

Appendix B SEWER AND WATER TESTING REQUIREMENTS

B.01 Gravity Sanitary Sewer Deflection Test

- a. Test 8 inch diameter and larger PVC, ABS, and PVC composite pipe for a maximum deflection of 5 percent not less than 30 days after final full backfill has been placed.
- b. Conduct deflection tests with a representative of the City present.
- c. The deflection probe shall be designed specifically for testing the deflection of the type and size of pipe subject to test.
- d. Conduct tests by pulling an approved deflection probe (mandrel), having a diameter not less than 95 percent of the base inside diameter or average inside diameter of the pipe, through the sewer line without mechanical pulling devices. Have a proving ring with an inside diameter equal to the outside diameter of the probe available at the time the probe is used, to verify that the probe has the proper diameter by inserting the probe into the ring. The pipe shall be measured in accordance with ASTM D2122.
- e. Repair or replace pipes exceeding a deflection of 5 percent and then retest until satisfactory test results are obtained. Upon obtaining satisfactory deflection test results, retest the affected sewer section for leakage.

B.02 Gravity Sanitary Sewer Leakage Testing

- a. Test all sanitary sewers, including service connections, for leakage by air testing in accordance with the following steps and ASTM F1417. In the event of conflict, the requirements of ASTM F1417 take precedence.
- b. Conduct air tests after backfilling. The contractor may conduct air tests before backfilling the trench as a check for defects and workmanship, but such tests are at the contractor's option and are not a substitute for tests required after backfilling has been completed.
- c. Test each section of pipe for obstructions prior to testing for leakage using mandrels, solid cylinders, or balls with diameters of 95 percent of the pipe diameter. Remove obstructions.
- d. Ensure that plugs used during leakage tests are of a length at least equal to the diameter of the pipe being tested to ensure a water-tight seal. Pneumatic plugs shall be able to resist internal pressures without external blocking.



- e. Dampen walls of air permeable pipe prior to conducting air tests. Dampening of the pipe walls and obstruction testing may be accomplished at the same time by propelling a snug-fitting inflated ball or other approved device through the pipe with water.
- f. Conduct an air test between each two consecutive manholes by plugging each end of the section to be tested and all pipe outlets in the section with suitable test plugs; one plug used at a manhole shall have an inlet tap or other provision for connecting an air hose from the air supply equipment.
- g. The equipment shall include valves to control the rate at which air flows into the test section and pressure gages with minimum graduations of 0.1 psi and an accuracy of +/- 0.04 psi to monitor the air pressure within the test section.
- h. Apply air pressure slowly to the test section until the pressure reaches 4.0 psi, plus an adjustment of 0.433 psi for each foot of ground water above the pipe crown in the line being tested. Internal air pressure, including adjustment for ground water, should never exceed 5.0 psi.
- i. When the pressure reaches 4.0 psi, plus adjustment for ground water, throttle the air supply so that the internal pressure is maintained between 4.0 and 3.5 psi for at least 2 minutes to permit temperature stabilization. When the pressure has stabilized at 3.5 psi or above, disconnect the air supply, start a stopwatch, and allow stopwatch to run until the pressure has dropped 1.0 psi.
- j. Calculate the permissible time allocated for the 1.0 psi pressure drop on the basis of the diameter and length of main sewer tested, no adjustment being made for service connections included in the test section. The air test for a section shall be considered acceptable if the time elapsed for the 1.0 psi pressure drop is equal to or greater than the time indicated, and shall be considered unacceptable if the elapsed time is less than that indicated in the following tables:
- k. For sewers of all pipe types, except plastic:

Minimum Holding Time In Minutes Required For 1.0 psi Pressure Drop						
Nominal Pipe Diameter (Inches)	Length Of Main Line Tested *					
	100'	200'	300'	400'	500'	600'
4	0.3	0.6	0.9	1.2	1.5	1.8
6	0.7	1.4	2.1	2.8	3.5	4.2
8	1.2	2.4	3.6	4.8	6.0	7.2
10	1.5	3.0	4.5	6.0	7.5	9.0
12	1.8	3.6	5.4	7.2	9.0	10.8
15	2.1	4.2	6.3	8.4	10.5	12.6



