SECTION 02516
WATER LINES – DISINFECTION AND TESTING

PART 1. GENERAL

1.1 The work to be performed shall consist of the installation of water lines according to the specifications and the Standard drawings herein.

1.2 Design drawings must be prepared and sealed by a Professional Engineer licensed by the State of Tennessee. Profile Drawings may be required as directed by the OWNER.

1.3 The CONTRACTOR shall be responsible for safely storing materials needed for the work until they have been incorporated into the completed project.

PART 2. PRODUCTS

2.1 The OWNER will inspect all materials at the site for conformance to the specifications. At the OWNER's discretion, the CONTRACTOR may be required to supply certified mill tests, samples, or other suitable forms of verification that the material meets the required specifications.

PART 3. EXECUTION

3.1 DISINFECTION AND SAMPLING (Reference *AWWA C651* for further details.)

A. The basic disinfection procedure consists of the following steps:

1. Inspecting all materials to be used to ensure the integrity of the materials.
2. Preventing contaminating materials from entering the water main or components during storage, construction, or repair.
3. Removing, by flushing or other means, those materials that may have entered the water main.
4. Disinfecting any residual contamination that may remain, and flushing the disinfected water from the main.
5. Protecting the existing distribution system from backflow due to hydrostatic pressure test and disinfection procedures.
6. Documenting that an adequate level of disinfectant contacted each pipe to provide disinfection.
7. Determining the bacteriological quality by laboratory test after disinfection.
8. Final connecting of the approved new water main to the active distribution system.

B. If dirt or other foreign material that has gotten into a pipe will not, in the opinion of the OWNER, be removed by flushing, the interior of the pipe shall be cleaned and swabbed with a disinfecting solution of 5 percent hypochlorite.

C. Unless otherwise stated, disinfection shall be performed using chlorine or a chlorine-based chemical compound. The OWNER may allow use of alternate disinfection substances and/or methods on a case-by-case basis.

D. Table I gives chlorine amount needed for each 100 feet of line for pipes of various diameters. A 1 percent chlorine solution may be prepared either with 1 pound of calcium hypochlorite for each 8.5 gallons of water or with sodium hypochlorite.

TABLE I
Disinfectant Amounts Needed to Produce 10 - 300 mg/l Chlorine Residuals in 100 Feet of Water Main of Various Sizes

Pipe Size, Inches	100% Chlorine, lbs				1% Chlorine Solution, Gallons				68% (HTH) Calcium Hypochlorite, lbs			
PPM	10	50	100	300	10	50	100	300	10	50	100	300
4	0.005	0.027	0.055	0.164	0.07	0.33	0.65	1.96	0.008	0.04	0.08	0.24
6	0.012	0.061	0.123	0.368	0.15	0.74	1.47	4.42	0.018	0.09	0.18	0.54
8	0.022	0.109	0.218	0.655	0.26	1.31	2.62	7.85	0.032	0.16	0.32	0.96
10	0.034	0.171	0.341	1.023	0.41	2.05	4.09	12.27	0.050	0.25	0.50	1.51
12	0.0	0.2	0.5	1.5	0.59	2.95	5.89	17.67	0.07	0.36	0.72	2.17
14	0.1	0.3	0.7	2.0	0.80	4.01	8.02	24.05	0.10	0.49	0.98	2.95
16	0.1	0.4	0.9	2.6	1.05	5.24	10.47	31.42	0.13	0.64	1.28	3.85
18	0.1	0.6	1.1	3.3	1.33	6.63	13.25	39.76	0.16	0.81	1.63	4.88
20	0.1	0.7	1.4	4.1	1.64	8.18	16.36	49.09	0.20	1.00	2.01	6.02
22	0.2	0.8	1.7	5.0	1.98	9.90	19.80	59.40	0.24	1.21	2.43	7.28
24	0.2	1.0	2.0	5.9	2.36	11.78	23.56	70.69	0.29	1.44	2.89	8.67
26	0.2	1.2	2.3	6.9	2.77	13.83	27.65	82.96	0.34	1.70	3.39	10.17
28	0.3	1.3	2.7	8.0	3.21	16.04	32.07	96.21	0.39	1.97	3.93	11.80
30	0.3	1.5	3.1	9.2	3.68	18.41	36.82	110.45	0.45	2.26	4.52	13.55
32	0.3	1.7	3.5	10.5	4.19	20.94	41.89	125.66	0.51	2.57	5.14	15.41
34	0.4	2.0	3.9	11.8	4.73	23.64	47.29	141.86	0.58	2.90	5.80	17.40
36	0.4	2.2	4.4	13.3	5.30	26.51	53.01	159.04	0.65	3.25	6.50	19.51
38	0.5	2.5	4.9	14.8	5.91	29.53	59.07	177.21	0.72	3.62	7.24	21.73
40	0.5	2.7	5.5	16.4	6.55	32.73	65.45	196.35	0.80	4.01	8.03	24.08
42	0.6	3.0	6.0	18.1	7.22	36.08	72.16	216.48	0.89	4.43	8.85	26.55
44	0.7	3.3	6.6	19.8	7.92	39.60	79.19	237.58	0.97	4.86	9.71	29.14
46	0.7	3.6	7.2	21.7	8.66	43.28	86.56	259.67	1.06	5.31	10.62	31.85
48	0.8	3.9	7.9	23.6	9.42	47.12	94.25	282.74	1.16	5.78	11.56	34.68
50	0.9	4.3	8.5	25.6	10.23	51.13	102.27	306.80	1.25	6.27	12.54	37.63
52	0.9	4.6	9.2	27.7	11.06	55.31	110.61	331.83	1.36	6.78	13.57	40.70
53	1.0	4.8	9.6	28.7	11.49	57.45	114.91	344.72	1.41	7.05	14.09	42.28
54	1.0	5.0	9.9	29.8	11.93	59.64	119.28	357.85	1.46	7.31	14.63	43.89

