

## **SECTION 02619 – PRESTRESSED CONCRETE CYLINDER PIPE**

### **PART 1 - GENERAL**

#### **1.01 SUMMARY**

- A. This Section provides for prestressed concrete cylinder pipe, fittings, specials, bolts, gaskets, and appurtenances for pipes 16 through 144-inches in diameter.
- B. This section includes Materials, Design of Pipe, Joints, Closure Assemblies, Test Plugs, Fittings and Specials, Pipe Marking, Exposed Metal Surfaces, Testing

#### **1.02 SPECIFICATION MODIFICATIONS**

- A. It is understood that throughout this section these Specifications may be modified by appropriate items in Section 01015 – Specific Project Requirements, or as otherwise indicated on the Contract Drawings.

#### **1.03 RELATED SECTIONS**

- A. Section 02200 – Excavation and Trenching
- B. Section 02618 – Ductile Iron Pipe Water Main
- C. Section 02675 – Water Man Testing, Disinfection and De-chlorination

#### **1.04 CODES AND STANDARDS**

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.
- B. American Society for Testing and Materials (ASTM):
  - ASTM A307 Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
  - ASTM A648 Specification for Steel Wire, Hard Drawn for Prestressing Concrete Pipe
  - ASTM C33 Specification for Concrete Aggregates
  - ASTM C150 Specification for Portland Cement
  - ASTM C454 Practice for Disintegration of Carbon Refractories for Alkali
  - ASTM D1248 Polyethylene Plastics Molding and Extrusion Materials
- C. American Water Works Association (AWWA):
  - AWWA C105 Polyethylene Encasement for Ductile-Iron Pipe Systems
  - AWWA C207 Steel Pipe Flanges for Waterworks Service, Sizes 4 Inch Through 144 Inch
  - AWWA C300 Reinforced Concrete Pressure Pipe, Steel Cylinder Type
  - AWWA C301 Prestressed Concrete Pressure Pipe, Steel Cylinder Type
  - AWWA C303 Concrete Pressure Pipe, Bar-Wrapped Steel Cylinder Type
  - AWWA C304 Design of Prestressed Concrete Cylinder Pipe
  - AWWA M9 Manual of Water Supply Practices, Concrete Pressure Pipe
- D. American National Standards Institute (ANSI):
  - ANSI B16.1 Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800

ANSI B16.21 Nonmetallic Flat Gaskets for Pipe Flanges

- E. The Society for Protective Coatings (SSPC):  
SSPC SP5 White Metal Blast Cleaning

1.05 DEFINITIONS

- A. Not used

1.06 PROVIDED BY CITY

- A. Not used

1.07 SUBMITTALS

- A. Submit as specified in Section 01300 – Submittals
- B. Shop Drawings
1. Submit the following for acceptance prior to fabrication:
    - (a) Pipe and joint details.
    - (b) Special, fitting, and coupling details.
    - (c) Laying and installation schedule with a pipe elevation for each pipe joint.
    - (d) Specifications, data sheets, and affidavits of compliance for protective shop coatings and linings.
    - (e) Pipe manufacturer's design calculations: In accordance with paragraph PIPE DESIGN REQUIREMENTS.
    - (f) Provide one copy of the pipe manufacturer's video illustrating the installation of the pipe.
- C. Product Data
1. Certificates and Affidavits: Submit the following for acceptance prior to shipment:
    - (a) Affidavit of compliance with applicable standards
    - (b) Certificate of origin for all steel flanges.
    - (c) Test certificates.
    - (d) Certification from gasket manufacturer that the gasket materials are compatible with the joints specified herein and are recommended for the specified field test pressure and for potable water service. Gaskets shall be certified as suitable for potable water that has been treated with chlorine or chloramines. Natural rubber will not be accepted.
    - (e) Certification of joint lubricant suitable for use in potable water piping.
    - (f) Exterior Coatings: Product information indicating that epoxy coating materials are suitable for use in potable water systems.
  2. Manufacturer's Testing Data: Submit the following in accordance with paragraph MANUFACTURER'S TESTING DATA:
    - (a) Proof of Design
- D. Other Submittals
1. Computer program for quality control tracking (reference paragraph QUALITY ASSURANCE). Submit upon request of the City.
  2. Qualifications for Manufacturer's Field Service Representative. Submit upon request of the City.
  3. Manufacturer's Certification of Instruction in accordance with paragraph MANUFACTURER'S FIELD SERVICE REPRESENTATIVE.