Minimum Holding Time In Minutes Required For 1.0 psi Pressure Drop						
Nominal Pipe Diameter (Inches)	Length Of Main Line Tested *					
	100'	200'	300'	400'	500'	600'
18	2.4	4.8	7.2	9.6	12.0	14.4
21	3.0	6.0	9.0	12.0	15.0	18.0
24	3.6	7.2	10.8	14.4	18.0	21.6
27	4.2	8.4	12.6	16.8	21.0	25.2

* Interpolate time for intermediate lengths.

- I. For sewers of plastic pipe only:

Minimum Holding Time In Minutes:Seconds Required For 1.0 psi Pressure Drop **								
Nominal Pipe Diameter (Inches)	Length Of Main Line Tested *							
	100'	150'	200'	250'	300'	350'	400'	450'
4	3:46	3:46	3:46	3:46	3:46	3:46	3:42	3:46
6	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
21	19:50	26:10	34:54	43:37	52:21	61:00	69:48	78:31
24	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33
27	28:51	43:16	57:41	72:07	86:32	100:57	115:22	129:48

* Interpolate time for intermediate lengths.

** If the test section fails and service connections were included in the test, re-compute test time to include service connections in accordance with 9.6 of ASTM F1417.

- m. Sewers 30 Inches in Diameter and Larger: Conduct individual air tests at joints and lift holes, along with visual inspection. Perform air tests in accordance with all applicable requirements of sanitary sewer leakage testing for pipes smaller than 30 inches in diameter, with a test to be acceptable if the pressure holds or drops less than 1 psi in 5 seconds.

B.03 Manhole Tests

- a. Test each manhole after assembly and after all lift holes have been plugged with non-shrink grout and, at the contractor's option, before or after completing backfilling.



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- b. Test by drawing a vacuum on the manhole using equipment specifically designed for such testing.
- c. Plug and brace pipes entering the manhole to prevent being drawn into the manhole.
- d. Place a test head with necessary gages and connections at the inside of the top of the cone section and seal in accordance with the manufacturer's instructions.
- e. Draw a vacuum of 10 inches of mercury and then shut the vacuum pump off.
- f. With valves closed, measure the time for the vacuum to drop to 9 inches. The test shall be successful if the time measured meets or exceeds the values indicated in the following table:

Minimum Test Times In Seconds						
Manhole Depth	Manhole Diameter *					
	48"	60"	72"	84"	96"	108"
8' or less	20	26	33	40	48	56
10'	25	33	41	50	58	67
12'	30	39	49	59	69	79
14'	35	46	57	68	80	92
16'	40	52	65	77	91	104
18'	45	59	73	87	102	116
20'	50	65	81	97	113	129
22'	55	72	89	106	123	140
24'	59	78	97	116	135	152
26'	64	85	105	125	148	168
28'	69	91	113	135	157	179
30'	74	98	121	144	168	192
32'	79	104	128	154	179	204
34'	83	110	136	162	190	217
36'	88	116	144	172	201	229
38'	93	122	152	182	213	242
40'	97	128	159	191	223	254

* When there is a transition involved, add the times for each size based on the depth associated with each size.

B.04 Repair / Replacement of Sanitary Sewers

- a. For any sewer test section failing to meet the limits of the requirements of the City, locate and remedy the defects causing the failure, retest the section, and continue repairs or replacement until the limits of the Specifications are satisfied.
- b. For sewers not accessible, should a test fail due to other than a leaking plug, conduct a closed circuit television inspection of the test section to determine the cause of the



failure.

