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Drinking Water Treatment: Shock Chlorination

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Protecting private water supplies from bacterial contamination is critical to assuring good water quality. Shock chlorination can eliminate bacteria from water systems.

Water Testing

Public water systems routinely are tested for contaminants, including bacterial contamination. If a public water supply is not bacteriologically safe, the water supplier must provide public notification and must take immediate steps to provide water safe for human consumption.

Unlike public water supplies that are regularly tested to ensure the water is safe to drink, individuals or families using private water supplies are responsible for testing for contamination. Generally, a private water supply should be tested for coliform, fecal, and/or *E. coli* bacterial safety:

- at least once a year.
- when a new well is constructed.
- when an existing well is returned to service.
- any time a component of the water system is opened for repair.
- whenever the well is inundated by flood waters or surface runoff.
- whenever bacterial contamination is suspected as might be indicated by continuing illness.

For additional information on the bacterial safety of drinking water, see *Drinking Water: Bacteria* (G1826).

If test results indicate that coliform, fecal, and/or *E. coli* bacterial contamination is occurring, shock chlorination is the most widely suggested method of treatment. However, shock chlorination should not be a substitute for a potable water supply. Protecting the water supply from contamination should be the primary goal for assuring good water quality. Before shock chlorination be sure well construction is adequate to prevent entry of contaminants, and find and eliminate the source of the contamination. The best way to prevent a water supply from being contaminated by bacteria is to eliminate the bacteria's access to the water source. If the bacterial contamination is recurring, another disinfection process such as continuous chlorination, distillation, ozonation, or ultraviolet radiation is required rather than shock chlorination.

If test results indicate that iron, manganese, and/or sulfur bacteria are present, shock chlorination is recommended for treatment. While shock chlorination may not entirely eliminate these nuisance bacteria, it will usually help manage the bacteria for a period of time.

Contaminants Removed by Shock Chlorination

Shock chlorination can be used to deactivate a variety of pathogenic and nonpathogenic microorganisms in drinking water including coliform bacteria; fecal and *E. coli* bacteria; and iron, manganese, and sulfur bacteria.

Water used for drinking and cooking should be free of coliform, fecal, and/or *E. coli* bacteria. Coliform bacteria is commonly found in the environment. Human and animal waste can be sources of fecal and *E. coli* bacteria in drinking water. These sources of bacterial contamination include runoff from feedlots, pastures, dog runs, and other land areas where animal wastes are deposited. Additional sources include waste from improperly designed, located, installed, or maintained septic systems or residential lagoons. Another way bacteria can enter a water supply is through inundation or infiltration by flood water or by surface runoff. Contamination can also occur during or after well construction or repair.

Water also can be contaminated with naturally occurring nuisance organisms such as iron bacteria, manganese bacteria, and sulfur bacteria. These nonpathogenic (not health threatening) bacteria occur in soil, shallow aquifers and some surface waters. The bacteria feed on the minerals in water. These bacteria can form slime which can clog water systems and can produce an odor in drinking water.

Shock chlorination is the introduction of a strong chlorine solution into the entire water distribution system (well, pump, distribution pipeline, hot water heater, etc.). Shock chlorination is an effective treatment method to eliminate pathogenic bacteria in drinking water supplies. In addition, shock chlorination can be effective in managing iron, manganese, and/or sulfur bacteria.

Shock chlorination is recommended as follows:

- Upon completion of a new well.
- Any time the water distribution system is opened for repairs or maintenance.
- Following possible contamination by flood water or surface runoff.
- To treat **nonrecurring** coliform, fecal and/or *E. coli* bacterial contamination. Continuous chlorination, or another disinfection process, is required for treating recurring contamination in a water supply.

- To manage iron, manganese, and sulfur bacteria in a water supply.

Contaminants Not Removed by Shock Chlorination

No one treatment method manages all contaminants. Chlorination will not remove nitrate from water. Chlorination will not remove heavy metals, calcium and magnesium (hard water minerals), fluoride, and many other compounds.

Treatment Principles

Shock chlorination consists of mixing sufficient chlorine-based chemical with well water to create a solution containing 200 milligrams per liter (mg/l), or parts per million (ppm) of free chlorine throughout the entire water distribution system (well, distribution pipeline, water heater, pressure tank and other equipment).

Safety

Before beginning the shock chlorination process, fresh water should be run into a five gallon container. If concentrated chlorine accidentally comes in contact with eyes or skin, use this fresh water to flush the affected area for 10 to 15 minutes. If an individual gets some of the chlorine solution in their eyes, they should see a doctor after thoroughly flushing the affected eye.

A second safety practice is to wear appropriate safety clothing and equipment, including goggles to protect eyes, rubber gloves to protect hands, and rubber boots on feet. A waterproof suit, coveralls, or full-length apron can help to prevent discoloration on clothing.