4. Manufacturer's Field Service Reports in accordance with paragraph  
MANUFACTURER'S FIELD SERVICE REPRESENTATIVE.

#### 1.08 QUALITY ASSURANCE

- A. Manufacturer shall have at least 5 years of experience in the design and manufacture of pipe, fittings, specials, and appurtenances. Submit information upon request by City.
- B. Minimum required qualifications and experience shall include manufacture of a pipeline at least 5 miles in length, of equal or larger diameter than the pipe to be provided, with joints, lining, and coating suitable for the same or greater pressure rating, which has performed satisfactorily for the past 5 years. Submit information upon request by City.
- C. Pipe shall be manufactured only in a facility having a current certificate under the compliance audit program of the American Concrete Pressure Pipe Association (ACPPA).
- D. Manufacturer's Quality Assurance Plan: In addition to the requirements of AWWA and ASTM, the pipe manufacturer must have an established quality assurance program. The program must document the various raw material components that go into manufacturing each piece of pipe for this project. Each individual pipe section must be identified and every production sequence documented, with all pertinent information recorded and stored. The information must be retrievable by material, project, and shipping dates. As a minimum the following data shall be input into a City-approved computer program and submitted:
  1. Pipe serial number.
  2. Joint ring steel manufacturer and Certification of AWWA Standards.
  3. Cylinder manufacturing date.
  4. Cylinder steel manufacturer and Certification of AWWA Standards.
  5. Core placement date, cement type, and concrete mix design.
  6. Core kiln number.
  7. Prestressing wire manufacturer, heat, and core number.
  8. Prestressing date.
  9. Coating date, cement type.
  10. Coating kiln number.
  11. Shipping date.

#### 1.09 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Ship, move, and store with provisions to prevent movement or shock contact with adjacent units.
- B. Handle with equipment capable of work with adequate factor of safety against overturning or other unsafe procedures.
- C. Follow the provisions for the delivery, storage, protection and handling products to and at site provided in Section 01000 – General Project Requirements, paragraph PRODUCT DELIVERY, STORAGE AND HANDLING.
- D. Pipe, fittings, and accessories shall be handled in a manner that will ensure installation in a sound, undamaged condition. Equipment, tools, and methods used in unloading, reloading, hauling, and laying pipe and fittings shall be such that the pipe, pipe coating, and fittings are not damaged. Use slings, lifting lugs, hooks, and other devices designed to protect pipe, joint elements, linings, and coatings. Hooks shall not be used.

- E. Under no circumstances shall pipe or accessories be dropped or dumped.
- F. Pipe and fittings shall not be moved by inserting anything into pipe ends.

**1.10 PIPE DESIGN REQUIREMENTS**

- A. Unless otherwise indicated in Section 01015 – Specific Project Requirements, concrete cylinder pipe shall be design in accordance with the following paragraphs.
- B. Furnish pipe of materials, joint types, and sizes as indicated on the drawings or as specified except as noted herein.
- C. Pipe and fittings shall be designed in accordance with AWWA M9 and AWWA C304.
- D. Pipe and fittings shall be designed to withstand the simultaneous application of the following external loadings and internal pressures under the specified conditions.

<b>Table 1 – Design Parameters for Concrete Cylinder Pipe</b>	
<b>Parameter</b>	<b>Criterion</b>
Fluid Unit Weight	62.4 lb./ft <sup>3</sup>
Outdoor Environment	365 days
Relative Humidity	60 percent
Time Before Filling	365 days
Minimum Cover Depth	15 feet
Live Load	H-20 at 3 feet
Minimum Working Pressure	200 psi
Minimum Surge Pressure	100 psi
Minimum Test Pressure	300 psi
Bedding Angle	45°

- E. Pipe Manufacturer’s Design Calculations: Pipe manufacturer’s design calculations for the pipe and fittings shall be signed and sealed by a Registered Professional Engineer licensed in the State of Missouri. The manufacturer’s engineer shall be a current employee of the pipe manufacturer and shall have had at least 5 years of experience with the pipe manufacturer. The calculations shall confirm the pipe wall thickness, amount of prestressing wire required, concrete compressive strength, steel cylinder thickness, and other parameters used in the design.

