

PUBLIC HEALTH DEPENDS ON PROPER WATER MAIN REPAIR AND DISINFECTION

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Some experts estimate that only about 20 per cent of waterborne disease outbreaks are reported and documented, so the problem may be much more widespread. Failure to properly disinfect new or repaired water distribution mains and finished water storage facilities and wells violates regulations and can result in enforcement action.

Many small water systems contract backhoe or plumbing contractors to repair water mains. Still, water system officials are responsible for work done in their water systems. Each system's chief operator is responsible for and must oversee any repair work to ensure contractors use approved methods.

Leak Location

The first step is to locate the leak or repair area. Before work begins, the area must be isolated to the fewest customers and the least number of water mains by locating and operating the appropriate main valves.

Water pressure of less than 20 psi presents a health hazard, because it can result in contamination of water mains and customer plumbing. The larger the area affected, the higher the probability of contamination. Shutting off a well or water tower and putting the entire system out of service creates a health hazard for the entire community. This approach isn't recommended even if a boil-water notice is issued.

Repair

No amount of flushing, disinfecting or sampling of a main after repair can make up for unsanitary handling of materials or unsanitary practices during the repair.

Trenching The repair process starts with digging a repair trench, which must be dug on both sides of the main and be wide and long enough to accommodate a trench box and access ladder. Because soil around a leaking main is water soaked and unstable, trench boxes should be used. In addition, most operators aren't willing to slope trench

walls at a 45-degree angle, especially when digging is required in yards or streets. Ladders should be used to safely access and exit trenches.

The repair trench must be sized to allow an operator to safely work on the problem area with enough room to clean the area and handle repair materials in a sanitary manner. The trench must be deep enough below the main for a repair clamp or other fittings to be installed, without coming into contact with trench water or soil.

Trench Water Proper handling of trench water is essential to repairing a main break in a sanitary manner. Studies on water main breaks reveal trench water and soil are contaminated with total coliform, *E. coli* and other bacteria. Therefore, trench water must be removed from the pipe area to be repaired. Installers must ensure repair materials don't come in contact with trench water or soil during installation. This requires that trenches be deep enough to keep water below the pipe, and trench pumps must be available to control the trench water. It may be necessary to place gravel in the bottom of a trench to control mud and water splashing. If the trench pump's capacity is inadequate, work should stop until additional or larger pumps are provided to control the trench water.

Flushing Repairing water mains requires flushing large amounts of water and disposing of strongly chlorinated water. If the chlorinated water infiltrates a stream, river, lake, pond or other water body, it can lead to fish kills and regulatory violations resulting in enforcement action. In addition, strong chlorine solutions can kill vegetation and make property owners unhappy. System operators must know where the flushed water will flow and have the means to dechlorinate and properly dispose of the water.

Repair Clamps and Parts Before a repair clamp is installed on a pipe, the pipe must be cleaned of any soil and washed, using clean rags and a 1–5 per cent bleach

solution. When handling strong chlorine solutions, always follow appropriate safety practices. A large plastic orchard sprayer filled with a bleach solution is the best way to provide an adequate amount of bleach for this purpose.

Just before the repair clamp is installed on the pipe, the interior of both sides of the clamp should also be cleaned and thoroughly sprayed with the bleach solution. Cleaning is easier if the repair clamp has been stored, hauled and handled in a sanitary manner before installation. In addition, it's helpful to handle the clamp with clean hands or gloves, avoid setting it in dirt or mud, and prepare it in a clean area before taking it into the trench for installation. The same procedures must be followed when installing a tapping tee or saddle, including the tapping valve, pipe, fittings and tapping equipment.

Pressurised Repair These procedures must be followed even if the main is repaired while it remains full of water pressurised at 20 psi or more. For systems that provide continuous disinfection and maintain adequate disinfection residuals in the distribution system, leaks repaired under pressure present little danger of contamination and may not require disinfection after the repair. However, if a system doesn't provide continuous disinfection or if the main isn't repaired under pressure, disinfection is required.

Open-Cut Repair If a main must be cut open for repair, surrounding dirt must be removed to allow cleaning of all areas that may come into contact with repair fittings. The interior and exterior of each end must be cleaned of soil and washed with clean rags and a 1–5 per cent bleach solution. If a strong chlorine solution can be safely flushed from the affected area, calcium hypochlorite tablets should be placed in the ends of the pipe. Before doing so, all service lines in the affected area should be turned off to prevent strongly chlorinated water from entering customer plumbing. Use

a food-grade adhesive to keep the tablets in place. The required number of tablets varies based on pipe diameter and length.

The interior of couplings, repair pipe and other fittings must be cleaned and washed with a bleach solution just before installation. Depending on the repair pipe length, a cloth swab soaked in bleach may be needed to clean and disinfect the pipe's interior. Both exterior ends of the repair pipe must be cleaned and disinfected in the same manner as the water main ends. Ensure couplings and repair pipe aren't contaminated with soil or trench water during installation. The same procedures must be followed when replacing or installing a new valve, elbow, hydrant or flushing device.

Disinfection

When repair is completed, the affected section of the main should be slowly filled with water to displace any air. If chlorine tablets are placed in the main, they should remain in place for several hours to allow the chlorine to dissolve and the repair area to be disinfected.

