AWS Technical Report: Eliminating Odors in Water Heaters and Piping on Municipal Water Sources

1.0 Introduction and Background

The incidence of rotten egg odor or black water in water lines is due to the reaction of sulfates and microorganisms in water. To determine the source of the odor, it is important to check to see whether the cold water contains odor, or just the hot water. Run the hot water to notice the odor. Then move to another faucet and run the cold water. If the cold water has an odor, then the source is in the cold water. If the hot water alone has odor, then the odor is occurring primarily in the water heater.

Black or rusty slime, and/or stringy-appearing growths on the sides of toilet flush tanks (above) may indicate the presence of bacterial growth. Water heaters (right) are prime sources of odors when bacteria react with the anode rod inside.

Odors Caused by Bacteria

Some waters contain an excessive amount of sulfates with various strains of sulfate bacteria. These bacteria, harmless to health, will react in stagnant water that has been depleted of oxygen, and will produce hydrogen sulfide gas, using the hydrogen ion from the anode cathode reaction. Almost all water heaters have

"anode rods" which in a cathode-anode reaction, produce excess ions that wear off the anode rod and adhere to the inside glass lining of the water heater, preventing corrosion. The greater the activity of the anode, the greater the amount of hydrogen ion and hydrogen sulfide gas. These bacteria (typically the "desulfovibrio" or a related species) can be killed with adequate amounts of chlorine by periodic shock chlorination.

These bacteria cannot grow in the presence of atmospheric oxygen, which may account for their not being noticed in cold water lines.

Odors Can Develop in City Water High in Sulfates & Low in Chlorine

If your water comes from a municipal ("city") water source, the water is usually chlorinated and stored in above ground atmospheric holding or storage tanks. It is unusual that this type of water will have produce odors in the cold water lines. It can occur in some situations however, if your home is located at the end of the distribution, far away from the chlorination station, and the piping is ductile iron pipe.

Even though the water entering a pipeline from the city water treatment plant can be free of odor, the water may develop odors directly in the distribution line. This can be caused by old iron distribution systems that provide an environment for the sulfate bacteria to grow. Increased bacterial growth depletes both the oxygen and the chlorine residual in the piping. By the time it reaches the house it can be free of chlorine residual and odors can easily develop.

Odors can develop even in cold water piping in the home, especially in galvanized iron piping. Often iron piping in the house is of an older age and can be corroded, providing a good environment for the bacteria to grow and odors to develop. If there is an odor in the cold water, and the source is chlorinated city water, its best to trace and see if the piping is iron piping, and then replace it with copper. As a first step to this process, one can chlorinate the piping and sanitize it, and see if the odor can be eliminated.

Other Odors

Other causes for odors are very high chlorine concentration (leading to chlorine odors), or algae and other organic material in the city water source itself. There is nothing the homeowner can do on a one-time basis to correct these types of odors. For these problems, one could install a filtration system or if that isn't feasible, contact the city water utility and tell them what you are experiencing to see if it can corrected at by the water utility.

2. Procedure for Chlorinating Home Piping Systems to Eliminate Sulfur Odors in Cold Water Piping on City Water

If there is a sulfur odor, or "rotten-egg" odor in the cold water, then you can use shock-chlorination to either temporarily or permanently eliminate the odor. Shock-chlorination will kill the bacteria in the cold water lines and loosen up scale and slime that may have developed in the piping. If the odor is only in the hot water, go to Section 3 to see instructions on chlorinating and about water heaters.

Unless you are familiar with your plumbing system and handling chlorine you should not attempt to chlorinate your own piping. This should only be attempted by a licensed water treatment professional or plumber.