Since the water supply will be temporarily interrupted during the shock chlorination process, having access to an adequate potable water supply will be critical. A water supply for drinking and cooking should be identified for the period between introduction of chlorine to the water system and receiving water test results after completion of the shock chlorination process. Purchasing bottled drinking or distilled water is one option. Disinfecting and storing water from your water source may be another option. Needs will differ, depending on age, physical condition, activity, diet, and climate, but most people need to drink at least two quarts (eight cups) of water each day. Hot weather conditions can increase the amount needed. Children, nursing women and ill people also will need more. In addition to drinking water, supplies for food preparation will be needed.

Well Chlorination

Chlorine is very volatile so it is dangerous to work with in confined areas. Make sure the work area is well ventilated. Prepare a mixture of one-half gallon of regular household chlorine bleach that contains 5 percent to 6 percent sodium hypochlorite per 5 gallons of fresh water. Check the label or call the manufacturer's toll-free number provided on the label for information on the sodium hypochlorite concentration of a specific chlorine product. Avoid using bleaches containing fragrances, soaps, or other additives for drinking water disinfection. Use this mixture to disinfect the well pit, spring house or other portions of the distribution equipment that may contribute bacteria to the water supply (pump, motor, pressure tank, and exposed wiring conduits).

Drain as much water from the system as possible. For systems with pressure tanks containing a bladder, the rubber air-water separator inside the tank could be damaged by the chlorine solution. Check manufacturers' recommendations to determine if the pressure tank should be bypassed. For pressure tanks without bladders, release the air so that the tank can be filled with chlorinated water. Drain water from the water heater so that chlorinated water can be circulated through the hot water pipelines.

Check with the manufacturer of water softeners, sand filters, iron removal filters, activated carbon filters, reverse osmosis filters, or any other water treatment equipment in place prior to shock chlorinating the system. Water softeners, sand filters, and iron removal filters can often be backwashed with a strong chlorine solution. Activated carbon and reverse osmosis filters should generally be removed from the distribution system during shock chlorination and until the chlorine has been flushed from the distribution system.

Follow the shock chlorination steps below.

Step 1. **Determine the diameter of the well.** Measure the inside diameter of the well in inches.

Step 2. **Determine the volume of water per foot for the well.** Using *Table I*, find the volume of water per foot for your well. Use the diameter of the well determined in Step 1. Find the gallons per foot for that well diameter. *Example: The well is measured to have a 6-inch diameter. The gallons per foot of depth for a 6-inch well is 1.47 gallons.*

For large diameter wells or cisterns, contact the Nebraska Department of Health and Human Services for information on how to disinfect your system.

Table I. Volume of water contained per foot of well depth.

Well casing diameter (inches)	*Water volume per foot of water depth (gallons)*[1]
4	0.65
6	1.47
8	2.61

[1]Volume of water calculated as the volume of a cylinder in cubic feet multiplied by 7.48 gallons/cubic foot.

Step 3. **Determine the depth of water in the well.** The company that constructed the well should be able to provide you with the well depth and water level. *Example: The well is 50 feet deep and the water level is at 20 feet. The well contains 30 feet of water (50-20=30 feet)*

Step 4. **Determine the total gallons of water in the well.** Multiply the depth of water in the well determined in Step 3 by the gallons of water per foot for your well determined in Step 2. This is the total gallons of water in the well. *Example: Multiply 30 feet (the depth of the water in the well) by 1.47 gallons of water per foot to get 44 gallons of well water (30 x 1.47 = 44 gallons of water in the well)*

Step 5. **Estimate the volume of water in the distribution system.** Total the water storage in the system, including the water heater, pressure tank, etc., and add 50 gallons for the pipeline. *Example: The system has a 30-gallon hot water heater and a 30-gallon pressure tank. 30 gallons (water heater) + 30 gallons (pressure tank) + 50 gallons (pipeline) = 110 gallons in the distribution system.*

Step 6. **Determine the water contained in the entire system.** Add the water volume in the well determined in Step 4 and the water contained in the distribution system determined in Step 5 to determine the total water volume to be shock chlorinated. *Example: 44 gallons in the well + 110 gallons in the distribution system = 154 total gallons to be shock chlorinated*

Step 7. **Determine the amount of chlorine product required for a 200 ppm solution.** *Table II* lists the product amounts needed to create a 200 ppm free chlorine solution in

each 100 gallons of water using typically available sources. Determine the amount of product necessary for shock chlorination of your system by dividing the total water volume by 100; then multiplying this number by the amount of product needed per 100 gallons. Use the worksheet at the end of this guide. *Example: For our example we will use liquid household bleach containing 5 percent to 6 percent sodium hypochlorite (NaOCl); Divide 154 (total gallons) by 100 = 1.54 100-gallon units. Multiply 1.54 100-gallon units times 3 pints/100-gallon units = 4.62 pints. You would need about 4 1/2 pints of liquid household bleach containing 5 percent to 6 percent NaOCl.*