E. While chlorine is being applied, the CONTRACTOR shall manipulate valves under the direction of the OWNER so that the treatment dosage will not flow back line that is supplying the water. The OWNER shall perform and document sufficient chlorine residual checks in the adjacent system to assure no highly chlorinated water is

introduced back into the water system. The CONTRACTOR , under the direction of the OWNER, shall continue the application of chlorine until the entire line being treated is filled with the chlorine solution. Contact time (CT) shall be equivalent to retaining an initial residual of 25 mg/l for 24 hours in the main. The OWNER shall document the date and time that the chlorine is added to the line and the initial chlorine concentration. Then the CONTRACTOR shall operate all valves and hydrants in the line being treated so that appurtenances can also be disinfected. After 24 hours, the treated water shall have a detectable free chlorine concentration throughout the line. The OWNER shall document the end chlorine concentration and the date and time it was recorded. Alternate methods using higher disinfectant residuals and shorter retention times may be used, with OWNER's consent, to reduce detention time as described in AWWA Standard C651.

F. After the applicable retention period, the CONTRACTOR shall flush the ~~heavily~~ hyperchlorinated water from the line until the chlorine concentration in the water leaving the main is no higher than that generally prevailing in the system, but not less than 0.20 mg/l. The CONTRACTOR shall perform such flushing only at sites where there is adequate drainage and as approved by the OWNER. The OWNER shall document the start and end date, time, and chlorine concentration of the final flush.

G. The CONTRACTOR at the discretion of the OWNER shall use dechlorination and/or other treatment techniques if the treated water flushed from the line presents a hazard to the environment.

H. The velocity of the water used to flush a line shall be at least 2.5 fps. The flow rates required to produce this velocity in various sizes of pipe are shown in Table II.

TABLE II
REQUIRED OPENINGS TO FLUSH PIPELINES
(40 PSI RESIDUAL PRESSURE)

Pipe Size (Inches)	Flow Required To Produce 2.5 fps Velocity (gpm)	Orifice Size (Inches)	Hydrant Outlet (Number)	Hydrant Nozzles Size (Inches)
4	100	15/16	1	2-1/2
6	220	1-3/8	1	2-1/2
8	390	1-7/8	1	2-1/2
10	610	2-5/16	1	2-1/2
12	880	2-13/16	1	2-1/2
14	1,200	3-1/4	2	2-1/2
16	1,565	3-5/8	2	2-1/2
18	1,980	4-3/16	2	2-1/2
20	2,440	--------	2	2-1/2

24	3,470	--------	2	2-1/2

I. The CONTRACTOR shall be responsible for maintaining sanitary conditions during handling, installation, and testing of mains, valves, blowoffs and other components as per *Section 4.3* of the current *AWWA Standard C651*. Reactive measures, such as flushing, shall not replace cleaning, swabbing, covering, and other preventive actions to insure components are installed with cleaned, disinfectant-wetted surfaces.