**PART 2 - PRODUCTS**

**2.01 CONCRETE CYLINDER PIPE**

- A. Pipe shall be manufactured in accordance with AWWA C301 except as modified herein. Prestressed concrete cylinder pipe shall be embedded cylinder type for all sizes.
- B. All prestressed concrete cylinder pipe, fittings, and specials shall be fabricated, lined, and coated by the pipe manufacturer.
- C. Cement shall be ASTM C150, Type II. The 28-day test cylinder concrete compressive strength used for the design of the pipe shall not exceed 7,000 psi. If a

test cylinder compressive strength between 6,500 psi and 7,000 psi is used for design, a concrete mix design shall be submitted.

- D. Fine aggregate shall be clean natural or manufactured sand as required by ASTM C33. No “rebound” shall be allowed in the cement mortar used for pipe.
- E. Rubber gaskets shall be synthetic rubber.
- F. Design of Pipe
  - 1. Design shall conform to AWWA M9 and AWWA C304 and as specified:
  - 2. Pipe Cylinder
    - (a) The cylinder hoop stress at 1.5 times working pressure shall not exceed the yield strength of the steel. A minimum cylinder thickness of 10 gauge shall be furnished.
    - (b) Cold-rolled sheets will not be acceptable.
    - (c) The length of pipe with restrained joints shall be as indicated on the drawings or as specified. Restrained joints and pipe cylinders shall be designed to withstand the calculated stresses at all points along the pipe with restrained joints. The maximum longitudinal stress in pipe cylinders shall not exceed 13,500 psi at the specified working pressure; or 17,000 psi at the specified working pressure plus surge pressure, or the field test pressure, whichever is the greatest.
  - 3. Mortar Coating
    - (a) Mortar coating thickness shall be a minimum of one (1-inch) over the prestressing wire.
- G. Joints:
  - 1. Bell-and-Spigot
    - (a) Provide bell-and-spigot-type joints for all buried pipe unless otherwise specified or indicated on the drawings.
    - (b) Provide joints with steel joint rings and O-ring rubber gaskets conforming to AWWA C301.
    - (c) Protect interior surface of the completed joint by grouting with Portland cement mortar.
    - (d) The exterior surface of the completed joint shall be covered with a wide joint diaper (harness clamp restrained joint diaper with full width closed cell polyethylene foam lining) filled with grout.
    - (e) All bells and spigots shall be the deep joint type (minimum 4-1/8 inches in joint depth).
  - 2. Flanged
    - (a) Provide flanged joints for all interior and exposed exterior pipe except where otherwise specified or indicated on the drawings.
    - (b) Flanges shall have a pressure rating not less than that required for pipe.
    - (c) Flanges, bolts, and gaskets shall conform to AWWA C207, Class D and shall be drilled ANSI B16.1 Class 125.
  - 3. Coupled
    - (a) Furnish couplings where indicated on the drawings.
    - (b) Furnish pipe ends suitable for receiving the style of coupling indicated on the drawings or as specified.
    - (c) Furnish anchored couplings where restraint is required to withstand specified operating or hydrostatic test pressure and where indicated on the drawings.
  - 4. Special