The amount of time required to disinfect a main depends on the strength of the chlorine dose. For example, if a 100-mg/L dose is used, the tablets must remain for three hours. Next, the chlorinated water should be flushed from the main and properly handled. Provisions to remove the strong chlorine from the water may be necessary.

If chlorine tablets aren't used, the affected section of main should be flushed at scouring velocities to remove dirt or colored water, and disinfected. Table 1 shows the velocities that must be reached in water mains of different sizes to provide adequate flushing.

The affected section of the main should be flushed and chlorinated in the same way as a new water main. AWWA Standard C651, 'Disinfecting Water Mains', recommends flushing and chlorination where practical; a situation isn't impractical just because a system or its contractor doesn't have the necessary equipment or doesn't want to make the effort. Three chlorination methods are presented, but two of the methods – using calcium hypochlorite tablets or granules – work only if the main is cut open for repair. The third method is continuous feed.

To use the continuous-feed method, the system or its contractor must have the necessary equipment to feed a chlorine solution into the water main. Basic

Table 1. Required Flow to Maintain Residual Pressure.

Pipe Diameter (in.)	Flow (gpm)	Number of 2.5-in Hydrant Openings
2	26	1
2.5	38	1
3	60	1
4	105	1
6	225	1
8	400	1
10	600	1
12	900	2
16	1,600	2

These velocities must be reached to provide adequate flushing.

equipment consists of a tank to hold the chlorine solution and a pump to force the solution into the water main. The solution tank should be polyethylene with a tight-fitting lid and valved fittings to connect the pump and tank.

Tank size depends on the length of water line to be disinfected, but tanks larger than 50 gal are difficult to move by hand. Pump size also depends on the amount of line to be disinfected, but a 5-gpm pump should be adequate for most repair jobs. If an electric pump is used, a portable power source must be available. The pump must include hoses and fittings to connect it to the solution tank and to the water main.

A valve should be provided on the discharge side of the pump to control pump output. The volume of chlorine solution to disinfect a water main is small if it's injected directly into the water main as shown in Table 2.

Table 2. Chlorine Required to Produce Desired Concentration.

Pipe Diameter (in.)	1% Chlorine Solution (gal)
4	0.16
6	0.36
8	0.65
10	1.02
12	1.44
16	2.60

Inject chlorine solution directly into a water main to minimise required volume.

However, if an existing service line is used to inject chlorine into the main, the service line's entire volume must be displaced to get chlorine to the main. For example, 100ft of 3/4-in. diameter pipe contains 2.77 gal of water, and 100ft of 1-in. diameter pipe contains 4.04 gal of water. If solution is pumped through a fire hydrant, the entire volume of the fire hydrant and its leg line must be displaced to get chlorine to the main.



No amount of flushing, disinfecting or sampling of a main after repair can make up for unsanitary handling of materials or unsanitary practices during the repair. For example, it's helpful to handle a repair clamp with clean hands or gloves, avoid setting it in dirt or mud, and prepare it in a clean area before taking it into the trench for installation.

In addition, 10ft of 6-in. diameter pipe contains 14.7 gal of water. If a service line or hydrant isn't available, a tap should be made to the water main near the isolating valve upstream of the line break.

Before starting the chlorination process, all service lines in the affected area should be turned off to prevent strongly chlorinated water from entering customer plumbing. After a chlorine source is connected to the water line, a hydrant or flushing device downstream of the repair site should be opened, and the isolating valve upstream from the repair should be opened partially to provide a low flow of water through the main.

At the same time, chlorine solution is pumped into the main until at least a 25mg/L residual is obtained at each hydrant or flushing device in the affected area. If there are multiple hydrants or flushing devices, they should be opened in succession until at least a 25-mg/L residual is measured at each.

Hydrants or flushing devices and the isolating valve are shut off after the desired residual is obtained. After 24 hours, the chlorine residual in the main should be at least 10mg/L. If it's less than 10mg/L, the chlorination process should be repeated.

Most water system operators don't want to wait 24 hours before restoring service to customers. Fortunately, the contact time required to disinfect a main can be reduced if the chlorine residual is increased. If the chlorine concentration is increased to 100mg/L, the contact time can be reduced to three hours. During the process, the chlorine residual shouldn't drop below 50mg/L. If the dose is increased to 300mg/L, contact time can be reduced to 15 minutes. However, you must safely dispose of the strongly chlorinated water.

Flushing And Advisories

After disinfection, the affected area must be flushed to remove air, contamination, or coloured water and until chlorine residuals are less than 4 mg/L. Service to customers can then be turned on and the main returned to service. Most homes are higher than the water mains. If pressures are low in a main, they will be even lower in household plumbing. Therefore, it's important to notify each customer that a main repair involving possible low water pressures has occurred.

The notice should advise each customer to flush all plumbing on their premises to remove any contamination, air or coloured water before they use the water. The notice must also advise residents to boil water for drinking or culinary purposes and ask them to notify the water system if they notice any colour or odour (other than chlorine) in the water. These advisories can be hand delivered using doorknob hangers or door stuffers or distributed electronically.

Advisories shouldn't be lifted until special water samples are collected upstream and downstream of the main repair and are negative for coliform bacteria. If a large area of the system was affected, more than two water samples may be required. The system operator should contact the appropriate regulatory authority for guidance. If any sample is positive for coliform bacteria, an advisory must continue, additional disinfection and flushing are required, and system operators should contact the appropriate authority for guidance.

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