SECTION 33 05 05.30
SEWER SYSTEM TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Testing of all gravity sewer pipe, laterals and manholes.

B. Related Sections:
   1. 01 33 00 Submittal Process
   2. 33 31 11 Gravity Sewer Piping
   3. 33 05 61 Sanitary Sewerage Manholes

1.02 REFERENCES

A. American Society of Testing Materials
   1. C1091 Standard Test Method for Hydrostatic Infiltration and Exfiltration Testing of Vitrified Clay Pipe Lines
   2. C1244 Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill
   3. D3034 Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings

1.03 CONTRACTOR SUBMITTALS

A. Submittals shall be made in accordance with the Section 01 33 00 Submittals Process

B. The contractor shall notify the District a minimum of 3 business days in advance of its proposed testing schedule for review and concurrence.

C. A testing plan shall be submitted to the District that includes a testing schedule, including proposed plans for bypassing flows (if any), control and disposal. Following approval of testing plan, the District and any impacted services shall receive a minimum three business day notice before implementation.

D. Testing plan shall include information for all test equipment to be used, including valves, plugs, mandrels, gauges, or other control equipment and materials shall be determined and furnished by the contractor, subject to District review. No materials shall be used which would be injurious to the construction or its future function.

1.04 QUALITY ASSURANCE

A. Comply with Section 01 43 00 Quality Assurance.

PART 2 PRODUCTS

2.01 MATERIALS REQUIREMENTS

A. All test equipment, chemicals for disinfection, temporary valves, bulkheads, or other water control equipment and materials shall be determined and furnished by the Contractor subject to the Engineer's approval. No materials shall be used which would be injurious to the construction or its future function.

PART 3 EXECUTION

3.01 GENERAL

A. Unless otherwise provided herein, water for testing gravity sewer pipe, laterals and manholes will be furnished by STPUD; however, the Contractor shall make all necessary provisions for conveying the water from STPUD-designated source to the points of use.

B. Prior to final approval by the District, all sewer mains and appurtenances shall be subjected to a test or tests that will determine their degree of water tightness and test or tests that will ascertain the correctness of their horizontal and vertical alignment.

C. When other underground utilities are to be installed as a part of the construction or as a part of a larger project or subdivision related to the sewer installation, testing shall be conducted after all other utilities have been installed in the area of the new sewer line and laterals. This does not preclude the Contractor from also conducting testing at earlier times to ensure to himself that the lines were acceptably installed prior to other utility work in the area.

D. All tests shall be performed under the direct observation of the District or its authorized representatives.

E. Any remedial work required to correct construction deficiencies discovered as a result of any official test or inspection shall be accomplished by the Contractor in a manner approved by the District and at the sole expense of the Contractor. Portions of the original construction which require remedial work shall be completely retested and/or reinspected following the attempted rectification by the Contractor.

3.02 CLEANING

A. Before any test is performed, the pipe installation shall be cleaned in the following manner:
   1. The Contractor shall furnish an inflatable spherical rubber ball of a size that will inflate to fit snugly into the pipe to be tested.
   2. The ball shall be placed in the uppermost manhole on the pipe to be cleaned, and water shall be introduced behind it.
   3. The ball shall pass through the pipe with only the force of the water impelling it.

4. All debris flushed out ahead of the ball shall be removed at the first manhole where its presence is noted. In the event cemented or wedged debris or a damaged pipe shall stop the ball, the Contractor shall remove the obstruction and/or make necessary repairs.

3.03 TESTING OF SEWER MAINS

A. Mandrel Test for Mandrel Test for Gravity Sewers - After completion of the sewer line, including all required backfilling and cleaning, his test may be required on all or selected sections of the project area. At the option of the District, deflection testing shall be conducted not less than 30 days following installation of pipe. A deflection test limit of 7.5% of the pipe base inside diameter is adopted. This test shall be conducted under the direct observation of the District personnel using a properly sized "go, no-go" deflection mandrel constructed in accordance with ASTM specification D3034. The mandrel shall be furnished by the Contractor and meet with the District's approval. The mandrel shall be hand pulled through the pipe. No devices except the tow rope can be utilized to assist the mandrel through the pipe. Locations with excessive deflection shall be repaired. The following table lists pipe and 7.5% deflection mandrel sizes:

SDR 26 Pipe Size, Inches	Base Inside Diameter, Inches	7.5% Deflection Mandrel Diameter Inches
6	5.612	5.19
8	7.488	6.93
10	9.342	8.64
12	11.102	10.27
15	13.575	12.56

B. After the Mandrel Test, an infiltration or exfiltration test shall be required.
   1. An infiltration test shall be used when, through dewatering efforts, field observation, or via monitoring well, it is determined that groundwater is 5 feet or more above the crown of pipe at the midpoint of the test section. All pipes leading into the specified sewer test section shall be completely plugged by the Contractor with mechanical stoppers so that no water introduced into the section can escape through the mains, branch sewers or service laterals. Conduct in accordance with ASTM C1091 Standard Test Method for Hydrostatic Infiltration Testing of Vitrified Clay Pipe Lines, as follows:

      a. Cease dewatering activities for at least 3 days for the pipe section to be tested.
      b. Plug the upstream end of the pipeline to be tested to prevent the entrance of water or wastewater, while providing any required bypass pumping.
      c. Measure volume of infiltration, with the maximum rate or volume of groundwater entering the pipe as follows:

E = 0.00002*L*D*(H)^0.5

Where:

L: Length of pipeline (ft)

E: Allowable leakage in gallons per minute of pipeline tested

D: Internal diameter of the pipe (in)

H: Difference in elevation (ft) between the water surface in the upper manhole and the invert of the pipe at the lower manhole; or, if groundwater is present above the invert of the pipe in the lower manhole, the difference in elevation between the water surface in the upper manhole and the groundwater at the lower manhole.

2. Exfiltration Test: Where the sewer line is above the water table, an exfiltration test shall be used.
   a. All pipes leading into the specified sewer test section shall be completely plugged by the Contractor with mechanical stoppers so that no water introduced into the section can escape through the mains, branch sewers or service laterals.
   b. The Contractor shall then fill the test section with water and continue to introduce water into the section until a static head of water five feet (5') above the top of the pipe or pipes at the most elevated point of the test section has been established.
   c. The Contractor shall then measure and record at approved periodic intervals a total test time of not less than four (4) hours, the volume of water added to the test section in order to maintain a total static head of water five feet (5') above the highest top of pipe elevation.
   d. A single manhole section shall not be acceptable if the exfiltration from it exceeds the rate of fifty (50) gallons per inch nominal diameter of main pipe per mile of length in twenty four (24) hours.
   e. A group of one (1) or more manhole sections, or the complete system of sections as an average, shall not be acceptable if the exfiltration from them exceeds the rate of fifty (50) gallons per inch nominal diameter of main pipe per mile of length in twenty four (24) hours.

3.04 TESTING FOR MANHOLES

A vacuum test or exfiltration test shall be used for testing manholes, as follows:

A. Vacuum Test:
   1. Procedures outlined in ASTM C1244 should be followed while completing the vacuum test.
   2. Use acceptable equipment approved by the District. Vacuum test equipment shall be used per the manufacturer’s specifications.

3. A vacuum of 10-inches mercury should be drawn on the manhole. The time, in seconds, for the vacuum to drop to 9-inches mercury shall be measured and shall not be less than the times listed below for manholes.

Time (s)	Manhole Diameter (in)
60	48
75	60
90	72

4. Manholes showing leakage in excess of that allowed (time less than that indicated in table) shall be repaired or reconstructed as necessary to reduce the leakage to that specified. All failures shall be retested after the necessary repairs have been completed.

B. Manhole Exfiltration Test

1. Water tightness of manholes may be tested in connection with tests of sanitary sewers or at the time the manhole is completed and backfilled. The test shall be as follows:

2. The contractor shall plug all inlets and outlets with approved stoppers or plugs.

3. The manhole shall be filled with water to the top of the frame.

4. The water shall stand in the manhole for a minimum of one hour to allow the manhole material to reach maximum absorption.

5. The contractor shall refill the manhole to the original depth.

6. The time of the test will be determined by the District to fit the various field conditions.

7. The manhole shall be refilled to the original depth and the amount of water required to fill the manhole shall be recorded after a minimum of four (4) hours.

8. If the amount of water added does not exceed the limits shown in Table II, then the manhole has passed the test. Even though the leakage may be less than the specified amount, the contractor shall stop any leaks that may be observed to the satisfaction of the District.

TABLE II – Manhole Exfiltration Volumes

Depth of Manhole (ft.)	Allowable Amount of water added (gal.)
0-5	1
6-7	1-1/2
8-10	2
11-12	2-1/2
13-15	3
16-18	3-1/2
19-20	4

3.05 VIDEO TESTING

A. Video Test- All sewer collectors and laterals shall be T.V. inspected prior to pavement placement when the complete job is ready for television inspection based on the following work having been completed and approved by the District:

1. All sewer pipelines are installed, backfilled, and compacted.

2. All manholes are in place, all channeling is complete and pipelines are accessible from manholes, and testing completed.

3. All other underground facilities, utility piping and conduits are installed.

4. Final sub grade is complete. For wet weather periods, placement of aggregate base has been completed.

5. Pipelines to be inspected have been cleaned and flushed

6. Final infiltration or exfiltration test has been completed

B. After the above work is complete, the contractor shall schedule the video inspection. The video test shall be done in the presence of the District's inspector. Water is to flow through the lines for 12 hours prior to the T.V. work. During the video for service, water must be present for camera orientation. The camera shall have a device to measure depths of any sags.

C. If no deficiencies are observed, the work will be considered satisfactory.

D. A videotape will be made and given to the District; defects requiring corrections will be determined by the District.

E. Notification will be made in writing of any deficiencies revealed by the video that will require repair. If corrective work is indicated and viewing of the videotapes is desired, the District shall be contacted to set a time for the viewing with the Engineer.

F. Corrective work shall be done in accordance with the specifications following approval by the District. District reserves the right to require another test of any repair.

G. Those portions of the pipeline system that have been corrected will be re-inspected.

H. The following observations from television inspections will be considered defects in the construction of sewer pipelines and will require correction prior to paving:

1. Low spots, in excess of allowable sags

2. Joint separations

3. Cocked joints present in straight runs or on the wrong side of pipe curves

4. Cracked or damaged pipe

5. Dropped joints

6. Infiltration

7. Debris or other foreign objects

8. Other obvious deficiencies

9. Irregular condition without logical explanation

10. Standing water in service laterals

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SECTION 33 11 13

WATER DISTRIBUTION PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: PVC pipe, ductile iron pipe, steel pipe and HDPE pipe for water distribution, including fittings and joints.

B. Related Sections:
1. 31 20 00 Earthwork
2. 31 23 19 Dewatering
3. 33 12 13 Water Service Connections
4. 33 12 16 Water Distribution Valves
5. 33 13 00 Water Pipeline Testing and Disinfection

1.02 REFERENCES

A. American Water Works Association
1. C110 Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In.
2. C111 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
3. C104 Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
4. C105 Polyethylene Encasement for Ductile-Iron Pipe Systems
5. C115 Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
6. C150 Thickness Design of Ductile Iron Pipe
7. C151 Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids
8. C153 Ductile-Iron Compact Fittings for Water Service
9. C200 Steel Water Pipe – 6 in. and Larger
10. C206 Field Welding of Steel Water Pipe
11. C207 Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In.
12. C208 Dimensions for Fabricated Steel Water Pipe Fittings
13. C600 Installation of Ductile-Iron Water Mains and their Appurtenances
14. C606 Grooved and Shouldered Joints
15. C900 PVC Pressure Pipe and Fabricated Fittings, 4 In. Through 12 In.
16. C905 PVC Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In.
17. M11 Steel Pipe: A Guide for Design and Installation
18. M23 PVC Pipe – Design and Installation

B. American Society of Testing and Materials (ASTM)
1. A36 Carbon Structural Steel
2. A47 Ferritic Malleable Iron castings
3. A139 Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over)
4. A183 Carbon Steel Track Bolts and Nuts
5. A307 Carbon Steel Bolts and Studs
6. A536 Ductile Iron Castings
7. A572 High Strength Low Alloy Columbian-Vanadium Structural Steel

8. D638 Test Method for Tensile Properties of Plastics
9. D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
10. D1248 Polyethylene Plastics Extrusion Materials For Wire and Cable
11. D1505 Test Method for Density of Plastics by the Density-Gradient Technique
12. D2240 Test Method for Rubber Property - Durometer Hardness
13. D2241 PVC Pressure-Rated Pipe (SDR Series)
14. D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
15. D3350 Polyethylene Plastics Pipe and Fittings Materials
16. F894 Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
17. F714 Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

C. American Society of Mechanical Engineers (ASME)
1. B16.1 Cast Iron Pipe Flanges and Flanged Fittings

D. Underwriters Laboratory (UL)
1. 1285 Pipe and Couplings, Polyvinyl Chloride (PVC), and Oriented Polyvinyl Chloride (PVCO) for Underground Fire Service.

1.03 SUBMITTALS

A. Shop Drawings:
   a. Indicate thickness of pipe wall, lining and coating, type of joint and joint restraint, if any.
   b. Details of straight pipe, fittings, and specials, showing thickness and dimensions of plates, detail of welds, and materials; listing of proposed service and tabulated layout schedules.

B. Project Redlines: The Contractor shall provide project redlines for all piping installed, including but not limited to valves locations, meter boxes, and hydrants, in accordance with Section 01 33 00 2.08.

C. Test Results:
1. All pipe: All materials testing shall be based upon applicable ASTM Test Methods referenced herein for the materials specified. A report of the test results shall be furnished. All costs of such inspection and tests shall be borne by the Contractor.
2. HDPE:
   a. The pipe shall be tested for dimensions, ring stiffness constant (RSC), flattening, and joint tightness, in accordance with the requirements of ASTM F894. A report of the test results shall be furnished.
   b. The stress regression testing shall have been done in accordance with ASTM D2837, and the manufacturer shall provide a product supplying a minimum Hydrostatic Design Basis (HDR) of 1,600 psi, as determined in accordance with ASTM D2837.
3. Fusible PVC:
   a. Submit manufacturer's specific technical data with complete information on physical properties of pipe and pipe dimensions pertinent to this job

b. Complete calculations including lists of parameters, all formulas and all other data showing the design of the new pipe.
c. Qualification of fusion technicians shall be documented by the pipe supplier, and shall be current as of the date of the welding for the project.
d. Contractor shall register and/or record the parameters required by the pipe supplier and these Specifications, and provide them to the District as the Work proceeds.

D. Certification:
1. All pipe:
a. Manufacturer's certificates of compliance shall be furnished by the Contractor.
b. A certificate of “Compliance with Specification” or suitable alternative shall be furnished for all materials to be supplied.
2. HDPE:
a. The Contractor shall provide certification from the pipe manufacturer that stress regression testing has been performed on the specific product. The said certification shall include a stress life curve per ASTM D2837. The certification shall state that the pipe was manufactured from one specific resin in compliance with these specifications. The certificate shall state the specific resin used, its source, and list its compliance to these specifications.
b. Provide certification that the pipe conforms to dimensions and tolerances specified in Part 2.02 and that the pipe has been inspected and meets industry accepted manufacturer standards.

PART 2 PRODUCTS

2.01 GENERAL

A. All pipe shall be new, not from manufacturer’s inventory.

B. Any pipe that does not meet specifications or has been rejected, shall be removed from the jobsite and disposed of by the Contractor at no extra cost to the Owner.

C. Where new fittings are to be cut into or attached to existing piping or where connections are to be made to existing piping, the Contractor shall furnish and install the necessary sleeves, flanges, nipples, couplings, fittings, etc. needed to accomplish the cutting-in or connections, whether specifically indicated on the Plans or not.

D. All Pipe must be NSF 61 compliant.

2.02 PIPE

A. Ductile Iron Pipe
1. Pipe shall have a minimum pressure rating of 150 psi conforming to AWWA C150 and C151.

2. Pipe with screw-on shall have a minimum pressure rating of 150 psi conforming to AWWA C115.
3. Ductile iron pipe shall be coated on the inside with cement mortar conforming to AWWA C104/ANSI A.21.4, and seal coated on the inside and outside with bituminous coating.
    a. Coating shall be applied on clean bare metal surfaces.
    b. Coating shall extended to the ends of spigots and shoulders of hubs.