J. Upon completion of bacteriological testing, hydrostatic testing should be performed to ensure integrity of the new pipeline system.

3.2 BACTERIOLOGICAL TESTING FOR NEW MAINS

A. Once a new water line has undergone final flushing but before it is placed into service, the OWNER shall collect samples for bacteriological testing from both ends of the main line and the ends of any branch lines connected to the main line. In the case of extremely long lines, additional samples will be collected at intervals of approximately 2500 feet or as determined by the OWNER. Additional sampling may be required if the OWNER determines sanitary conditions have not been maintained.

B. Samples will be collected in sterile bottles containing sodium thiosulfate as specified by *Standard Methods for the Examination of Water and Wastewater*. A hose shall not be used to collect samples; as a last resort, fire hydrants may be used as sampling points. A corporation cock may be installed in the main with a copper-tube gooseneck assembly. After samples have been collected, the gooseneck assembly may be removed and retained for future use.

C. Two sets of samples taken 24 hours apart or one set of samples taken 48 hours or longer after flushing will be collected by the OWNER and tested for bacteriological quality by a state-certified laboratory. Each set of samples will consist of at least two samples representing water from both ends of the main line. If the initial disinfection fails to produce satisfactory samples, the CONTRACTOR at no cost to the OWNER will repeat disinfection and flushing until the two consecutive sample sets taken 24 hours apart produce satisfactory results.

D. When the samples tested are found to be satisfactory, the water line should be hydrostatically tested.

3.3 HYDROSTATIC PRESSURE TEST - Ductile Iron

A. All testing shall be scheduled with the OWNER.

B. Mains and services shall be pressure tested as a complete system or as directed by the OWNER.

C. All newly installed and backfilled pipe or any valved section thereof shall be subjected to a hydrostatic pressure test, conducted in the presence of the OWNER. If testing against a previously existing valve and the valve leaks, the CONTRACTOR shall be responsible for the valve. However, the OWNER shall not be liable for costs or lost time incurred by the CONTRACTOR when attempting to test a line against a faulty valve.

D. Water used to conduct the hydrostatic testing shall be of the same quality required for KUB tap water.

E. Each valved section of pipe shall be slowly filled with water, and a test pressure equal to the 1.5 times the normal working pressure (but not less than 200 psi) shall be applied for a minimum of 2 hours. Test pressure shall be based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge. A pump shall be connected to the pipe in a manner satisfactory to the OWNER. The CONTRACTOR shall furnish the labor and equipment, including the pump pipe, connections, gauges, and all necessary apparatus.

F. The hydrostatic pressure test shall be conducted by measuring, through a calibrated meter, the amount of water, which enters the test section under 200 psi or normal working pressures (whichever is greater) for a period or at least 2 hours. No installation will be accepted until the hydrostatic testing allowance is less than the number of gallons per hour as determined by the following formula:

$$L = \frac{SD\sqrt{P}}{148{,}000}$$

L = allowable leakage gallons/hour
S = length of pipeline tested, in feet
D = nominal diameter at the pipe, inches
P = average test pressure during the leakage test, psig

G. The following table has been developed for the commonly used sizes of ductile iron pipe with the nominal laying length of 20 feet, under a test pressure of 200 psi. The hydrostatic testing allowance formula above may be used when conditions differ from those stated parameters.

Pipe Diameter (Inches)	**Allowable Leakage per 1000 feet (Gallons/Hr)**
8	0.66
12	0.99
16	1.32

20	1.66
24	1.99
30	2.48
36	2.98

H. Cracked or defective pipes, fittings, valves, or hydrants discovered in consequence of this hydrostatic pressure test shall be replaced with sound material in the manner specified at no cost to the OWNER. The test shall be repeated until the results are satisfactory to the OWNER. A recording chart shall be used to document the results of the test if requested by the OWNER.

