



Drinking Water Contaminants

Lead

Small quantities of lead can be a serious health concern, especially for infants, children, and developing fetuses. This NebGuide discusses how to safely manage lead in a domestic water supply.

Bruce I. Dvorak, University of Nebraska–Lincoln Extension Environmental Engineering Specialist

Becky M. Schuerman, UNL Extension Associate, Domestic Water and Wastewater

Any lead exposure, even low levels, can be a serious health concern, especially for infants, children, and developing fetuses. This NebGuide discusses how to safely manage lead in a domestic water supply (or often referred to as a private well). This NebGuide includes discussion related to topics such as lead services lines and changes in public water supply regulations related to lead in drinking water.

Lead in Drinking Water

Lead rarely occurs naturally in drinking water. Most lead contamination takes place at some point in the water-delivery system. Materials in the water-delivery system that may contain lead include service connections, brass or chrome-plated brass faucets, and plumbing with lead solders. Contamination occurs as a result of corrosion of plumbing materials used to construct parts of the water-delivery system, releasing lead into the water.

The characteristics of water vary greatly depending on the source, and some waters may be naturally more corrosive. Several factors cause water to be corrosive including water having high acidity (pH less than 8.0), high temperature such as water from a water heater, and low mineral content (such as from a reverse osmosis system) evidenced by a low total dissolved solids (TDS) content. Generally, naturally soft water is more corrosive than hard water, because it is more acidic and has low TDS. Treating naturally hard water with an ion exchange water softening unit, reverse osmosis unit, or distillation unit may change

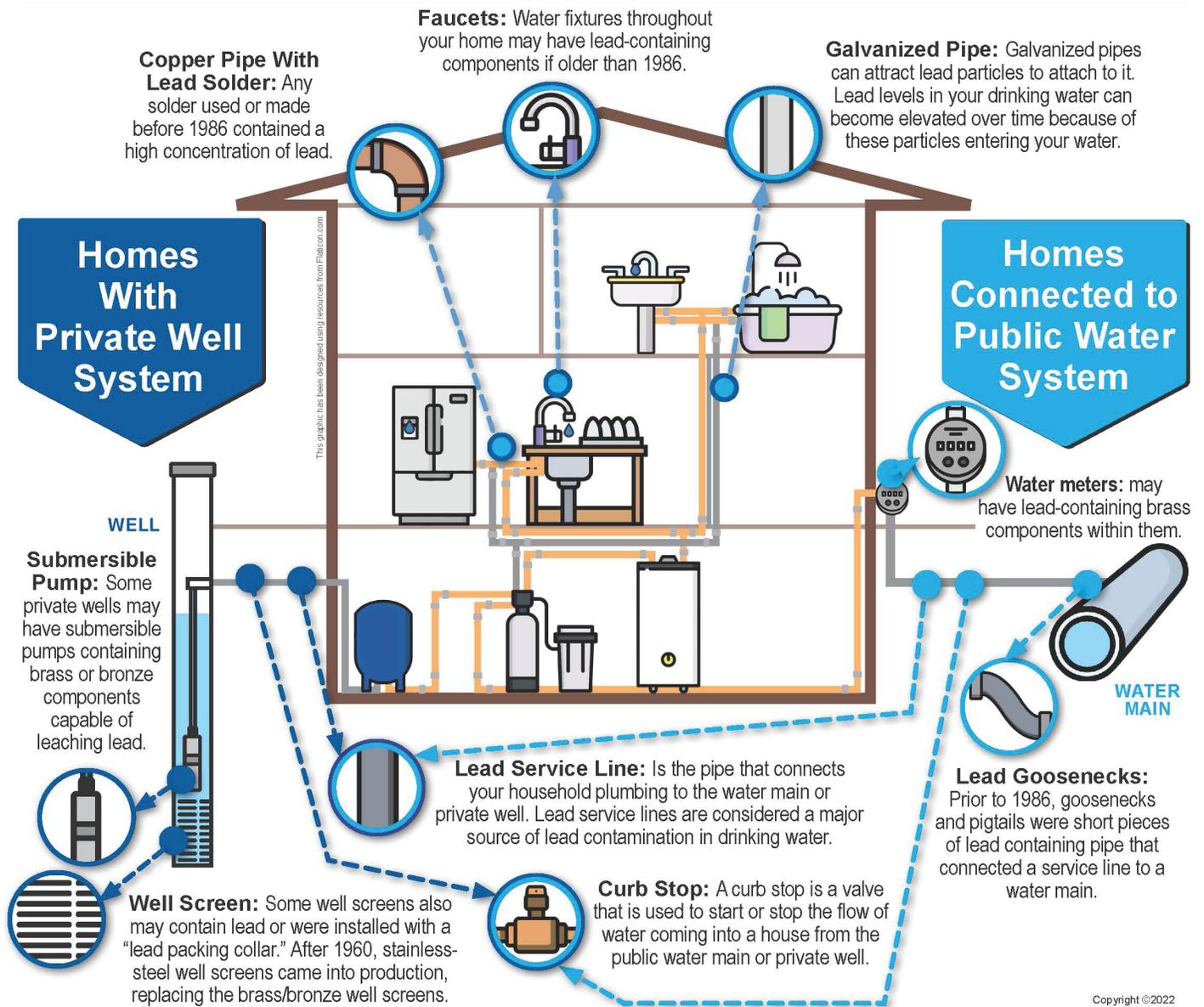
the water chemistry enough to increase the water's ability to dissolve lead.