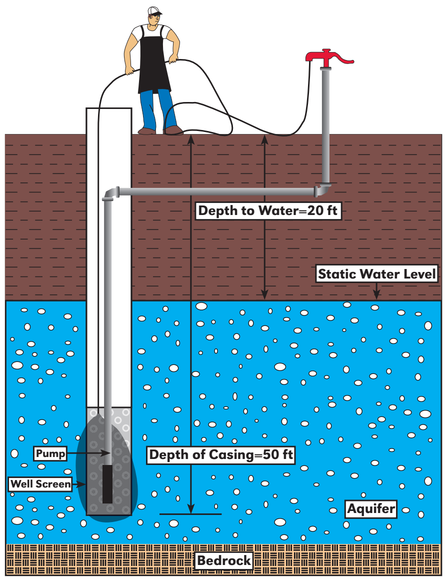

Figure 1. Recirculating water through a nearby hydrant after the introduction of concentrated chlorine into a well in order to thoroughly mix chlorine with the well water.

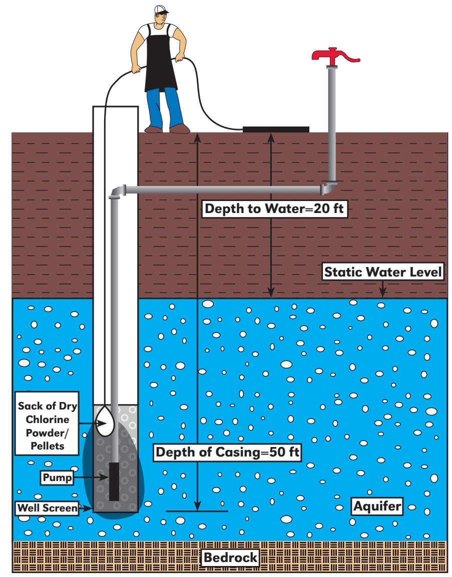

Figure 2. Introduction of powdered or pelleted chlorine materials into a large diameter well using a burlap sack attached to a long nylon rope.

If you use liquid chlorine bleach, select a product that contains 5 percent to 6 percent NaOCl. Check the product label or call the manufacturer's toll free number provided on the label to confirm the NaOCl concentration of a particular product. While many household bleaches contain 5 percent to 6 percent NaOCl, household bleach products are also available with considerably lower concentrations, including products with 2.5 percent to 3 percent NaOCl. Avoid bleaches with fragrances, soaps, or other additives. Use fresh, newly purchased bleach since bleach loses its effectiveness with age and with exposure to light or heat.

When chlorine is added to water it reacts with certain components in the water including iron, manganese, sulfur, microorganisms, plant material, and others. These components "tie up" some of the chlorine, making it unavailable for disinfection. The chlorine that does not react with these components is available for disinfection. This is called free chlorine. The amounts recommended in *Table II* should provide sufficient free chlorine for most drinking water supplies, including those containing minerals. Concerned individuals can test the chlorine concentration by using test kits available from some plumbing, home improvement, and water supply equipment dealers. Be certain the kit tests free chlorine, not total chlorine.

Table II. Amount of chemical required to create a free chlorine concentration of about 200 ppm.

Chemical name	*Amount per 100 gallons of water*
Liquid Household Bleach (5% to 6% NaOCl)	3 pints
Commercial Strength Bleach (12% to 17% NaOCl)	1 pint
Chlorinated Lime (25% $CaOCl_2$)	11 ounces
Dairy Sanitizer (30% $CaOCl_2$)	9 ounces
High-test calcium hypochlorite[a] (65% to 75% $Ca(OCl)_2$)	4 ounces

[a]High-test hypochlorite is available as a powder and as a tablet.

The disinfecting effectiveness of chlorine is impacted by water temperature and pH. A well professional may treat for these parameters when shock chlorinating a well. A homeowner will most likely not be able to treat for these water quality parameters when performing shock chlorination, and the amounts recommended in *Table II* should provide sufficient free chlorine in most situations.

Step 8: **Introduce the chlorine material into the well and distribution system.** The best way to introduce chlorine material into the well is to dissolve the predetermined amount of chlorine in a 5-gallon bucket of fresh water. Be sure the bucket is plastic and has been thoroughly washed. Pour the chlorine solution into the well. Try to splash the solution on the sidewalls of the well casing as much as possible. Attach a hose to the water hydrant or faucet nearest the well and run water through the hydrant and back into the well (*Figure 1*). This will thoroughly mix the chlorine solution and well water.