B. Steel Pipe:
1. Steel shall conform to ASTM A36 or A572 Grade 42.
2. Pipe shall conform to AWWA C200 and ASTM A139 Grade B.
3. Size and wall thickness shall be as shown on the Plans and indicated in the Specifications.
4. Steel pipe shall be designed in accordance with AWWA Manual M11.
5. Steel pipe shall be coated inside and outside with a 100% solids, thermosetting, fusion bonded dry powder epoxy resin (Scotchkote No. 206-N as manufactured by 3M Company, or equal). Application shall be by the fluidized bed method. Coating thickness shall be at least 10 mils DFT. Surface preparation shall include grinding of all irregularities, welds, and weld splatter and blasting to a near white surface in accordance with Steel Structures Painting Council (SSPC) Guidelines (SP-10).

C. PVC Pipe:
1. NOMINAL DIAMETERS 6 TO 12 INCHES: Pipe shall meet the requirements of AWWA C900, with a minimum pressure rating of 235 psi. Pipe shall have outside diameters of ductile iron pipe sizes. Pipe shall also meet the requirements of ASTM D2241 and UL 1285. Each length of pipe shall be capable of withstanding without failure 600 psi hydrostatic pressure for a minimum of 5 seconds. The integral bell shall be tested with the pipe.
2. NOMINAL DIAMETERS 14 TO 18 INCHES: Pipe shall meet the requirements of AWWA C905, with a minimum pressure rating of 235 psi. Pipe shall have outside diameters of ductile iron pipe sizes as listed below. Pipe shall also meet the requirements of ASTM D2241 and UL 1285. Each length of pipe shall be capable of withstanding without failure 600 psi hydrostatic pressure for a minimum of 5 seconds. The integral bell shall be tested with the pipe.
3. Provisions shall be made for contraction and expansion at each joint with a rubber ring and integral thickened bell as part of each joint. The rubber ring shall meet the requirements of ASTM D 2241. The bell section shall be at least as strong as the pipe barrel.
4. At least 85 percent of the total footage of pipe installed shall be furnished in standard lengths of 20 feet. The remaining footage of pipe may be in random lengths of not less than 10 feet long.
5. Manufacturers: C900 or C905 "Big Blue" or "Blue Brute" pipe manufactured by J-M Manufacturing Company, Inc. and Formosa Plastics Corporation, U.S.A, MAY NOT be used.

D. HDPE Pipe:
1. Pipe shall be high density polyethylene pipe. Size and SDR rating of polyethylene pipe shall be as shown on the Plans and indicated in the Specifications.

2. Materials used for the manufacture of polyethylene pipe and fittings shall be extra high molecular weight, high density ethylene/hexene copolymer PE 3408 polyethylene resin meeting the below listed physical property and pipe performance requirements:

Property	Specification	Units	Pipe
Material Designation	PPI/ASTM	-	PE 3408
Material Classification	ASTM D1248	-	III C 5 P34
Cell Classification	ASTM D3350	-	345434C
Density	ASTM D1505	gm/cm^3	0.955
Flex Modulus	ASTM D790	psi	135,000
Tensile	ASTM D638	psi	3,200
Hardness	ASTM D2240	Shore "D"	65
Compressive Strength (Yield)	ASTM D638	psi	1,600
Tensile Strength @ Yield (Type IV Spec)	ASTM D638 (2"/min)	psi	3,200
Elongation @ Yield	ASTM D638	%	8 min.
Modulus of Elasticity	ASTM D638	psi	130,000
NSF Listing	Standard #14	-	"Listed"

3. Material shall conform to ASTM F714 and meet accepted manufacturer standards for:
   - Diameter
   - Straightness
   - Wall Thickness
   - Ovality
   - Concentricity
   - Toe-in
   - Quick Burst
   - Overall Workmanship
   - Pressure and Ductility
   - Inspection ID and OD
   - Joint Length
   - Print Line
4. The pipe shall be extruded using a melt homogenizing/plasticating extruder and appropriate die. The extruder screw design should be customized for the HDPE being processed to minimize melt fracture of the molecular structure, thus reducing the molecular weight and changing some physical properties from resin to pipe. The resin should be processed at its appropriate melt temperature. The extruded tubular melt will be vacuum or pressure sized in downstream cooling tanks to form round pipe to specification diameter and wall thickness with a "matte-finish" surface.
5. The pipe shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. The pipe shall be homogenous throughout and free of visible cracks, holes, voids, foreign inclusions, or other deleterious defects, and shall be identical in color, density, melt index and other physical properties throughout.
6. The pipe shall be extruded from resin meeting specifications of ASTM D-3350 with a cell classification of PE:345434C; and ASTM D-1248 pipe grade resin type III, Class C, Category 5, grade P34 polyethylene compound. The pipe shall

provide the long term endurance characteristics recognized by: a compressive pipe ring environmental stress crack resistance greater than 1,000 hours; a slow crack growth resistance greater than 32 days; an impact strength (toughness) greater than 48 in-lb/in notch; and rotary fatigue endurance at 1,600 psi bending stress with F_o>20,000 cycles.

2.03 FITTINGS

A. General:
   1. Fittings shall include all tees, crosses, reducers, and elbows as shown on the Contract Drawings and shall include all nuts, bolts and gaskets necessary for the installation requirements.

B. For Ductile Iron Pipe:
   1. Fittings shall be as specified in ANSI A 21.10 or A 21.53 (AWWA C110 or C153), of the same pressure rating and same joint configuration as the pipe with which they are to be used.
   2. All fittings shall be smooth cement-lined in accordance with ANSI A 21.4 (AWWA C104). Special attention shall be given to bare metal. All lining shall extend to the faces of flanges, to the end of spigots, or to the shoulder of hubs, as the case may be.
   3. In addition, all fittings shall be coated inside and outside with bituminous material.

C. For Steel Pipe:
   1. Fitting shall be steel and shall conform to ASTM A36 or A572 Grade 42.
   2. Fittings shall conform to AWWA C200 and AWWA C208, except where specific dimensions are called out on the Plans. .
   3. Steel fittings shall be designed in accordance with AWWA Manual M11.
   4. Fittings shall be heated and cured in accordance with the manufacturer's recommendation.
   5. Fittings and headers fabricated from steel pipe require hydrostatic testing.

D. For PVC Pipe:
   1. Fittings shall be ductile iron fittings as described in Part 2.03.B (above).
   2. Fittings shall be properly sized for the dimensions of the pipe being used.

E. For HDPE Pipe:
   1. Ductile Iron Fittings:
      a. Fittings shall be ductile iron fittings as described in Part 2.03.B (above). Fittings shall be properly sized for the dimensions of the pipe being used.
      b. Only flanged fittings shall be used when specified with high-density polyethylene piping systems. Mechanical joint fittings shall not be used.
      c. The joining system between high-density polyethylene pipe and flange fittings shall be made by a method recommended by the pipe manufacturer or submitted by the Contractor and approved by the Engineer.
   2. Standard HDPE fittings:
      a. Standard commercial products manufactured by injection molding or by extrusion and machining, or fabricated from PE pipe conforming to this specification.

b. The fittings shall be fully pressure rated by the manufacturer to provide a working pressure equal to the pipe for 50 years service at 73.4°F with an included 2:1 safety factor.
c. The fittings shall be manufactured from the same resin type, grade, and cell classification as the pipe itself.
d. The manufacture of the fittings shall be in accordance with good commercial practice to provide fittings homogeneous throughout and free from crack, holes, foreign inclusions, voids, or other defects. The fittings shall be as uniform as commercially practicable in color, opacity, density and other physical properties.
e. The minimum "quick-burst" strength of the fittings shall not be less than that of the pipe with which the fitting is to be used.

2.04 PIPE JOINTS

A. General
1. All pipe which will operate under pressure shall be properly protected from the effects of thrust at all fittings where the pipeline changes direction, changes size, or ends, using concrete thrust blocks, or restrained joints where required.
a. Concrete thrust blocks shall be sized so as to give bearing against undisturbed vertical earth banks sufficient to absorb the thrust from line pressure, allowing an earth bearing of 200 pounds per square foot per foot of depth below natural grade to a maximum of 1,000 pounds per square foot. (Earth bearing value may be increased, if substantiated by soils analysis). The line pressure shall be the product of the nominal cross sectional area of the pipe and the test pressures as specified for each type of pipe. The concrete shall be placed, unless specifically indicated otherwise on the Plans, so that the pipe joints and fittings will be accessible. Concrete used for all thrust blocks shall be a Class C as identified Section 03 30 00 of these specifications.
2. Pipe joints shall be provided as specified or as indicated on the contract drawings.

B. For Ductile Iron Pipe:
1. Flanged Joints:
a. Flanges: Gaskets shall be synthetic rubber, either ring or full faced and a minimum of 1/8-inch thick for ductile iron pipe. Flanges shall be one of the following with diameter, thickness, drilling, and other characteristics in accordance with ANSI B16.1:
1) Cast integrally with the pipe.
2) Screw-on: Comply with the following:
a) Long hub, threaded, and specially designed for ductile iron pipe.
b) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
b. Bolt Holes: Two-holed and aligned at both ends of pipe.
c. Cap Screw or Stud Bolt Holes: Tapped.
d. Bolts and Nuts:
1) High strength low alloy hardware shall be used for all buried applications having the characteristics specified in AWWA C111 / ANSI A 21.11.

2) 316 Stainless Steel hardware with flouropolymer coating shall be used in all underwater or vault installations.

e. Protective Coating: both the following.
1) Petrolatum wrap tape consisting of plastic fiber felt saturated with petrolatums, plasticizers, and corrosion inhibitors.
a) Trenton No. 1 Wax Tape (Trenton Corporation)
b) Or equal.
2) “Rock Shield” type material
a) Trenton Guard Wrap (Trenton Corporation)
b) Poly-ply (Trenton Corporation)
c) Or equal.

2. Mechanical Joints: AWWA C111/ANSI A 21.11
3. Push-On Rubber Gasket Joints: AWWA C111/ANSI A 21.11.
4. Plain-end Joints:
a. Flanged Coupling Adaptor
1) Sleeve-type flanged coupling adaptors shall be:
a) Smith-Blair Type 913;
b) Dresser Style 128;
c) Or equal.
b. Flex Coupling Adaptor
1) Sleeve-type mechanical couplings shall be:
a) Smith-Blair Type 411;
b) Dresser Style 38;
c) Or equal.
2) Sleeve-type mechanical couplings shall have the stop removed from the middle ring.
c. Bolts and nuts for buried service shall be mad of non-corrosive high-strength, low-alloy steel having the characteristics specified in AWWA C111 / ANSI A 21.11, regardless of any other protective coating.
d. Where washers are required, they shall be of the same material as the associated bolts.
e. Where required for resistance to pressure, mechanical couplings shall be restrained in accordance with Chapter 13 of AWWA M11, including Tables 13-4, 13-5 and 13-5A, and Figure 13-20.
5. Restrained Joints:
a. Mechanical Joints:
1) Megalug as manufactured by EBAA Iron Sales.
2) MJ Field Lok Gasket and Gland as manufactured by United States Pipe and Foundry Company.
3) Grip Ring Pipe Restrainer as manufactured by Romac Industries
4) Or Approved Equal
b. Push-On Joints:
1) Comprised of ductile iron locking segments inserted through slots in the bell face, providing positive axial lock between the bell interior surface and a retainer weldment on the spigot end of the pipe, or a retainer weldment through a boltless system, providing a positive restraint against joint separation; with a safety factor of 2 under a pressure equal to the specified test pressure; capable of easy disassembly without cutting or burning of the gasket; suitable for the following working pressures: For 4 through 24 inch Pipe: 350 pounds per square inch gauge.

a) TR Flex as manufactured by United States Pipe and Foundry Company;
b) or equal.

C. For Steel Pipe:
1. Flanged Joints:
a. As described in Part 2.04.B.1 (above).
b. Flanges for steel pipe and fittings shall be flat faced conforming to AWWA C207, Class D. Flange bolts and nuts shall conform to ASTM A307, Grade B. Flange gaskets shall be full faced, compressed non-asbestos 1/16-inch thick.
2. Mechanical Joints:
a. As described in Part 2.04.B.2 (above).
3. Push-on Rubber Gasket Joints:
a. As described in Part 2.04.B.3 (above).
4. Plain-End Joints:
a. As described in Part 2.04.B.4 (above).
b. Welded joints: field welding of steel pipe will not be allowed without the permission of the Engineer. Field welding, if allowed, shall conform to AWWA C206.
5. Restrained Joints:
a. As described in Part 2.04.B.5 (above).
6. Grooved Joints:
a. AWWA C606, as complemented and modified below, radius-cut type, with following components:
1) Couplings: Rigid type, cast from ductile iron in accordance with ASTM A536, Grade 65-45-12 or malleable iron in accordance with ASTM A47, Grade 32510.
2) Bolts and Nuts: ASTM A183, Grade 2.
3) Gaskets: Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure; material for following services:
a) Halogenated butyl.
4) Fittings: AWWA C 606, rigid radius-cut groove.
a) Center-to-Center Dimensions: AWWA C 110/ANSI A 21.10.
b) Wall Thickness and Other Characteristics: AWWA C153.
b. Flanged Unit Connections: Flanged to grooved joint adapters or a long enough spool with 1 end flanged and the other grooved to prevent interference with the operation of adjacent valves, pumps, or other items.

D. For PVC Pipe:
1. Mechanical Joints:
a. As described in Part 2.04.B.2 (above).
2. Push-on Rubber Gasket Joints:
a. As described in Part 2.04.B.3 (above).
3. Plain-End Joints:
a. As described in Part 2.04.B.4 (above).
b. Welded Joints
1) Pipe to be welded shall be extruded with plain ends. The ends shall be square to the pipe and free of any bevel or chamfer. There shall be no bell or gasket of any kind incorporated into the pipe.

2) Connections to fused PVC pipe may be made using restrained, ductile iron fittings only.

4. Restrained Joints:
   a. As described in Part 2.04.B.5 (above).

E. For HDPE Pipe:
1. Plain-End Joints:
   a. As described in Part 2.04.B.4 (above).
   b. Welded Joints
      1) Pipe to be welded shall be extruded with plain ends. The ends shall be square to the pipe and free of any bevel or chamfer. There shall be no bell or gasket of any kind incorporated into the pipe.

PART 3 EXECUTION

3.01 GENERAL

A. All piping and appurtenances shall be installed in accordance with manufacturers recommendations.

B. When pipe laying is interrupted, or stopped at the end of the work shift, the open ends of pipe shall be sealed with a watertight plug, or other means acceptable to the Engineer, to prevent water from entering the pipe.

3.02 MATERIAL DELIVERY, STORAGE, HANDLING AND PROTECTION

A. All piping shall be delivered in a clean and undamaged condition.

B. All piping materials, fittings, valves, and accessories shall be carefully handled during loading, unloading, and installation. All pipe, fittings, and related appurtenances shall be handled in a manner that will insure installation in sound, undamaged, like new condition. Pipe should be loaded, off-loaded, and otherwise handled in accordance with AWWA M23, and all of the manufacturer's guidelines should be followed.

C. In shipping, material shall be blocked in such a manner as to prevent damage to castings or cement lining.

D. All pipe shall be bundled or packaged in such a manner as to provide adequate protection of the ends during transportation to the site. Flanged pipe shall have the flange faces protected. Any pipe damaged in shipment shall be replaced as directed by the Engineer.

E. Each pipe shipment should be inspected prior to unloading to see if the load has shifted or otherwise been damaged. Notify Engineer immediately if more than immaterial damage is found. Each pipe shipment should be checked for quantity and proper size, color and type.

F. All material shall be carefully lowered to the ground by mechanical means. Pipe shall be handled and supported with the use of woven fiber pipe slings or approved

equal. Care shall be exercised when handling the pipe to not cut, gouge, scratch or otherwise abrade the piping in any way. Pipe and fittings with cement mortar or epoxy lining or special coatings shall handled with rubber covered hooks, or other type of equipment to prevent damage. Off-loading devices such as chains, wire rope, chokers, or other pipe handling implements that may scratch, nick cut, or gouge the pipe are strictly prohibited.

G. During removal and handling, be sure that the pipe does not strike anything. Significant impact could cause damage, particularly during cold weather.

H. If appropriate unloading equipment is not available, pipe may be unloaded by removing individual pieces. Care should be taken to insure that pipe is not dropped or damaged. Pipe should be carefully lowered, not dropped from trucks.