Lead in drinking water from service lines, solder, and plumbing or fixtures is most often a problem in either very old or very new homes and buildings, and occasionally from materials used in private wells. However, any home or building may be susceptible. The sources of lead in a home are illustrated on the next page in Figure 1, with sources of lead from outside the home shown on the left of the house for those with a private well and on the right for homes connected to a public water supply. Note that a service line is a pipe that connects a home or building to a public water supply or private well

Through the early 1900s it was common in some areas of the country to use lead pipes for interior plumbing. Lead piping was also used for service connections to join residences and establishments to public water supplies. Lead piping is most likely found in homes and buildings built before 1930, occasionally in homes built before 1950, and rarely in homes after 1950 (unless the house was built over the site of a previous home, and an existing service line was used). Copper piping replaced lead piping, but lead-based solder was used to join copper piping. It is likely lead-based solder was used in any home or building built before 1986. The U.S. Environmental Protection Agency (EPA) published a public drinking water rule in 1991 that emphasized eliminating lead from components of the water delivery system.

Today, brass materials are used in nearly 100 percent

SOURCES OF LEAD IN DRINKING WATER IN HOMES



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Fig. 1. Sources of Lead in Drinking Water in Homes.

of all residential, commercial, and municipal water distribution systems. Many household faucets, plumbing fittings, check valves and well pumps are manufactured with brass parts. Brass contains some lead to make casting easier and the machining process more efficient. As of January 2014, federal regulations allow no more than 0.25 percent lead content in the wetted surface area of brass plumbing components labeled "leadfree." "Leadfree" brass components manufactured before 2014 could have as much as 8.0 percent lead content.

Often, hard water minerals are deposited on the interior of plumbing. These deposits form a mineral scale

lining, such as calcium carbonate, inside pipes and fittings, which protects against lead contamination. It may take up to five years for an effective mineral scale lining to form. A change in water source or treatment methods that result in a change in water chemistry can either prevent or dissolve the scale, eliminating its possible protective effect. Households that remove hardness from water with an ion exchange water softening unit, reverse osmosis unit, or distillation unit may experience problems with the loss of existing preventive scale in the lines receiving that water.

A lead service line (LSL) is a pipe made of lead that is used in potable water distribution to connect to a water

main to a user's premises, as illustrated in Figure 1 showing potential sources of lead. Additional components of the connection to a public water system that may contain lead include older water meters, curb stops, and lead goose-necks that connect the service line to the water main.