There are two methods of filling a household or other piping system with a chlorine solution:

Method 1: **Use a standard centrifugal pump, sump pump or other pump and pump in a 80 to 100 ppm chlorine solution into a household piping system that is de-pressurized, filling the pipes up with the chlorine solution**. This involves shutting the water pressure off from the street, and draining the household pipes and then pumping in a solution of chlorine from a clean, new plastic trashcan or other clean container. The fixtures and faucets are

opened and the solution is pumped until the chlorine solution is present in all the fixtures, including the water heater and hot water lines. To chlorinate a home that is 2 stories or less, use a pump that can develop at least 20 psi at 5 gallons per minute. After a chlorine residual of 50 to 100 ppm is detected at each faucet or fixture (using a high-range chlorine test kit, not a pool or hot tub test kit) the chlorine solution is allowed to remain in the pipes for 12 to 24 hours.

Method 2: Use a high-pressure metering pump. Professional water treatment specialists and distribution system operators would use this method. This involves leaving the water system under pressure and using a high pressure, low-volume metering pump to inject a concentrated chlorine solution under pressure, while the water is running in the house. After a chlorine residual of 50 to 100 ppm is detected at each faucet or fixture (using a high-range chlorine test kit, not a pool or hot tub test kit) the chlorine solution is allowed to remain in the pipes for 12 to 24 hours. This method saves time and is as effective as Method 1.

Method 1 – Shock chlorination of piping systems by injecting a 100 ppm chlorine solution using a centrifugal, sump pump or other pump:

1. Shut off the main line coming in to the house. Identify an outside hose bib or other opening in the incoming piping. If no hose bib or opening exists, install a ½" threaded opening and a hose bib into the main line to use for injecting the chlorine solution. Open up several of the faucets or taps in the house and drain the water from the household piping.

2. Hook up pump using garden hose or other hoses to the main line.

3. Mix 1 ounce of household bleach or ½ ounces of pool chlorine (12% sodium hypochlorite) for every 4 gallons of water in a clean trashcan or other plastic container. This will create a 98 ppm chlorine solution (or approximately 100 ppm). The amount of solution needed will vary depending on the size of the piping, but typically there is approximately 100 to 300 gallons of water in most home piping systems

4. Run the water in the house until the bleach solution has filled all the pipes and a strong odor of chlorine is coming from the fixtures or faucets, both hot and cold.

Create a 100 ppm chlorine solution:

Household bleach is 5% chlorine (sodium hypochlorite)
5% = 50,000 parts per million ("PPM")
1 gallon = 128 fluid ounces 4 gallons = 512 oz.

$\frac{\text{1 oz @ 50,000 pm}}{\text{512 oz.}} = 98 \text{ ppm}$

Add 1 oz bleach for every 4 gallons water OR
Add 4 oz (1/2 cup) for every 16 gallons water OR
Add 8 oz (1 cup) for 32 gallons of water.

5. Allow the water to sit for 12 hours. Retest for chlorine residual. If the water contains less than 10 ppm of chlorine, repeat entire procedure. The slime, scale, and odor-producing bacteria will interact with the chlorine and reduce the amount of chlorine residual in the piping. If it uses up all the chlorine, or the chlorine residual is less than 10 ppm, then the procedure may need to be repeated.

6. Flush the piping and fixtures well to flush out scale and colored from water from the piping. Unscrew aerators and fixtures to avoid these items becoming plugged with sediment that may have been loosened in the chlorination process.

Caution: this will often loosen up scale, iron deposits and other materials in the piping, which can clog fixtures, appliances and valves in the piping system, causing a lot of problems. Care should be taken when flushing the piping, and all aerators removed to prevent clogging. In some extreme cases of corroded piping, the piping could fail and start to leak after this procedure.

If you are on septic tank: in most cases, it won't harm the septic tank to flush 50 to 100 ppm of chlorine residual into it, on a one-time basis, with the water from a household piping system. If you want to be extra certain, after chlorination, you can add in some "septic tank starter" or beneficial bacterial material, down the toilet and establish beneficial bacteria in the septic tank. This can be purchased at any hardware store.

Method 2: Shock chlorination of piping systems using a high-pressure metering pump without draining the piping first:

1. Shut off the main line coming in to the house. Identify an outside hose bib or other opening in the incoming piping. If no hose bib or opening exists, install a ½" threaded opening into the main line to use for injecting the chlorine solution.

