has also been asked by Polk County to prepare six Spill Prevention Control and Containment (SPCC) plans.

HYDROGEN SULFIDE IN WATER SYSTEMS: WHAT'S THAT SMELL?

By James R. Chastain, Jr., PhD, PE, MPH

It is not uncommon for Hydrogen Sulfide (H_2S) to be found in Florida well waters. From a public health standpoint, the concentrations of H_2S found in these waters are not physically harmful. Adverse physical effects are from inhalation, not ingestion, and don't normally occur until the H_2S reaches levels around 20 to 50 mg/L. This is well above concentrations commonly found in most raw water supplies. The primary issue with its presence in drinking water is that, even at very low concentrations, it may contribute to taste and odor problems. Its existence is prototypically characterized as a "rotten egg" odor. In addition to the odor complaints, H_2S can contribute corrosiveness and other nuisance conditions within the distribution system and in home piping. This article will briefly discuss some of the issues commonly encountered while seeking to manage H_2S concentrations.

Water for the vast majority of Florida community water systems is pumped from wells (i.e., groundwater supplies). Because the water is below ground and not exposed to the atmosphere, the subsurface environment is generally classified as anaerobic or chemically reducing. This provides ideal conditions for the formation of H_2S. Oxidized forms of sulfur (primarily sulfates and bisulfates) tend to be reduced back toward its elemental form, where H_2S is an intermediate step. The generic equation for this transformation is shown in reaction 1.

$$SO_4^{2-} + \text{(sulfur-reducing anaerobic bacteria)} = H_2S + 2H_2O + 2OH^- \quad (1)$$

Not all groundwaters have these characteristics, but it is not uncommon for a water plant manager to have a well that does have a small quantity of H_2S among its chemical constituents.

Due to the aesthetic impacts of H_2S on drinking water, the Florida Department of Environmental Protection (FDEP) has promulgated rules covering its management in community water systems. The primary rule, located in Section 62-555.315 FAC, specifically addresses issues related to the removal of total sulfide from water. Depending on the concentration, different treatment methods may be warranted. For instance, if total sulfide is present at concentrations greater than 0.3 mg/L, the recommended method of removal is aeration. Depending on the concentration, different types of aeration may be used. These types include conventional, forced draft, or packed tower aeration. Aeration is the most common method of managing H_2S at water treatment facilities. To understand how this process works, a brief review of some basic water chemistry elements will be helpful.

H_2S Removal by Air Stripping

Aeration as a unit operation depends on two basic principles: equilibrium conditions and mass transfer considerations. The water to be treated is in equilibrium chemically with its component species and physically in equilibrium with the atmosphere above the water surface. These equilibrium conditions define the limits of the gas transfer process. Aeration is an effective removal mechanism because H_2S exists as a dissolved gas in the raw water. Incidentally, the function of aeration is not specifically to oxygenate the water; rather it is to strip the dissolved gas (H_2S) out of the raw water by changing the equilibrium conditions of the water and thus drive the dissolved gas out.

The removal of H_2S by air stripping is defined by application of Henry's Law. Henry's Law, which is generally associated with dilute solutions, relates the concentration of a gas in the water to the partial pressure of the gas above the liquid. It is recalled that partial pressure is pressure that a particular gas exerts as it moves toward equilibrium. Equilibrium occurs as gasses flow from regions of higher partial pressure to regions of lower pressure. The larger this difference, the faster the flow.

To remove the H_2S it is first necessary to determine how much of it exists in the water. This is a function of pH and temperature. pH is usually the primary variable because the raw water temperature remains fairly uniform. Hydrogen sulfide exists in equilibrium in three different forms as shown in reactions 2 and 3 and their respective pK (disassociation) values.

$$H_2S = HS^- + H^+ \qquad pK_a = 7.1 \qquad (2)$$

$$HS^- = S^{2-} + H^+ \qquad pK_a = 14 \qquad (3)$$

Figure 1 is a diagram showing the speciation of hydrogen sulfide as it varies with varying the water pH.

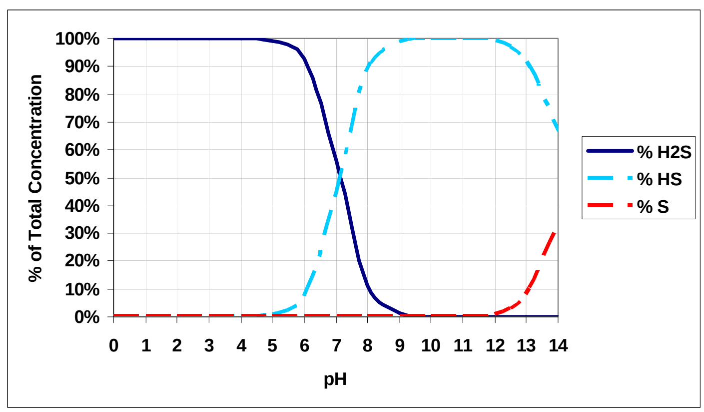

Figure 1: Hydrogen Sulfide - pH Dependence Diagram

In drinking water systems, total sulfide is primarily composed of H_2S and HS^-. At a pH equal to 7.0 for instance, approximately 56% of the total sulfide is H_2S while 44% is present as HS^-. At a pH equal to 8.0, only 11% of total sulfide is present in the H_2S form while the remaining 89% is HS^-. Of the different sulfide forms, only the H_2S molecule is removed by air stripping. It is important, therefore, to note that at elevated pH values the efficiency of aeration for the removal of hydrogen sulfide is significantly diminished. Again, only sulfur in the H_2S form can be removed by aeration by stripping.