I. Storage:
   1. HDPE Pipe: Pipe lengths should be stored and placed on flat, level ground, with no rocks, timbers or other objects under the pipe. Pipe should be stored in the unit packaging provided by the Manufacturer until ready for use. Caution should be exercised to avoid compression, damage, or deformation to the ends of the pipe.
   2. All Other Pipe shall be stored off the ground in conformance with the Manufacturer's instructions.

J. The interior of the pipe, as well as all end surfaces, should be kept free from dirt and foreign matter.

K. If pipe is to be stored for periods of 1 year or longer, the pipe should be shaded or otherwise shielded from direct sunlight. Covering of the pipe which allows for temperature build-up is strictly prohibited. Pipe should be covered with an opaque material while permitting adequate air circulation above and around the pipe as required to prevent excess heat accumulation.

L. Pipe shall be stored and stacked per the manufacturer's guidelines.

M. Pipe, fittings and accessories shall be carefully inspected by the Contractor before and after installation, and those materials found defective shall be rejected.

N. Any length of pipe showing a crack or blow that may have caused an incident fracture, even though no such fracture can be seen, shall be marked as rejected.
   1. For PVC and HDPE pipe, any scratch or gouge greater than 10% of the wall thickness will be significant and can be rejected unless determined acceptable by the Engineer.

O. Pipe and fittings shall be free from fins and burrs.

P. Pipe and fittings in which the lining or coating has been damaged shall be immediately removed from the job site and replaced with new materials.
   1. In instances where damage is minimal, the Contractor may, with approval from the Engineer, have the damage repaired by a qualified representative of the pipe manufacturer or fabricator.

Q. Do not drop or pound pipe to fit grade.

R. Before being placed in position, pipe, fittings and accessories shall be cleaned and shall be maintained in a clean condition.

3.03 ALIGNMENT

A. All piping shall be installed to lines, grades, and elevations indicated on the contract drawings.

B. All deviations from the line, grade, or elevation as indicated on the contract drawings shall be approved in writing by the Engineer.

C. The Contractor is responsible for coordinating all other work to insure that piping is installed as indicated on the Contract Drawings.

D. Piping intended to be straight shall be straight. Deflections from a straight line or grade shall be approved in writing by the Engineer and shall be accomplished by the use of approved fittings.

3.04 PIPE INSTALLATION

A. General: All piping shall be installed as specified, as indicated on the contract drawings and in a manner acceptable to the Inspector.

B. Special Instructions for Installation of Ductile Iron Pipe:
   1. Install ductile iron piping in accordance with AWWA C600
   2. Lay mechanical joint or bell and spigot pipe with 1/8 inch space between the spigot and shoulder of the pockets.
   3. Special Techniques:
      a. Polyethylene Encasement: Wrap ductile iron pipe and fittings to be buried with minimum 8 mil thick polyethylene encasement. Repair tears and make joints with double plastic tape wrap.
         1) Polyethylene: AWWA C105.
         2) Plastic Tape Wrap: One of the following or equal:
            a) Polyken Number 910 as manufactured by Polyken Pipeline Coatings.
            b) Tapecoat CT as manufactured by The Tapecoat Company.

3.05 FIELD JOINING (FUSION WELDING)

A. HDPE:
   1. Sections of polyethylene pipe shall be joined into continuous lengths on the project site. The joining method shall be the butt fusion method and shall be performed in strict accordance with the pipe manufacturer's recommendations. The butt fusion equipment used in the joining procedures shall be capable of meeting all conditions recommended by the pipe manufacturer, including, but not limited to, temperature requirements of 400°F, alignment, and interfacial fusion pressure as recommended by the pipe manufacturer.
   2. Butt fusion joining shall be 100% efficient offering a joint weld strength equal to or greater than the tensile strength of the pipe. Socket fusion shall not be used.

Extrusion welding or hot gas welding of HDPE shall not be used for pressure pipe applications nor in fabrications. Unions, grooved-couplers, transition fittings and mechanical couplers may not be used.

3. The pipe shall not be deflected either vertically or horizontally in excess of the recommendations of the manufacturer.

B. PVC

1. Lengths shall be assembled in the field with butt-fused joints. The Contractor shall follow the pipe supplier's guidelines for this procedure. All fusion joints shall be completed as described in this specification.
2. Fusible PVC pipe will be fused by qualified fusion technicians certified and experienced in the type and size of pipe being used.
3. Only appropriately sized and outfitted fusion machines that have been approved by the pipe supplier shall be used for the fusion process. Fusion machines must incorporate the following properties, including the following elements:
    a. HEAT PLATE – Heat plates shall be in good condition with no deep gouges or scratches. Plates shall be clean and free of any debris or contamination. Heater controls shall function properly. Cord and plug shall be in good condition. The appropriately sized heat plate shall be capable fo maintaining a uniform and consistent heat profile and temperature for the size of pipe being fused, per the pipe supplier's guidelines.
    b. CARRIAGE – Carriage shall travel smoothly with not binding at less than 50 psi. Jaws shall be in good condition with proper inserts for the pipe size being fused. Inset pins shall be installed with no interference to carriage travel.
    c. MACHINE BODY – Overview of machine body shall reveal no obvious defects, missing parts, or potential safety issues during fusion.
    d. DATA LOGGING DEVICE – The current version of the pipe supplier's recommended and compatible software shall be used. Datalogging device operations and maintenance manual shall be with the unit at all times.
4. Pipe rollers shall be used to support pipe to either side of fusion machine.
5. Utilize a weather protection canopy in inclement or windy weather, to allow full machine motion of the heat plate, fusion assembly and carriage. If weather conditions persist such that the Contractor is unable to meet the parameters required by the pipe supplier and these Specifications, the fusion process shall cease until the inclement weather passes and the parameters can be achieved.
6. Use only facing blades specifically design for cutting fusible PVC pipe.

3.06 QUALITY ASSURANCE

A. Pressure testing of all pipe installations shall be done in conformance with Section 33 13 00 Water Pipeline Testing and Disinfection of the specifications.

B. Disinfection of piping and appurtenances, as applicable, shall be in conformance with Section 33 13 00 Water Pipeline Testing and Disinfection of the specifications.

END OF SECTION

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SECTION 33 12 13
WATER SERVICE CONNECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Water service connections from water mains up to the property line, including curb stop.

B. Related Sections:
   1. 33 11 13 Water Distribution Piping
   2. 33 12 16 Water Valves
   3. 33 13 00 Pipeline Testing and Disinfection

1.02 REFERENCES

A. American Water Works Association (AWWA)
   1. C800 Underground Service Line Valves and Fittings
   2. C901 Polyethylene Pressure Pipe and Tubing, ½" through 3" for Water Service

B. American Society of Testing and Materials (ASTM)
   1. A536 Ductile Iron Castings

C. American Society of Mechanical Engineers (ASME)
   1. ANSI-ASME B1.20.1 General Purpose Pipe Threads

PART 2 PRODUCTS

2.01 GENERAL

A. All piping, valves and fittings used for service connections shall conform to the AWWA C800 standard for "Underground Service Line Valve and Fittings".

B. All fittings for water service connections shall conform to ASME B1.20.1 having N.P.T. threads.

C. In no case shall copper or copper alloy pipe or fittings be attached to steel pipe, except by means of dielectric coupling expressly made for this purpose and service. Tracer wire shall terminate at the meter, to provide a discontinuity between the private service line and the District's distribution system.

D. All brass components used in the water distribution system shall be "lead-free" in compliance with California law (AB 1953).

2.02 SERVICE SADDLES

A. Service saddles shall be installed per project details.

B. Service saddles shall have a bearing area of sufficient width along the axis of the pipe so that the pipe will not be distorted when the saddle is made tight

C. For PVC pipe, saddles shall be sized such that the upper end of the OD range is equal to the outside diameter of the pipe.

2.03 CURB AND CORPORATION STOPS

A. Curb and corporation stops shall be as specified on drawings.

PART 3 EXECUTION

3.01 GENERAL

A. All service connections which would require crossing existing sewer force mains shall be installed utilizing an open trench method. Additionally, any service connections not crossing existing sewer force mains shall be installed utilizing a trenchless method such as a mole. The Contractor shall submit a written proposal describing the method to be employed, which will be subject to the review and approval of the Engineer.

B. The Contractor shall indicate sending and receiving pit locations in the field which must be approved by the Engineer. It is the intent of this specification that a majority of the length of all service connections be installed using the proposed trenchless method.

C. All new service lines shall be installed, including new curb stops, to a point adjacent to existing services and shall be flushed, pressure tested and disinfected along with the new water main, per Section 33 13 00. The new curbstop can be used to facilitate flushing to expel trapped air and to insure adherence to the sterilization specifications. After all the lines have been successfully pressure tested and have passed the disinfection test, they shall be connected to existing service. A new service box shall be installed and brought to proper grade. The price for the new service box and installation shall be included in the unit price for each service.

3.02 SERVICE TAPS

A. Contractor shall install service saddles at locations shown on the Contract Drawings

B. An internal shell cutter shall be used to drill through the corporation stop to minimize shavings, retain the coupon, and reduce stress. Single fluted shell cutter or twist drills shall not be used. Cutting lubricant shall be used on the cutting and tapping edges of the tool.

3.03 HOT TAP

A. All hot tapping of existing mains shall be performed by the District, as directed on the Contract Drawings.

END OF SECTION

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SECTION 33 13 00
WATER PIPELINE TESTING AND DISINFECTION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: flushing, testing and disinfection of all pipelines and appurtenances for water.

B. Related Sections:
   1. 33 11 13 Water Distribution Piping
   2. 33 12 16 Water Valves
   3. 33 12 13 Water Service Connections

1.02 REFERENCES

A. American Water Works Association (AWWA)
   1. B300 Hypochlorites.
   2. C200 Steel Water Pipe 6” in Diameter and Larger
   3. C600 Installation of Ductile Iron Water Pipes and Their Appurtenances
   4. C651 Disinfecting Water Mains.(attached)
   5. C900 Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In.-12 In. for Water Transmission and Distribution
   6. C906 Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) through 63 in. (1,600 mm), for Water Distribution and Transmission.

B. South Tahoe Public Utility District Standards
   1. Water System Connection Disinfection and Testing Guide (attached)

1.03 CONTRACTOR SUBMITTALS

A. Submittals shall be made in accordance with Section 01 33 00 Submittals Process.

B. The following submittals and specific information shall be provided.

   1. A detailed, project-specific testing procedure and schedule, including proposed plans for water conveyance, control, disposal~~,~~ and disinfection, shall be submitted in writing for approval a minimum of 48 hours before testing is to start.

1.04 QUALITY ASSURANCE

A. Comply with the Section 01 43 00 Quality Assurance.

PART 2 PRODUCTS

2.01 MATERIALS REQUIREMENTS

A. All test equipment, chemicals for disinfection, temporary valves, bulkheads, or other water control equipment and materials shall be determined and furnished by the Contractor subject to the Engineer's approval. No materials shall be used which would be injurious to the construction or its future function.

B. Chlorine for disinfection shall be in the form of sodium hypochlorite solution only. Sodium hypochlorite shall be in accordance with the requirements of AWWA B300.

PART 3 EXECUTION

3.01 GENERAL

A. Testing and disinfection of waterlines shall conform to the requirements of this section and to the District's "Water System Connection Disinfection and Testing Guide", unless otherwise authorized in writing by the Engineer. Alternative testing and disinfection procedures shall be submitted by the Contractor for review and approval in conformance with Part 1.03.B.1, above.

B. Unless otherwise provided herein, water for testing and disinfecting water pipelines will be furnished by STPUD; however, the Contractor shall make all necessary provisions for conveying the water from STPUD-designated source to the points of use.

C. All pressure pipelines shall be tested. Disinfection shall be accomplished by chlorination and shall be completed by the contractor. All bacteriological testing operations shall be performed by District Laboratory Personnel in the presence of the Engineer and Contractor.

D. Disinfection operations shall be scheduled by the Contractor as late as possible during the contract time period so as to assure the maximum degree of sterility of the facilities at the time the Work is accepted by the Engineer and the Inspector. Mains, services, and hydrants shall be tested at the same time. Bacteriological testing shall be performed by District Laboratory Personnel in the presence of the Engineer and Contractor.

3.02 HYDROSTATIC TESTING OF PIPELINES

A. Pressure Test with Maximum Leakage Allowance for Steel, Ductile Iron, or PVC Pipe
   1. All PVC, Ductile Iron, and Steel pressure pipe shall be tested for leakage per AWWA C200, C600, or C900 depending on pipe type, for a minimum duration of 2 hours at 150 psi and measured at the lowest point in the line. Any sections of the pipelines indicating more than the allowable leakage shall be repaired and retested until the leakage is less than the allowable indicated below. The leakage test shall be made after backfilling. Any visible leaks shall also be repaired.

2. Do not test sections longer than 2,000 ft. in total pipe length without prior approval of the Engineer.
3. Pressure test piping after completion of visible leaks test during water absorption period.
4. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period.
5. Successful completion of the pressure test with maximum leakage allowance shall have been achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred. Calculate the allowable leakage by the following formula:

$$L = \frac{(S * D * \sqrt{P})}{133{,}200}$$

Wherein the terms shall mean:
L = Allowable leakage in gallons per hour.
S = Length of the test section in feet.
D = Nominal diameter of the piping in inches.
P = Average observed test pressure in pounds per square inches, gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

B. Presssure Test with Maximum Leakage Allowance for HDPE Pipe
1. All HDPE pressure pipe shall be tested for leakage per AWWA C906.

3.03 DISINFECTING PIPELINES

A. New Mains
1. General
a. All equipment and pipelines intended to carry potable water shall be sterilized before placing in service.
b. Disinfection and bacteriological testing of new mains shall be performed in accordance with the guidelines provided by AWWA C651, in addition to the standards written below.
2. Flushing
a. Before disinfection, the Contractor shall ensure all foreign matter has been flushed from equipment and pipeline.
b. Contractor shall provide hoses and temporary pipes as required to dispose of flushing water without damage to adjacent properties.
c. Flushing velocities shall be at least 2.5 fps. For large diameter pipe here it is impractical or impossible to flush the pipe at 2.5 fps velocity, clean the pipeline in place from the inside by brushing and sweeping, then flush the line at a lower velocity.
d. **Water used for disinfection may be discharged into the District's sanitary sewer manhole at the project site with prior approval of the Engineer. During any discharge into the District's sewer system, the Contractor shall provide monitoring to assure against surcharging the system.**
3. Additions to AWWA C651:
a. Strict adherence to all sections of AWWA standard C651 is required.

b. Section 4.1 of AWWA C651 shall be followed as written except that sodium hypochlorite is the only form of chlorine to be used for disinfection.
c. Section 5.1.1 of AWWA C651 shall be followed as written except that at least two sample sets, obtained on successive days at a minimum of 24 hours apart, shall be collected from the new main and each branch.
    1) A sample set consists of three samples for every 1,200 foot section of pipelines: one at the each end and one in the middle. An extra sample is needed for each additional 600 feet of pipe.
    2) Water service lateral connections or dedicated sample ports should be used for sample taps. Samples must not be taken from fire hydrants, unless approved by the Engineer.
    3) The sample tap should be flushed enough to clear the sample line and ensure that the sample is from the main. Sample taps should be installed at least one (1) foot above grade to prevent contamination from soil.
d. A standard heterotrophic plate count (HPC) will be required. This sample will be drawn at the same time as the first sample set for coliforms. HPC must be less than 500 cfu per mL, in accordance with Section 5.1.4 of AWWA C651.