- (a) Furnish pipe with joints suitable for attaching to valves and accessories and for indicated transitions.
- (b) Joints shall be plain end, flanged, mechanical, or as otherwise indicated on the drawings or as specified.
- (c) Adapters may be furnished in lieu of pipe with special joints.
- 5. Restrained
  - (a) Provide either clamp-type or snap-ring type rubber and steel joints acceptable to City where restraint is required for joint to withstand specified operating and hydrostatic test pressure.
  - (b) The length of pipe with restrained joints shall be as indicated on the Drawings or as specified.
- H. Closure Assemblies
  - 1. Provide closure assemblies acceptable to City where indicated on the drawings and as required by the sequence of construction.
- I. Test Plugs
  - 1. Provide pressure test plugs where required to test the installation.
  - 2. Design test plugs to withstand hydraulic test pressure and external loading.
  - 3. Join test plugs to pipe with selected joint and restrain as required to maintain internal pressures with external loading applied.
  - 4. Provide outlets of proper size to facilitate flushing and disinfection.
- J. Fittings and Specials
  - 1. Fabricate conforming to AWWA C301 and M9.
  - 2. Design to withstand internal pressure and external loading not less than that of adjoining pipe.
  - 3. Furnish fittings with bell-and-spigot ends where such fittings connect with concrete pipe.
  - 4. Furnish wall fittings with approved anchor ring where indicated on the drawings. Such fittings shall be of ductile iron or fabricated steel.
  - 5. Furnish all adapters, outlets, and other specials as specified or where indicated on the drawings.
  - 6. Furnish openings for air valve, drain, sampling, sensing, testing, and other connections with threaded bosses or flanged outlets sized and located where indicated on the drawings. Steel connections shall be lined and coated with mortar or other protective coating material if mortaring is not feasible.
  - 7. Provide tangent blow-off and drain assemblies where indicated on the drawings. Outlet shall be a minimum 6-inch anchored mechanical joint spigot.
  - 8. Short Bevel Fittings: Furnish and maintain two nominal full bevels and four nominal half bevel bends on site during pipe installation for minor alignment adjustments. Replenish as used until pipe is installed. Return unused bevels to pipe manufacturer.

## 2.02 MARKINGS

- A. All pipe and fittings shall be marked in conformance with the standard specification under which the pipe is manufactured and as otherwise specified.
- B. The following information shall be marked on each pipe, fitting, and special:
  - 1. Design pressure.
  - 2. Laying schedule number on all fittings and specials.
  - 3. Date of casting.
  - 4. Length of any short pipe.

### 2.03 EXTERIOR COATINGS

- A. All exposed interior and exterior metal surfaces, including joint rings, outlets, adapters, closure pieces, and miscellaneous steel, shall be coated with an epoxy meeting NSF International requirements for contact with potable water. Submit product information in accordance with paragraph SUBMITTALS.

### 2.04 MANUFACTURER'S TESTING

- A. Hydrostatic Testing of Pipe
  1. The pipe manufacturer shall hydrostatically test each cylinder after the joint rings have been attached.
  2. Test shall be completed prior to delivery to the Site
  3. The hydrostatic test pressure shall be a minimum of 75 percent of the cylinder design and shall be applied for a minimum of 1 minute.
- B. The manufacturer shall hydrostatically test completed pipe prior to shipment to job site. Pipe of each size and class shall be selected at random by the City; however, no more than 10% of the pipe will be tested unless there are lengths that fail the test. The hydrostatic test pressure shall be a minimum of 1.5 times the test pressure and shall be for a minimum of five minutes, during which time the coating shall be checked for exterior cracks. Any pipe with visible cracks, at the specified test pressure, shall be rejected

### 2.05 PROOF OF DESIGN

- A. Proof of design tests for each pipe size and joint configuration shall be performed by the manufacturer, witnessed and sealed by the Independent Testing Service selected by the City
- B. The results of the tests shall be submitted to the City for review and approval prior to the start of manufacture.
- C. The purpose of the tests are to prove the adequacy of the design and quality for each size and class of pipe and joint manufactured per the specification requirements.
  1. One standard length from each size and class of pipe shall be selected.
  2. The manufacturer shall conduct a combined load test to verify the design of the pipe.
  3. Strain gauges shall be placed strategically on the outside of the core and outside of the mortar coating to verify a zero allowable tensile stress with the following loads applied.
  4. An external load, equivalent to the maximum fill height in any one class, shall be applied simultaneously to the internal pressure, equivalent to the working pressure plus surge.
  5. The testing apparatus shall be designed to allow the entire pipe to deflect uniformly under the application of external load while maintaining a watertight seal.
  6. Bell and spigot configured bulkheads, which add stiffness to the pipe ends, will not be permitted.

### 2.06 POLYETHYLENE ENCASEMENT

- A. As specified in Section 02618 – Ductile Iron Pipe Water Main.