Some private wells may have submersible pumps containing brass or bronze capable of leaching lead. Some well screens also may contain lead, or were installed with a "lead packing collar." After 1960, stainless steel well screens came into production, replacing the brass/bronze well screens. Potential lead contamination also exists if the well is a driven (also often called sandpoint); driven sandpoint wells to provide potable water cannot be constructed in Nebraska. Driven wells are those constructed by driving assembled lengths of pipe into the ground in loose soil such as sand. These wells are normally 2 inches or less in diameter and less than 50 feet deep. Poor design and vulnerable aquifers associated with driven wells make them susceptible to contamination, and consumption of water from existing driven wells is not recommended. Industry professionals may be able to correct problems and/or possible "weak links" regarding well location or construction.

Non-Drinking Water Sources of Lead

The primary source of lead exposure for most children is not from lead-contaminated water. Instead, it is most often from deteriorating lead-based paint and lead-contaminated dust. Lead-based paint was commonly used for home interiors and exteriors, and a wide variety of painted, commonly used consumer products prior to 1978 when it was banned from residential use by the U.S. Consumer Product Safety Commission. Additional sources of lead in the environment include lead-contaminated soil; toys and other surfaces coated with lead-based paint; lead-contaminated food; imported food in lead-soldered cans; non-FDA regulated ceramics with lead glazes; and leaded crystal. This is not a complete list of possible lead sources and exposure to lead is a cumulative process, so multiple small sources of exposure can have a large impact. Questions or concerns related to sources of lead or potential health effects from lead exposure should be directed to a physician.

Indications of Lead in Water

Lead does not noticeably alter the taste, color, or smell of water and therefore can only be detected through water quality analysis. The effects of low levels of lead toxicity in humans may not be obvious. There may be no symptoms

present, or symptoms may be mistaken as other illnesses. The only way to know the concentration of lead in water is through sampling and laboratory testing as described in the subsequent Testing Section.

Potential Health Effects

Lead ingestion has no known health benefits to humans. It can be absorbed through the digestive tract and lungs and is carried by the blood throughout the body. Lead is a cumulative poison, meaning it accumulates in the body until it reaches toxic levels. The severity of the effects of lead poisoning varies depending on the concentration of lead in the body. This concentration can be determined with a blood test. Generally, lead in drinking water is not the predominant source of lead for individuals experiencing lead poisoning. But lead-contaminated drinking water can increase total lead exposure, particularly the exposure of infants who drink baby formulas and juices mixed with water containing lead or eat cereals mixed with that water.

Excess lead in the human body can cause serious and irreversible damage to the brain, kidneys, nervous system, and red blood cells. Children more rapidly absorb any lead consumed than adults do because their bodies are still growing. A child's mental and physical development can be irreversibly stunted by lead poisoning. Lead poisoning can contribute to lower IQ levels, hyperactivity, shortened attention spans, increased behavior problems, difficulty in academic achievements, slowed growth, hearing problems, and anemia. While some effects of lead poisoning may diminish if exposure is reduced, others are irreversible. Young children, infants, and fetuses are particularly vulnerable to lead poisoning. An amount of lead that would have little effect on an adult can greatly affect a child. Pregnant and nursing women are susceptible to the impacts of lead as well. Reduced growth of the fetus and premature birth are two side effects that can result from lead poisoning within pregnant women. When women who are nursing consume lead, they can expose their baby to lead through their breastmilk. The Centers for Disease Control and Prevention recommend all children be tested for lead with a blood test. Parents or guardians should consult their physicians with any questions or concerns.

Adults who have been exposed to lead poisoning can suffer from cardiovascular effects, increased blood pressure and incidence of hypertension, decreased kidney function, and reproductive problems in men and women. It is important to remember that the health impacts from lead exposure are expansive, and they impact people differently depending on their age and condition.

Showering and bathing in water contaminated by lead in excess of the EPA's action level is safe for children and adults. Lead in water is not absorbed by human skin. However, individuals should avoid cooking with or consuming anything but cold water, and not use warm or hot water from a water heater for either. Boiling water will not remove lead from the water, it may even concentrate the lead levels due to water evaporation during the boiling process. Hot water dissolves lead from plumbing materials more readily than cold water. **Consumers should especially avoid using water from a hot water tap for making baby formula.**