4. Disinfection and Testing Procedures:
    a. Charge and chlorinate the line in accordance with AWWA C651, as modified above. Record initial chlorine level in main.
    b. The chlorinated water shall be retained in the pipeline for at least 24-hours. If water temperature is less than 5 degrees C, the time required for the chlorinated water to remain in the pipeline shall be no less than 48-hours.
    c. All valves and hydrants in the treated section shall be operated during the 24-hour chlorination period to disinfect the appurtenances.
    d. At the end of the 24-hour period (or 48-hour period as required in Part 3.03.A.4.a, above), the treated water in all portions of the main shall be tested by District laboratory personnel and found to have a residual of not less than 10 mg/L free chlorine.
    e. Before the first bacteriological sample is taken, the main shall be flushed so that the total chlorine residual is no greater than that currently in the water distribution system.
    f. Samples for bacteriological and HPC testing shall be collected by District laboratory personnel.
    g. After the first sample for bacteriological testing is taken, the water will remain undisturbed in the main for 24 hours, after which, a second set of samples for bacteriological testing shall be collected by District laboratory personnel. In the event that at the time of the second bacteriological sampling the total chlorine residual is greater than that in the water distribution system, the water line will be flushed until the total chlorine residual is no greater than that of the water in the distribution system. It will be the Engineers discretion to decide whether or not water in the main must remain undisturbed for an additional 24 hours before the second bacteriological sample is taken.
5. The new main shall be approved as disinfected when all of the following have been achieved:
    a. All bacteriological tests on two successive days must be negative for total coliform organisms.

b. HPC is found to be less than 500 cfu per mL, in accordance with Section 5.1.4.

6. Scheduling
   a. The time required for completing the disinfection and bacteriological testing is at least 4 days and can require up to 6 days, even if test results are acceptable on the first try.
   b. If the test results show the presence of coliform organisms, more time will be required for further disinfection and testing.
   c. Flushing of the disinfected water main may take considerable time and should be considered in scheduling work.
   d. The laboratory should be notified at least 24-hours prior to initial disinfection.
   e. The Contractor shall provide personnel to assist the District lab personnel to obtain samples.

B. Repaired Mains, including system interties: The disinfection and bacteriological testing of repaired water mains shall be performed in accordance with the guidelines provided by AWWA C651 and the additions that are written below.
   1. All repairs performed by the Contractor, shall be coordinated with the Engineer
   2. New pipe segments and fitting shall be swabbed with sodium hypochlorite, as well as the exposed ends of the repaired section.
   3. Schedule lab to take tests within 24 hours. Continue until two (2) consecutive negative samples are collected. Corrective action by the contractor may be required and could include flushing, charging, slug chlorination and/or additional repairs at the direction of the Engineer.

END OF SECTION

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WATER SYSTEM CONNECTION
DISINFECTION AND TESTING GUIDE

Contents

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Definitions

District:	South Tahoe Public Utility District
Owner:	The party (private or public) for which a Contractor is performing work on the District's water system
Contractor:	A Contractor licensed by the State of California to perform the type of work proposed on the District's water system on behalf of the Owner.
Chlorine Residual:	Concentration of chlorine species present in water after the oxidant demand has been satisfied.
Sodium hypochlorite:	Sodium hypochlorite contains approximately 5 percent to 15 percent available chlorine

I. Introduction

This Disinfection and Testing Guide has been developed to instruct Contractors in the minimum accepted methods by which new water connections to the existing public water system are tested and disinfected for acceptance. The methods that will be presented are from the latest edition of the American Water Works Association (A.W.W.A) Disinfection Procedures C651, and the District's Standard Specifications. The Contractor shall not deviate from any of the requirements of this Guide without written District consent. At no time shall a new portion of pipeline be connected to the District's existing Water System until the new pipeline has been properly disinfected and has passed all bacteriological tests.

II. Procedure

Prior to beginning work Owner or Contractor shall develop and provide to the District a written Disinfection Procedure incorporating the requirements below. Only liquid chlorine, Sodium Hypochlorite is allowed to be used for disinfection. Potable water may be supplied from a temporary backflow-protected connection to the existing distribution system or other supply source approved by the District. The backflow assembly shall be a District tested and Approved Reduced Pressure Principle backflow assembly **(see Figure 1).**

III. Initial Tie In Connection

Tie in to the existing District's Water System will be conducted by Hot Tap or Cut In method.

Cut-In Method

Cut In method may be performed by the Contractor, and must be closely coordinated with District Staff to notify affected Customers and to facilitate the shut-down of the District's Water System at the Tie in point. **At no time is the Contractor or any other non-District personnel allowed to operate existing valves on the District's Water System.** The installation work must be conducted in a safe and sanitary condition. The pipe trench shall be continuously dewatered to maintain the water level well below the open pipe ends. All new materials to be installed, tools, and all exposed surfaces of the existing pipe shall be kept clean and sanitary by spraying and swabbing with sodium hypochlorite.

Hot Tap Method

If a Hot Tap is selected, the work to tap the main will be performed by the District, with advance notice. The saddle and valve are to be provided and installed on the main by the Owner's Contractor. Scheduling with District for Hot Tap or Shut Down shall be in writing a minimum of 2 working days. Following the hot tap, disinfection and bacteriological tests will be conducted by trained District personnel from a nearby sampling location on the existing system.

IV. Leak Testing

Assembled piping and appurtenances from the point of tie in at the existing District Water System to the terminus point of the new pipeline (generally defined by a service valve or backflow protection device), shall be tested for leaks. The method of leak testing shall be determined based on the assembled length of the new piping and appurtenances (fittings and valves).

Assembled Length of 20 linear feet or less

Assembled piping of 20 linear feet (lf) or less shall be visually inspected for leaks by District personnel after it has been assembled, disinfected, installed, and charged. To facilitate inspection, the Contractor shall not backfill the trench until

after the new piping is charged to system pressure, and District personnel have completed the visual inspection. For safety, the Contractor is required to restrain and/or brace the exposed piping to District satisfaction before the line is charged by the District. **At no time is the Contractor or any other non-District personnel allowed to operate existing valves on the District's Water System.**

Assembled Length of greater than 20lf

Assembled piping of greater than 20lf shall be hydrostatically pressure-tested prior to being disinfected and connected to the District's Water System, for a minimum of 2 hours at the rated pressure for the assembled piping (typically 150 psi), as measured at the lowest point in the line. To test, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period. Successful completion of the pressure test with maximum leakage allowance shall have been achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred. Calculate the allowable leakage by the following formula.

$$L = \frac{(S * D * \sqrt{P})}{133{,}200}$$

Wherein the terms shall mean:
L = Allowable leakage in gallons per hour.
S = Length of the test section in feet.
D = Nominal diameter of the piping in inches.
P = Average observed test pressure in pounds per square inches, gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

V. Disinfection

New tie-in fittings and valves shall not be connected to the District's Water System until they have been disinfected. New piping shall not be connected to the tie-in fittings and valves until it has been disinfected, flushed (if necessary) and tested. The method of disinfection shall be determined based on the assembled length of the new piping and appurtenances (fittings and valves), from the point of tie in at the existing District Water System to the terminus point of the new pipeline (generally defined by a service valve or backflow protection device).

Assembled Length of 20 linear feet or less

Pipeline installations of 20 linear feet (lf) or less shall be spray disinfected and swabbed with sodium hypochlorite immediately before being installed. Because the entire interior of the assembled piping is visible, it shall be inspected for particulate contamination and re-swabbed, if necessary, prior to installation; flushing is not required.

Assembled Length of greater than 20lf

Pipeline installations of greater than 20lf shall be protected from contaminating materials from entering the pipe and appurtenances during storage, construction, or repair and noting potential contamination at the construction site. Upon completion of installation and successful hydrostatic testing as required by District, remove particulate materials that may have entered the water main or appurtenances by flushing or other means, prior to proceeding with disinfection. The flushing velocity in the main shall not be less than 3.0 ft/sec. **Table 1** shows the rates of flow required to produce a velocity of 3.0ft/sec. in commonly used sizes of pipe. (NOTE: flushing is no substitute for preventive measures during construction. Certain contaminants, such as caked deposits, resist flushing at any feasible velocity, and

pigging of the main, or other suitable method acceptable to the District, may be required.) Where such flow rates are not possible, flushing at the maximum expected flow rate for the line for 2-3 volumes may be allowed with approval from the District.

To disinfect, at a point not more than 5 ft downstream from the beginning of the new main, water entering the new main shall receive a dose of chlorine fed at a constant rate such that the water will have not less than 25mg/L free chlorine. To ensure that an appropriate concentration is achieved, the free chlorine concentration shall be measured at regular time intervals in accordance with the procedures described. **Table 2** gives the amount of chlorine required for each 100 ft of pipe for various pipe diameters. Solutions with a minimum 1 percent chlorine concentration may be prepared with sodium hypochlorite. Chlorine application shall not cease until the entire main is filled with chlorinated water. The chlorinated water shall be retained in the main for at least 24 hr., during which time valves and hydrants in the treated section shall be operated to ensure disinfection of the appurtenances. At the end of this 24-hr period, the treated water in all portions of the main shall have a residual of not less than 10 mg/L of free chlorine as determined by District Lab personnel. After the applicable retention period, heavily chlorinated water should not remain in prolonged contact with pipe. In order to prevent damage to the pipe lining or to prevent corrosion damage to the pipe itself, the heavily chlorinated water shall be flushed 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 that is acceptable for domestic use. Chorlinated water shall be disposed of appropriately, and shall not be discharged to the District's Sewer System without prior written consent. After disinfection, the chlorinated water in the new pipe shall be replaced with water at background chlorine level, prior to collecting samples for bacteriological testing.

VI. Bacteriological Testing

Bacteriological Testing will be performed on all assembled piping.

Assembled Length of 20 lf or less

Samples will be collected by District personnel from a nearby sampling port on the existing system after the new piping has been connected to the system.

Assembled Length of greater than 20lf

Prior to connection of the new piping to the existing system, District staff will collect samples for every 1,200ft of the new pipeline and appurtenances, plus one set from the end of the line and at least one from each branch greater than one pipe length**,** for a minimum of three test sites per 1200 feet of new assembled piping. The sample ports shall be installed by the Contractor (see **Figure 2**). The District 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 by the District's lab 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 standard Heterotrophic Plate Count (HPC) test may be required at the option of the District 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. If the initial disinfection fails to produce satisfactory bacteriological results, or if other results indicate unacceptable water quality, the main may be reflushed and shall be resampled. If check samples fail to produce acceptable results, the main shall be rechlorinated until satisfactory results are obtained.

VII. Final Connection

Assembled Length of greater than 20lf

Water mains and appurtenances must be completely aseembled, flushed (when required), disinfected, and satisfactory bacteriological sample results received (when required) prior to permanent connections being made to the active distribution system. Sanitary construction practices must be followed during installation of the final connection so that there is no contamination of the new or existing water main with foreign material or groundwater.

Comments

If you have any questions about this Guide please call the South Tahoe public Utility District Engineering Department at 530.544.6474.

Figure 1
Suggested temporary flushing/testing connection

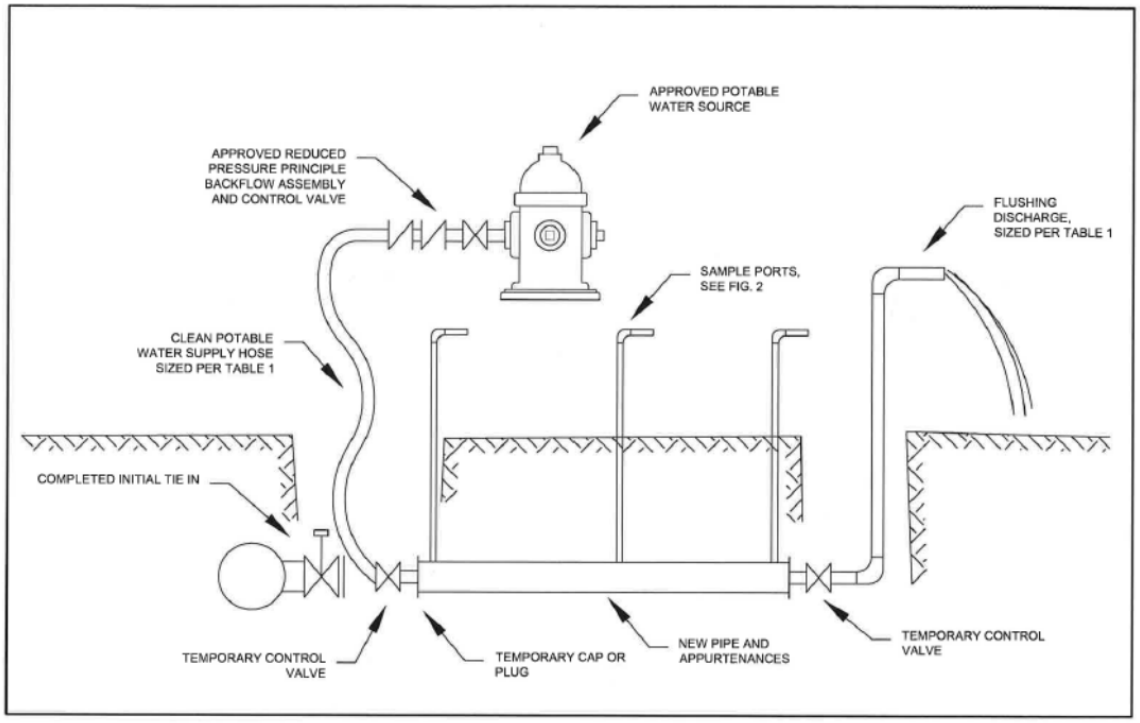

Figure 2
Typical Sample Port

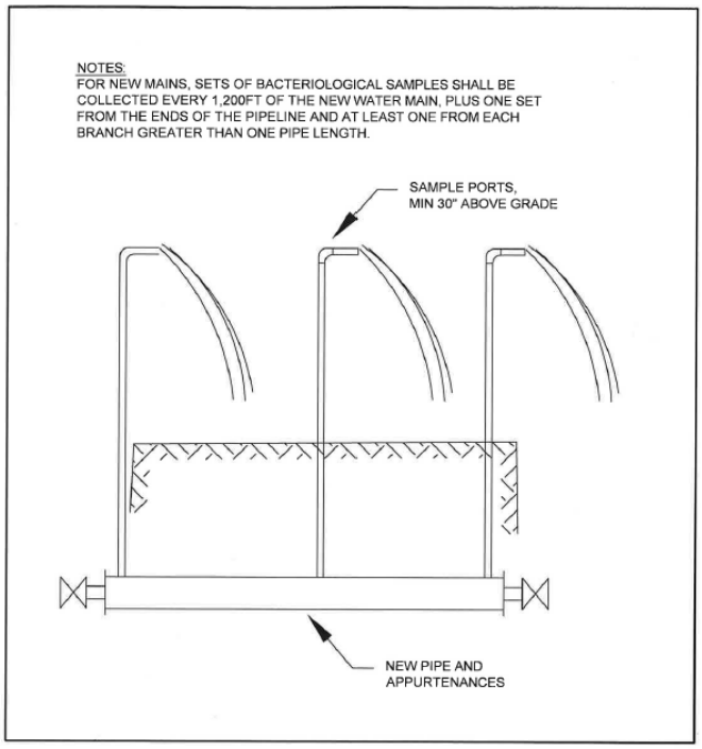

Table 1

Required flow and openings to flush pipelines at 3.0ft/sec

New Pipe Diameter	GPM Flow Required to Produce 3.0ft/sec.	Size of Supply	Size of FH Supply	Size of Discharge Flushing
4”	120	2”	2½”	2”
6”	260	2”	2½”	2”
8”	470	Two 2”	2½”	4”
10”	730	Two 2”	2½”	4”
12”	1,060	Three 2”	4½”	6”

Table 2

Chlorine required to produce an initial 25mg/L concentration in 100ft of pipe by diameter

New Pipe Diameter	100% Chlorine	1% Chlorine
4”	0.013lb	0.16gal
6”	0.030lb	0.36gal
8”	0.054lb	0.65gal
10”	0.085lb	1.02gal
12”	0.120lb	1.44gal

ANSI/AWWA C651-14
(Revision of ANSI/AWWA C651-05)

American Water Works Association

Dedicated to the World's Most Important Resource™

AWWA Standard

Disinfecting Water Mains

Effective date: Feb. 1, 2015.
First edition approved by AWWA Board of Directors Sept. 30, 1947.
This edition approved June 8, 2014.
Approved by American National Standards Institute Nov. 18, 2014.