### 2.07 TESTING OF JOINTS

- A. Each joint shall be tested at a pressure not less than 1.5 times the test pressure.

- B. In addition to being tested in the un-deflected condition, at least one joint of each size and type shall be tested at the maximum angle of deflection recommended by the manufacturer.
- C. When testing restrained joints, the piping shall not be blocked to prevent separation and the joint shall not leak or show evidence of failure.
- D. When angular deflection is required at restrained bell-and spigot joints, special bevels shall be provided for the exact angle or the deflection shall be obtained by opening joints on one side. Deflections by opening joints on one side shall not exceed the values recommended by the manufacturer and shall be proven by joint testing.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Use equipment, methods, and materials ensuring installation to lines and grades indicated.
- B. Maintain within tolerances specified or acceptable laying schedule.
  - (a) Alignment: 1 inch per 100 feet in open cut or tunnel.
  - (b) Grade: 1 inch per 100 feet.
- C. Accomplish horizontal and vertical curve alignments with bends, bevels, and joint deflections.
  - (a) Limit interior joint opening in concrete pipe except for open side on deflected joints to:
    - (b) 3/8-inch in laying schedule.
    - (c) 1/2-inch in actual installation.
    - (d) Use short specials in curve as indicated.
- D. Obtain acceptance of method proposed for transfer of line and grade from control to the Work.
- E. Install pipe of size, materials, strength class, and joint type with embedment indicated for plan location.
- F. Install pipe with bell ends in direction of laying. Obtain City approval for deviations there from.
- G. Clean interior of all pipe, fittings, and joints prior to installation. Exclude entrance of foreign matter during installation and at discontinuance of installation.
  - (a) Close open ends of pipe with snug-fitting closures.
  - (b) Do not let water fill trench. Include provisions to prevent flotation should water control measures prove inadequate.
  - (c) Remove water, sand, mud, and other undesirable materials from trench before removal of end cap.
- H. Brace or anchor as required to prevent displacement after establishing final position.
- I. Perform only when weather and trench conditions are suitable. Do not lay in water.
- J. Observe extra precaution when hazardous atmospheres might be encountered.

### 3.02 JOINTING

- A. General Requirements
  - 1. Locate joint to provide for differential movement at changes in type of pipe embedment, impervious trench checks, and structures.
    - (a) Not more than 200 mm (8 inches) from structure wall, or



- (b) Support pipe from wall to first joint with concrete cradle structurally continuous with base slab or footing or
- (c) As indicated.
- 2. Perform conforming to manufacturer's recommendations.
- 3. Clean and lubricate all joint and gasket surfaces with lubricant recommended.
- 4. Use methods and equipment capable of fully seating or making up joints without damage.
- 5. Check joint opening and deflection for specification limits.
- B. Special Provision for Jointing Concrete Pipe:
  - 1. With rubber gaskets to steel joint rings:
    - (a) Check gasket position and condition with feeler gauge prior to installation of next section.
    - (b) Grout and/or point or seal joint spaces as follows:
      - (i) With stiff mortar of one part Portland cement as specified for pipe and one part sand. For pipe 600 mm (24-inch) and greater, trowel into entire circumference of joint to provide smooth, flush surface across joint. For pipes less than 600 mm (24 inches) in diameter, butter interior joint space of the bell with cement mortar prior to joining. Excess mortar squeezed out of the joint space by the joining action is to be smoothed by drawing an inflated swab through the pipe.
      - (ii) With grout of pouring consistency made of one part Portland cement and two parts sand, retained by a wide cloth diaper strapped or wired to the pipe. Use diaper designed for the joint. Rod grout with stiff wire formed to pipe curvature during pouring. Use diapered grout seal on restrained clamp-type and snap-ring type joints.
      - (iii) Lay pipe sufficiently in advance of pointing and grouting to preclude damage to mortar.
  - C. With rubber gaskets to concrete joint: Check gasket position with feeler gauge prior to installation of next section.
  - D. Pressure pipe installation shall conform to AWWA M9.