Figure 1: Typical metering pumps with adjustable speed and pump stroke adjusting knobs. These adjusting knobs make it easy to meter in 10% to 100% of pump output and adjust output of pump for various applications.

2. Hook up a 24 gallon per day output metering pump to the line, using a injection check valve so the water cannot back-feed into the metering pump. See Figure 2. If metering pump has a different output, adjust speed of pump or solution strength. In this procedure, a concentrated chlorine residual will be injected while the pipes are under line pressure from the street or city-water system, so a check valve is used on the piping, to prevent the water from backing up into the metering pump. Make sure to use a metering pump that can develop pressures higher than the line pressure you are injecting into.

3. Determine flow rate. Open up the faucets hot and cold and read the water meter to determine gallons per minute.

4. Use the formula and example below to adjust the metering pump:

Example: Compute metering pump setting to achieve 100 ppm applied chlorine dosage in a water stream flowing at 5 gallons per minute, using full strength household bleach:

$$\frac{5 \text{ gpm} \times 100 \text{ ppm} \times 1440 \text{ (minutes/day)}}{52{,}500 \text{ (ppm of laundry bleach)}} = 13.7 \text{ gallons per day}$$

Output of pump is 24 gallons per day. The example above calls for 13.7 gallons a day output.

$$\frac{13.7 \text{ gallons per day}}{24.0 \text{ gallons per day}} = .57 \text{ or } 57\%$$

Set metering pump speed to 57%, which is 13.7 gal/day

5. Run the water in the house or piping until the bleach solution has filled all the pipes and a strong odor of chlorine is coming from the fixtures or faucets, both hot and cold. If possible, test the water at each fixture to verify that there is at least a 50 ppm chlorine residual, using a DPD method test kit.

6. Allow the water to sit for 12 hours. Retest for chlorine residual. If the water contains less than 10 ppm of chlorine, repeat entire procedure. The slime, scale, and odor-producing bacteria will interact with the chlorine and reduce the amount of chlorine residual in the piping. If it uses up all the chlorine, or the chlorine residual is less than 10 ppm, then the procedure may need to be repeated.

7. Flush the piping and fixtures well to flush out scale and colored from water from the piping. Unscrew aerators and fixtures to avoid these items becoming plugged with sediment that may have been loosened in the chlorination process.