American Water Works Association | STANDARD | Since 1881

Approved American National Standard ANSI

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AWWA Standard

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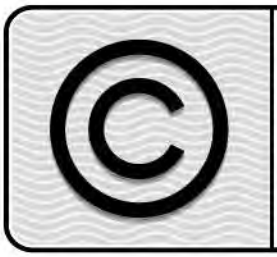

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The AWWA Standards Committee on Disinfection of Facilities, which reviewed and approved this standard, had the following personnel at the time of approval:

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Contents

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Tables

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Foreword

This foreword is for information only and is not a part of ANSI/AWWA C651.*

I. Introduction.

I.A. *Background.* This standard describes methods of disinfecting newly constructed potable water mains; mains that have been removed from service for planned repairs or for maintenance that exposes them to contamination; mains that have undergone emergency repairs because of physical failure; and mains that, under normal operation, continue to show the presence of coliform organisms. The disinfecting agents discussed in this standard are chlorine solutions that may be derived from liquid chlorine (Cl_2), calcium hypochlorite ($Ca(OCl)_2$), or sodium hypochlorite (NaOCl). Combinations of free chlorine residual and contact time are provided. Chlorine dosage reference tables are provided as appendix B of this standard.

I.B. *History.* This standard was first approved on Sept. 30, 1947, by the AWWA Board of Directors and published as 7D.2-1948, A Procedure for Disinfecting Water Mains. Revisions were approved on Sept. 14, 1948; Mar. 6, 1953; May 27, 1954; June 2, 1968; and June 7, 1981. All were done under the designation ANSI/AWWA C601, Standard for Disinfecting Water Mains. In 1986, the designation of the standard was changed to ANSI/AWWA C651, and the subsequent editions were approved on Jan. 26, 1986; June 18, 1992; June 20, 1999; and Jan. 16, 2005. This edition was approved on June 8, 2014.

I.C. *Acceptance.* In May 1985, the US Environmental Protection Agency (USEPA) entered into a cooperative agreement with a consortium led by NSF International (NSF) to develop voluntary third-party consensus standards and a certification program for direct and indirect drinking water additives. Other members of the original consortium included the Water Research Foundation (formerly AwwaRF) and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association (AWWA) and the Association of State Drinking Water Administrators (ASDWA) joined later.

In the United States, authority to regulate products for use in, or in contact with, drinking water rests with individual states.† Local agencies may choose to impose requirements more stringent than those required by the state. To evaluate the health

* American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.
† Persons outside the United States should contact the appropriate authority having jurisdiction.

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effects of products and drinking water additives from such products, state and local agencies may use various references, including

1. An advisory program formerly administered by USEPA, Office of Drinking Water, discontinued on Apr. 7, 1990.
2. Specific policies of the state or local agency.
3. Two standards developed under the direction of NSF*: NSF/ANSI 60, Drinking Water Treatment Chemicals—Health Effects, and NSF/ANSI 61, Drinking Water System Components—Health Effects.
4. Other references, including AWWA standards, *Food Chemicals Codex*, *Water Chemicals Codex*,† and other standards considered appropriate by the state or local agency.

Various certification organizations may be involved in certifying products in accordance with NSF/ANSI 60. Individual states or local agencies have authority to accept or accredit certification organizations within their jurisdictions. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

Annex A, "Toxicology Review and Evaluation Procedures," to NSF/ANSI 60 does not stipulate a maximum allowable level (MAL) of a contaminant for substances not regulated by a USEPA final maximum contaminant level (MCL). The MALs of an unspecified list of "unregulated contaminants" are based on toxicity testing guidelines (noncarcinogens) and risk characterization methodology (carcinogens). Use of Annex A procedures may not always be identical, depending on the certifier.

ANSI/AWWA C651 does not address additives requirements. Thus, users of this standard should consult the appropriate state or local agency having jurisdiction in order to

1. Determine additives requirements including applicable standards.
2. Determine the status of certifications by parties offering to certify products for contact with, or treatment of, drinking water.
3. Determine current information on product certification.

II. Special Issues.

II.A. *Information on Application of This Standard.* Generally, it is easier to disinfect a new main than one that has had emergency repairs in terms of access, sanitary control, and the time available for disinfection, sampling, and testing.

* NSF International, 789 North Dixboro Road, Ann Arbor, MI 48105.

† Both publications available from National Academy of Sciences, 500 Fifth Street, NW, Washington, DC 20001.

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For a new main, there is typically more time available for disinfection and testing since there is no immediate demand from customers. Given the often significant amount of time and materials involved in a new water main project, careful disinfection and testing of the main are reasonable and necessary to ensure public health protection.

Conditions for pipe repair projects vary tremendously in terms of the size of the repair, the sanitary conditions, and the time constraints resulting from immediate customer demands. It should be noted if the line is depressurized or opened to the environment prior to or during repair, the sanitary integrity of the pipe is compromised and it is critical to follow sanitary procedures throughout the repair—not just as it is being returned to service. Crews responsible for the repair of mains should be aware of the potential health hazards and be trained to carefully observe prescribed construction practices and disinfection procedures.

Because of the differences between initial installation and repair, the disinfection requirements for each situation are also different. The installation of new mains requires that two sets of samples for coliform analysis are collected at least 16 hr apart, or two sets collected 15 min apart after at least a 16-hr rest period. For repaired mains that are depressurized and/or wholly or partially dewatered, one set of samples may be required, and depending on the sanitary conditions, the line may be returned to service prior to the completion of bacteriological testing. For repaired mains that are maintained under pressurized conditions at all times, bacteriological testing is not required

When required, samples are now specified to be collected at least 16 hr apart, or 15 min apart after a 16-hr rest period. The purpose of this change is to consider the balance between public health, improved test methods, and timely work completion. This timing is sufficient to allow bacterial regrowth within the line if there was a contamination problem and provides more flexibility in the scheduling of various work activities.

Bacteriological testing in accordance with Sec. 5.1 is used to verify the absence of coliform organisms and is generally accepted as verification that disinfection of the pipeline has been accomplished; and following sanitary practices for handling and installation of pipe, valves, fittings, and accessories, coupled with adequate flushing of the line before disinfection, is necessary to ensure the disinfected pipeline will be ready for connection to the water system. Failure to pass the bacteriological test requires that the flushing or disinfection process be repeated. It must be remembered that the final water quality test is not the primary means for certifying the sanitary condition of a main. The sanitary

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handling of materials, the practices during construction, and the continual inspection of the work are the primary means for ensuring the sanitary condition of the water main.

Four methods of disinfecting newly constructed water mains are described in this standard: the tablet method, the continuous-feed method, the slug method, and the spray method. The utility should decide which of these methods is most suitable for a given situation. Factors to consider when choosing a method should include the length and diameter of the main, type of joints present, availability of materials, equipment required for disinfection, training of the personnel who will perform the disinfection, and safety concerns. For example, if gas chlorination is the chosen chemical when either continuous-feed or slug methods are being used, use only properly designed and constructed equipment; makeshift equipment is not acceptable when liquid chlorine (gas) cylinders are used.

Thorough consideration should be given to the impact of highly chlorinated water flushed into the environment. If there is any question that damage may be caused by chlorinated-waste discharge (to fish life, plant life, physical installations, or other downstream water uses of any type), then an adequate amount of reducing agent should be applied to water being disposed of in order to thoroughly neutralize the chlorine residual remaining in the water.

The tablet method cannot be used unless the main can be kept clean and dry. It cannot be used in large-diameter mains if it is necessary for a worker to enter the main to grout joints or perform inspection because the tablets may release toxic fumes after exposure to moist air. When using the tablet method, the chlorine concentration is not uniform throughout the main because the hypochlorite solution is dense and tends to concentrate at the bottom of the pipe. The use of the tablet method precludes preliminary flushing. The tablet method is convenient to use in mains having diameters up to 24 in. (600 mm), and it requires no special equipment.

The continuous-feed method is suitable for general application. Preliminary flushing removes light particulates from the main but not from the pipe-joint spaces. The chlorine concentration is uniform throughout the main.

The slug method is suitable for use in large-diameter mains where the volume of water makes the continuous-feed method impractical and difficult to achieve for short attachments. The slug method results in appreciable savings of chemicals used to disinfect long large-diameter mains. Also, this method reduces the volume of heavily chlorinated water to be flushed to waste.

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The spray method is suitable for use in large-diameter transmission lines where spray equipment can be used to disinfect all surfaces of the pipe. This method reduces the volume of heavily chlorinated water to be flushed to waste.

The purpose of all four chlorination methods is to disinfect water lines, resulting in an absence of coliforms as confirmed by laboratory analysis. As noted above, the four methods attempt to provide flexibility in responding to specific situations. The tablet and continuous-feed methods both have initial chlorine concentrations of 25 mg/L and a minimum contact time of 24 hr. Because the tablet method cannot be flushed and cleaned prior to disinfection, the required free chlorine residual must be detectable (≥0.2 mg/L) after 24 hr. Because the continuous-feed method can be used to flush particles, a higher free chlorine residual of 10 mg/L is required after 24 hr. To meet the needs of situations requiring reduced contact times, the slug method allows only a 3-hr contact time but requires a 100-mg/L initial chlorine dosage. For larger transmission lines, spray disinfection using 200 mg/L free chlorine may be a suitable option, minimizing discharges of highly chlorinated water. While the contact times of the methods may not be identical, the end result, absence of coliforms, is the same for all four methods.

Disinfectants other than chlorine may be appropriate to use. Although this standard describes only the use of liquid chlorine (gas), sodium hypochlorite solutions, and calcium hypochlorite, the applicability of other disinfectants should be evaluated. Ozone and chemical cleaners have been used, and these warrant further investigation. Whichever disinfectant or method is selected, approval from the local regulatory agency may be required.

III. Use of This Standard. It is the responsibility of the user of an AWWA standard to determine that the products described in that standard are suitable for use in the particular application being considered.

III.A. *Purchaser Options and Alternatives.* This standard is written as though the disinfection work will be performed by the purchaser's personnel. Where the work is to be performed using a separate contract or as part of a contract for installing mains,* appropriate provisions should be included in the purchase documents to ensure that the constructor is specifically instructed as to its responsibilities. The following information should be provided by the purchaser.

* Refer to other AWWA standards and manuals for design criteria and installation procedures for various pipe materials.

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1. Standard used— that is, ANSI/AWWA C651, Standard for Disinfection of Water Mains, of latest revision.

2. Approval requirements before use.

3. Those procedures included in the standard that are designated as optional, that are to be included in the purchase documents.

4. Whether compliance with NSF/ANSI 60, Drinking Water Chemicals—Health Effects, is required.

5. Whether compliance with NSF/ANSI 61, Drinking Water System Components—Health Effects, is required.

6. Details of other federal, state or provincial, and local requirements (Section 4).

7. Form of chlorine to be used (Sec. 4.1.1, 4.1.2, and 4.1.3).

8. Method of chlorination (Sec. 4.3, 4.4, 4.5, and 4.6).

9. Flushing locations, rates of flushing, and locations of drainage facilities (Sec. 4.4.2, 4.9.1, and 4.9.2).

10. Responsibility for tapping existing mains and connections to new mains (Sec. 4.4.3[1], 4.4.3[2], and 4.10).

11. The number and frequency of samples for bacteriological tests (Sec. 5.1.1, 5.1.2, and 5.2).

12. Method of taking samples (Sec. 5.1.3).

III.B. *Modification to Standard.* Any modification of the provisions, definitions, or terminology in this standard must be provided by the purchaser.

IV. Major Revisions. Major revisions made to the standard in this edition include the following:

1. Clarified differences in the requirements between new and repaired mains (foreword II.A, Sec. 1.1, and 4.11).

2. Changed the requirement for bacteriological sampling in new mains from two sets of samples 24 hr apart to add two options for two sets of samples: Option A samples are 16 hr apart, and Option B samples are 15 min apart after a 16-hr rest period (foreword II.A and Sec. 5.1).

3. The flushing rate of 2.5 ft/sec has been increased to 3.0 ft/sec for a scour flush based on testing performed under Water Research Foundation Project No. 4307, which indicates the threshold velocity of 2.5 to 3.0 ft/sec for successful flushing (2.5- to 3.0-log removal) of sand particles. Since this is a threshold velocity, 3.0 ft/sec was chosen for the standard (Sec. 4.4.2 and Table 3).

4. Added spray disinfection method for large transmission mains (Sec. 4.6).

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5. Appendix C has been deleted, and instead, a reference to ANSI/AWWA C655 is made for dechlorination (Sec. 4.7 and 4.9.2).

6. Developed a rationale for evaluating risk during pipe repairs and the level of disinfection and sampling needed under those conditions (Sec. 4.11).

V. Comments. If you have any comments or questions about this standard, please call the AWWA Engineering and Technical Services at 303.794.7711, FAX at 303.795.7603; write to the group at 6666 West Quincy Avenue, Denver, CO 80235-3098; or email the group at standards@awwa.org.

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AWWA Standard

Disinfecting Water Mains

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes essential procedures for the disinfection of new and repaired potable water mains. New water mains shall be disinfected before they are placed in service. Water mains taken out of service for inspection, repair, or other activities may or may not require disinfection and sampling, depending on the risk of contamination. This standard describes the process for evaluating the risk under different conditions.

Sec. 1.2 Purpose

The purpose of this standard is to define the minimum requirements for the disinfection of water mains, including the preparation of water mains, application of chlorine, and sampling and testing for the presence of coliform bacteria.

Sec. 1.3 Application

This standard can be referenced in the purchase documents for the disinfection of water mains and can be used as a guide for the preparation of water mains, application of chlorine, and sampling and testing for the presence of coliform bacteria. The stipulations of this standard apply when this document has been referenced and only to the disinfection of water mains.

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SECTION 2: REFERENCES

This standard references the following documents. In their latest editions, they form a part of this standard to the extent specified within the standard. In any case of conflict, the requirements of this standard shall prevail.

ANSI*/AWWA B300—Hypochlorites.

ANSI/AWWA B301—Liquid Chlorine.

ANSI/AWWA C652—Disinfection of Water Storage Facilities.

ANSI/AWWA C655—Field Dechlorination.

APHA,† AWWA, and WEF.‡ *Standard Methods for the Examination of Water and Wastewater.*

AWWA Manual M12, *Simplified Procedures for Water Examination.*

NSF/ANSI 61—Drinking Water System Components–Health Effects.

SECTION 3: DEFINITIONS

The following definitions shall apply in this standard:

1. *Available chlorine:* A measure of the amount of chlorine in chlorinated lime, hypochlorite compounds, chloramines, and other materials that are used for disinfection compared with the amount in elemental (liquid or gaseous) chlorine.

2. *Chlorine, combined:* The amount of chlorine combined with ammonia (NH_3) or other compounds in water.

3. *Chlorine, free:* Also called *free available chlorine*, the amount of chlorine available as dissolved gas (Cl_2), hypochlorous acid (HOCl), and hypochlorite (OCl^-) that is not combined with ammonia (NH_3) or other compounds in water that is available for disinfection.

4. *Chlorine residual:* Concentration of chlorine species present in water after the oxidant demand has been satisfied.

5. *Chlorine, total:* A combination of free chlorine, combined chlorine, and organochlorine species.

6. *Constructor:* The party that provides the work and materials for placement or installation.

* American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.
† American Public Health Association, 800 I Street NW, Washington, DC 20001.
‡ Water Environment Federation, 601 Wythe Street, Alexandria, VA 22314.

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7. *Liquid chlorine (gas):* the commercially available form of liquefied elemental chlorine gas. (The term *liquid chlorine* is sometimes used to describe a hypochlorite solution. This use of the term is discouraged. See ANSI/AWWA B300, Hypochlorites.)

8. *Manufacturer:* The party that manufactures, fabricates, or produces materials or products.

9. *Purchaser:* The person, company, or organization that purchases any materials or work to be performed.

10. *Supplier:* The party that supplies material or services. A supplier may or may not be the manufacturer.

11. *Organochlorine:* Any organic compound containing chlorine as a constituent. Organochlorine compounds can form when chlorine reacts with organic substances.

SECTION 4: REQUIREMENTS

Materials shall comply with the requirements of the Safe Drinking Water Act and other federal regulations for potable water, wastewater, and reclaimed water systems as applicable.

Sec. 4.1 Forms of Chlorine for Disinfection

The forms of chlorine that may be used in the water main disinfection operations are liquid chlorine (gas), sodium hypochlorite solution, and calcium hypochlorite granules or tablets.

4.1.1 *Liquid chlorine (gas).* Liquid chlorine (gas) conforming to ANSI/AWWA B301 contains 100 percent available chlorine and is packaged in steel containers usually of 100-lb, 150-lb, or 1-ton (45.4-kg, 68.0-kg, or 907.2-kg) net chlorine weight. Liquid chlorine (gas) shall be used only (1) in combination with appropriate gas-flow chlorinators and ejectors to provide a controlled high-concentration solution feed to the water to be chlorinated; (2) under the direct supervision of someone familiar with the biological, chemical, and physical properties of liquid chlorine (gas) and who is trained and equipped to handle any emergency that may arise; and (3) when appropriate safety practices are observed to protect working personnel and the public. Makeshift equipment is not acceptable when liquid chlorine (gas) cylinders are used.