Identifying whether your home has a lead service line

The service line is the line that runs from the water source to the home. No matter whether your water source is a private well or a public water supply, generally there are three approaches to identifying lead services lines: records, water quality sampling, and excavation. In some cases, property records, or installation and water main repair records may include information concerning the materials used for service lines. Public water supplies will utilize these records to identify locations with lead service lines, when available. Water quality sampling methods, such as taking multiple samples as discussed in the private water supply testing section below, can suggest whether there is a lead service line. Low lead levels do not ensure the absence of a lead service line, but it suggests a low probability of their existence. Public water supply staff or a licensed contractor may intentionally or accidentally expose a portion of a service line and visually inspect it at that time to identify whether it contains lead. Note that lead is a dull colored, soft material. If a pipe is primarily lead, it turns a shiny silver color when scratched and a magnet will not be attracted to it. When identified, the lead service line should be removed and replaced at the time of excavation; service line replacement costs are typically the responsibility of the property owner. Public water system customers should check with their municipality to know who is responsible for the costs affiliated with service line replacement.

Testing

Testing Public Water Supplies

In Nebraska, water supplied by public water systems is regulated by the U.S. Environmental Protection Agency (EPA) and Nebraska Department of Environment and Energy (NDEEA). Public water system means a system for

providing the public with water for human consumption through pipes or other constructed conveyances, if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days per year. A public water system is either classified as a community water system or a non-community water system.

With the Lead and Copper Revised Rule, the sample site selection criteria emphasizes sampling from locations that may contain lead service line (LSL). Public water systems must complete an LSL Inventory of their distribution systems to identify at-risk homes. In Nebraska and nationally, a percentage of at-risk homes are monitored at the tap, with the number of tap-sampling sites based on the number of people served by the public water supply. Additional monitoring for other water-quality parameters affecting corrosion is required to optimize any required treatment and determine compliance with lead standards. The American Water Works Association encourages water utilities to collaborate with homeowners to replace lead service lines to reduce risk of lead contamination in water.

Utilities that identify a lead service line (LSL) when replacing/repairing a water main typically will replace the utility-owned part of the service line and cannot reconnect to the customer owned-lead line. In some cases, a customer will be forced to pay for the replacement of their part of the line. In many communities, both public water system crews and private plumbing contractors can do the LSL replacement work. Some utilities around the United States are either replacing lead service lines or cost-sharing with homeowners. Depending on the local site conditions, lead service line replacement (LSLR) can cost from \$1,200 to \$12,300, with an average of \$4,700, according to a 2019 EPA publication.

If water comes from a public water supply, consumers can contact the water utility to inquire about the lead concentration in the water and seek guidance as to the sampling protocol that has been found to be most effective in that community at identifying lead within fixtures, pipes, and a lead service line (if one serves that home).

Testing Private Water Supplies

Water quality from private wells is not currently regulated at the federal level or by Nebraska state government. Thus, the regular testing of a private water supply is not required under state or federal law. If consumers want to know the concentration of lead in a private water supply, they will need to have the water tested at their own expense.

Although private water supplies are not subject to any regulations concerning lead contamination, users of private water supplies may want to test their water supply. This is especially true if a problem is suspected or if children or pregnant women consume the drinking water.

Tests to determine the presence of lead in drinking water should be performed by a laboratory certified for lead testing. The Nebraska Department of Health and Human Services (NDHHS) Public Health Environmental Laboratory certifies laboratories to conduct tests for drinking water supplies in accordance with the Nebraska Safe Drinking Water Act. A certified laboratory might not be certified to analyze all potential drinking water contaminants. Rather, certification must be obtained for each specific contaminant. This certification means that recognized, standard tests, and quality control procedures are used. For additional information see *Drinking Water: Certified Water Testing Laboratories in Nebraska*, G1614.

Test kits and dip strips are available for do-it-yourself lead testing outside of a laboratory environment. These kits can be difficult to use due to the need for color matching and may not provide accurate and reliable lead measurement.

To determine whether lead is present in a private drinking water supply and to determine the possible source of the contamination, water must be tested using specific sampling procedures. Carefully follow all directions provided by the laboratory, and use provided containers when collecting water samples.

It is recommended not to sample water from a tap that is attached to a water softener, because softened water may be much more corrosive and may result in higher lead concentrations, if lead-containing plumbing materials are present. Generally, it is not recommended to drink softened water.

