COMMON CUSTOMER COMPLAINT:

"MY HOT WATER STINKS"

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Although taste and odor problems can affect both hot and cold water, usually hot water causes more complaints - especially complaints about the rotten egg stench. A number of conditions can contribute to the occurrence of these odors. This article reviews a few of the basics relating to the formation of rotten egg odors, especially those associated with hot water.

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. Non-pathogenic anaerobic bacteria, such as *Desulfuvibrio 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.

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 increases, 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

The concentration of hydrogen sulfide in the water of an aquifer is dependent on the environment in which the bacteria must work. The energy source for the bacteria in the aquifer is primarily the oxidation of organic matter. The oxidation of the organics may be slowed by the lack of essential nutrients for bacterial growth. A low rate of oxidation of organics would results in a low source of energy to be utilized by the sulfate-reducing bacteria; this, in turn, would result in a low concentration of hydrogen sulfide.

Hydrogen sulfide may be effectively oxidized to sulfur or sulfates by chlorination. The chemical reaction of sulfide oxidation by chlorination may be represented by two equations:

$$CI_2 + S^2 - 2\ CI + S \quad (1)$$

$$4CI_2 + S^2 + 4H_2O - 8\ HCI + SO_4 - 2\ (2)$$

The oxidation to sulfur (Eq 1) is an instantaneous primary reaction. The secondary reaction of oxidation to sulfate (Eq 2) 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.

Maintain chlorine residuals

It is important to maintain chlorine residuals throughout the distribution system in order to suppress the growth of sulfate bacteria. If existing chlorine residuals are exposed to excess bacterial activity in the distribution system, the results can be a reduction in the residual levels. Bacterial activity then increases the corrosion rate, which in turn increases bacterial activity, since excess electrons to be utilized by the bacteria are provided by the corrosion of the metal. Therefore, bacterial activity in the system in the absence of adequate chlorine residuals causes not only odor problems by also certain types of corrosion of distribution mains.

Chlorine depletion and related problems are made worse by the stagnant water environment of dead-end lines, where bacteria can flourish. Looping of distribution lines to eliminate dead ends and periodic flushing of low-flow lines can reduce the concentration of the sulfate-reducing bacteria and help to avoid the problems they cause.

Cathodic protection

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 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 surface. There will be no corrosion of 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 to participate as the catalyst in the sulfate-reducing reaction.

Ion-exchange water softener

A frequent contributor to the odor problem is the ion-exchange water softener. The softened water is more corrosive than the water was before calcium and magnesium ions were exchanged for sodium ions. Therefore, the use of a softener increases the rate at which the magnesium anode is sacrificed. This provides more energy to the bacteria, accelerating the rate of sulfate reduction and increasing the odor complaints.

Remedy for rotten egg odor

To remedy rotten egg odors in hot water, any one of the following methods may be used: (1) maintaining chlorine residuals, (2) flushing low-flow distribution lines, (3) killing the bacteria with increased heat, (4) replacing magnesium anode rods with zinc, (5) removing the cathodic-protection anode entirely.

Maintaining chlorine residuals. Maintaining a chlorine 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 a nonchlorinated system, periodic disinfection and flushing of the water heater tank with a chlorine bleach solution may be sufficient. If the problem is severe or persistent, a chlorine feeder system may be required.

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

Killing bacteria with heat. The thermal death point of sulfate-reducing bacteria is approximately 140^0 F (60^0 C). Water heaters are usually factory set at 140^0 F +/- 10^0 F (60^0 C +/- 6^0 C), which is the "medium" setting on the temperature control dial. Increasing the temperature to the "high" setting (160^0 F, or 71^0 C) for several hours and flushing the tank should kill the sulfate-reducing bacteria and greatly reduce the odor problem until the population of the bacteria becomes high again.

CAUTION: The hot water tank must have an operable pressure relief valve; otherwise, this method of treatment may be dangerous. The temperature setting must be reduced following treatment to eliminate the risk of persons being scalded from dangerously hot water and to avoid high energy cost.

Replacing magnesium anode rods. Zinc has an electrode potential that is much closer to that of the steel tank than magnesium. If a zinc anode is used instead of magnesium, the zinc will sacrifice fewer excess electrons to reduce the sulfates. This remedy will not eliminate problems associated with sulfate-reducing bacteria, but it can greatly reduce them.

Removing cathodic-protection anode. Removal of the cathodic-protection anode is not a preferred method, but it may alleviate the odor problem. The method eliminates all cathodic protection from the tank, which may shorten tank life, especially where water softeners are in use.

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