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4.1.2 *Sodium hypochlorite.* Sodium hypochlorite conforming to ANSI/AWWA B300 is available in liquid form in glass, rubber-lined, or plastic containers typically ranging in size from 1 qt (0.95 L) to 5 gal (18.92 L). Containers of 30 gal (113.6 L) or larger may be available in some areas. Sodium hypochlorite contains approximately 5 percent to 15 percent available chlorine, and the storage conditions and time must be controlled to minimize its deterioration. (Available chlorine is expressed as a percent of weight when the concentration is 5 percent or less, and usually as a percent of volume for higher concentrations. Percent × 10 = grams of available chlorine per liter of hypochlorite.)

4.1.3 *Calcium hypochlorite.* Calcium hypochlorite conforming to ANSI/AWWA B300 is available in granular form or in 5-g tablets and must contain approximately 65 percent available chlorine by weight. The material should be stored in a cool, dry, and dark environment to minimize its deterioration.

CAUTION: Tablets dissolve in approximately 7 hr and must be given adequate contact time. Do not use calcium hypochlorite intended for swimming pool disinfection, as this material has been sequestered and is extremely difficult to eliminate from the pipe after the desired contact time has been achieved.

Sec. 4.2 General Considerations for All Methods of Chlorination

4.2.1 *General.* Four methods of chlorination are explained in this section: tablet, continuous feed, slug, and spray. The tablet method gives an initial chlorine dose of 25 mg/L; the continuous-feed method gives a 24-hr chlorine residual of not less than 10 mg/L; the slug method gives a 3-hr exposure of not less than 50 mg/L free chlorine; and the spray method gives a 30-min exposure of not less than 200 mg/L free chlorine. Caution should be used with highly chlorinated water when conducting hydrostatic pressure testing and with high-volume flushing of water.

4.2.2 *Flushing.* Potable water shall be used for disinfection, hydrostatic pressure testing, and flushing. Drainage should take place away from the construction or work area. Adequate drainage must be provided during flushing. If applicable, the valve(s) isolating the main from existing system should be locked out and tagged out to prevent unintentional release of the elevated chlorine residual water used for disinfection.

4.2.3 *Dechlorination.* When dechlorination is required, it is recommended that any high-velocity flushing be completed prior to disinfection. Dechlorination equipment may not be capable of handling high flows with high levels of chlorine.

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Table 1 Weight of calcium hypochlorite granules to be placed at beginning of main and at each 500-ft (150-m) interval

Pipe Diameter (*d*)		Calcium Hypochlorite Granules	
in.	*(mm)*	*oz*	*(g)*
4	(100)	1.7	(48)
6	(150)	3.8	(108)
8	(200)	6.7	(190)
10	(250)	10.5	(298)
12	(300)	15.1	(428)
14 and larger	(350 and larger)	$D^2 \times 15.1$	$D^2 \times 428$

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

Sec. 4.3 Tablet/Granule Method of Chlorination

4.3.1 *Tablet method.* The tablet method consists of placing calcium hypochlorite granules or tablets in the water main during installation and then filling the main with potable water to create a chlorine solution. This method may be used only if the pipes and appurtenances are kept clean and dry during construction.

WARNING: This procedure must not be used on solvent-welded plastic or on screwed-joint steel pipe because of the danger of fire or explosion from the reaction of the joint compounds with the calcium hypochlorite.

4.3.2 *Placement of calcium hypochlorite granules during construction.* Calcium hypochlorite granules shall be placed at the upstream end of the first section of pipe, at the upstream end of each branch main, and at 500-ft (150-m) intervals. The quantity of granules at each location shall be as shown in Table 1.

4.3.3 *Placement of calcium hypochlorite tablets during construction.* Calcium hypochlorite tablets (5-grams) shall be placed in the upstream end of each section of pipe to be disinfected, including branch lines. Also, at least one tablet shall be placed in each hydrant branch and in other appurtenances. 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 2 shows the number of tablets required for commonly used sizes of pipe. Calcium hypochlorite tablets shall be attached by an adhesive meeting the requirements of NSF/ANSI 61. There shall be adhesive only on the broadside of the tablet attached to the surface of the pipe. Attach tablets inside and at the top of the main. If the tablets are attached before the pipe section is placed in

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Table 2 Number of 5-g calcium hypochlorite tablets required for dose of 25 mg/L*

Pipe Diameter		Length of Pipe Section, *ft (m)*				
		13 (4.0) or less	18 (5.5)	20 (6.1)	30 (9.1)	40 (12.2)
in.	*(mm)*	Number of 5-g Calcium Hypochlorite Tablets				
4	(100)	1	1	1	1	1
6	(150)	1	1	1	2	2
8	(200)	1	2	2	3	4
10	(250)	2	3	3	4	5
12	(300)	3	4	4	6	7
16	(400)	4	6	7	10	13

*Based on 3.25-g available chlorine per tablet

the trench, their positions shall be marked on the pipe exterior to indicate that the pipe has been installed with the tablets at the top.

4.3.4 *Filling and contact time.* When installation has been completed, the main shall be filled with water such that the full pipe velocity is no greater than 1 ft/sec (0.3 m/sec). Fill rate must be carefully controlled to ensure tablets do not come loose from pipe. Precautions shall be taken to ensure that air pockets are eliminated. As an optional procedure, if required by the purchaser, water used to fill the new main shall be supplied through a temporary connection that shall include an appropriate cross-connection control device, consistent with the degree of hazard, for backflow protection of the active distribution system (see Figure 1).

The chlorinated water shall remain in the pipe for at least 24 hr. If the water temperature is less than 41°F (5°C), the water shall remain in the pipe for at least 48 hr. A detectable free chlorine residual (≥0.2 mg/L) shall be found at each sampling point after the 24- or 48-hr period.

Sec. 4.4 Continuous-Feed Method of Chlorination

4.4.1 *Continuous-feed method.* The continuous-feed method consists of completely filling the main with potable water, removing air pockets, then flushing the completed main to remove particulates, and refilling the main with potable water that has been chlorinated to 25 mg/L. After a 24-hr holding period in the main there shall be a free chlorine residual of not less than 10 mg/L.

4.4.2 *Preliminary flushing.* Before the main is chlorinated, it shall be filled with potable water to eliminate air pockets and flushed to remove particulates. The flushing velocity in the main shall not be less than 3.0 ft/sec (0.91 m/sec) unless

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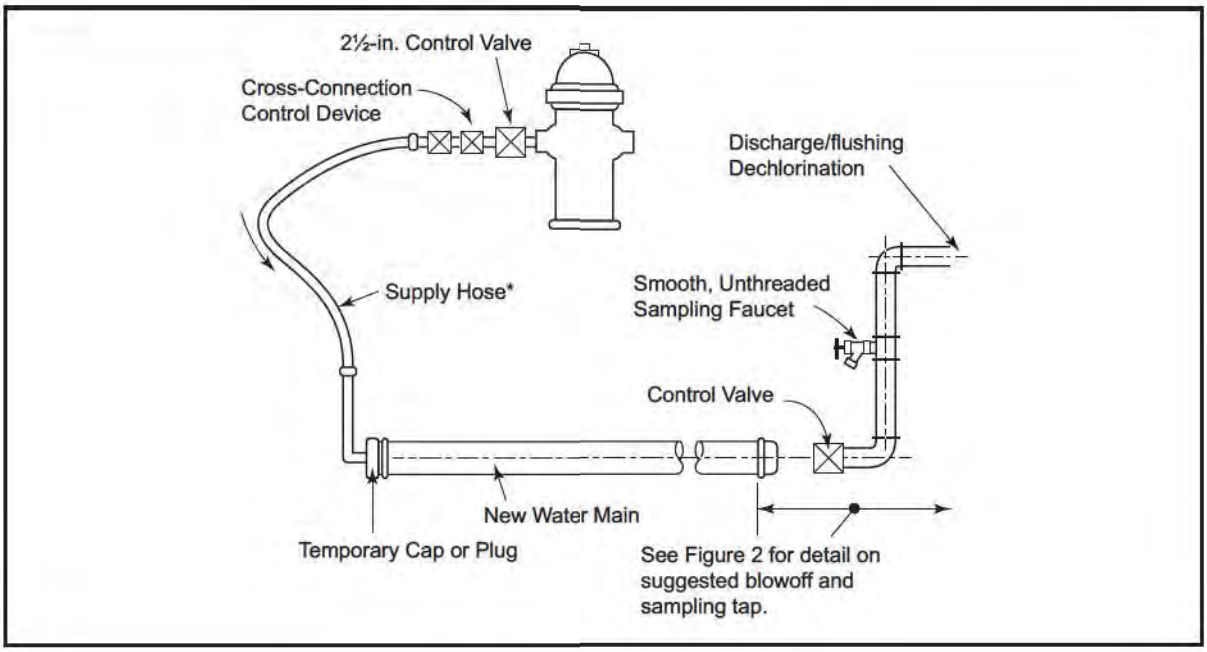

NOTE: Figure 1 applies to pipes with diameters 4 in. (100 mm) through 12 in. (300 mm). Larger sizes must be handled on a case-by-case basis.

*Clean potable-water hose only. Size and number of taps per Table 3. This hose must be removed during the hydrostatic pressure test.

Figure 1 Suggested temporary flushing/testing connection

Table 3 Required flow and openings (either taps or hydrants) to flush pipelines at 3.0 ft/sec (0.91 m/sec) (40 psi [276 kPa] residual pressure in water main)*

Pipe Diameter		Flow Required to Produce 3.0 ft/sec (approx.) Velocity in Main		Size of Tap Used, *in. (mm)*			Number of Hydrant Outlets	
				1 (25)	1½ (38)	2 (51)		
in.	*(mm)*	*gpm*	*(L/sec)*	Number of Taps Required on Pipe†			2½-in. (64-mm)	4½-in. (114 mm)
4	(100)	120	(7.4)	1	—	—	1	1
6	(150)	260	(16.7)	—	1	—	1	1
8	(200)	470	(29.7)	—	2	—	1	1
10	(250)	730	(46.3)	—	3	2	1	1
12	(300)	1,060	(66.7)	—	—	3	2	1
16	(400)	1,880	(118.6)	—	—	5	2	1

*With a 40-psi (276-kPa) pressure in the main with the hydrant flowing to atmosphere, a 2½-in. (64-mm) hydrant outlet will discharge approximately 1,000 gpm (63.1 L/sec); and a 4½-in. (114-mm) hydrant outlet will discharge approximately 2,500 gpm (160 L/sec).

†Number of taps on pipe based on 3.0-ft/sec discharge through 5 ft (1.5 m) of galvanized iron (GI) pipe with one 90° elbow.

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the purchaser determines that conditions do not permit the required flow to be discharged to waste. Table 3 shows the rates of flow required to produce a velocity of 3.0 ft/sec (0.91 m/sec) in commonly used sizes of pipe. (NOTE: flushing is no substitute for preventive measures during construction. Certain contaminants, such as caked deposits, resist flushing at any feasible velocity, and pigging of the main, or other suitable method acceptable to the purchaser, may be required.) Where such flow rates are not possible, flushing at the maximum expected flow rate for the line for 2–3 volumes may be acceptable. For larger mains, pigging (or other suitable method acceptable to the purchaser) is an option in place of high velocity flushing.

For 24-in. (600-mm) or larger diameter mains, an acceptable alternative to flushing is to broom-sweep the main, carefully removing sweepings prior to filling and chlorinating the main. WARNING: OSHA requirements for confined space need to be addressed before entering a pipeline.

4.4.3 *Procedure for chlorinating the main.*

1. Potable water may be supplied from a temporary backflow-protected connection to the existing distribution system or other supply source approved by the purchaser. The cross-connection control device shall be consistent with the degree of hazard for backflow protection of the active distribution system (see Figure 1). The flow shall be at a constant, measured rate into the newly installed water main. In the absence of a meter, the rate may be approximated using a Pitot gauge in the discharge, measuring the time to fill a container of known volume, or measuring the trajectory of the discharge and using the formula shown in Figure 2. The main should undergo hydrostatic testing prior to disinfection.

2. At a point not more than 10 ft (3 m) downstream from the beginning of the new main, water entering the new main shall receive a dose of chlorine fed at a constant rate such that the water will have not less than 25 mg/L free chlorine. To ensure that an appropriate concentration is achieved, the free chlorine concentration shall be measured at regular time intervals in accordance with the procedures described in *Standard Methods for the Examination of Water and Wastewater* or AWWA Manual M12, or using appropriate chlorine test kit (see appendix A).

Table 4 gives the amount of chlorine required for each 100 ft (30.5 m) of pipe for various pipe diameters. Solutions with a minimum 1 percent chlorine concentration may be prepared with sodium hypochlorite or calcium hypochlorite. The latter solution requires 1 lb (454 g) of calcium hypochlorite in 8 gal (30.3 L) of water.

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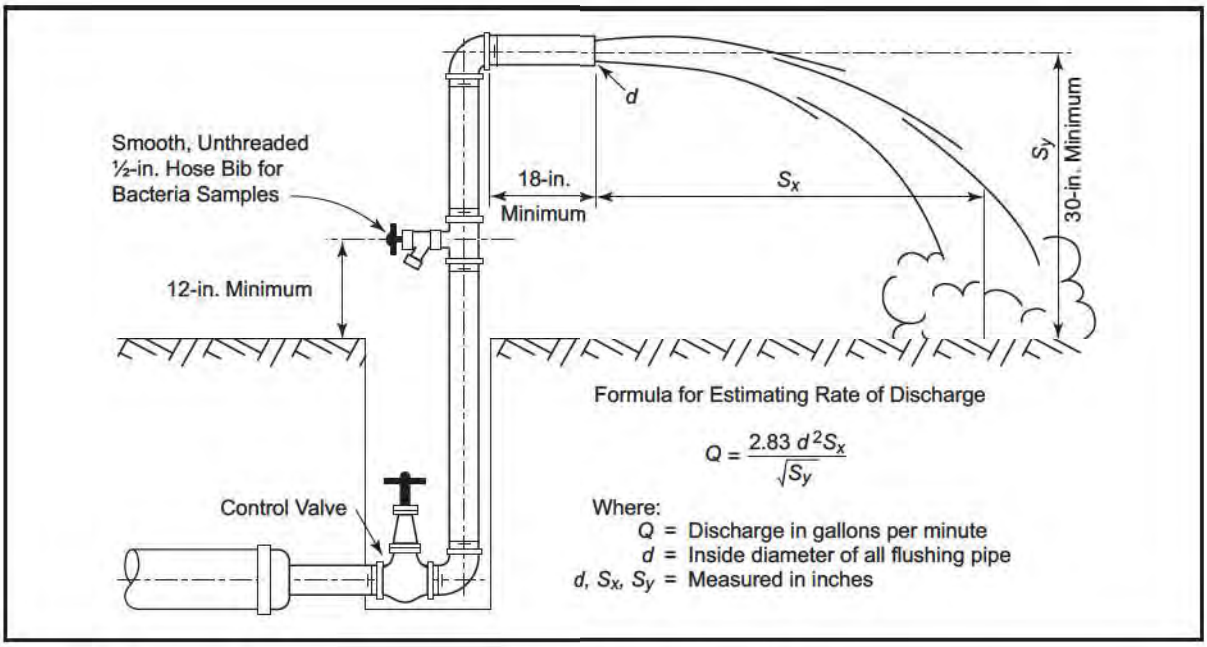

NOTE: This figure applies to pipes up to and including 8-in. (200-mm) diameter.

Figure 2 Suggested combination blowoff and sampling tap

Table 4 Chlorine required to produce an initial 25-mg/L concentration in 100 ft (30.5 m) of pipe by diameter

Pipe Diameter		100% Chlorine		1% Chlorine Solution	
in.	*(mm)*	*lb*	*(g)*	*gal*	*(L)*
4	(100)	0.013	(5.9)	0.16	(0.6)
6	(150)	0.030	(13.6)	0.36	(1.4)
8	(200)	0.054	(24.5)	0.65	(2.5)
10	(250)	0.085	(38.6)	1.02	(3.9)
12	(300)	0.120	(54.4)	1.44	(5.4)
16	(400)	0.217	(98.4)	2.60	(9.8)

3. Chlorine application shall not cease until the entire main is filled with chlorinated water. The chlorinated water shall be retained in the main for at least 24 hr, during which time valves and hydrants in the treated section shall be operated to ensure disinfection of the appurtenances. At the end of this 24-hr period, the treated water in all portions of the main shall have a residual of not less than 10 mg/L of free chlorine.