Collect samples from taps that are in use by your household for drinking water. In general, water that comes in contact with lead in the plumbing will continue to dissolve lead over time. For this reason, the highest lead concentration in drinking water will result from water that has sat motionless in the plumbing system, in contact with lead-containing components, for an extended period of time (e.g., several hours or overnight). To evaluate the household's or building's highest lead concentration, collect a sample of the water that has sat motionless in the plumbing system—in contact with suspected lead-containing components—for six or more hours. This is sometimes called a “first-draw” sample.

The length of time the tap should be run prior to collecting the water sample will depend on where the suspect-

ed lead-containing components are located in relation to the tap being used.

Collect the very first water drawn if suspected lead-containing components are close to the cold-water tap. The first-draw sample will suggest if a water tap or plumbing very near the tap contains lead. If there is a concern that lead may be in other plumbing in a house, or more likely in a lead service line, one of the following procedures can be used.

A straightforward sampling approach is used by Denver, Colorado's, water utility, Denver Water, in areas with older homes. Three water samples are collected after at least 6 hours of stagnation from a commonly used cold water tap (e.g., kitchen or bathroom) flowing at the peak flow rate: (1) collect the first water to flow from the tap, (2) collect a sample at the peak flow rate starting at 30 seconds of flushing, and (3) collect a sample at the peak flow rate starting at 60 seconds after the start of flushing. Generally, a house with an average lead concentration of 5 parts per million (ppm) or higher from the three samples should be considered likely to be served by a lead service line.

For homes with more complex plumbing or longer plumbing distances to the exterior lead service line, sequential sampling can be used to determine whether there is lead in a specific part of the interior plumbing or the service line outside the home. This sampling approach attempts to obtain a sample representative of the highest contamination and identify the approximate water travel time to the location with the lead-containing components. If sequential sampling is used, collect the samples after at least 6 hours of stagnation (e.g., first thing in the morning before any water use) and use a medium flow rate of water to minimize the disturbance of corrosion deposits in the pipe system. Collect a sample from the first flush, and then depending on the anticipated length of plumbing, collect a sample every minute for between 5 (large house) and 10 minutes (very large building with long outside distance to well), depending on the anticipated length of plumbing.

The NDHHS Public Health Environmental Laboratory recommends:

1. **Test water that has stagnated in the pipes. There must be a minimum of 6 hours, but preferably no more than 8 hours, during which no water is used from the tap the sample is taken from and any taps adjacent or close to that tap.** It is recommended that either early mornings or evenings upon returning home are the best sampling times to ensure that the necessary stagnant water conditions exist. Stagnant water is recommended because it allows the water to

pick up any lead that may be present in the plumbing of your home.

2. A kitchen or bathroom cold-water faucet should be used for sampling. If you have a water softener on your kitchen tap(s), collect your sample from the bathroom tap that is not attached to a water softener, if possible. Do not remove the aerator from the faucet prior to sampling. When ready to take the sample, open the tap and collect the first water to flow from the cold water tap by placing the opened sample bottle below the faucet. Do not allow anything to touch (contaminate) the inside lip or cap of the container. Fill the sample bottle to the neck of the bottle and turn off the water.
3. Tightly cap the sample bottle and follow the sample instructions as to labeling, packaging, and submitting the sample.

Interpreting Test Results

Public Water Supply Test Results

The quality of water supplied by public water systems is regulated by the EPA and the NDEE. Public drinking water standards established by EPA fall into different categories, including action levels. An action level is the concentration of a contaminant in water that, if exceeded in a specified percentage of water samples tested, triggers action a water system must follow. Those required actions may include additional monitoring, treatment, or other.