- c. When failure is the result of a leaking sewer joint, the joint may be chemically grouted.
- d. Television inspection and chemical grouting of sewer joints shall comply with all applicable "Recommended Specifications for Sewer Collection System Rehabilitation" of the National Association of Sewer Service Companies as approved by the City. Furnish the City video tapes of all television inspections.
- e. If a manhole test is unsuccessful, make repairs and retest until a satisfactory test is obtained.
- f. Repair all visible leakage in sewers and manholes, even though tests may have been satisfactory.

B.05 Pressure and Leakage Testing for Force Mains

- a. Ductile Iron Pipe Force Mains
 - (1) Test all ductile iron pipe force mains for leakage in accordance with the following steps and AWWA C600. In the event of conflict, the requirements of WWA C600 take precedence.
 - (2) Isolate main from adjacent existing main and new main of differing pipe materials, and apply pressure by pumping clean water from a container into the main via 1 inch corporation stops.
 - (3) Test pressure shall be 150 psi unless valves in existing mains are involved within section of new main being tested, in which case test pressure may be 100 psi if City determines that the older existing valves may not seal properly; and shall not vary by more than +5 psi.
 - (4) Start pressure test in an afternoon and keep pressure on for 18 hours, and then maintain test pressure for an additional 2 hours by pumping water from the container into the main.
 - (5) At the end of the 2 hour period, measure the water used.
 - (6) Loss by leakage shall not exceed that as determined by the following formula in which L is the allowable leakage in gallons per hour; S is the length of pipe tested in feet; D is the nominal diameter of the pipe in inches; and P is the average test pressure during the leakage test in pounds per square inch gage.



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

- (7) When testing against closed metal-seated valves, allow an additional leakage per closed valve of 0.0078 gallons/hour/inch of nominal valve size.
- (8) Pressure test at each side of intermediate valves at this time by shutting each valve, exhausting the pressure on one side, and applying the test pressure of 150 psi or more to the main on the opposite side of the valve for approximately 10 minutes as determined by the City. Repeat this procedure for each intermediate valve.

b. PVC Pipe Force Mains

- (1) Test all PVC pipe force mains for leakage in accordance with the following steps and AWWA C605. In the event of conflict, the requirements of WWA C600 take precedence.
- (2) Isolate main from adjacent existing main and new main of differing pipe materials, and apply pressure by pumping clean water from a container into the main via 1 inch corporation stops.
- (3) Test pressure shall be 150 psi, unless valves in existing mains are involved within section of new main being tested, in which case test pressure may be 100 psi if the City determines that the older existing valves may not seal properly; and shall not vary by more than +5 psi.
- (4) Start pressure test in an afternoon and keep pressure on for 18 hours, and then maintain test pressure for an additional 2 hours by pumping water from the container into the main.
- (5) At the end of the 2 hour period, measure the water used.
- (6) Loss by leakage shall not exceed that as determined by the following formula in which L is the allowable leakage in gallons per hour; N is the number of joints in the length of pipe tested; D is the nominal diameter of the pipe in inches; and P is the average test pressure during the leakage test in pounds per square inch gage.

$$L = \frac{ND\sqrt{P}}{7,400}$$

- (7) When testing against closed metal-seated valves, allow an additional leakage per closed valve of 0.0078 gallons/hour/inch of nominal valve size.



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- (8) Pressure test at each side of intermediate valves at this time by shutting each valve, exhausting the pressure on one side, and applying the test pressure of 150 psi or more to the main on the opposite side of the valve for approximately 10 minutes as determined by the City. Repeat this procedure for each intermediate valve.

c. Polyethylene Pipe Force Mains

- (1) Test all Polyethylene pipe force mains for leakage in accordance with the following steps.
- (2) Isolate main from adjacent existing main and new main of differing pipe materials, and apply pressure by pumping clean water from a sterilized container into the main via 1 inch corporation stops.
- (3) Remove all free air from the test section, and raise the pressure at a steady rate to 150 psi and allow to stand without makeup pressure for sufficient time, usually 2 to 3 hours, to allow for expansion of the pipe. Measure pressure as close as possible to the lowest point of the test section.
- (4) After equilibrium is established, pressurize the test section to 150 psi, turn off the pump, and hold the final test pressure for 2 hours.
- (5) Measure the amount of water required to return the test section to 150 psi. Allowable amounts of water for expansion during the pressure test shall not exceed those in the following table:

Allowances For Expansion* (U.S. Gallons Per 100 Feet Of Pipe)	
Nominal Pipe Diameter (Inches)	2 Hour Test
6	0.60
8	1.0
10	1.30
11	2.0
12	2.3
14	2.8
16	3.3
18	4.3
20	5.5
22	7.0
24	8.8

* These allowances only apply to the test period and not to the initial expansion phase.