Another method of shock chlorinating a large diameter well is to place tablets or powder in a weighted porous sack (tightly woven burlap works well). Raise and lower the sack in the well water (*Figure 2*). Remember that only the portions of the well coming in contact with the chlorine will be disinfected. Be sure to allow the sack to touch the bottom of the well during this process.

For small diameter wells (4- to 6-inch diameter) there isn't enough room in the well casing to use a sack. Instead, dissolve tablets or powder in a bucket of water and introduce into the well casing as described for using liquid chlorine sources. Again, use a nearby hydrant and hose to circulate water through a portion of the distribution system to assure that the chlorine material is thoroughly mixed with well water.

Regardless of how you introduce the chlorine material into your well, start and stop the pump several times to ensure that the chlorine is thoroughly mixed with well water. Recirculate the water until a strong chlorine smell has been noted for at least five minutes.

After the chlorine has been placed in the well and the casing, etc., has been washed down, move around the water distribution system and open each faucet (hot and cold), hydrant or other water outlet. Allow water to flow until a strong chlorine odor reaches that position in the system. Then close the valve at that location. Do this with all faucets, hydrants and other outlets in the system.

If a strong chlorine odor is not detected at each site, add more chlorine to the well. This may be an indication that the product has lost effectiveness or is not of the concentration it was thought to be.

Step 9: **Let the chlorine disinfect the system.** The disinfecting effectiveness of chlorine depends on the amount of time the available chlorine is in contact with the water and plumbing (contact time). To allow adequate disinfection contact time, refrain from using water from the well for at least two to three hours, preferably overnight. Longer contact times will result in a more effective disinfection of the system.

Step 10: **Flush the system to remove the chlorine.** After the water system chlorination has been completed, the entire system must be emptied of chlorine and thoroughly flushed with fresh water. Run water out of each faucet or hydrant until the chlorine odor dissipates. Distribute the waste water on gravel roads or other areas without plants or aquatic life, which it might harm.

If your house is served by a septic system for wastewater treatment, do not allow more than 50 gallons of chlorinated water to enter the septic system. If possible, attach a hose to outlets inside the house and distribute the water to a nongrass area away from the house. The chlorine will eventually evaporate.

Step11: **Retest the water supply for bacterial contamination.** The final step is to retest the water to ensure that the water source is coliform, fecal, and/or *E. coli* bacteria free. Take a water sample one to two weeks after shock chlorinating the well, using the same procedures as before. Though most shock chlorination treatments are successful, do not drink the water until the laboratory results confirm that no coliform, fecal, or *E. coli* bacteria are present. Retest the well every month for two to three months to be sure contamination is not reoccurring. If test results are negative, an annual water analysis program can be reinstated.

If the water supply continues to develop coliform, fecal, or *E. coli* bacterial contamination problems after being shock chlorinated, other options must be considered. Options might include repairing the well, or constructing a new well. Continuous disinfection of the water supply using continuous chlorination, distillation, ozonation, or ultraviolet radiation may be an option. See *Drinking Water Treatment: An Overview (EC703), Drinking Water Treatment: Distillation* (G1493) and *Drinking Water Treatment: Continuous Chlorination* (G1496) for more information on these continuous disinfection options.

Nuisance iron, manganese, and sulfur bacteria are more resistant to shock chlorination than other types of bacteria. You may have to repeat the shock chlorination procedure several times to manage these bacteria. In addition, these types of bacteria tend to recur, so periodic chlorination may be needed to control the problem.

Chlorine Solution Calculation Worksheet

Process	*Example:*	*Your well:*
1. Diameter of well:	6 inches	__________inches
2. Volume of water per foot: (See *Table I*)	1.47 gallons	__________gallons
3a. Depth of casing:	50 feet	__________feet
3b. Depth to water:	20 feet	__________feet
3c. Total depth of water: (3a - 3b)	30 feet	__________feet
4. Total volume of water in casing: (No. 2 x No. 3c)	44 gallons	__________gallons
5. Volume of water in the system:	110 gallons	__________gallons
6. Total volume of water: (No. 4 + No. 5)	154 gallons	__________gallons
Calculate Amount of Chlorine Product for a 200 ppm Free Chlorine Solution:		
Chlorine product used: liquid household bleach		
7a. Product needed per 100 gallons:	3 pints	__________(ounces/pints)
7b. Total product needed: (No. 6 divided by 100) x No. 7a	4.5 pints	__________(ounces/pints)

Acknowledgment

This revision is based on the original NebGuide, *Shock Chlorination of Domestic Water Supplies,* by William Kranz, Extension Irrigation Specialist, DeLynn Hay, Extension Water Resources Specialist, and Al Ackerman, Nebraska Department of Health, now known as Nebraska Department of Health and Human Services.

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