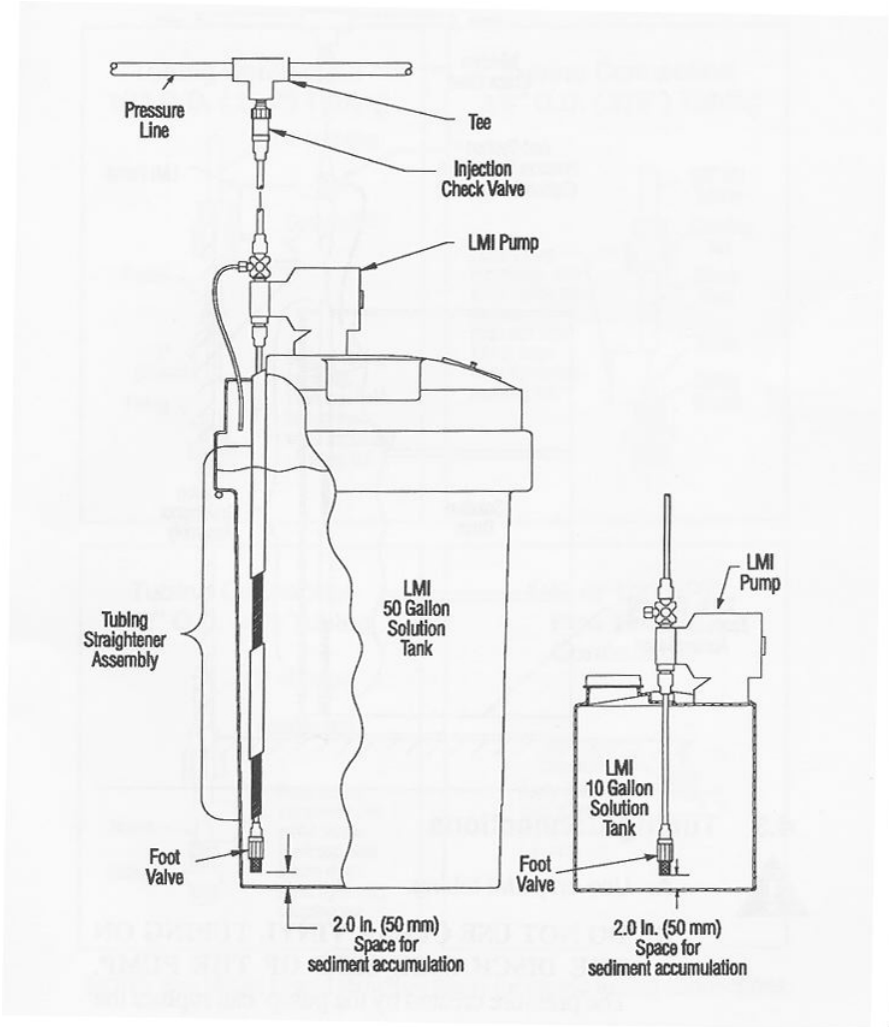
If the Odor Returns

After this procedure is completed, the odor will be eliminated. If it returns within a few weeks, then the chlorination procedure can be repeated. However, in many cases the cold water will still have problems with recurring odors due to continued presence of sulfate bacteria and low chlorine residuals in the water. At this point all one can do is to replace the iron piping with copper.

Caution: this will often loosen up scale, iron deposits and other materials in the piping, which can clog fixtures, appliances and valves in the piping system, causing a lot of problems. Care should be taken when flushing the piping, and all aerators removed to prevent clogging. In some extreme cases of corroded piping, the piping could fail and start to leak after this procedure.

If you are on septic tank: in most cases, it won't harm the septic tank to flush 50 to 100 ppm of chlorine residual into it, on a one-time basis, with the water from a household piping system. You can also restart the septic tank bacteria with a septic tank bacterial starter kit available from the hardware store..

Figure 2: Typical metering pump and solution tank installation showing injection valve in piping, using a LMI brand metering pump.



3. Odors in Water Heaters and Hot Water Pipes Only

If the cold water does not contain odors, but the hot water does, then a thorough sanitizing of the water heater tank will eliminate the odor. See the procedure below. **If you are not familiar with the functions of your water heater, DO NOT ATTEMPT this yourself. You can have this done by a licensed plumber to avoid damage to your water heater, or causing electrical problems, or gas explosions by improperly restarting the water heater if gas. Note: If the water heater is old and corroded, cleaning the sediment from the water and sanitizing by chlorination could cause the water heater to leak.**

Procedure for Chlorination of Hot Water Heaters to Eliminate Odors

1. Turn off the manual switch if the water heater is electric. For gas heaters, turn the control to Pilot. Make sure the pilot is still lit so you can restart the water heater when the procedure is completed.