- (6) Under no circumstances shall the total time under test pressure exceed 8 hours. If a test is not completed due to leakage, equipment failure, etc., the test section shall be allowed to “relax” for 8 hours prior to the next test.
- (7) If main and valves do not pass the leakage test, locate and repair the leak or leaks, and repeat testing procedure until successful. Repair visible leaks regardless of the amount of leakage.
- (8) Pressure and leakage testing is the responsibility of the Contractor, who shall provide all materials, labor, and equipment, and pay for the total volume of water used.

d. Completion of Tests

- (1) After successful completion of testing, mains shall be flushed and cleaned and all connections made prior to acceptance.

B.05 Pressure and Leakage Testing for Water Mains

- a. Subject all mains to a pressure and leakage test before connecting to existing mains and before making connections between water mains of differing pipe materials.
- b. Test each valve-to-valve section separately. If the contractor elects to test more than one valve-to-valve section, the allowable leakage for the test will be based upon the shortest valve-to-valve section in the test.
- c. Ductile Iron Pipe
 - (1) Perform in accordance with AWWA C600 and the following.
 - (2) Isolate main from adjacent existing main and new main of differing pipe materials, and apply pressure by pumping clean water from a sterilized container into the main via 1 inch corporation stops.
 - (3) Test pressure shall be 150 psi, unless valves in existing mains are involved within section of new main being tested, in which case test pressure may be 100 psi if the City determines that the older existing valves may not seal properly; and shall not vary by more than +5 psi.
 - (4) Start pressure test in an afternoon and keep pressure on for 18 hours, and then maintain test pressure for an additional 2 hours by pumping water from the container into the main.
 - (5) At the end of the 2 hour period, measure the water used.



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- (6) Loss by leakage shall not exceed that as determined by the following formula in which L is the allowable leakage in gallons per hour; S is the length of pipe tested in feet; D is the nominal diameter of the pipe in inches; and P is the average test pressure during the leakage test in pounds per square inch gage.

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

- (7) When testing against closed metal-seated valves, allow an additional leakage per closed valve of 0.0078 gallons/hour/inch of nominal valve size.
- (8) When hydrants are in test section, perform test with closed hydrant valves.
- (9) Pressure test at each side of intermediate valves at this time by shutting each valve, exhausting the pressure on one side, and applying the test pressure of 150 psi or more to the main on the opposite side of the valve for approximately 10 minutes as determined by the City. Repeat this procedure for each intermediate valve.

d. PVC Pipe Material

- (1) Perform in accordance with AWWA C605 and the following.
- (2) Isolate main from adjacent existing main and new main of differing pipe materials, and apply pressure by pumping clean water from a sterilized container into the main via 1 inch corporation stops.
- (3) Test pressure shall be 150 psi, unless valves in existing mains are involved within section of new main being tested, in which case test pressure may be 100 psi if the City determines that the older existing valves may not seal properly; and shall not vary by more than +5 psi.
- (4) Start pressure test in an afternoon and keep pressure on for 18 hours, and then maintain test pressure for an additional 2 hours by pumping water from the container into the main.
- (5) At the end of the 2 hour period, measure the water used.
- (6) Loss by leakage shall not exceed that as determined by the following formula in which L is the allowable leakage in gallons per hour; N is the number of joints in the length of pipe tested; D is the nominal diameter of the pipe in inches; and P is the average test pressure during the leakage test in pounds per square inch gage.