Based on the EPA's Lead and Copper Revised Rule, the Maximum Contaminant Level Goal (MCLG) for lead is zero, and the EPA has established an enforceable lead concentration for public water supplies as noted subsequently. There is a lead trigger level (TL) of 10 micrograms per liter ($\mu\text{g}/\text{l}$), which can also be expressed as 10 parts per billion (ppb) in addition to the lead action level (AL) of 15 $\mu\text{g}/\text{l}$ or 15 ppb. There are specific actions that have to be implemented with an exceedance of 10 ppb TL. It is meant to get water systems to begin formulating a plan to lower the lead levels in their drinking water before hitting the problematic 15 ppb AL. At a minimum, systems must sample annually or more frequently if otherwise required to do so at the standard number of sites and implement goal based LSLR program. They must conduct annual outreach to LSL customers and implement a corrosion control treatment (CCT) study if CCT is not installed or re-optimize if CCT already exists. As of July 2022, the TL and AL for the lead rule are under review by the EPA and may be modified in the future.

If the lead AL is exceeded, the public water supplier must initiate the actions described in the "Options" section.

Private Water Supply Test Results

Because EPA and Nebraska regulations do not apply to private drinking water wells, users of private drinking water may consider the EPA established action level of 15 ppb as a guideline in assessing the risk associated with their water supply. If lead concentrations are found to be above 15 ppb, private drinking water users are encouraged to voluntarily follow EPA guidelines, and reduce the lead concentration in the water, taking into account health risks, costs, and benefits.

Options

Addressing Lead in Public Water Supplies

All water systems exceeding the EPA's lead action level are required to complete additional monitoring. The lead action level is discussed in the "Interpreting Test Results" section.

The Lead and Copper Revised Rule requires that a follow-up sample must be collected within 30 days of learning the results for each lead tap sample site that exceeds the AL of 15 ppb. Water systems must also subsequently implement a "find-and-fix" approach. Systems will be required to report the results to the state. Systems must determine if a "fix" is needed, e.g. adjustment to CCT, flushing portions of the distribution system, or other strategies. Systems that identify a fix that is out of their control, such as premise plumbing, must provide documentation to the state.

A public water system exceeding the EPA action level in more than 10 percent of sampled homes is required to take action to reduce lead levels. The system must initiate corrosion control treatment, source water treatment, and public education. Corrosion control treatment may involve changing the pH and/or adding food grade corrosion control inhibiting compounds like polyphosphates to the water entering the system. Source water treatment may be to change the treatment method if it is resulting in the water being more corrosive, such as by changing the pH or removing too many of the minerals.

Addressing Lead in Private Water Supplies

If water tests indicate lead is present in drinking water and testing determines the source is household plumbing, users should first try to identify and eliminate the lead

source. If it is neither possible nor cost-effective to eliminate the lead source, flushing the water system before using the water for drinking or cooking may be an option.

Flushing the system involves disposing the water that has sat motionless in the plumbing system, in contact with lead-containing components for an extended period of time. This could take as little as thirty (30) seconds or longer than five minutes depending on the system. Anytime the water has not been used for several hours, the water should be run until it becomes as cold as it will get. Each faucet must be flushed individually before using the water for drinking or cooking. Water run from the tap during flushing can be used for non-consumption purposes such as watering plants, washing dishes or clothes, or cleaning.

Flushing may not be effective in reducing the lead concentration of water in apartments, offices, or other similar large buildings with large-diameter supply pipes joined with lead-based solder.

If water tests indicate the presence of lead, and the source was determined to be beyond the household plumbing, the first course of action is to identify and eliminate the source, if possible. The well and the pump should be checked for potential lead sources. A licensed water well contractor may be able to help determine whether any of the well components are a source of lead contamination.

In addition to identifying potential lead sources, consumers should consider the corrosivity factor. One practice that may increase corrosion is the grounding of electrical equipment (including telephones) to water pipes. Electric current traveling through the ground wire accelerates the corrosion of lead in the pipes. In this case, a qualified electrician should be consulted.

Home Treatment of Water to Remove Lead

If it is not possible or cost-effective to eliminate the source of lead in drinking water, water treatment or an alternative drinking water source (i.e. bottled water) should be considered for drinking and cooking.