2. Close the cold-water inlet valve at the water heater.

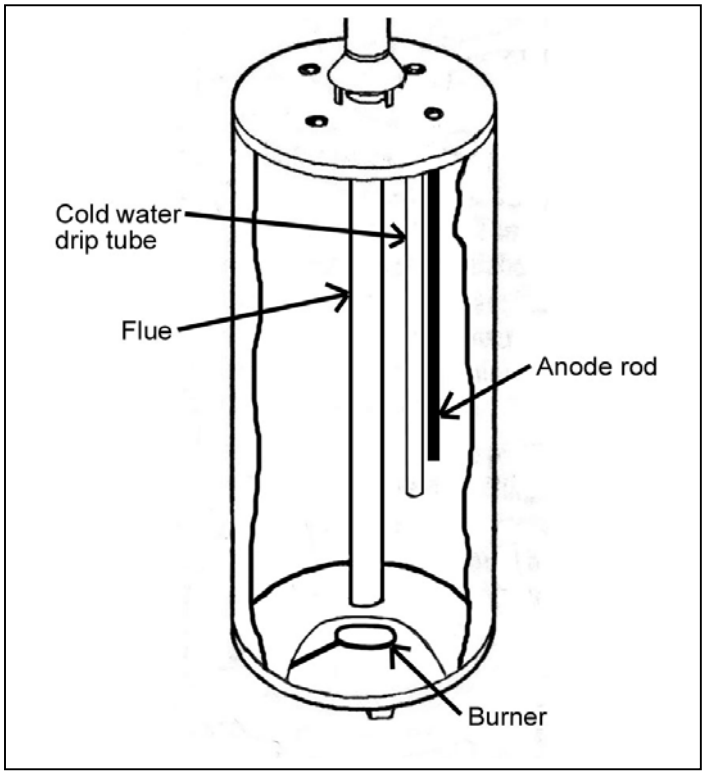
3. Open a nearby hot water faucet and the T&P (temperature and pressure valve, located on the top of the water heater) valve to relieve tank pressure. Note of caution: T&P valves may need replacing if defective or old.

4. Drain the water of enough water to compensate for the bleach to be added. Use a hose connected to the drain valve if an open drain is not adjacent to the water heater. Tip: have on hand a hose bib cap, available at any hardware store. When the procedure is completed, in some cases the drain valve will leak, and a hose bib cap can be screwed on the end of the drain valve, preventing the need for a drain valve replacement. Or replace the valve if desired with a new drain valve.

5. Remove T&P valve, anode rod, or disconnect the hot water outlet pipe from the water heater.

6. For best results and to preserve the life of your water heater, inspect the anode rod. If corroded, replace with a new aluminum/zinc anode rod, which will create fewer odors.

Figure 3 Typical gas water heater cut-away showing anode rod and cold water dip tube.



7. Pour one gallon of household bleach, or ½ gallon of pool chlorine for each 30 gallons of water heater tank capacity. Use the T&P valve, anode rod or hot water outlet pipe opening to pour the chlorine in. Re-pipe the water heater and close the T&P valve.

8. Open the cold-water inlet at the heater and fill the tank with water. Observe the water level through the closest hot water faucet. Close inlet valve when the tank is full.

9. Leave the bleach mixture in the heater for one hour.

10. After one hour, open the cold valve again, open all the hot water faucets and allow the bleach mixture to clean the hot water supply pipes. Drain the remaining chlorine solution from the tank through the heater drain valve.

11. Close the heater drain valve, and completely fill the tank with fresh water. Leave the water in the tank for 15 minutes.

12. After 15 minutes, purge the hot water supply lines and drain the water from the tank though the heater drain valve, flushing out any sediment if present. Close the drain valve.

13. Make sure you purge all air from hot water lines from the open hot water faucets. Close the hot water faucet after all the air is out of the system.

14. Check for water leaks at all fittings used; repair as necessary.

15. Turn on the manual electrical switch, or turn the gas control knob back to "On" and verify that the heater burners have lit and turned back on.

16. Check for normal water heater operation.

If the Odor Returns to the Hot Water

After this procedure is completed, the odor will be eliminated. If it returns within a few weeks, then the chlorination procedure can be repeated. However, in many cases the cold water will still have problems with recurring odors due to continued presence of sulfate bacteria and low chlorine residuals in the water.

Some solutions (for those on municipal water systems with odors in the water heater) are:

- Remove the anode rod and replace with an aluminum/zinc anode rod if you haven't already.

- Replace the water heater with a plastic lined water heater, an instantaneous water heater, or a commercial stainless steel water heater (none of which have anode rods).

4. More about water heater anodes and water heater corrosion:

All glass-lined water heaters have sacrificial anode rods. This is a rod made of magnesium or aluminum, that's formed around a steel core wire, and is screwed into the top of the tank. Physically connected to the steel of the tank, it creates an electrochemical reaction, similar to that of a battery, whereby the anode corrodes and the steel remains intact. When there's no sacrificial metal left on the anode, the tank rusts out.

