"Oldie But a Goodie" From 1981

Phew! My Hot Water Smells Like Rotten Eggs

by David J. Hack

One of Opflow's *most requested articles in history, this classic explanation for hot water that smells like rotten eggs continues to inform readers today.*

Taste and odor problems can affect hot or cold water, but hot water problems usually bring complaints of smells like rotten eggs.

The rotten egg odor is caused by hydrogen sulfide (H_2S) gas. The odor is repulsive, but the gas is not usually harmful at the low concentrations that occur in a household water system.

Chemical Causes

Rotten-egg odors result from a chemical process that involves three primary components:

- sulfur (S)
- electrons
- bacteria

Sulfur. Sulfur often appears in water as sulfate ions ($SO_4^{=}$), which are quite stable. However, sulfate can convert to sulfides ($S^{=}$) and hydrogen sulfide gas by the gain of eight electrons (negative charges). The gain of negative charges is called a reduction reaction.

Electrons. The sulfate-reduction reaction requires energy. Electrons are the energy source. Excess electrons may occur in water as the result of the decay of organic matter or the corrosion of metals. Sulfate may convert to the less stable sulfur form of sulfide in the presence of excess electrons, but this conversion is not entered into easily. A catalyst is required to speed up the reaction if it is to take place at a rate sufficient to cause the nuisance odor.

Bacteria. The nonpathogenic, bacteria, *Desulfuvibrio desulfuricans*, produces enzymes that have the power to accelerate the sulfate-reduction reaction. However, the sulfate-reducing bacteria lack the ability to reduce the sulfates to sulfides without the external energy source provided by the excess free electrons.

All three components of the reaction: the sulfates, the sulfate-reducing bacteria, and the excess electrons must be present for hydrogen sulfide to be produced.

Time. An influencing factor is the length of time that the water is in contact with the reaction. Even at a very low reaction rate, the H_2S may build in concentration to objectionable levels given enough time.

If you can substantially reduce any one of the four factors, you can control the odor problem.

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Sulfates occur in most groundwater environments at sufficient levels to form objectionable concentrations of H_2S gas. The sulfate-reducing bacteria will grow almost anywhere the other reaction components exist. The water may be in the ground for a near-infinite period of time. Therefore, this leaves the availability of electrons as the principle controlling factor for the occurrence of hydrogen sulfide in groundwater.

Deep wells that are cased and sealed to state specifications have few organics. In addition, they may lack the nutrients needed to support the bacteria that feed on the few organics available.

In these wells, the availability of free electrons is limited and little hydrogen sulfide is produced. However, even at an extremely low rate of H_2S production, the long time that the water is in contact with the reaction may provide objectionable concentration of the gas.

The rotten egg odor in groundwater can be controlled at the well. Hydrogen sulfide may be oxidized to sulfur or sulfates by chlorination. In Missouri, the typical chlorine dosage for a deep well in Missouri varies between 0.5 to 1.0 mg/L to control the rotten egg odor plus another 0.5 to 1.0 mg/L for the distribution system.

H_2S in the Distribution System

Bacterial activity in the distribution system may be responsible for nuisance odor problems and accelerated corrosion of unprotected mains and household plumbing. As the corrosion releases more excess electrons, the activity of the sulfate-reducing bacteria is also accelerated.

H_2S in Water Heaters

Water heater tanks can provide an ideal environment for the production of hydrogen sulfide gas. Modern steel water heaters are glass-lined to prevent corrosion. However, it is impossible to assure 100 percent coverage, especially since cracks may occur while the tank is in service.

Anode prevents corrosion. To protect steel exposed by small cracks in the glass coating, a long rod, or anode, is used to provide cathodic protection. The rod is usually made of magnesium, which corrodes more easily than steel. This corrosion frees many electrons that provide a protective film over the cracks in the glass. The steel will not corrode as long as the magnesium anode remains in the tank.

The number of electrons liberated by the corrosion of the magnesium anode may greatly exceed the amount required to protect the exposed steel of the water heater tank. The excess electrons provide the energy needed by the sulfate-reducing bacteria to produce H_2S gas.

Conditions are right. Sulfate-reducing bacteria thrive in the temperature range of most water heaters. In addition, the water heater tank provides for an extended contact time. Where there are many free electrons due to the corrosion of the anode, the hot water heater can be a major contributor to rotten egg odor problems. If the odor is not detected at the cold water tap, the water heater is probably to blame for odor problems.

Aggravating the problem. Many household activities can aggravate the problem: infrequent use of hot water, such as with vacation homes or being away for a weekend, or the use of iron plumbing, which is more likely to corrode than copper or PVC. A water softener reduces $CaCO_3$ levels, which reduces protection from corrosion.

Remedies

Replace the magnesium anode. Magnesium is commonly used for cathodic protection anodes because it provides much corrosion protection at the least cost. However, this level of protection is often not needed. Consult a reputable dealer of water heaters for a replacement anode that provides protection without supporting the sulfate-reduction reaction that causes the H_2S gas.

Chlorination. Maintaining a chlorine residual of 1 mg/L throughout the distribution system inhibits bacterial activity. In a nonchlorinated system, homeowners may disinfect and flush their water heater tanks with a chlorine bleach solution.

Kill the bacteria with increased heat. Sulfate-reducing bacteria die at about 140°F (60°C). Water heaters are factory set at 140°F ± 10°F (60°C ± 6°C), which is the medium setting on the temperature control dial. Increasing the temperature to the high setting, 160° F (71° C), for several hours should kill the sulfate-reducing bacteria, then flushing to remove the dead cells should control the odor until the population of bacteria recovers.

Caution: The 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 prevent scalding hot water and to avoid high energy costs.

Periodic flushing of low-flow water lines. Flushing low-flow lines and looping water mains to eliminate dead ends will reduce problems associated with bacterial activity.

David Hack wrote this article for the September 1981 Opflow. *At that time, he was a water specialist with the Missouri Department of Natural Resources in Jefferson City, Mo. When the article appeared again in July of 1990, Hack worked as a project engineer for Marshall Engineering and Surveying in Columbia, Mo.*

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ground for an electrical system? It is critically important that the operator understands the safety hazards of this practice. Procedures for changing meters and fixing line breaks that avoid the dangers of electrical shock should be in place in any system where this is a consideration. The Town of Fort Erie, Ont., has established guidelines for its employees (see page 38), which address many of the safety concerns.

Conclusion

Thanks to the town of Fort Erie, Ont., for sharing its guidelines with our readers; and, particularly, thanks to Doug Atkins, utility supervisor, and Grant Boutin, utilities lead hand.

For further information on the history of this issue and the development of AWWA's position on this subject, see JOURNAL AWWA, February 1980, "Grounding of Electrical Circuits to Water Services: National Electric Code Versus AWWA Policy." AWWA also has papers available through Waternet that address issues of corrosion and health effects associated with electrical grounding.

For further information on this and related topics, call Joe McDonald, AWWA Small Systems Program coordinator, at (800) 366-0107.