

SECTION 33 01 10.15**DISINFECTING PIPELINES****PART 1 GENERAL**

1.01 SCOPE OF WORK

- A. Flush and disinfect all pipelines installed under this Contract as indicated in the Drawings. This would include furnishing the necessary labor, tools, transportation, and other equipment for the operation of valves, hydrants, and blowoffs during chlorination. Install, and if directed by the AW Project Manager, remove all chlorination taps required for disinfection. Disinfection will be performed under the supervision of AW.

1.02 WORK BY AW

- A. AW reserves the option to provide/furnish the chlorine and chlorination equipment. AW will furnish water for testing, flushing and disinfecting pipelines. AW will also reserve the right to perform bacteriological testing and may collect the sample.

1.03 PROTECTION

- A. Chlorine disinfection and dechlorination shall be under the direct supervision of someone familiar with the physiological, chemical, and physical properties of the form of chlorine used. They shall be trained and equipped to handle any emergency that may arise. All personnel involved shall observe appropriate safety practices to protect working personnel and the public.
- B. The forwards of AWWA Standards B300 and B301 contain information and additional reference material regarding the safe handling of hypochlorites and liquid chlorine. The Contractor shall familiarize himself with this information prior to performing any disinfection work.

1.04 SUBMITTAL

- A. Conform to the requirements of Section – Submittal Procedures

1.05 RELATED WORK

- A. Observe the precautions described in Section – Piping – General Provisions to avoid contamination during installation of the pipeline.

1.06 REFERENCES

- A. Refer to current AWWA Standard C651 for Disinfecting Water Mains.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

- A. Furnish liquid chlorine and/or calcium hypochlorite and injection equipment as needed to disinfect all pipelines and appurtenances.
- B. Liquid chlorine contains 100% available chlorine and is packaged in steel containers, usually of 100 lb, 150 lb, or 1 ton net chlorine weight. Liquid chlorine shall be furnished in accordance with AWWA B301.
- C. Calcium hypochlorite is available in granular form or in approximately 5-g tablets, and contains approximately 65% available chlorine by weight. The material should be stored in a cool, dry, and dark environment to minimize its deterioration. Do not use calcium hypochlorite intended for swimming pool disinfection, as this material (containing trichloroisocyanuric acid) has been sequestered and is extremely difficult to eliminate from the pipe after the desired contact time had been achieved.
- D. Calcium hypochlorite must conform to AWWA B300.

PART 3 EXECUTION

3.01 PREPARATION

- A. All pipelines shall be pressure and leak tested, flushed, and cleaned of debris and dirt prior to application of the disinfectant. Flushing shall continue until the volume in the newly installed main has turned over at least one time unless AW determines that conditions do not permit the required volume to be safely discharged to waste.

3.02 APPLICATION OF DISINFECTANT

- A. Methods to be used for disinfection are those detailed in ANSI/AWWA C651 Disinfecting Water Mains.

3.03 WATER MAINS

Three methods of chlorination are described below. The third method, using tablets of hypochlorite, is only permitted by expressed approval of AW and under

no circumstance allowed for projects of 2000 feet or more. Otherwise, information in the forward of AWWA Standard C651 will be helpful in determining the best method to be used.

A. Continuous Feed Method

1. Set-up

- a. The continuous feed method consists of completely filling the main with potable water to remove all air pockets, flushing the completed main to remove particulates, and then refilling the main with potable water that has been chlorinated to 25mg/l. After a 24-hour holding period in the main, there shall be a free chlorine residual of not less than 10 mg/L in collected samples.
- b. Chlorine can be applied in advance of preliminary flushing by swabbing joints with bleach or placing calcium hypochlorite granules in the pipe in areas where contamination is suspected. In any such case, the Contractor shall make sure and take appropriate action to make sure that the flushed water is dechlorinated.
- c. Preliminary flushing - Prior to being chlorinated, fill the main to eliminate air pockets and flush to remove particulates. The flushing velocity in the main shall be not less than 3 ft/sec unless the AW Project Manager determines that conditions do not permit the required flow to be discharged to waste. Table 1 below shows the rates of flow required to produce a velocity of 3 ft/sec in pipes of various sizes.

NOTE: Flushing is no substitute for preventive measures during construction. Certain contaminants such as caked deposits resist flushing at any feasible velocity.

TABLE 1
Required Flow and Openings to Flush Pipelines
(40 psi Residual Pressure in Water Main)*

Pipe Diameter (inches)	Flow Required to Produce 3 ft/sec velocity in main (gpm)	Size of Tap, (inches)			Number of 2½-inch Hydrant Outlets to Use
		1	1-1/2	2	
		Number of taps on Pipe †			
4	120	1	-	-	1
6	260	-	1	-	1
8	470	-	2	-	1
10	730	-	3	2	1
12	1060	-	-	3	2
16	1880	-	-	5	2

*With a 40 psi pressure in the main with the hydrant flowing to atmosphere, a 2½-inch hydrant outlet will discharge approximately 1,000 gpm and a 4½-inch hydrant outlet will discharge approximately 2,500 gpm.

† Number of taps on pipe based on discharging through 5 feet of galvanized iron pipe with one 90° elbow.

- d. In mains of 24-inches or larger diameter, an acceptable alternative to flushing is to broom-sweep the main, carefully removing all sweepings prior to chlorinating the main.

OSHA requirements for confined space need to be addressed prior to entering a pipeline.

2. Chlorinating the Main

- a. Potable water may be supplied from a temporary backflow-protected connection to the existing distribution system or other supply approved sources. The cross connection control device shall be consistent with the degree of hazard for backflow protection of the active distribution system. The flow shall be at a constant, measured rate into the newly installed water main. In the absence of a meter, approximate the rate by placing a Pitot gauge in the discharge or measuring the time to fill a container of known volume. The main should undergo hydrostatic pressure testing prior to disinfection.
- b. At a point not more than 10 feet downstream from the beginning of the new main, dose the water entering the new main with chlorine fed at a constant

rate such that the water will have not less than 25 mg/L free chlorine. Measure the chlorine concentration at regular intervals to ensure that this concentration is provided. Measure chlorine in accordance with the procedures described in the current edition of the AWWA Manual M12 or of *Standard Methods for the Examination of Water and Wastewater*.

- c. Table 2 below gives the amount of chlorine required for each 100 feet of pipe of various diameters. Solutions of 1 percent chlorine may be prepared with calcium hypochlorite. The solution requires 1 pound of calcium hypochlorite in 8 gallons of water.

TABLE 2
Chlorine Required to produce 25 mg/L
Concentration in 100 feet of Pipe by Diameter

Pipe Diameter (inches)	100% Chlorine (lb)	1% Chlorine Solution (gallons)
4	0.013	0.16
6	0.030	0.36
8	0.054	0.65
10	0.085	1.02
12	0.120	1.44
16	0.217	2.60

- d. During the application of chlorine, position valves so that the strong chlorine solution in the main being treated will not flow into water mains in active service. Do not stop the chlorine application until the entire main is filled with heavily chlorinated water. Keep the chlorinated water in the main for at least 24 hours. During this time, operate all valves and hydrants in the section treated in order to disinfect the appurtenances. At the end of this 24-hour period, the treated water in all portions of the main shall have a residual of not less than 10 mg/L free chlorine.
- e. Hypochlorite solution may be applied to the water main with a gasoline or electrically powered chemical feed pump designed for feeding chlorine solutions. Feed lines shall be of such material and strength as to safely withstand the corrosion caused by the concentrated chlorine solutions and the maximum pressures that may be created by the pumps. Check all connections for tightness before the solution is applied to the main.
- f. If gaseous chlorine in solution is permitted by the AW Project Manager and proposed by the Contractor, the preferred equipment for the gas application employs a feed vacuum-operated chlorinator to mix the chlorine

gas, in combination with a booster pump for injecting the chlorine gas solution water into the main to be disinfected. Direct feed chlorinators cannot be used. (A direct feed chlorinator is one which operates solely from the pressure in the chlorine cylinder.)

B. Slug Method

1. Set-up

- a. The slug method consists of placing calcium hypochlorite granules in the main during construction; completely filling the main to eliminate all air pockets, flushing the main to remove particulates, and slowly flowing a slug of water containing 100 mg/L of free chlorine through the main so that all parts of the main and its appurtenances will be exposed to the highly chlorinated water for a period of not less than 3 hours.

2. Chlorinating the main.

- a. Potable water may be supplied from a temporary backflow-protected connection to the existing distribution system or other supply approved sources. The cross connection control device shall be consistent with the degree of hazard for backflow protection of the active distribution system. The flow shall be at a constant, measured rate into the newly installed water main. In the absence of a meter, approximate the rate by placing a Pitot gauge in the discharge or measuring the time to fill a container of known volume. The main should undergo hydrostatic pressure testing prior to disinfection.
- b. At a point not more than 10 feet downstream from the beginning of the new main, dose the water entering the new main with chlorine fed at a constant rate such that the water will have not less than 100 mg/L free chlorine. Measure the chlorine concentration at regular intervals to ensure that this concentration is provided. Measure chlorine in accordance with the procedures described in the current edition of the AWWA Manual M12 or of *Standard Methods for the Examination of Water and Wastewater*. The chlorine shall be applied continuously and for a sufficient period to develop a solid column or "slug" of chlorinated water that will, as it moves through the main, expose all interior surfaces to a concentration of approximately 100 mg/L for at least 3 hours.
- c. The free chlorine residual shall be measured in the slug as it moves through the main. If at any time it drops below 50 mg/L, stop the flow, relocate the chlorination equipment to the head of the slug, and as flow is resumed, apply chlorine to restore the free chlorine in the slug to not less than 100 mg/L.

- d. As the chlorinated water flows past fittings and valves, operate related valves and hydrants so as to disinfect appurtenances and pipe branches.

C. Tablet Method

1. Set-up

- a. The tablet method consists of adhering calcium hypochlorite tablets in the water main as it is being installed and then filling the main with potable water when installation is completed. This method may be used only if the pipes and appurtenances are kept clean and dry during construction and with permission by AW for short main installations.

2. Chlorinating the Main

- a. Placing of Calcium Hypochlorite Tablets -. During construction, 5-g calcium hypochlorite tablets shall be placed in each section of pipe. Also, one such tablet shall be placed in each hydrant, hydrant branch, and other appurtenance. The number of 5-g tablets required for each pipe section shall be $0.0012 d^2L$ rounded to the next higher integer, where d is the inside pipe diameter, in inches, and L is the length of the pipe section, in feet. Table 3 below shows the number of tablets required for commonly used sizes of pipe. The calcium hypochlorite tablets shall be attached by an adhesive meeting the NSF/ANSI 61 requirements. There shall be no adhesive on the tablet except on the broadside attached to the surface of the pipe and no adhesive applied or spilled on the pipe surface. Excess adhesive must be removed immediately using mechanical means or an NSF-approved adhesive solvent. Attach all the tablets inside and at the top of the main, with approximately equal numbers of tablets at each end of a given pipe length. If the tablets are attached before the pipe section is placed in the trench, their position shall be marked on the section so it can be readily determined that the pipe is installed with the tablets at the top.

TABLE 3
 Number of 5-g Calcium Hypochlorite Tablets required for dose of 25 mg/L *

Pipe Diameter	Length of Pipe Section, ft				
	13 or less	18	20	30	40
inches	Number of 5-g Calcium Hypochlorite Tablets				
4	1	1	1	1	1
6	1	1	1	2	2
8	1	2	2	3	4
10	2	3	3	4	5
12	3	4	4	6	7
16	4	6	7	10	13

* Based on 3.25g available chlorine per tablet.

- b. Filling and Contact - When installation has been completed, the main shall be filled with water at a rate such that water within the main will flow at a velocity no greater than 1 ft/sec. Precautions shall be taken to ensure that air pockets are eliminated. Fill rate must be carefully controlled to ensure tablets do not come loose from the pipe. This water shall remain in the pipe for at least 24 hours. If the water temperature is less than 41°F (5°C), the water shall remain in the pipe for at least 48 hours. A detectable free chlorine residual (≥ 0.2 mg/l) shall be found at each sampling point after the 24 or 48 hr period.

D. Spray Disinfection For Large Transmission Main

For very large transmission mains (where equipment and personnel may safely enter the main), spray disinfection may be appropriate and efficient means of achieving disinfection. For this method, refer to ANSI/AWWA C652, Sec. 4.3.2 (Disinfection of Water Storage Facilities; Chlorination Method 2.) In general, once the pipe is cleaned, spray a 200 mg/l free chlorine solution on all surfaces. After 30 min, fill line and sample as described in Sec 3.05.

3.04 DISPOSAL OF HEAVILY CHLORINATED WATER

- A. Do not keep heavily chlorinated water in contact with pipe for more than 48 hours after the applicable retention period. In order to prevent damage to the pipe

lining or corrosion damage to the pipe itself, flush the heavily chlorinated water from the main fittings, valves, and branches until chlorine measurements show that the concentration in the water leaving the main is no higher than that generally prevailing in the distribution system or is acceptable for domestic use. Take all steps necessary to dechlorinate water where required per Paragraph 3.04B and 3.04C below. Contact the local sewer department to arrange for disposal of the heavily chlorinated water to the sanitary sewer if applicable or permissible.

- B. Neutralize the chlorine residual of the water being disposed of by treating with one of the chemicals listed in Table 4 below. Select an alternative disposal site if a sanitary sewer system is unavailable for disposal of the chlorinated water.
- C. The proposed alternative disposal site shall be inspected and approved by AW. Apply a reducing agent to the chlorinated water to be wasted to completely neutralize the chlorine residual remaining in the water. (See Table 4 for neutralizing chemicals. Do not overdose neutralizing chemicals as this may result in adverse environmental impacts. Only dose the amount required to neutralize the amount of chlorine present). Contact Federal, State and local regulatory agencies, where necessary, to determine special provisions for the disposal of heavily chlorinated water.

TABLE 4
Pounds of chemicals required to neutralize various residual chlorine concentrations in 100,000 gallons of water

Residual Chlorine Concentration mg/L	Sulfur Dioxide (SO ₂) lb	Sodium Bisulfite (NaHSO ₃) lb	Sodium Sulfite (Na ₂ SO ₃) lb	Sodium Thiosulfate (Na ₂ S ₂ O ₃ · 5H ₂ O) lb	Ascorbic Acid (C ₆ O ₈ H ₆) lb
1	0.8	1.2	1.4	1.2	2.1
2	1.7	2.5	2.9	2.4	4.2
10	8.3	12.5	14.6	12.0	20.9
50	41.7	62.6	73.0	60.0	104.0

- D. Test for chlorine residual throughout the disposal process to be sure that the chlorine is neutralized.
- E. Submit a plan of disposal of flushed water to AW for approval

3.05 BACTERIOLOGICAL TESTING

A. Standard conditions for new mains.

It should be recognized that the primary means of ensuring the sanitary integrity of a main are the sanitary handling of materials, the practices during construction, and continual inspection of work. After disinfection and final flushing such that typical system chlorine residuals are present, if the system operates with a residual, samples shall be collected as follows:

- a. For new mains, the purchaser has two options for the bacteriological testing for total coliform analysis.

Option A: Before approving a main for release, take an initial set of samples and then resample again after a minimum of 16 hr using the sampling site procedures outlined. Both sets of samples must pass for the main to be approved for release.

Option B: Before approving a main for release, let it sit for a minimum of 16 hr without any water use. Then collect, using the sampling site procedures outlined and without flushing the main, two sets of samples a minimum of 15 min apart while the sampling taps are left running. Both sets of samples must pass for the main to be approved for release.

A set of samples includes all samples collected along the length of the pipeline, as described below:

- i. For new mains, sets of samples shall be collected every 1,200 ft (370 m) of the new water main, plus one set from the end of the line and at least one from each branch greater than one pipe length.
- ii. If trench water has entered the new main during construction or if, in the opinion of the purchaser, excessive quantities of dirt or debris have entered the new main, bacteriological samples shall be taken at intervals of approximately 200 ft (61 m), and the sampling location shall be identified (see Sec. 5.1.3 for sampling location details). Samples shall be taken of water that has stood in the new main for at least 16 hr after final flushing has been completed.
- iii. A standard heterotrophic plate count (HPC) test may be required at the option of the purchaser because new mains do not typically contain coliform bacteria but often contain HPC bacteria. If sample results show HPC greater than 500 CFU/mL, flushing should resume and another set of HPC and coliform samples collected until no coliform are present and the HPC is less than 500 CFU/mL.

b. Standard conditions for repaired mains.

For repaired mains that were depressurized and/or wholly or partially dewatered, one set of samples may be required, and depending upon the sanitary conditions, the line may be reactivated prior to the completion of bacteriological testing. Samples shall be collected downstream of the repair site and at intervals of approximately 200 ft (61 m) within the length of pipe that was shut down. If direction of flow is not known, samples shall be collected on either side of the repair site.

- B. Samples shall be collected by a person knowledgeable in collecting samples for bacteriological sampling or arrange for AW to collect the sample. Coordinate with AW and submit samples to AW for testing of bacteriological (chemical and physical) quality. Testing will be in accordance with *Standard Methods of the Examination of Water and Wastewater*. Samples shall show the absence of coliform organisms; and the presence of a chlorine residual. Samples shall also be tested for turbidity, pH, and standard heterotrophic plate count (HPC). HPC levels must be consistent with levels normally found in the distribution system to which the new main is connected.
- C. Bacteriological tests must show complete absence of coliforms and acceptable HPCs. If tests show the presence of coliform or unacceptable HPCs, perform additional flushing and disinfection of the pipeline until acceptable tests are obtained, all at no cost to AW. The Contractor will not be charged for the additional testing performed by AW.

3.06 RETESTING AND TESTING SOURCE WATER

- A. At the time of initial flushing the main to remove material and test for air pockets, Contractor may request AW to continue flushing until the desired chlorine residual is met at the discharge point. Notification must be provided in advance and the Contractor shall be prepared to test for chlorine at intervals of no more than five minutes as the water clears. This will provide the Contractor with some assurance that the source water is chlorinated.
- B. If the subsequent tests for bacteriological contamination conducted by the Contractor fail, the Contractor may request AW to continue flush from the source water into the new pipe system until a chlorine residual is found at the discharge point. Notification must be provided in advance and the Contractor shall be prepared to test for chlorine at intervals of no more than five minutes as the water clears. The operation of all existing system valves shall be by AW at the Contractor's expense and the discharge point must be opened prior to opening existing valves to avoid contamination. This will provide the Contractor with some assurance that the source water is chlorinated for subsequent tests.

3.07 DISINFECTION PROCEDURES FOR CUTTING INTO OR REPAIRING EXISTING MAIN

The planned, unplanned, or emergency repair of a water main or appurtenance (e.g., valve) is time sensitive—an important goal is to minimize the disruption of water service to customers. Nonetheless, the repair work needs to be accomplished using sanitary and safe procedures by well-trained crews with proper supervision and guidance.

A. Basic disinfection.

Work should follow basic disinfection and contamination prevention procedures:

1. Preventing contaminants from entering the existing pipe during the repair such as by maintaining positive pressure in the leaking pipe until the repair site on the pipe is fully exposed, by maintaining a dewatered trench, and by keeping all pipe materials being used in the repair in a clean and sanitary condition.
2. Inspecting and cleaning, followed by disinfection of spraying or swabbing with a minimum 1 percent chlorine solution:
 - Exposed portions of existing pipe interior surfaces
 - Pipe materials used in the repair
 - Handheld materials and tools used to make the repair
3. As appropriate, advising affected customers to adequately flush their service lines upon return to service.

B. Selection of disinfection procedure.

The disinfection procedure selected should be determined by the conditions and severity of the main break. Many leaks or breaks can be repaired under controlled conditions without depressurizing the water main, such as when applying a clamp to a small crack or hole, thus preventing contaminants from entering the water system. In most other situations, the water main can be maintained pressurized until the break site is secured and the pipe is fully exposed. Some circumstances (e.g., severe erosion of the local environment or icing of the roadway) that impact public safety may require that water pressure be substantially reduced prior to exposing the pipe in the area of the leak. In some cases, situations become catastrophic where there is a pipe blowout and a loss of water pressure prior to shutdown, requiring disinfection procedures equivalent to those of a new main installation.

The procedures below describe the contamination risks and the associated disinfection and sampling requirements for different scenarios of pipeline repair. Specific situations not captured below need to be evaluated and the appropriate disinfection and sampling methods followed.

I. Controlled pipe repair without depressurization.

In this situation, activities are well controlled and a full shutdown is not needed, thus maintaining positive pressure to the area of shutdown and around the break site at all times. The repair site is exposed and the trench is adequately dewatered so that the repair site can be cleaned and disinfected by spraying or swabbing with a minimum 1 percent chlorine solution. The water main is then returned to service with flushing to obtain three volumes of water turnover, making sure that the flushed water is visually clear. No bacteriological testing is necessary.

II. Controlled pipe repair with depressurization after shutdown.

In this situation, after the repair site has been exposed and secured from trench soil/ water contamination, the water main is depressurized by a shutdown to complete the repair. The repair site should be cleaned and disinfected by spraying or swabbing with a minimum 1 percent chlorine solution. The water main is then returned to service with flushing to scour the pipe and obtain three volumes of water turn- over, making sure that the flushed water is visually clear. It is advisable to check for a typical system chlorine residual, and if not found, to continue flushing until residuals are restored to levels maintained in the distribution system by the water utility—if the system operates with a disinfectant residual. When the existing pipe has to be opened and the interior surfaces of the water system exposed to the environment, additional procedures need to be followed. The existing pipe should be inspected and cleaned with the help of flushing water into the trench, where possible, until the flush water runs visually clear. The repair site should be accessible and the trench adequately dewatered so that the repair site can be cleaned and disinfected by spraying or swabbing with a minimum 1 percent chlorine solution. Additionally, any accessible upstream and downstream interior of the existing pipe should be disinfected by swabbing or spraying with a minimum 1 percent chlorine solution. If the repair requires a full pipe section replacement, the new pipe should be inspected, cleaned, and disinfected from both ends by swabbing with a minimum 1 percent chlorine solution. The water main may then be returned to service after flushing to scour the pipe and obtain three volumes of water turnover. The flushed water should run visually clear, have measurable chlorine residual if the system operates with a residual, and be checked with

bacteriological testing. The pipeline may be returned to service prior to obtaining bacteriological results.

- III. Uncontrolled pipe break with a likelihood of water contamination or loss of sanitary conditions during repair.

In situations in which the existing main to be repaired could not be protected and kept free of contamination and there are obvious signs of contamination (e.g., muddy trench water flowing into the broken pipe and a leaking sewer pipe in the trench, or catastrophic pipe failure where pipe is open and there is a likelihood that contamination was drawn into the active system) or when a controlled repair situation turns into a situation in which the internal pipe and water have become contaminated, the procedures outlined under Section 3.03 should be followed where practical. These methods specify chlorine doses of 25–300 mg/L; however, such levels may present greater harm if the line or services cannot be reliably isolated or shut down and exposure of customers to high concentrations of chlorine cannot be controlled. Free chlorine residuals up to 4 mg/L (based on annual averages) are allowed by federal drinking water regulations; therefore this level is suggested as a minimum to be maintained for at least 16 hr in conjunction with flushing, coliform sampling, and associated customer education.

- C. Flushing – Thorough flushing is the most practical means of removing contamination introduced during repairs. If valve and hydrant location permit, flushing toward the work location from both directions is recommended. Flushing shall be started as soon as the repairs are completed and shall be continued until discolored water is eliminated.
- D. Slug Chlorination – Where practical, in addition to flushing, the section of the main in which the break is located shall be isolated, all service connections shut off, and the section flushed and chlorinated as described in Paragraph 3.03B above (Slug Method). The dose may be increased to as much as 300 mg/L and the contact time reduced to as little as 15 minutes. After chlorination, flushing shall be resumed and continued until discolored water is eliminated and the chlorine concentration in the water exiting the main is no higher than the prevailing water in the distribution system or that which is acceptable for domestic use.
- E. Bacteriological Samples – Bacteriological samples following procedures in Paragraph 3.05 above shall be taken after repairs are completed to provide a record for determining the procedure's effectiveness. If the direction of flow is unknown, then samples shall be taken on each side of the main break. If positive bacteriological samples are recorded, then the situation shall be

evaluated by AW to determine corrective action. Daily sampling shall be continued until two consecutive negative samples are recorded.

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