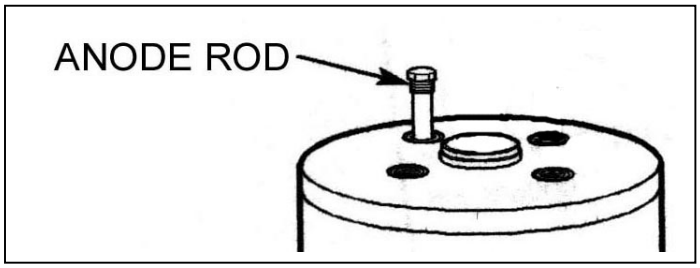
All metals fall somewhere on the galvanic scale, and the "nobler" ones will remain intact while the lesser ones will corrode. When steel and copper are touching, the steel will corrode while the copper remains intact. That's why dielectric unions are necessary on items like copper flex connectors.

Magnesium and aluminum are less noble than steel, which is why they're used for anode rod. The anode rod can be unscrewed and replaced, even though it's difficult sometimes to get the old anode rods out sometimes. An anode's life depends on the quality of water, the amount of use the tank gets and the quality of the tank. If the water is aggressive or corrosive, the anode rods should be inspected yearly and replaced as needed.

Removing the Anode Rod

1. Close the cold-water gate valve.
2. Turn the control to pilot if gas, or turn off the electrical power switch if electric water heater.
3. Remove the vent pipe to allow working room, a gas water heater.
4. Open a hot-water fauce to relieve pressure. If the hot water doesn't stop running after you open a faucet in the house, then the gate valve cold-water shut off is not shutting off completely. At this point, turn off the main water line to the house and replace the valve if needed.
5. Let a gallon or so of water out the drain valve.
6. Locate the anode rod. On some tanks, the hex head of the anode is exposed and in sight, such as in this picture. On others, it's hidden sometimes under a sheetmetal top that's foamed into place.
7. Remove the anode rod per the following tips:

Top of typical gas heater, vent pipe rmoved



Anode rod is located on the top of the water heater tank near the back and usually has a hex head.

In some applications, the anode rod is hidden beneath sheet metal, and one must drill through the sheet metal (not too far) and then use a screwdriver to feel around and find the hex head. The anode will most likely be on the backside of the tank, 1 1/2 inches out from the flue in a semicircle between the hot and cold ports.

Once it's found, drill another hole and use it as a start for cutting a hole with tin snips to give access to the anode. Be careful of the sharp sheet metal edges.

On some water heater tanks, there is no hex-head anode, just a combination nipple/anode/hot water outlet, shown on the right. You can determine this by disconnecting the hot-water side flex connector, and running a long screwdriver or similar implement down the nipple. If it stops after a couple of inches, it has run into the combo rod. Original anodes are not installed with pipe thread seal tape and they can be very hard to remove.

Take a 1 1/16-inch socket wrench and a cheater bar to put on the end of it to give maximum leverage, and loosen the anode.

The new anode rods are 44 inches long. Pulling out the old one can be accomplished by bending it if there is no headroom. A new one can in some cases be bent when installing and then straightened there is lack of headroom above the water heater, or you can get anode-rods that's are

In some cases you may have to use a segmented anode, which has been milled down to the core wire, which is soft. That allows the segments to be bent, inserted in the tank, and straightened out.

In some cases, if there is a vent, you can run the anode rod up the vent pipe and then back down.

If more than six inches of core wire is exposed, or the anode is splitting, replace it. Put the new one in with pipe thread seal tape to make next removal easier.

If you cannot get the old anode rod out, you can install a combination anode/nipple rod on the hot side. Disconnect the hot-side plumbing, remove the old nipple with a pipe wrench, and put in the new rod (with pipe thread seal tape!).

Galvanized steel nipples (left) will eventually rust and corrode, causing the nipple to plug up with rust. They may collapse if they need to be removed. It is better to use a plastic-lined dielectric steel nipple (right), which can't react with water or other metals.

Questions? Contact us at
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