### 3.03 CLOSURE PIECES

- A. Connect two segments of pipeline or a pipeline segment and existing structure with short sections of pipe fabricated for the purpose.
- B. Observe Specifications regarding location of joints, type of joints, and pipe materials and strength classifications.
- C. Field-fabricated closures (except ductile iron pipe and fittings), where required, shall be concrete encased between adjacent flexible joints.
- D. May be accomplished with sleeve coupling:
  - 1. Of length such that gaskets are not less than 75 mm (3 inches) from pipe ends.
  - 2. Wrap exterior of buried steel couplings with polyethylene encasement conforming to AWWA C105

### 3.04 TEMPORARY PLUGS

- A. Furnish and install temporary plugs at each end of Work for removal by others when completed ahead of adjacent contract.
- B. Remove from pipe laid under adjacent contract in order to complete pipe connection when work by other contractor is finished prior to work at connection point under this Contract.

- C. Plugs
  1. Test plugs as manufactured by pipe supplier.
  2. Fabricated by Contractor of substantial construction.
  3. Secured in place in a manner to facilitate removal when required to connect pipe.
  
- 3.05 POLYETHYLENE ENCASMENT
  - A. Polyethylene encasement shall be installed on all pressure pipe, fittings, valves and other appurtenances.
  - B. Install polyethylene encasement in accordance with Section 02618 – Ductile Iron Pipe Water Main, paragraph POLYETHYLENE ENCASEMENT.
  
- 3.06 APPLICATION OF EXTERIOR COATINGS
  - A. Clean exposed metal joint surfaces to SSPC-SP5 quality and 0.04-0.06 mm (1.5-2.5 mils) profile depth.
  - B. Apply two coats of epoxy in different colors at a minimum of 0.3-mm (12 mils) dry film total thickness.
  
- 3.07 MANUFACTURER’S FIELD SERVICE REPRESENTATIVE
  - A. The field service representative shall have a minimum of 5 years of experience as a representative of the pipe manufacturer in the area providing such services or shall be a registered professional engineer possessing a minimum of 2 years of experience in the area of manufacture of pipe and service representation.
  - B. The City shall have the right of final acceptance of the field service representative based on a resume of the individual indicating the minimum experience required above.
  - C. Pipe manufacturer shall provide a qualified field service representative to be on-site in accordance with the following:
    1. The field service representative shall visit the site and inspect, check, instruct, guide, direct the pipe installation Contractor’s procedures for pipe handling, laying, and jointing.
    2. Site visits shall be made at the start of pipe installation for each crew and at each connection to an existing pipe.
    3. The field services representative shall be on site full-time when restrained joint pipe, fittings, and bevels are being installed.
    4. The field services representative shall visit the site as often as necessary to perform installation checks, by means of physical verification of the gasket position in the pipe joint (feeler gauge). Each pipe joint shall also be checked by the Contractor as instructed by the pipe manufacturer’s field service representative to determine that the joint and the means of restraint are installed properly.
    5. The pipe manufacturer’s field service representative shall attend the Preconstruction Conference, all progress meetings, final acceptance testing, and start-up.
    6. The pipe manufacturer’s field service representative shall coordinate his services with the Contractor.
    7. Certification of Instruction: The pipe manufacturer’s field service representative shall furnish to the City a written report certifying that the pipe installation Contractor’s installation personnel have been properly instructed and have demonstrated the proper pipe handling and installation procedures.

8. Manufacturer's Field Service Reports:
  - (a) The Contractor shall provide the pipe field service representative's written report of each site visit. At a minimum, the report shall include the following information:
    - (i) Date of observations
    - (ii) Summary of finding
    - (iii) List of joints inspected
  - (b) Reports shall be submitted on a monthly basis with the Contractor's Monthly Pay Application.
- D. All costs for these services shall be included in the Bid.