3.4 HYDROSTATIC PRESSURE TEST - HDPE

A. All testing shall be scheduled with the OWNER.

B. Mains and services shall be pressure tested as a complete system or as directed by the OWNER.

C. Water lines installed using HDPE pipe shall pass a hydrostatic pressure test pressure equal to the 1.5 times the normal working pressure (but not less than 200 psi) for a period of 2 hours minimum and 4 hours maximum.

D. The total test time including initial pressurization, initial expansion and time at test pressure shall not exceed eight hours. If the pressure test is not completed within 8 hours, the test section shall be depressurized, and allowed to relax for at least 8 hours before reapplying the test pressure.

E. Hydrostatic pressure test shall be conducted following manufacturer and accepted industry recommendations.

F. The OWNER shall be notified at least 24 hours prior to beginning any testing and shall be present during the test procedure. Test results shall be recorded in the as built drawings for the project including date, name of CONTRACTOR, name and signature of CONTRACTOR's employee responsible for testing, test pressure, and test duration. A recording chart shall be used to document the results of the test if requested by the OWNER.

G. Monitored make-up water test shall consist of an initial expansion and test phase. During the initial expansion phase, the test section is pressurized to the test pressure and sufficient make-up water is added each hour for three hours to return to the test pressure.

Make-up Water Allowance (gallons per 100 feet of pipe)

Nominal Pipe Size	1 Hour Test	2 Hour Test	3 Hour Test
2”	0.07	0.11	0.19
6”	0.3	0.6	0.9
8”	0.5	1.0	1.5
12”	1.1	2.3	3.4

After the initial expansion phase, about four hours after pressurization, the test phase begins. The test phase may be two or three hours after which a measured amount of make-up water is added to return to the test pressure. The amount of make-up water added shall not exceed the allowable make-up water allowance.

3.5 DISINFECTION PROCEDURE AFTER CUTTING INTO EXISTING LINES

A. The disinfection procedure for tie-ins on existing components is slightly different from that for new mains. Tie-ins made under pressure and where the components remain full will, in general, not require internal disinfection and sampling. Flushing and sampling is necessary when a tie-in requires the components to be dewatered and depressurized, as it presents the possibility of contamination being introduced into the system. The OWNER shall provide guidance as needed to the CONTRACTOR to determine proper action in these situations.

The general procedure for handling tie-ins is listed in the following steps:

1. Inspecting all materials to be used to ensure the integrity of the materials.
2. Preventing contaminating materials from entering the water main or components during storage and construction (trench treatment).
3. Disinfecting, swabbing, and cleaning replacement components prior to installation
4. Removing, by flushing or other means, those materials that may have entered the water main or other components.
5. Sampling to determine bacteriological quality by laboratory test after disinfection.
6. Returning the replacement components back into service after bacteriological samples are taken. It is permissible to return tie-in sections to service as soon as samples are taken and before results are obtained.
7. If necessary, removing the repaired components from service and repeating flushing and sampling until bacteriological samples are negative as directed by OWNER.

B. When an existing line is opened, whether by accident or design, the excavated area is subject to contamination from many sources, particularly under wet or muddy

conditions. The CONTRACTOR shall, as directed by the OWNER, apply liquid hypochlorite to disinfect the exposed trench area around the tie-in. Dry granular or tablet hypochlorite shall be used for pools of standing water due to the more controlled release of disinfectant. Application amount shall be sufficient to cause a faint chlorine odor and be reapplied as necessary to maintain sanitary conditions. These steps shall be repeated as necessary to minimize the possibility of contamination of the main, fittings, or other components.

C. The sampling procedure for a tie-in section, which has been dewatered and/or lost pressure is as follows:

1. The OWNER shall take a single bacteriological sample from a point, which represents the water in the tie-in area. If the direction of flow is unknown, two samples, one from each side of the tie-in area shall be taken. The main and other components can then be returned to service as soon as samples are taken. It is not necessary to wait until sample results are available before putting the main back into service.
2. If the sample is positive for coliform, repeat sampling by the OWNER shall include one sample from each side of the original sample point, as well as the point itself (total of three samples). The process shall be repeated until sampling results are negative. Additional flushing/disinfection may be required prior to taking the repeat samples.
3. Actions following positive sample results may vary according to regulatory requirements. The CONTRACTOR shall act at the direction of the OWNER until satisfactory sampling results are obtained.

END OF SECTION