4. Direct-feed chlorinators, which operate solely from gas pressure in a chlorine cylinder, shall not be used for the application of liquid chlorine (gas). (The

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danger of using direct-feed chlorinators is that water pressure in the main can exceed gas pressure in the chlorine cylinder. This allows backflow of water into the cylinder, resulting in severe cylinder corrosion and the escape of chlorine gas.)

The preferred equipment for applying liquid chlorine (gas) is a solution-feed, vacuum-operated chlorinator and a booster pump. The vacuum-operated chlorinator mixes the chlorine gas in solution water; the booster pump then injects the chlorine solution into the main to be disinfected. Hypochlorite solutions may be applied to the water main with a chemical-feed pump designed for feeding chlorine solutions. Feed lines shall be made of material capable of withstanding the corrosion caused by the concentrated chlorine solutions and the maximum pressures that may be created by the pumps. All connections shall be checked for tightness before the solution is applied to the main.

Sec. 4.5 Slug Method of Chlorination

4.5.1 *Slug method.* The slug method consists of completely filling the main to eliminate air pockets; flushing the main to remove particulates; then slowly flowing through the main a slug of water dosed with chlorine to a concentration of 100 mg/L. The slow rate of flow ensures 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 hr.

4.5.2 *Preliminary flushing.* Same as Sec. 4.4.2.

4.5.3 *Procedure for chlorinating the main.*

1. Potable water may be supplied from a temporary backflow-protected connection to the existing distribution system or other supply source approved by the purchaser. The cross-connection control device shall be consistent with the degree of hazard for backflow protection of the active distribution system (see Figure 1). The flow shall be at a constant, measured rate into the newly installed water main. In the absence of a meter, the rate may be approximated using a Pitot gauge in the discharge, measuring the time to fill a container of known volume, or measuring the trajectory of the discharge and using the formula shown in Figure 2. The main should undergo hydrostatic testing prior to disinfection.

2. At a point not more than 10 ft (3 m) downstream from the beginning of the new main, water entering the new main shall receive a dose of chlorine fed at a constant rate such that the water will have not less than 100 mg/L free chlorine. To ensure that this concentration is achieved, the free chlorine concentration shall be measured at regular time intervals sufficient to guide the completion of the successful loading of the target chlorine concentration. The chlorine shall be applied

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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 hr.

3. 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, the flow shall be stopped; chlorination equipment shall be relocated at the head of the slug; and, as flow resumes, chlorine shall be applied to restore the free chlorine in the slug to not less than 100 mg/L.

4. As chlorinated water flows past fittings and valves, related valves and hydrants shall be operated so as to disinfect appurtenances and pipe branches.

Sec. 4.6 Spray Disinfection for Large Transmission Lines

For very large transmission mains (where personnel or equipment may safely enter the pipe), spray disinfection may be an 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 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. 5.1.

Sec. 4.7 Basic Disinfection Procedure for New Mains

The basic disinfection procedure consists of

1. Inspecting materials to be used to ensure their integrity.
2. Preventing contaminating materials from entering the water main during storage, construction, or repair and noting potential contamination at the construction site.
3. Removing, by flushing or other means, those materials that may have entered the water main or appurtenances.
4. Preventing contamination of existing mains from cross-connection during flushing, pressure testing, and disinfection.
5. Pressure testing the water main to ensure the main meets the purchaser's allowable leakage rate. Hydrostatic pressure tests should be conducted with potable water.
6. Chlorinating and adequately documenting the process used for disinfection.
7. Flushing the chlorinated water from the main. Refer to ANSI/AWWA C655 Field Dechlorination for dechlorination procedures, if dechlorination is required.

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8. Determining the bacteriological quality of water samples collected from the pipe by laboratory test after disinfection.

9. Final connecting of the newly disinfected water main to the active distribution system without sacrificing sanitary practices and conditions.

Sec. 4.8 Preventive and Corrective Measures During New Construction

4.8.1 *General.* Heavy particulates generally contain bacteria and prevent even very high chlorine concentrations from contacting and killing these organisms. Therefore, the procedures of this section must be observed to ensure that a water main and its appurtenances have been thoroughly cleaned for the final disinfection by chlorination. Also, any connection of a new water main to the active distribution system before the receipt of satisfactory bacteriological samples may constitute a cross-connection. Therefore, the new main must be isolated until bacteriological tests described in Section 5 of this standard are satisfactorily completed.

4.8.2 *Keeping pipe clean and dry.* The interiors of pipes, fittings, and valves shall be protected from contamination.

4.8.2.1 Openings. Openings in the pipeline shall be closed with watertight plugs when pipe laying is stopped at the close of the day's work or for other reasons, such as rest breaks or meal periods. Rodent-proof plugs may be used when watertight plugs are not practicable and when thorough cleaning will be performed by flushing or other means.

4.8.2.2 Stringing pipe. Pipe delivered for construction shall be strung to minimize the entrance of foreign material.

4.8.2.3 Delays. Delay in placement of delivered pipe invites contamination. The more closely the rate of delivery is correlated to the rate of pipe laying, the lower the risk of contamination.

4.8.3 *Joints.* Joints of pipe in the trench shall be completed before work is stopped. If water accumulates in the trench, the plugs shall remain in place until the trench is free of standing water and mud that may enter the pipe.

4.8.4 *Packing materials.* Yarning or packing material shall consist of molded or tubular rubber rings, rope of treated paper, or other approved materials. Materials such as jute or hemp shall not be used. Packing material shall be handled in a manner that avoids contamination.

4.8.5 *Sealing materials.* No contaminated material or any material capable of supporting growth of microorganisms shall be used for sealing joints. Sealing material or gaskets shall be handled in a manner that avoids contamination. The lubricant used in the installation of sealing gaskets shall be suitable for use in

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potable water meeting the requirements of NSF/ANSI 61 and shall not contribute odors. It shall be delivered to the job in closed containers and shall be kept clean and applied with dedicated clean applicators.

4.8.6 *Cleaning and swabbing.* If dirt enters the pipe, it shall be removed and the interior pipe surface swabbed with a minimum 1 percent free chlorine disinfecting solution. If, in the opinion of the purchaser, the dirt remaining in the pipe will not be removed using the flushing operation, the interior of the pipe shall be cleaned using mechanical means, such as a hydraulically propelled foam pig (or other suitable device acceptable to the purchaser) in conjunction with the application of a minimum 1 percent free chlorine disinfecting solution. The cleaning method used shall not force mud or debris into the interior pipe-joint spaces and shall be acceptable to the purchaser.

4.8.7 *Wet-trench construction.* If it is not possible to keep the pipe and fittings dry during installation, a scour flush at 3.0 ft/sec (0.91 m/sec) or greater for a minimum of three pipe volumes (see Table 3) followed by slug or continuous-feed chlorination and bacteria testing before release is required. For larger mains, pigging or other suitable method acceptable to the purchaser is an option in place of high-velocity flushing.

4.8.8 *Flooding by storm or accident during construction.* If the main is flooded during construction, it shall be cleared of the floodwater by draining and flushing with potable water until the main is clean. The section exposed to the floodwater shall then be filled with a chlorinated potable water that, at the end of a 24-hr holding period, will have a free chlorine residual of not less than 25 mg/L. The chlorinated water may then be drained or flushed from the main. If chemical contamination occurs, such as a hydraulic oil leak or petroleum product spill, the pipe sections exposed to the contamination should be replaced and not reused for potable water applications. After construction is completed, the main shall be disinfected using the continuous-feed, slug, or spray methods.

4.8.9 *Backflow protection (optional).** As an optional procedure (if required by the purchaser), the new water main shall be kept isolated from the active distribution system using a physical separation (see Figure 1) until satisfactory bacteriological testing has been completed and the disinfection water flushed out.

Water required to fill the new main for hydrostatic pressure testing, disinfection, and flushing shall be supplied through a temporary connection between the

* Optional Sec. 4.8.9 is not included as part of the standard unless required by the purchaser.

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distribution system and the new main or other supply source approved by the purchaser. The temporary connection shall include an appropriate cross-connection control device consistent with the degree of hazard (a double check valve assembly or a reduced pressure zone assembly) and shall be disconnected (physically separated) from the new main during the hydrostatic pressure test. It will be necessary to reestablish the temporary connection after completion of the hydrostatic pressure test to flush out the disinfectant water prior to final connection of the new main to the distribution system. NOTE: Exposure to high levels of chlorine or high pH can cause severe irritation to customers. Also, the chlorinated water can be high in disinfection by-products.

Sec. 4.9 Final Flushing for New Mains

4.9.1 *Clearing the main of heavily chlorinated water.* After the applicable retention period, heavily chlorinated water should not remain in prolonged contact with pipe. In order to prevent damage to the pipe lining or to prevent corrosion damage to the pipe itself, the heavily chlorinated water shall be flushed 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 that is acceptable for domestic use.

4.9.2 *Disposing of heavily chlorinated water.* The environment to which the chlorinated water is to be discharged shall be inspected. If there is any possibility that the chlorinated discharge will cause damage to the environment, a neutralizing chemical shall be applied to the water to be wasted to thoroughly neutralize the residual chlorine (see ANSI/AWWA C655 for neutralizing chemicals). Where necessary, federal, state, local, or provincial regulatory agencies should be contacted to determine special provisions for the disposal of heavily chlorinated water.

Sec. 4.10 Final Connections to Existing Mains

Water mains and appurtenances must be completely installed, flushed, disinfected, and satisfactory bacteriological sample results received prior to permanent connections being made to the active distribution system. Sanitary construction practices must be followed during installation of the final connection so that there is no contamination of the new or existing water main with foreign material or groundwater.

4.10.1 *Connections equal to or less than one pipe length (generally ≤20 ft [6 m]).* The new pipe, fittings, and valve(s) required for the connection may be spray disinfected or swabbed with a minimum 1 percent solution of chlorine just

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before being installed, if the total length of the connection from the end of a new main to the existing main is equal to or less than 20 ft (6 m).

4.10.2 *Connections greater than one pipe length (generally >20 ft [6 m]).* The pipe required for the connection must be set up aboveground, disinfected, and bacteriological samples taken, as described in Section 5, if the total length of the connection from the end of a new main to the existing main is greater than 20 ft (6 m). After satisfactory bacteriological sample results have been received for the predisinfected pipe, the pipe can be used in connecting the new main to the active distribution system. Between the time the satisfactory bacteriological sample results are received and the time that the connection piping is installed, the ends of the piping must be sealed with plastic wraps, watertight plugs, or caps.

Sec. 4.11 Disinfection Procedures When Cutting Into or Repairing Existing Pipe

4.11.1 *General.* 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. Refer to preventive and corrective measures described previously in Sec. 4.8.2, 4.8.3, 4.8.4, and 4.8.5. Follow all personal protection precautions when working with chlorine solutions.

4.11.2 *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.

4.11.3 *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,

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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 described in Sec. 4.11.3.1 through 4.11.3.3 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.

Note that the procedures explained in Sec. 4.11.3.1, 4.11.3.2, and 4.11.3.3 for distribution mains may need to be modified for large transmission mains. Large mains may need additional work (such as having a valve replaced or requiring a special order on a connection), may be out of service for more than a day, or may not be able to accommodate a scour flush. These modifications need to be made on a case-by-case basis but should still take into account the procedures outlined in ANSI/AWWA C651.

4.11.3.1 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. 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.

4.11.3.2 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-

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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 a 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.

4.11.3.3 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 in Sec. 4.3, 4.4, 4.5, or 4.6 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. Such situations require careful review and need to balance the public health risks of the pipeline failure as well as the repair process.

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Where practical and appropriate considering the risks of public exposure to high concentrations of chlorine, in addition to the procedures previously described in this standard, the section of pipe in which the break is located shall be isolated, all service connections shut off, and the section flushed and disinfected. If the slug chlorination method is employed, the dose may be increased to as much as 300 mg/L and the contact time reduced to as little as 15 min. After chlorination and repair, perform scour flushing at 3.0 ft/sec (0.91 m/sec) or greater for a minimum of three pipe volumes and continue until discolored water is not observed and the chlorine residual is restored to the levels maintained in the distribution system by the water utility.

For larger-diameter pipe (12 in. and greater), if a water velocity of 3.0 ft/sec (0.91 m/sec) cannot be achieved, it is desirable to flush at the maximum flow for the main until three pipe volumes have been displaced before returning the main to service. The flushed water should run visually clear, and have typical system chlorine residual (if the system operates with a disinfectant residual).

For very-large-diameter pipe (where personnel may safely enter the pipe), in lieu of flushing following disinfection, the interior of the pipe at the repair site may be cleaned by sweeping or high pressure wash using potable water before disinfection. Standing water and debris from the cleaning must be removed from the pipe prior to disinfection. The affected pipe shall be disinfected by swabbing or spraying with a minimum 1 percent chlorine solution.

After following the appropriate methods above, prior to returning the pipe to service, the efficacy of the disinfection procedure shall be verified by testing for the absence of coliform bacteria. If allowed by local regulations, the pipeline may be returned to limited service prior to obtaining bacteriological results with proper notification of the affected customers.

4.11.4 *Temporary service lines.* Temporary water service lines to customers during main repair activities shall be disinfected prior to use. Materials shall meet the NSF/ANSI 61 certification for potable water use. Disinfection should be accomplished by the procedures in Sec. 4.4 or 4.5 followed by scour flushing at 3.0 ft/sec (0.91 m/sec) or greater for a minimum of three pipe volumes (see Table 3), or until the water runs visually clear and preferably a measurable chlorine residual is restored.

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SECTION 5: VERIFICATION

Sec. 5.1 Bacteriological Tests

5.1.1 *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:

5.1.1.1 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 in Sec. 5.1.1.2.

5.1.1.2 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.

5.1.1.3 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.

5.1.1.4 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.

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5.1.2 *Standard conditions for repaired 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 repair work, and continual inspection of work. After disinfection and final flushing, samples shall be collected as follows:

5.1.2.1 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. Refer to Sec. 4.11.

5.1.2.2 For repaired mains that were maintained under pressurized conditions at all times, disinfection and/or testing may not be required. Refer to Sec. 4.11.3.

5.1.2.3 However, under either main repair scenario, it is advisable where possible to provide a scour flush to clear before the release of the repaired section.

5.1.3 *Sampling procedure.* Samples for bacteriological analysis shall be collected in sterile bottles treated with sodium thiosulfate, in accordance with Section 9060—Samples of *Standard Methods for the Examination of Water and Wastewater.* Hoses and fire hydrants are not recommended for the collection of samples that will be used to make decisions on the bacteriological quality of drinking water. However, if no sampling port is available, cleaned fire hydrants that have been cleared of standing water and/or other sanitized sampling apparatus (i.e., sanitized tubing, hose, gooseneck, spigot) may be used with the understanding that they do not represent optimum access to the water main for bacteriological sampling. A suggested combination blowoff and sampling tap used for mains up to and including 8-in. (200-mm) diameter is shown in Figure 2. There should be no water in the trench up to the connection for sampling. The sampling pipe must be dedicated and clean and disinfected and flushed prior to sampling. 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 and the corporation cock should be capped or taped for future reuse. If corporation cocks are placed at the 12 o'clock position, they may be struck more easily during future excavations.

5.1.4 *Sample results.* Samples shall be tested for bacteriological quality in accordance with *Standard Methods for the Examination of Water and Wastewater* and shall show the absence of coliform bacteria.

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In addition, it is recommended that samples be tested for acceptable aesthetic quality (e.g., chlorine residual, pH, alkalinity, specific conductance, turbidity). Levels should be as expected or typical for the water system. For new mains, a standard heterotrophic plate count 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.

5.1.5 *Record of compliance.* The record of compliance shall be the bacteriological test results certifying that the water sampled is free of coliform bacteria contamination.

5.1.6 *Redisinfection.* If the initial disinfection fails to produce satisfactory bacteriological results, or if other results indicate unacceptable water quality, the main may be reflushed and shall be resampled. If check samples fail to produce acceptable results, the main shall be rechlorinated by the continuous-feed or slug method until satisfactory results are obtained—that being acceptable samples taken as described in Sec. 5.1.1.1.