### 3.08 FIELD TESTING

- A. Acceptance Tests for Pressure Pipelines:
  1. Perform hydrostatic pressure and leakage tests.
    - (a) Conform to AWWA C600 procedures.
      - (i) As modified herein.
      - (ii) Shall apply to all pipe materials specified.
    - (b) Perform after backfilling.
  2. Test separately in segments between sectionalizing valves, between a sectionalizing valve and a test plug, or between test plugs.
    - (a) Select test segments such that adjustable seated valves are isolated for individual checking.
    - (b) Contractor shall furnish and install test plugs.
      - Including all anchors, braces, and other devices to withstand hydrostatic pressure on plugs.
      - Be responsible for any damage to public or private property caused by failure of plugs.
  3. Limit fill rate of line to available venting capacity. Fill rate shall be regulated to limit velocity in lines when flowing full to not more than 0.15 to 0.30 m/s (0.05 to 1 fps).
  4. The City shall make water for testing available to Contractor at nearest source.
  5. Contractor to provide equipment and labor to accurately measure and control flow rates.
  6. Pressure and Leakage Test:
    - (a) Conduct at pressure determined by following formula:  
 Test gradient El. (as specified by The City) - El. gauge x (.4335) = test pressure on gauge. Minimum test pressure shall be 160 psi for 12" and smaller water mains, and 225 psi for 16" and larger water mains.  
 $P_{pt}$  = test pressure in psi at gauge elevation
    - (b) Be at least 2-hour duration. Maintain pressure throughout test  $\pm$  34.5 kPa (+5 psi) of test pressure.
    - (c) Leakage test shall be conducted concurrently with the pressure test.
    - (d) Acceptable when leakage does not exceed that determined by the following formula:
      - (i) In metric units:  
 $L_m = 0.0000014 SD(P)^{1/2} / 2$ , in which  
 $L_m$  = allowable leakage, in liters per two hours

S = length of pipe tested in meters  
 D = nominal diameter of the pipe, in millimeters  
 P = average actual leakage test pressure in kPa

- (ii) In English units:
  - L = 0.0000075 SD(P)<sup>1/2</sup> /2, in which
  - L = allowable leakage, in gallons per two hours
  - S = length of pipe tested, in feet
  - D = nominal diameter of the pipe, in inches
  - P = average actual leakage test pressure in psig
- (e) These formulas are based on an allowable leakage of 1.08 L/day/km/mm (11.65 gpd/mile/in) of nominal diameter at a pressure of 1034 kPa (150 psi).
- (f) When testing against closed metal-seated valves, an additional leakage per closed valve of 1.2 mL/h/mm (0.0078 gal/hr/in) of nominal valve size shall be allowed.
- (g) When hydrants are in the test section, the test shall be made against the main valve in the hydrant.
- (h) Repeat test as necessary.
  - (i) After location of leaks and repair or replacement of defective joints, pipe, fittings, valves or hydrants. All visible leaks are to be repaired regardless of the amount of leakage.
  - (ii) Until satisfactory performance of test
- (i) The City will witness pressure and leakage test.

3.09 DISINFECTION

A. Disinfection of Pipelines for Conveying Potable Water:

1. Contractor shall provide all equipment and materials and perform conforming to AWWA C651.
  - (a) As modified herein.
  - (b) Include preliminary flushing, chlorination, and final flushing and piping for flushing.
2. Obtain approval of materials and acceptance of methods proposed for use.
3. May be conducted in conjunction with acceptance tests.
4. Contractor will provide sampling and laboratory testing.
5. Minimum preliminary flushing rates to produce 0.76 m/s (2.5 fps) velocity in main shall be as follows:

Pipe Size	Flow Rate	
16"	1200 gpm	12" discharge
30"	5500 gpm	12" discharge
42"	11,000 gpm	12" discharge

- (a) Provide equipment and labor to accurately measure and control flow rates
- (b) Dispose of flushing water without damage to public or private property.
6. A minimum initial dosage of 60 mg/L (ppm) in all portions.
  - (a) Allow to stand for 24 hours.
  - (b) Minimum 24-hour chlorine residual shall be at least 45 mg/L (ppm).
  - (c) De-chlorinate to 0 mg/L (ppm) chlorine.

- (d) Flush pipeline before use for potable water supply purposes. Dispose of final flushing water without damage to public or private property.
- 7. Repeat disinfection procedure should initial treatment fail to yield a passing Bac-T or minimum residual.
  - (a) At no additional cost to Owner.
  - (b) The City will provide water under terms stipulated for acceptance tests.

END OF SECTION