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(H_2S—Continued from page 6)

It should be noted that Dalton's Law of Partial Pressures and Henry's Law also imply that the aeration process will affect all the dissolved gasses in the water. Recall that Dalton's Law states that in a volume that contains several gasses, each gas will exert its own partial pressure independent of the other gasses, and the total pressure of all gasses is the sum of all the partial pressures. In other words, as the water is aerated to remove hydrogen sulfide it will affect other water parameters. For instance, aeration also will strip other available gasses out of the water such as NH_3, Volatile Organic Carbons (VOC), dissolved radon, methane, and CO_2.

It is of particular importance to note that a decrease in CO_2 leads to a decrease in alkalinity and a corresponding increase in pH. A decrease in alkalinity also results in a decrease in the buffering capacity of the water. Buffering capacity is important because it promotes a stable pH environment, which is a key variable in corrosion characteristics of the water and various chemical equilibrium reactions (both good and bad).

H_2S Removal by Chemical Oxidation

In addition to removing H_2S by stripping the dissolved gas from the water, H_2S and HS^- can be removed by chemical oxidation. However, this treatment alternative must be used with caution. Oxidation of hydrogen sulfide or bisulfide ions converts these forms to elemental sulfur. Elemental sulfur exists as a finely divided solid that may contribute to high turbidity readings if sulfur is present at high levels. Unless removed, the sulfur will flow out of the plant and into the distribution system. This is not typically associated with any adverse health effects, but can cause taste and odor problems in the future if certain bacteria exist in the distribution system that reconvert the elemental sulfur back to H_2S.

Chlorination is the means of oxidation most commonly used for this purpose. Again, because elemental sulfur is formed, unless a turbidity removal process follows, oxidation is not recommended for hydrogen sulfide removal when hydrogen sulfide is present at concentrations greater than 0.3 mg/L.

By the way, in addition to removing H_2S by stripping, aeration will provide a nominal reduction of H_2S by direct oxidation. This occurs because aeration increases the level of dissolved oxygen in water, which reacts with hydrogen sulfide to produce elemental sulfur as shown in reaction 4. High DO levels in water may accelerate corrosion reactions.

$$2H_2S + O_2 = 2S_{(s)} + 2H_2O \quad (4)$$

According to Section 62-555.315 F.A.C., if total sulfide is present in the water at concentrations less than 0.3 mg/L and dissolved iron is less than 0.1 mg/L, chlorination may be used for sulfide oxidation to elemental sulfur. Equation 5 outlines the oxidation of sulfide by chlorine species:

$$HS^- + OCl^- = S_{(s)} + Cl^- + OH^- \quad (5)$$

It is noted that the species shown in reaction 5 are the ones typically found in water systems. As discussed, speciation is dependent upon the pH of the water, and water systems typically have pH values between 7.0 and 8.0. At such pH, bisulfide ions and hypochlorite ions are the predominant species with respect to hydrogen sulfide and chlorine, respectively.

Given the stoichiometry of the reaction and the fact that 1 mole of hypochlorite is equivalent to 1 mole of elemental chlorine, a minimum free chlorine dosage of 2.2 mg/L should be employed to oxidize every 1 mg/L of sulfide as sulfur. Removal of H_2S by chlorination can significantly increase the chlorine cost at the water plant due to the required dosage.

Because chlorine species oxidize sulfide, iron, and manganese to insoluble particulate products it is important to utilize chlorination with caution and closely monitor the concentration of these species when sulfide and iron exceed 0.3 mg/L and 0.1 mg/L, respectively. The FDEP requires the turbidity of the finished water not to exceed the turbidity of the raw water by more than 2 nephelometric turbidity units (NTUs). In events that result in elevated turbidity readings, a filtration step needs to be utilized downstream of the oxidation step.

In summary, removing hydrogen sulfide from water is not necessarily as easy as just adding an aerator at the treatment plant. It is important to understand how much sulfur is actually being removed and what forms the remaining sulfur takes. The remaining sulfur will flow into the distribution system. Because there are no regulatory restrictions on this, in one sense there is no problem with this practice. However, if sufficient elemental sulfur or bisulfide is incorporated into the biofilms of the distribution system, it is possible that under appropriate conditions the H_2S could re-form and cause taste and odor problems for the customers.

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