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$$L = \frac{ND\sqrt{P}}{7,400}$$

- (7) When testing against closed metal-seated valves, allow an additional leakage per closed valve of 0.0078 gallons/hour/inch of nominal valve size.
- (8) When hydrants are in test section, perform test with closed hydrant valves.
- (9) Pressure test at each side of intermediate valves at this time by shutting each valve, exhausting the pressure on one side, and applying the test pressure of 150 psi or more to the main on the opposite side of the valve for approximately 10 minutes as determined by the City. Repeat this procedure for each intermediate valve.

e. Polyethylene Pipe Material

- (1) Perform in accordance with the following.
- (2) Isolate main from adjacent existing main and new main of differing pipe materials, and apply pressure by pumping clean water from a sterilized container into the main via 1 inch corporation stops.
- (3) Remove all free air from the test section, and raise the pressure at a steady rate to 150 psi and allow to stand without make-up pressure for sufficient time, usually 2 to 3 hours, to allow for expansion of the pipe. Measure pressure as close as possible to the lowest point of the test section.
- (4) After equilibrium is established, pressurize the test section to 150 psi, turn off the pump, and hold the final test pressure for 2 hours.
- (5) Measure the amount of water required to return the test section to 150 psi. Allowable amounts of water for expansion during the pressure test shall not exceed those in the following table:

Allowances For Expansion* (U.S. Gallons Per 100 Feet Of Pipe)	
Nominal Pipe Diameter (Inches)	2 Hour Test
6	0.60
8	1.0
10	1.30
11	2.0
12	2.3
14	2.8



16	3.3
18	4.3
20	5.5
22	7.0
24	8.8

* These allowances only apply to the test period and not to the initial expansion phase.

- (6) Under no circumstances shall the total time under test pressure exceed 8 hours. If a test is not completed due to leakage, equipment failure, etc., the test section shall be allowed to “relax” for 8 hours prior to the next test.
- (7) If main and valves do not pass the leakage test, locate and repair the leak or leaks and repeat testing procedure until successful. Repair visible leaks regardless of the amount of leakage.
- (8) Pressure and leakage testing is responsibility of the contractor, who shall provide all materials, labor, and equipment, and pay for the total volume of water used.

f. Completion of Tests

- (1) When disinfection and all tests on the water main have been successfully completed, main will be placed in service by the City.
- (2) No further Work on the main, valves, hydrants, and appurtenances will be permitted without full knowledge of the Work by the local official in charge of the water works system and the City.

B.06 Disinfection of Water Mains

- a. Comply with AWWA C651, except after flushing to remove sediment and other foreign matter, and after testing for leaks, disinfect the water mains by the addition and thorough dispersion of a chlorine solution in concentrations sufficient to produce a chlorine residual of at least 50 mg/l in the water throughout the mains, and allowing the solution to remain in contact with the interior surfaces of the main for a period of 24 hours.
- b. Preparation
 - (1) Verify that mains have been tested for leakage.
 - (2) Provide corporation stops required for exhausting air, for samples for testing of chlorine residual, and for chlorine solution injection.
 - (3) Flush mains to remove sediment and other foreign matter.



- (4) Exhaust air at fire hydrants and 1 inch corporation stops inserted at extremities and high points of the main, and at bacteria sampling and flushing assemblies.
- (5) Tests for chlorine residual will be performed by the City.
- (6) Manipulate existing valves so strong chlorine solution in the main being treated will not flow back into the mains supplying the water. Operation of existing valves will be by the City.

c. Mains Less Than 24 Inches in Diameter - Tablet Method

- (1) Provide an average chlorine dose of 25 mg/l by placing calcium hypochlorite granules or 5 gram tablets in main as it is being installed.
- (2) Place granules at upstream end of first pipe section, at the upstream end of each branch main and at 500 feet intervals in the following quantities, based on pipe diameter:

Nominal Pipe Diameter (Inches)	Calcium Hypochlorite Granules (Ounces)
4	1.7
6	3.8
8	6.7
10	10.5
12	15.1
14 and larger	D ² x 15.1

