# Stinky Water

By Jeff Swanson, OAWU Circuit Rider

The issue of 'stinky' water can usually be traced to hydrogen sulfide (H2S) gas. The odor is that of rotten eggs. Isn't that a wonderful smell to serve to your customers? Knowing that with the necessity of increasing water rates to cover your system's financial needs, it's hard to ask for more money for a product that is less desirable than bottled water. People are already paying more for bottled water than they are for the gasoline at the pumps. Although the odor is repulsive, it is not usually harmful as a health risk in the low concentrations that occur in distribution systems and households. Understandably, if it is not noticed in the cold water or at the source, the resulting customer complaints may be originating within their own homes due to natural reactions in their water heaters. Let's look at some of the origins, causes, and effects surrounding this stinky issue.

The first thing I would like to do is briefly review some basic chemistry terms to help understand the dynamics that cause this stinky subject. In the water industry, 'oxidation' and 'reduction' are terms that you have probably heard of before, but may have forgotten what they mean.

> OXIDATION: def. "Oxidation is the addition of oxygen, removal of hydrogen, or the removal of electrons from an element or compound. In the environment, organic matter is oxidized to more stable substances. The opposite of REDUCTION.
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> REDUCTION: def. "Reduction is the addition of hydrogen, removal of oxygen, or the addition of electrons to an element or compound. Under anaerobic conditions (no dissolved oxygen present), sulfur compounds are reduced to odor-producing hydrogen sulfide (H2S) and other compounds. The opposite of OXIDATION.

Sulfates in water will chemically reduce to sulfides by natural chemical processes; however, a microorganism catalyst is required for this reaction to take place at a significant rate. Nonpathogenic anaerobic bacteria, such as Desulfovibrio desulfuricans, form enzymes as a metabolic function that have the power to accelerate the sulfate-reduction reaction by decreasing the activation energies of the reaction. The subsequent production of hydrogen sulfide gas creates the distinctive rotten egg odor. In addition to microorganism activity, the presence of electrons helps to provide the energy necessary for the sulfate-reduction reaction. Excess electrons are made available by the oxidation of organic matter or corrosion of metals. To recap; the three components necessary to cause rotten-egg odors are: 1. sulfur, 2. bacteria, and 3. electrons. Please keep in mind that the sulfate-reducing bacteria lack the ability to reduce the sulfates to sulfides without the addition of an energy source caused by excess electrons.

**Excess Electrons:** The sulfate-reducing bacteria require an external source of energy in order to participate as the catalyst in the sulfate-reduction reaction. This energy source is provided by the excess electrons released by oxidation of organic matter or corrosion of metals.

Complaints of rotten egg odors are more common for hot water than cold. The solubility of the hydrogen sulfide decreases as the temperature increased, causing the gas to be expelled when hot water is released from the tap. Sulfate-reducing bacteria activities in the groundwater aquifer, distribution system, or hot-water-heater tank may all be responsible for the hydrogen sulfide concentration.

**Oxidation:** Hydrogen sulfide may be effectively oxidized to sulfur or sulfates by chlorination. The oxidation to sulfur is an instantaneous primary reaction. The reaction of oxidation to sulfate may take place simultaneously or proceed at a slower rate, depending on pH and concentration of reactants. Optimum pH ranges are 6.5 to 8.5, with the secondary oxidation rate increasing sharply between pH 6.5 and pH 7.3.

Theoretically, 8.5 mg/L of chlorine are required for each 1 mg/L of hydrogen sulfide to assure complete chemical oxidation. It may be most economical to reduce the hydrogen sulfide concentration by aeration prior to chlorination. Some applications that have utilized the process of aeration have also found that when dealing with high pH, have greatly benefited from the use of CO2 injection to lower the pH and accelerate the oxidation rate.

**Maintain Chlorine Residuals:** It is important to maintain chlorine residuals throughout the distribution system in order to suppress the growth of sulfate bacteria. Excess bacterial activity in the distribution system can result in the reduction of residual levels. Bacterial activity then increases the corrosion rate, which in turn increases bacterial activity, because excess electrons to be utilized by the bacteria are provided by the corrosion of the metal. Periodic flushing of low-flow lines and dead ends can reduce the concentration of the sulfate-reducing bacteria. Maintaining adequate chlorine residuals is necessary to inhibit excess bacterial activity.

**Water Heaters:** The method used to provide corrosion protection of most water heater tanks can produce an environment that is ideal for the production of hydrogen sulfide gas. Modern water heaters are glass lined to prevent corrosion, but assuring 100 percent glass coverage protection is impossible, especially since cracks may occur while the tank is in service. To prevent tank corrosion where small cracks or voids in the glass coating may occur, a long magnesium rod, an "anode," is used to provide cathodic protection. Because of the relative position of magnesium to steel in the electromotive series of metals, magnesium will corrode, producing an abundance of electrons that coat the exposed steel so long as the magnesium anode remains in the tank and has not been totally sacrificed to protect the tank wall.

The number of electrons liberated by the sacrifice of the magnesium anode is far greater than the amount required to protect the exposed steel of the water-heater tank. The excess electrons provide the external energy source required by the sulfate-reducing bacteria and in turn accelerate the sulfate-reducing reaction. Water softeners can also contribute to the odor problem. The softened water is more corrosive and therefore increases the rate at which the magnesium anode is sacrificed. This provides more energy to the bacteria and accelerates the rate of sulfate reduction and increases the odor complaints. Since most water heaters are factory set at 140F, and sulfate-reducing bacteria die at about 140F, increasing the temperature setting to 160F can more effectively kill the bacteria. Increasing the temperature for several hours, followed by a good flushing can help periodically. This process can be repeated once the bacterial population becomes high again. Customers should be made aware that water heaters should have an operable pressure relief valve and temperature adjustments should be made with caution to prevent scalding hot water and avoid high energy costs.

**The Remedies:** To remedy rotten odors in hot water, any one of the following methods may be used:

1. Maintaining chlorine residuals – Maintaining a residual of 1 mg/L throughout the distribution system oxidizes any hydrogen sulfide present and inhibits bacterial activity and corrosion associated with sulfate-reducing bacteria. In non-chlorinated systems, periodic disinfection and flushing of the water heater may be sufficient.
In the wells where the hydrogen sulfide problems may originate, 0.5 mg/L – 1.0mg/L of chlorine may be added to help control the odor and an additional similar amount added to the distribution system if necessary.

2. Flushing low-flow distribution lines – Flushing low-flow lines and looping distribution lines to eliminate dead ends can greatly reduce the concentrations of the sulfate-reducing bacteria and help to alleviate the problems they cause.

3. Killing the bacteria with increased heat – Periodically increase the water temperature in the water heater to 160F followed by flushing.

4. Replacing the magnesium anode rods with zinc anode rods – Zinc has an electrode potential that is much closer to that of the steel tank than magnesium and will impart fewer electrons that would support the rapid bacterial growth, or

5. Removing the cathodic-protection anode entirely – Please keep in mind that although this may help alleviate the odor problem, it may also shorten tank life.

In closing, it is important to always remember that customer satisfaction is an important aspect in maintaining good customer relations. When taste and odor complaints first come into the water system's office, make sure that they are handled immediately and that each one is recorded and kept on record for future reference. Such records a

requirement and are an excellent way to ‘trend’ the complaint data to help you more effectively remedy the situation. Additionally, it can provide helpful information to the customer that will allow them to make the necessary decisions to eliminate taste and odor problems in their own household.

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