Several treatment methods are suitable for removing lead from drinking water, including reverse osmosis, distillation, and filters specially designed to remove lead. Typically, these methods are used to treat water at only one faucet. Point-of-use or under sink reverse osmosis units are proven to be very effective at removing 90 percent or more of lead from water; they will typically produce a few gallons of treated water per day via a dedicated tap at the kitchen sink. Distillation can remove approximately 99 percent of lead from water, but these units typically sit on a kitchen counter, are relatively expensive to operate,

and will typically produce only 1 gallon of treated water per day. Some, but not all, drinking water filters placed in a faucet-mounted device, under the sink module, or in a pitcher may remove lead in addition to other water quality contaminants. Consumers can increase their level of confidence that a filter will remove lead by purchasing filters that have been tested by accredited third-party certification bodies for lead reduction and particulate reduction against NSF/ANSI Standards 42 and 53. Look for a label on the filter stating that it was certified against these standards and a statement that the filter will remove lead from the water. Filters that meet the NSF/ANSI 42 and 53 Standards often contain an activated carbon block filter and/or other adsorbents to remove lead.

As previously stated, simply boiling water will not remove lead from the water, it may even concentrate the lead levels due to water evaporation during the boiling process. A water softener can be used to pretreat water for either a reverse osmosis or distillation unit when water is excessively hard to minimize operational problems from the hardness, but the softener will not remove lead.

For additional information on these treatment options see *Drinking Water Treatment: Reverse Osmosis*, G1490, *Drinking Water Treatment: Distillation*, G1493, and *Drinking Water Treatment: Activated Carbon Filtration*, G1489. For a water treatment device to work effectively, it must be maintained and replaced according to the manufacturer's specifications.

Summary

Lead rarely occurs naturally in drinking water. It is more common for lead contamination to occur at some point in the water delivery system. Too much lead in the human body can cause serious damage to the brain, kidneys, nervous system, and red blood cells. Young children, infants, and fetuses are especially vulnerable to lead poisoning. To determine the presence of lead in drinking water and its possible source, a specific procedure must be used to collect samples and a certified laboratory should be used for testing. Public water supplies must comply with the EPA action level of 15 ppb lead. Management of a domestic or private drinking water well for lead is a decision made by the well owner and/or water user. A water test is the only way to determine the lead concentration. If drinking water exceeds the EPA lead standard of 15 ppb, steps can be taken voluntarily to reduce the risk. Options include removing the lead source, managing the water supply used for drinking and cooking by flushing water with high lead concentrations from the water system, using appropriate

water treatment equipment, or using an alternative water source. Options selected must be based on the specific situation. Consider the following steps to reduce lead in your drinking water.

Supplemental List: Important Steps You Can Take to Reduce Lead in Drinking Water

Have your water tested. Public water supply users should contact their water utility to have their water tested, to learn more about the lead levels in their drinking water, and the frequency in their community of homes where elevated lead levels have been detected.

Private water supply users should contact a certified water testing laboratory to order a lead sample kit and have samples analyzed. For additional information see *Drinking Water: Certified Water Testing Laboratories in Nebraska*, G1614.

Learn whether you have a lead service line. For public water supply customers, with a home built prior to 1986, contact the water utility about the possibility of having a lead service line. If it is unknown, inquire about its lead service line inventory program.

Run your water. If you are unsure of the amount of lead dissolution in your water or have potential dissolution from the pipes into your water, then before drinking, flush your home's pipes by running the tap, taking a shower, doing laundry, or doing a load of dishes. The amount of time to run the water will depend on whether your home has a lead service line or not, and the length of the lead service line. Residents should contact their water utility for recommendations about flushing times in their community.

Learn about construction in your neighborhood. Be aware of any construction or maintenance work that

could disturb your lead service line. Construction may cause more lead to be released from a lead service line.

Use cold water. Use only cold water for drinking, cooking, and making baby formula, because hot water will result in more lead dissolution into drinking water from water system components that contact the hot water. Remember, boiling water does not remove lead from water.

Clean your aerator. Regularly clean your faucet's screen (also known as an aerator). Sediment, debris, and lead particles can collect in your aerator. If lead particles are caught in the aerator, lead can get into your water.

Use your filter properly. If you use a filter, make sure you use a filter certified to remove lead. Read the directions to learn how to properly install and use your cartridge and when to replace it. Using the cartridge after it has expired can make it less effective at removing lead. Do not run hot water through the filter.

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