Where D is the inside pipe diameter in feet $D = d/12$

- (3) Place tablets in each pipe section, with number of tablets determined by the formula $0.0012d^2L$ rounded to the next highest integer, where d is the nominal inside diameter of pipe in inches, and L is the length of pipe section in feet, and place 1 tablet in each hydrant, hydrant branch, and other appurtenance. Attach tablets using a USDA approved food grade adhesive on only the side attached and at the inside top of the pipe upon pipe installation, and with approximately equal number of tablets at each end of a given pipe length.
- (4) Fill main with potable water such that water within the main will flow at a velocity no greater than 1 fps.
- (5) Take precautions as necessary to ensure air pockets are eliminated.
- (6) Keep water in pipe at least 24 hours, except if water temperature is less than 41 degrees F, then keep water in pipe at least 48 hours. A detectable chlorine residual



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should be found at each sampling point after the 24 hour period.

d. Mains Less Than 24 Inches in Diameter - Continuous Feed Method

- (1) Exhaust all air in main and flush main as thorough as possible with water pressure and outlets available. If no hydrant is installed at end of main, provide a tap large enough to develop a minimum 2.5 fps velocity in main. Disinfection can be accomplished by injecting a 1 percent chlorine solution into the main at a point not more than 10 feet downstream from beginning of new main. Pump potable water for the injector for delivering the 1 percent chlorine solution from a clean and sterile container. Control flow of water from the existing distribution system or other approved potable water source so as to flow slowly into new main during chlorine application, with rate of chlorine application in such proportion to the rate of water entering the main that the solution of clean water and chlorine in the main will have 25 mg/l minimum free chlorine.
- (2) Keep the solution in the main for 24 hours, during which time all valves and hydrants in the treated section shall be operated to ensure disinfection of appurtenances.
- (3) At the end of the 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. Mains 24 Inches in Diameter and Larger - Slug Method

- (1) Place calcium hypochlorite granules in main during construction.
- (2) Fill the main slowly and completely and exhaust all air.
- (3) Flush to remove particulates.
- (4) Flow a slug of water with 100 mg/l chlorine concentration slowly through main so the main and its appurtenances will be exposed to the highly chlorinated water for minimum 3 hours. If at any time the free chlorine residual in the slug drops below 50 mg/l, stop the flow, relocate the chlorination equipment at the head of the slug, and as flow is resumed, apply chlorine to restore the free chlorine in the slug to minimum 100 mg/l.
- (5) Operate valves and hydrants as the chlorinated water flows past to disinfect appurtenances and pipe branches.

f. Finalizing Chlorination:

- (1) After the applicable retention period thoroughly flush the main out with potable water from the distribution system until the main has approximately the same chlorine



content as water in the existing system.

- (2) Properly dispose of heavily chlorinated water. Provide required neutralizing chemical to neutralize the chlorine residual if there is any possibility that the chlorinated discharge will damage the environment.

g. Bacteriological Tests:

- (1) Bacteriological tests shall be performed before a main is placed in service.
- (2) At least two samples taken at 24 hour intervals shall show the water to be safe.
- (3) At least one set of samples shall be collected from every 1200 feet of new water main, plus one set from the end of the line and at least one set from each branch.
- (4) Before taking a sample, allow the water to flow from the sampling point for at least 1 minute. Thoroughly flame the outlet to kill all bacteria. Nothing should be allowed to touch the lip or top of the sample bottle while the sample is being taken. No hose or fire hydrant shall be used in the collection of samples.
- (5) If bacteriological tests show the water to be safe, the main may be placed in service.
- (6) If bacteriological tests show the water to be unsafe, the main shall be completely disinfected again by the Contractor, at no additional cost to the City.

h. Field Quality Control

- (1) When all tests on the water main have been successfully completed, the main will be placed in service by the City and no further Work on the main or its valves will be permitted without full knowledge of the work by the local official in charge of the water works system and the City.

