PART 1 GENERAL

1.01 SCOPE OF WORK

The Contractor shall furnish all labor, materials, tools, equipment and incidentals necessary to install all Prestressed Concrete Cylinder Pipe (PCCP), including fittings, specials, rubber gaskets, accessories and joint protection as shown on the drawings and as specified herein. The work shall include the testing of materials, pipe and pipelines.

1.02 RELATED WORK

A. Trenching, Backfilling and Compaction are addressed in Section ___.
B. Valves and Appurtenances are addressed in Section ___.
C. (Insert Other Section References as Necessary)

1.03 REFERENCE STANDARDS

The work as specified herein shall be governed by the latest revision/edition of the following standards and codes in effect at the time of bid opening:

A. American Water Works Association (AWWA)

1. AWWA C301 – Prestressed Concrete Pressure Pipe, Steel Cylinder Type
2. AWWA C304 – Design of Prestressed Concrete Cylinder Pipe
3. AWWA Manual M9 – Concrete Pressure Pipe, Manual of Water Supply Practices

B. American Society for Testing & Materials (ASTM International)

1. ASTM A27 – Standard Specification for Steel Castings, Carbon, for General Application
2. ASTM A36 – Standard Specification for Carbon Structural Steel
3. ASTM A185 – Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
4. ASTM A283 – Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
5. ASTM A285 – Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strengths
6. ASTM A370 – Test Methods and Definitions for Mechanical Testing of Steel Products
7. ASTM A497 – Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
8. ASTM A568 – Standard Specification for Steel, Sheet, Carbon and High-Strength, Low-Alloy, Hot Rolled and Cold Rolled, General Requirements for
9. ASTM A575 – Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
10. ASTM A576 – Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
11. ASTM A615 – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
12. ASTM A635 – Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for

13. ASTM A648 – Standard Specification for Steel Wire, Hard Drawn for Prestressing Concrete Pipe
14. ASTM A659 – Standard Specification for Commercial Steel (CS), Sheet and Strip, Carbon (0.16 Maximum to 0.25 Maximum Percent), Hot-Rolled
15. ASTM A663 – Standard Specification for Steel Bars, Carbon, Merchant Quality, Mechanical Properties
16. ASTM A675 – Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties
17. ASTM A706 – Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
18. ASTM A938 – Standard Test Method for Torsion Testing of Wire
19. ASTM A1011 – Standard Specification for Steel, Sheets and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
20. ASTM A1018 – Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability
21. ASTM A1039 – