GENERAL PROVISIONS
OF THE
SPECIFICATIONS

DISINFECTION OF MAINS, FACILITIES AND APPURTENANCES

1.00 PURPOSE

These specifications describe the work necessary to accomplish disinfection of new and repaired water mains and appurtenances. The work shall be performed in accordance with the latest revisions of AWWA Standard C651 except as herein specified, and as directed by the Engineer.

2.00 GENERAL

Personnel responsible for construction or repair of water mains shall be aware of the potential health hazards and shall be trained to carefully observe prescribed construction practices and disinfection procedures.

The Engineer shall approve all materials used in construction. Precautions shall be taken to prevent contamination of pipe, fittings, and other materials. Pipe and fittings shall be stored so as not to accumulate mud or water, and other material shall be stored in a clean, dry location. All pipe shall be inspected carefully before lowering in trench. Any visible evidence of contamination shall be removed and the interior cleaned of all dirt and foreign matter.

On any job where pipe is to be left open, such as during work breaks or overnight, the end of the pipe shall be carefully plugged to prevent entrance of small animals.

Disinfection shall be accomplished using one of the methods described on the following pages. The main shall be flushed prior to disinfection, except when the tablet method is used. The flushing velocity should be not less than 2.5 feet per second.

The forms of chlorine that may be used in the disinfection operations are as follows:

a) Sodium hypochlorite solution (5 percent to 12.5 percent available chlorine)

b) Calcium hypochlorite powder/granules (65 percent available chlorine)

c) Calcium hypochlorite tablets (5 grams, 65 percent available chlorine)

In general, disinfection shall be accomplished by closing gate valves as necessary to isolate the main and allowing heavily chlorinated water (25-100 mg/l available chlorine) to stand in the line for at least twenty-four hours. Any deviation from this procedure requires approval of the Engineer.

In cases where the main must be put into service as soon as possible, such as following emergency repairs, the chlorine contact time may be reduced by using a more concentrated chlorine solution (up to 300 mg/l). The solution shall remain in the line for the maximum possible contact period consistent with the need for service. In no case shall the contact time be less than 30 minutes. In cases of extensions where no gate valve is available to isolate chlorinated sections, apply chlorine and notify any consumers who might be affected. If the chlorine residual is higher than 4.0 mg/l, consumers need to be notified to not use the water until the disinfection is complete, and the residual is 4.0 mg/l or less. Service connections should be shut off to prevent accidental ingestion of highly chlorinated water.

At the end of the contact period, the line shall be thoroughly flushed until the chlorine level is normal for the main. The Contractor shall be responsible for disposing of excess chlorinated water in a manner best suited for the protection of the general public, the environment and property, and as directed by the Engineer.

The Contractor shall collect a sample for bacteriological examination as directed by the Engineer and deliver same to the Engineer's Office, on the regular printed label, giving the date, the sampling point and the estimate number for the job.

Many positive tests are due to improper sample collection. Where feasible, the sample should be taken through the same blowoff as used for flushing the heavily chlorinated water out of the main so that it is disinfected. See Appendix A for water sampling instructions.

The main chlorination report, Form 69, shall be filled out and sent to the Engineer's Office at the same time as the sample. All the information called for on the report shall be given including any additional facts that might be necessary in case the chlorination process is in any way unusual.

The action to take, following positive tests, will be noted on the laboratory report. The Contractor shall take the requested action immediately upon notification by Engineer of a positive test.

3.00 CHLORINE APPLICATION METHODS

Chlorine shall be applied by one of the following methods:

3.01 Method No. One - Calcium Hypochlorite Tablet Method

This method is specified for short jobs and for most small diameter pipe (up to 12 in.); it cannot be used where the pipe can become filled with trench water. The main cannot be flushed prior to disinfection, so the method requires that the pipe be kept clean during installation.

Comment [g1]:

Using an adhesive, fasten the required number of tablets (See Table I) to the inside top of every length of pipe as the main is laid. When hot tar is available on the job, it is the preferred adhesive for any type of pipe. Apply hot tar to the end of each tablet with a small piece of wood, about the size of a popsicle stick. When tar is not convenient, for cement line pipe use rubber cement for an adhesive. For galvanized pipe or other metal pipe either Permatex #2 or rubber cement may be used. In any event, care should be taken to see that the adhesive does not cover the sides or exposed end of the tablet so that water can come in contact with as much of the tablet as possible. Tubes of Permatex or rubber cement may be purchased locally at any auto parts store.

When installing bolted couplings, half a tablet shall be crushed and placed in the annular space between the coupling and the pipe in addition to the tablets placed in the pipe.

Fill the pipe slowly (velocity no greater than 1 ft./sec.) with water. Allow to stand 24 hours and proceed as outlined under general instructions.

TABLE I

CALCIUM HYPOCHLORITE TABLETS

NUMBER OF 5-GRAM TABLETS REQUIRED FOR MAIN DISINFECTION*

Length of Section	Diameter of Pipe 2”	4”	6”	8”	10”	12”	16”	18”	20”	24”
10’							5	6	7	10
13’	1	1	1	1	2	3				
18’	1	1	1	2	3	5	8	10	13	18
20’	1	1	1	2	4	5	9	12	14	21
30’	1	1	2	3	5	8	14	17	21	31
40’	1	1	3	5	7	10	18	23	28	41
48’							22	28	34	49

*Based on 3.25g available chlorine per tablet; to produce 25-50 mg/L available chlorine solution in line.

3.02 Method No. Two - Calcium Hypochlorite Powder in Couplings

This method is limited to new construction jobs using pipe coupled with “O” rings or couplings. The purpose of the procedure is to provide a strong chlorine solution (25-50 mg/L available chlorine) that will flow into annular spaces at pipe joints as the line is filled. It is subject to the same limitations as Method #1 and is considered somewhat inferior. However, it is more satisfactory than the hand pump sodium hypochlorite method (Method #3)

1. To each length of pipe, as it is laid, add a measured amount of calcium hypochlorite. The material should be dusted around the inside surface of the coupling and allowed to remain in the coupling. The amounts to add are shown in the following table (Table IV may also be used):

Pipe Diameter Inches	Length Feed	Teaspoon* Level Full
2	20	1/4
4	18	1/2
4	40	1
6	18	1
6	40	2
8	18	2
8	40	4
10	18	3
10	40	7
12	18	4
12	40	10

*One level teaspoon is approximately 6 grams of calcium hypochlorite.

2. When the installation is complete, admit water at a low rate (velocity no greater than 1 ft./sec.)

3. After filling, allow line to stand for at least 24 hours and follow the procedure with respect to the final flushing and taking of samples outlined in the general instructions.

3.03 Method No. Three - Sodium or Calcium Hypochlorite Solution with Hand Pump

1. Make up chlorine solution according to Table II.

2. Connect pump to main. Use a corporation cock for this purpose and make connection at or ahead of the inlet end of the new line. The actual location is a matter of convenience, providing the chlorine solution is applied to the water at or before it enters the main which is to be chlorinated.

3. If line has been flushed as specified in the general instructions, open hydrant or blowoff at outlet and adjust flow to one of the rates in Table III.

4. When the flow is adjusted to the required rate, start pumping concentrate chlorine solution into the line. Operate pump so as to deliver one gallon of solution in three minutes.

5. Continue pumping until orthotolidine test on sample taken from discharge end of line being treated shows a dark orange or red color. If contents of a can are used before test shows proper color, close valve or blowoff and refill can with chlorine solution before proceeding.

6. After finishing application of chlorine, close valve or blowoff and disconnect pump and flush pump thoroughly with fresh water. This is needed in order to prevent damage which will otherwise result if chlorine solution is allowed to remain in contact with metal parts of pump.

The suggested rates for water flow and chlorine pumping apply to mains of all ordinary sizes and are based on a chlorine dose (100 mg/L available chlorine) which will assure complete disinfection. If the available water flow is lower than indicated above, it will not be necessary to make a corresponding reduction in the chlorine pumping rate.

If the above procedure has to be varied because of some unusual condition, it will only be necessary to regulate the pump and control the water flow in such a way that a sample of the treated water will show a dark red or orange color when tested with orthotolidine. In such case, it is possible also to adjust the strength of the chlorine solution.

TABLE II

CHLORINE SOLUTION STRENGTH (100 MG/L)

HAND PUMP METHOD OF MAIN CHLORINATION

Amount of Chemical in 5 Gallons of Solution to
Produce 100 mg/L Available Chlorine When Pumped

Discharge Rate GPM	Grocery Store Sodium Hypochlorite (5% available Cl)	Concentrated Sodium Hypochlorite (12.5% available Cl)	Calcium Hypochlorite (65% available Cl)
10	1.0 quart	1.0 pint	0.25 lbs.
20	2.0 quarts	1.0 quart	0.50 lbs.
35	1.0 gallon	3.0 pints	0.75 lbs.
50	1.5 gallons	2.0 quarts	1.00 lbs.
75	2.0 gallons	3.0 quarts	1.50 lbs.
100	3.0 gallons	1.0 gallon	2.00 lbs.

1. Add enough water to indicated amount of chemical to make a total of five gallons of solution. For example, for a 50-gallon-per-minute discharge rate and using concentrated sodium hypochlorite, make up the chlorine solution by adding two quarts of the sodium hypochlorite to four and one-half gallons of water.

2. Operate the hand pump at the same rate in all cases. This rate is five gallons in fifteen minutes, or one gallon in three minutes.

3. Discharge rate depends on the size of job and will seldom exceed 50 gallons per minute. Rates up to 50 gpm can be regulated with sufficient accuracy by checking the time it takes to fill a five-gallon can. Higher rates of discharge may be estimated by using a vertical discharge pipe and measuring the height that the water rises above the top of the pipe.

4. Quantities given in Table II represent minimum requirements. Stronger solutions can be used if so desired. Indicated doses are approximate.

TABLE III

CHLORINE SOLUTION CONTACT TIME

HAND PUMP METHOD OF MAIN CHLORINATION

Discharge Rate	Time in Minutes for 100 ft. of Pipe					
GPM	2”	4”	6”	8”	10”	12”
10	2	7	15	26	41	59
20	-	3	7	13	20	29
35	-	2	4	8	12	17
50	-	-	3	5	8	12
75	-	-	2	4	6	8
100	-	-	-	3	4	6

The approximate time required for any job can be readily computed from the above table. In conjunction with Table II, it can be used also for determining what strength solution to apply the quantity of that solution needed for any given length of main. For example, 600 feet of 8-inch main, using a discharge rate of 50 GPM and concentrated sodium hypochlorite, would be fully treated in 30 minutes, and the total solution pumped in would be 10 gallons. This amount of solution, as seen from the information on Table II, would require two charges of two quarts each, or one gallon in all.

Table V is a nomograph which may be used to determine the capacity of various lengths and sizes of mains.

3.04 Method No. Four - Slug Method for Chlorination of Large (18 inches and larger) Pipelines

The pipeline shall have a direct contact with a concentrated (100 mg/L available chlorine) chlorine solution for a minimum period of three hours. This chloride solution shall be moved through the pipeline at a

uniform rate to give the required contact time. Chlorine solution shall be pumped into the pipeline after it has been filled with water.

The free chlorine residual shall be measured in the slug as it moves through the pipe. If it drops below 50 mg/L, additional chlorine shall be applied at the head of the slug to restore the free chlorine to not less than 100 mg/L.

As the chlorinated water flows past fittings and valves, related valves and hydrants shall be operated so as to disinfect appurtenances and pipe branches. The amount of solution, the length of time for the injection, and the rate of flow in the pipeline to carry the concentrated chlorine solution its entire length will be provided by the Engineer. The injection pump used shall be of minimum capacity to inject the chlorine solution at a uniform rate during the three-hour contact period.

3.05 Other Methods

None of the above methods are applicable to short tie-ins or to cutting in fittings in existing pipe. Such jobs generally preclude the use of high chlorine residuals and seldom permit the 24-hour period of contact. For short tie-ins, each end of each length of pipe shall be lightly dusted with calcium hypochlorite powder and all fittings that are cut in shall be similarly treated.

All effort shall be made to keep trench water out of the pipe when cutting in fittings or making tie-ins. When this is unavoidable, the trench water shall be treated with sodium hypochlorite solution or calcium hypochlorite powder or tablets. Enough chlorine shall be added so that the trench water has a noticeable chlorine odor.

On such jobs, it is particularly important that a sample be taken at the nearest tap downstream from the tie-in. If in doubt as to the direction of the flow of water, samples shall be taken on each side of the tie-in.

4.00 DISINFECTION OF TAPPING SLEEVES

Before a tapping sleeve is installed, the exterior of the main to be tapped shall be thoroughly cleaned and the inside surface of the tapping sleeve must be heavily dusted with calcium hypochlorite powder or swabbed with concentrated hypochlorite solution. If the annular space is filled with concrete, no special disinfection is required.

Equipment required includes a hydraulic test pump, solution hose, and a small container, such as a five-gallon can, for holding the chlorine solution.

Mounting the solution can and the pump on a suitable board can make a compact and convenient assembly. If this is done, the best arrangement is to put in a pipe connection between the tank and the suction side of the pump, and a bypass around the pump. The latter, serving as a filling line for the solution can, should be connected to tees on the suction and discharge and fitted with a valve.

5.00 EMERGENCY DISINFECTION PROCEDURE

See Appendix B.

6.00 CHEMICALS

Strong chlorine or hypochlorite solutions should be handled with care, since they are irritating to the skin and prolonged exposure to fumes is seriously irritating to the membranes in the nose and throat. These solutions will damage leather goods rapidly and bleach most fabrics.

TABLE IV

CAPFULS OF CALCIUM HYPOCHLORITE POWDER

REQUIRED FOR MAIN DISINFECTION*

Note: 1 ounce calcium hypochlorite = 1 full cap

Length of Section	2”	4”	6”	8”	10”	12”
13’		0.1	0.1	0.25	0.33	0.6
18’		0.1	0.2	0.33	0.5	0.7
20’	0.02	0.1	0.2	0.33	0.5	0.8
30’		0.1	0.3	0.5	0.8	1.2
40’		0.2	0.4	0.7	1.0	1.6
48’		0.2	0.5	0.8	1.3	2.0

	18”	21”	24”	30”	36”	48”
10’	1.0	1.0	1.2	1.8	2.9	7.2
18’	1.3	1.7	2.2	3.2	5.0	12.7
20’	1.4	1.8	2.2	3.2	5.0	12.7
30’	2.1	2.7	3.3	4.8	7.5	19.0
40’	2.8	3.6	4.4	6.4	10.0	25.4
48’	3.4	4.3	5.3	7.6	12.0	30.5

*Based on 65-percent (available chlorine) calcium hypochlorite, to produce 25-50 mg/l available chlorine solution in line.

APPENDIX A

Water Sampling Instructions:

The procedures to be used for taking water samples for either chemical tests or bacteriological examination are as follows:

Open the sample tap to obtain a smooth flow so that a sample can be taken without splashing. From a short service, the Contractor shall allow the water to flow for a minimum of one minute, and from a long service, allow the water to flow for a minimum of four minutes. (Water will travel about 18 feet per minute in a 3/4-inch pipe at a flow of 1/2 gpm).

The Contractor shall not open a faucet full force to flush a sample line because this will disturb sediment which is difficult to flush out. Avoid taking samples from fire hydrants. Samples shall be taken by the Contractor and delivered to the Engineer's office at 1221 South Bascom Avenue in San Jose, California.

Bacteriological Samples:

Bacteriological samples must be taken in a sterile 8-ounce wide mouth bottle furnished by the laboratory. When taking a sample, remove the lid, taking care to touch the lower portion of the bottle. The caps are sealed with clear plastic wrap, and bottles without an intact seal should not be used. Fill the bottle to within about 1/2-inch from the bottom of the neck. Never rinse a bacteriological sample bottle.

Chemical Samples:

Samples for chemical tests must not be taken in bacteriological sample bottles because these contain traces of sodium thiosulfate to destroy chlorine. Thiosulfate interferes with many chemical tests.

The Contractor shall label the sample legibly and accurately. If a number of sample bottles are labeled before the samples are collected, show that each sample corresponds with the label by putting your initials on the corner of the label when the sample is taken. Also, check to be sure each pre-labeled bottle has a sample in it.

Samples should never be stored in direct sunlight, and should be delivered to the Water Quality Department by 3:30 pm. Always store samples in an ice chest while in transport.

APPENDIX B

Procedures For Emergency Disinfection Of Water Mains

This section describes procedures for disinfecting water mains subjected to emergency repairs. The necessary steps include:

1. Minimize the entry of contaminants into the pipe.
2. Remove any contaminants that may have entered the pipe.
3. Disinfect any contaminants that remain.
4. Flush the disinfectant from the pipe.
5. Determine the bacterial quality after disinfection.

Minimize Entry Of Contaminants

As long as the main is pressurized (and water is observed to flow continuously from the break) it is not necessary to disinfect the pipe following repairs. If the main is shut down and depressurized during repair, the main shall be thoroughly flushed and disinfected before it is returned to service. The job is made easier and has a greater probability of success if special precautions are taken to ensure that the pipe stays as clean as possible during repair. The following precautions shall be taken:

1. Excavate to provide at least 18 inches of clearance all around the pipe.

2. Carefully observe the excavation site for signs of broken sewer lines, such as odor or sewer pipe pieces. If sewage is present, disinfection of the main is necessary.

3. Keep water pumped out of the trench to prevent dirty water from contacting the pipe.

Remove Contaminants

Contaminants shall be physically removed before attempting disinfection. Following any shutdown, always back flush in both directions. Achieve as much flushing velocity as is practical without causing damage to property. The minimum flushing velocity should be 2.5 feet per second (fps).

If the pipe is cut and a section is removed, back flush into the trench to remove pieces of pipe scale, or anything that may have broken loose or entered the pipe. Provide adequate pumping to keep the water level below the open pipe. In a small excavation, it may be necessary to dig a sump.

When back flushing the pipe, plug the open end of the side not being flushed. Use a cap, plastic bag with straps, or a redwood plug. As a general rule, flush with enough water to replace all of the pipe volume at least once. Always flush until the water runs clear.

Disinfection Of Pipe

The preferred disinfection procedure may vary with the availability of chemicals and equipment, as well as the nature of the main break. The two procedures described below, swabbing and hypochlorite injection, are applicable to a wide range of main-break situations.

Swabbing

This method is applicable to main breaks where significant contamination of the pipe (for example, by sewage) has not occurred. With this method, all new pieces of pipe, couplings, clamps, or sleeves are swabbed or sprayed with a concentrated solution of hypochlorite to disinfect the interior surfaces. Following swabbing, the repair is completed and the main flushed without allowing further contamination of the pipe and fittings. The procedure is as follows:

1. Back flush the existing pipe in both directions.

2. In a bucket, prepare a concentrated (1-percent available chlorine) hypochlorite solution. Add approximately 2 oz. (58g) of dry calcium hypochlorite to 1 gallon of water to produce a concentrated hypochlorite solution. This is equivalent to about 26 fl. oz. (0.76L) of household bleach (5-percent available chlorine) in 1 gallon of water.

3. Using clean rags dipped in the hypochlorite solution, swab the inside of both ends of the open pipe as far as can be reached. Swab the interior of all new pieces of pipe, couplings, clamps and sleeves that will be used in the repair. An acceptable alternative is to apply the hypochlorite solution using a sprayer.

4. As a safety precaution, wear proper eye and respiratory protection when working with hypochlorite. To prevent damage to skin and personal clothing, wear rubber gloves and protective clothing. Hypochlorite will irritate skin and bleach clothing, so avoid splashing the solution on yourself or co-workers.

5. Following completion of the repair, flush the main to remove high concentrations of hypochlorite and any materials dislodged from the pipe wall during the repair.

The swabbing method and variations thereof are quick and effective for main breaks where repairs are made without the threat of significant contamination by sewage. Most main breaks are disinfected using this technique. However, if there is a potential for more serious contamination (for example, when sewage is detected in the trench during repairs and the main has been shut down) the main should be disinfected more thoroughly. This is accomplished by filling the main with heavily chlorinated water. The method of choice is the hypochlorite injection method.

Hypochlorite Injection

Using this method, hypochlorite solution is injected into a flowing main to achieve high chlorine residual throughout the pipe section. Hypochlorite solution can be injected using a manual, gasoline, or electrically powered chemical-feed pump designed for feeding chlorine solutions (hypochlorinator). After sufficient contact time, the main shall be flushed to remove the heavily chlorinated water.

Ideally, disinfection is accomplished by maintaining a high chlorine residual (100 mg/L) throughout the pipe for at least 3 hours. However, this much time is not practical if customers are out of water, so disinfection is usually accomplished by using shorter contact times and higher chlorine dosages (at least 300 mg/L.) The following steps are necessary to ensure that adequate disinfection and safety for the consumer are provided:

1. Shut off all service connections prior to attempting disinfection. This will prevent the entry of highly chlorinated water to the consumer's premises.

2. In cases where flushing through the consumer's service line is not possible, remove the meter and install a standpipe at the meter connection. Extend the standpipe at least 12 in. above ground to prevent the backflow of dirty water from the meter box during flushing.

3. Install the hypochlorinator not more than 10 ft. from the downstream side of the valve that will supply water to the shut down area. The hypochlorinator may be adapted to pump through a hydrant or meter connection. If there is no such connection close to the supply valve, it may be necessary to tap the main in order to introduce hypochlorite.

4. Always flush the main to remove dirty water and air before attempting disinfection.

5. Following the flush, adjust the flow to a constant measured rate. The flow rate and the pipe size (diameter and length) will determine the time required to dispense the hypochlorite solution throughout the pipe.

In the absence of a meter, approximate the flow rate by measuring the time required to fill a container of known volume.

6. Begin disinfection by pumping hypochlorite solution into the repaired main. The minimum chlorine dosage should be 100 mg/L when the chlorine contact time is at least 3 hours.

   Table 1A indicates the gallons of hypochlorite solution (12.5%) available chlorine) necessary to achieve chlorine dosages of 100 and 300 mg/l in mains of various sizes. The table is useful for estimating the minimum amount of hypochlorite that will be necessary for any main disinfection.

   The hypochlorite pumping rate must be adjusted with the flushing rate to achieve the desired amount of hypochlorite in the main. The pumping rate is calculated from the formula:

   $$R=D/C \times Q$$

   Where: D is the desired chlorine dose
   C is the concentration of the concentrated hypochlorite solution
   Q is the flushing rate

   For example, to achieve a chlorine dose of 300 mg/l when flushing at a rate of 200 gpm, a 12.5% (125,000 mg/l) sodium hypochlorite solution must be pumped into the main at a rate of 0.48 gpm.

7. To determine when the hypochlorite solution has reached the end of the repair main, measure the chlorine residual at the terminal hydrant or blow off.

8. Once the residual has been detected at all blow-offs, shut down the main and allow the heavily chlorinated water to stand in the pipe. For a chlorine dose of 100 mg/L, the recommended minimum contact time is 3h.

9. If the main cannot be kept out of service for 3h, apply a chlorine dosage of at least 300 mg/L. Allow the chlorine solution to remain in the pipe for the maximum permissible contact period consistent with the need for service from the repaired main, but in no case should the contact time be less than 30 min.

Flush Disinfectant From Pipe

At the end of the hypochlorite contact period, flush the main until the chlorine residual has been reduced to the level normally present in water supplied to the area. As a general rule, flush until the pipe volume has been replaced at least once. Prior to restoring service, flush each service line to eliminate air and high concentrations of chlorine.

Determine Bacteriological Quality

Bacteriological samples shall be taken after repairs to provide a record of the effectiveness of the disinfection procedure. After the residual disinfectant has been removed from the repaired main, collect a sample from at least one point located immediately downstream of the repair. If the direction of flow is unknown, collect samples on each side of the repair.

A combination blow-off and sample tap is useful for sampling repaired mains. Samples also may be collected from customer services that have been disinfected and thoroughly flushed. Do not collect samples from hoses or fire hydrants. For additional information on sampling, refer to Appendix A.

END OF SECTION