NOTE: In the case of new mains, high velocities in the adjacent existing system, resulting from flushing the new main, may disturb sediment that has accumulated in the existing mains. When check samples are taken, it is advisable to sample water entering the new main to determine if excessive turbidity is present that could be interfering with results.

Sec. 5.2 Optional Sampling and Testing

If a pipeline is not promptly returned to service, the situation should be evaluated to determine if the water quality may have been impacted and if additional testing is warranted. Test results should confirm that the water quality is appropriate for distribution. Although this assessment is unique for each system, parameters considered for testing include disinfectant residual, total coliform bacteria, HPC, turbidity, pH, alkalinity, total chlorine, odor, and specific conductance.

SECTION 6: DELIVERY

This standard has no applicable information for this section.

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APPENDIX A

Chlorine Residual Testing

This appendix is for information only and is not a part of ANSI/AWWA C651.

SECTION A.1: DPD DROP DILUTION METHOD (FOR FIELD TEST)

The N, N-diethyl-p-phenylenediamine (DPD) drop dilution method of approximating total residual chlorine is suitable for concentrations above 10 mg/L, such as those applied in the disinfection of water mains or tanks.

Sec. A.1.1 Apparatus

1. A graduated cylinder for measuring distilled water.
2. An automatic or safety pipette.
3. Two dropping pipettes that deliver a 1-mL sample in 20 drops. One pipette is for dispensing the water sample, and the other is for dispensing the DPD and buffer solutions. The pipettes should not be interchanged.
4. A comparator kit containing a suitable range of standards.

Sec. A.1.2 Reagents

1. DPD indicator solution. Prepare as prescribed in *Standard Methods for the Examination of Water and Wastewater.*

Sec. A.1.3 Procedure

1. Add 10 drops of DPD solution and 10 drops of buffer solution (or 20 drops of combined DPD-buffer solution) to a comparator cell.
2. Fill the comparator cell to the 10-mL mark with distilled water.
3. With a dropping pipette, add the water sample one drop at a time; mix until a red color is formed that matches one of the color standards.
4. Record the total number of drops used and the final chlorine reading obtained (that is, the chlorine reading of the matched standard).
5. Calculate the milligrams per liter of free residual chlorine as follows:

$$\text{mg/L chlorine} = \frac{\text{reading} \times 200}{\text{drops of sample}}$$

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SECTION A.2: HIGH-RANGE CHLORINE TEST KITS

Several manufacturers produce high-range chlorine test kits that are inexpensive, easy to use, and satisfactory for the precision required.

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APPENDIX B

Chlorine Dosages

This appendix is for information only and is not a part of ANSI/AWWA C651.

Table B.1 Amounts of chemicals required to produce various chlorine concentrations in 100,000 gal (378.5 m^3) of water*

Desired Chlorine Concentration in Water		Liquid Chlorine Required	Sodium Hypochlorite Required						Calcium Hypochlorite Required	
			5% Available Chlorine		10% Available Chlorine		15% Available Chlorine		65% Available Chlorine	
mg/L		*lb*	*gal*	*(L)*	*gal*	*(L)*	*gal*	*(L)*	*lb*	*(kg)*
2		1.7	(0.77)	3.9	(14.7)	2.0	(7.6)	1.3	(4.9)	2.6	(1.18)
10		8.3	(3.76)	19.4	(73.4)	9.9	(37.5)	6.7	(25.4)	12.8	(5.81)
50		42.0	(19.05)	97.0	(367.2)	49.6	(187.8)	33.4	(126.4)	64.0	(29.03)

*Amounts of sodium hypochlorite are based on concentrations of available chlorine by volume. For either sodium hypochlorite or calcium hypochlorite, extended or improper storage of chemicals may have caused a loss of available chlorine.

Table B.2 Amounts of chemicals required to produce chlorine concentration of 200 mg/L in various volumes of water*

Volume of Water		Liquid Chlorine Required		Sodium Hypochlorite Required						Calcium Hypochlorite Required	
				5% Available Chlorine		10% Available Chlorine		15% Available Chlorine		65% Available Chlorine	
gal	*L*	*lb*	*(g)*	*gal*	*(L)*	*gal*	*(L)*	*gal*	*(L)*	*lb*	*(g)*
10	(37.9)	0.02	(9.1)	0.04	(0.15)	0.02	(0.08)	0.02	(0.08)	0.03	(13.6)
50	(189.3)	0.10	(45.4)	0.20	(0.76)	0.10	(0.38)	0.07	(0.26)	0.15	(68.0)
100	(378.5)	0.20	(90.7)	0.40	(1.51)	0.20	(0.76)	0.15	(0.57)	0.30	(136.1)
200	(757.1)	0.40	(181.4)	0.80	(3.03)	0.40	(1.51)	0.30	(1.14)	0.60	(272.2)

*Amounts of sodium hypochlorite are based on concentrations of available chlorine by volume. For either sodium hypochlorite or calcium hypochlorite, extended or improper storage of chemicals may have caused a loss of available chlorine.

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POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS (GRAVITY SEWER FLOW)

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Specifications for furnishing and installation of PVC pipe material and fittings used for gravity sewer flow, including mains and laterals.

B. Related sections:
   1. Section 01 33 00 Submittal Process
   2. Section 31 20 00 Earthwork
   3. Section 31 25 00 Erosion Control
   4. Section 33 01 30.13 Gravity Sewer and Manhole Testing
   5. Section 33 05 63 Precast Concrete Vaults
   6. Section 33 23 19 Dewatering
   7. Section 33 23 33 Trenching and Backfilling

1.02 REFERENCES

A. American Society of Testing and Materials (ASTM)
   1. A 615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
   2. C 270 – Standard Specification for Mortar Unit Masonry
   3. C 387 - Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete
   4. C 478 - Standard Specification for Precast Reinforced Concrete Manhole Sections
   5. C 920 - Standard Specification for Elastomeric Joint Sealants
   6. C 923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals
   7. F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
   8. C 1427 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
   9. D 1784 Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
   10. D 3034 Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings, for pipe sizes from 4-inch to 15-inch diameters. ASTM F679 for pipe sizes from 18-inch to 30-inch diameters.
   11. D 3212 Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

B. AMERICAN WATER WORKS ASSOCIATION (AWWA)
   1.

C. American Water Works Association (AWWA)

1. AWWA C213 - Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings
2. AWWA C900 - Polyvinyl chloride (PVC) pressure pipe and fabricated fittings, 4-in. through 60-in.
3. M23 PVC Pipe – Design and Installation

1.03 SUBMITTALS

A. Shop Drawings:
   1. The Contractor shall submit shop drawings for all pipe, gaskets, fittings, and G05 cleanout boxes and lids in accordance with the requirements of Section 01 33 00 Submittals Process and the requirements of the referenced standards.

B. Product data:
   1. On all submittals, provide material types, manufacturer, and grade of materials to be provided.
   2. Plugs to be used for sanitary sewer hydrostatic testing.

C. Certifications:
   1. Provide certificate of compliance from the manufacture that certifying that the products meet project specifications and applicable standards.

PART 2 MATERIALS

2.01 GENERAL

A. Polyvinyl Chloride Pipe (PVC) and Fittings - PVC pipe and fittings shall be made in accordance to ASTM D-3034 or ASTM F679, and ASTM D1784. Pipe shall be green unless otherwise approved. All pipes shall be UL/FM approved. Minimum wall thickness is SDR-26 or as specified on the plans, whichever is greater.

   1. Markings - Each standard or random length of pipe shall be clearly marked with the following:
      - Manufacturer's name and production code
      - Nominal pipe size, i.e. XX-inch
      - Cell classification or material code; i.e. 12454-B
      - Dimension ratio number; i.e. SDR-XX
      - Product type
      - ANSI/ASTM Standard specification designation; i.e. D3034

   2. Pipe Class - The SDR or wall thickness shall be as shown on the plans.

   3. Pipe Diameter – sewer mains shall be sized to maintain system flows between 2 and 8 feet per second and a depth-to-diameter (d/D) flow ratio of less than 0.7, if no size is defined on the Plans. In no case shall sewer mains be smaller than 8-inch diameter without written consent of the Engineer.

4. Laying Length - The standard laying length shall be 20 feet (plus/minus) 1 inch. A maximum of 15% may be furnished in random lengths of not less than 10 feet each unless shown on the plans.

5. Joint Type - Pipe joints shall be constructed with an integral bell and spigot with an elastomeric gasket push-on-type joint. Each spigot shall have a “home” reference mark to facilitate pipe assembly. The gasket shall be contained in a machined groove on the pipe spigot such that when compressed the gasket will not displace and will form a positive seal. The gasket shall meet all requirements of ASTM F-477; pipe lubricant shall be listed with NSF (National Sanitation Foundation). Solvent cement joints are strictly prohibited. Joint tightness shall be tested in accordance with ASTM D3212.

B. Fittings: Unless otherwise specified, wye branches shall be provided in the gravity main for service lateral connections. All fittings shall be of the same material as the pipe. No cored, tapped, or saddle type connections shall be allowed on new or replaced sections of sewer mains without approval in writing by the Engineer. All fittings shall be as manufactured and furnished by the pipe supplier or approved equal and have gasketed bell and/or spigot configurations compatible with the pipe.

C. Warning Tape - Warning tape shall be green non-metallic tape marked “sewerline” as shown on the plans.

D. Tracer wire - Tracer wire shall be furnished and installed with all new gravity sewer mains and laterals, with terminations and splices as shown on the plans.

PART 3 EXECUTION

3.01 GENERAL

A. Handling and Transportation - Handling and transportation of pipe shall be in accordance with the pipe manufacturer's published instructions. Heavy canvas or nylon slings of suitable strength shall be used for lifting and supporting materials. Chains or cables shall not be used.

B. Storage and Care - Pipe and fittings shall be stored in unit packages provided by the manufacturer. Caution shall be exercised to avoid compression, damage or deformation to bell ends of the pipe. If pipe is to be exposed to direct sunlight for more than 14 days, pipe must be covered with an opaque material while permitting adequate air circulation above and around the pipe to prevent excessive heat accumulation. Pipe and fittings shall not be placed on rocks or gravel, or other hard material which might damage the pipe. Store all rubber gaskets in a cool, well ventilated place and do not expose to the direct rays of the sun. Materials shall be protected from contact with oils, fuels, petroleum, or solvents.

C. Pipe Laying -

A. General - Pipe shall be laid in accordance with the pipe manufacturer's published instructions, as modified by referenced specifications and

herein.

B. Cleanliness - The interior of pipes shall be clean of foreign materials before sections of pipe are installed and shall be protected to prevent entry of foreign materials after installation. Open ends of installed pipe shall be sealed with watertight plugs or other approved means at times when pipe installation is not in progress. Groundwater shall not be allowed to enter the pipe.

C. Inspection Before Installation - All pipe and fittings shall be carefully examined for cracks and other defects while suspended and before installation. Spigot ends shall be examined with particular care as this area is the most vulnerable to damage from handling. Defective pipe or fittings shall be laid aside for inspection, for repairs or rejection, at the discretion of the District.

D. Lowering of Pipe Material into Trench - Proper implements, tools, and equipment, satisfactory to the District, shall be provided and used by the contractor, for the safe and convenient performance of the work. All pipe shall be carefully lowered into the trench piece by piece in such a manner as to prevent damage to the materials. Under no circumstances shall the pipe be dropped or dumped into the trench.

If damage occurs to any pipe or accessories in handling, the damaged material shall not be installed without District approval.

E. Laying of Pipe – Lay pipe as indicated in the plans. Pipe laying shall proceed upgrade in the prepared trench with spigot ends pointing in the direction of flow. Grade trench bottom to indicated elevation of pipeline and shape bottom to fit lower quadrant of pipe. After a section of pipe has been lowered into the prepared trench, the contractor shall clean the end of the pipe to be joined, the inside of the joint, and the rubber ring immediately before joining the pipe. The assembly of the joint shall be made in accordance with the recommendations of the manufacturer of the type of joint used. The bell and spigot joint shall be pushed "home" in line with the installation band. If a piece has been cut, the usable end shall be clearly marked to show the proper amount of installation distance. All special tools and appliances required for jointing assembly shall be provided by the contractor.

After the joint has been made, the contractor shall check pipe for alignment and grade. The trench bottom shall form a continuous and uniform bearing and support along the length of the pipe between joints. Sufficient pressure in making the joint shall be applied to assure proper pipe alignment and joint makeup. Sufficient pipe zone material shall be placed to secure the pipe and prevent movement before the next joint is installed.

When pipe is laid within a movable trench shield, all necessary precautions shall be taken to prevent pipe joints from pulling apart

when moving the shield ahead.

Precautions shall be taken to prevent excavated or other foreign material from getting into the pipe during the laying operation. At all times, when laying operations are not in progress, or whenever the workers are absent from the job, the contractor shall close and block the open end of the last laid section of pipe to prevent entry of foreign material or creep of the gasketed joints.

The contractor shall take all precautions necessary to prevent the "uplift" or floating of the line prior to the completion of the backfilling operation.

Where pipe is connected to manholes or concrete structures without using a flexible connector, connections shall be made so that the standard pipe joint is located not more than 2 feet from the outside edge of the structure, unless otherwise shown.
Pipes which are stubbed off for manhole construction or for connection by

F. Cutting of Pipe - Field cuts and connections shall be in accordance with the pipe manufacturer's published instructions.

The cutting of pipe for fittings or closure pieces shall be done in a neat and workmanlike manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. The pipe shall be marked around its entire circumference prior to cutting to assure a square cut. A factory finished beveled end shall be used as a guide for proper bevel angle and depth of bevel plus the distance to the insertion reference mark. The end shall be beveled using manufacturer recommendations. Sharp edges on the leading edge of the bevel shall be rounded off to approximate a factory bevel and smoothed to prevent the accumulation of debris.

G. Lines and Grades – Vertical and horizontal of alignment of lines shall be as shown on the plans.

1. Sewer mains shall be installed to the lines and grades shown on the Plans. Unless otherwise indicated on the Plans, Sewer mains shall maintain a slope of at least 1% between manholes. Deviation from this standard requires prior written consent of the Engineer.

2. Upper lateral slope must be in accordance with the California Plumbing Code; 4-inch lower laterals must have a 2% minimum slope and 4-feet of cover in the right-of-way unless approved by the Engineer in writing. Slope of 6-inch and larger laterals shall be as shown on the plans and shall have a manhole at the point of connection to the main.

3. Joint deflection shall be less than 75% of pipe manufacturer’s

recommended maximum. Only factory joints shall be allowed.

4. Vertical alignment – Pipe segments must provide a constant slope between nodes.

5. Grade Tolerance - Grade tolerance of the flow line of gravity pipelines must not exceed plus or minus 0.05-foot and there must not be any deviation in a 12-foot section greater than 0.05-foot.

6. Establishment of Grade and Alignment - The contractor may elect to furnish a laser beam system for grade and alignment control. The laser beam must have a minimum accuracy of plus or minus 0.01-foot per 100 feet, be self leveling, and have an alarm in the event the laser is out of level. Upon request by the District's field representative, a string line shall be established by the Contractor to confirm the pipe alignment at no cost to the District.

7. Sag Tolerance - The allowable sag tolerance, the total variation (plus or minus) from flow line grade, must not exceed the following:
   i. 1/4 inch for 4-inch or smaller pipe
   ii. 3/4 inch for 6 through 12-inch pipe
   iii. 1 inch for 15 through 36-inch pipe

H. Dewatering shall comply with Section 31 23 19. The excavation must be free of water at the time facilities are placed, flotation of piping shall be prevented at all times. Dewatering and the prevention of run-on water shall be maintained so as to prevent the loss of compaction, collapse of excavation walls, or formation boil or liquefied soil conditions.

I. Backfill - Backfill shall be placed and compacted in accordance to Section 31 20 00.

J. Cleaning – All lines shall be cleaned of debris prior to testing. Concrete slurry and rinse water shall be appropriately disposed of and not discharged to the sanitary sewer.

3.02 TESTING

A. Following cleaning of the new gravity main and removal of any foreign materials by the Contractor, testing shall be completed in accordance with Section 33 01 30.13 for deformation and leakage. Testing shall occur on complete pipe runs between manholes and/or flush inlets.

END OF SECTION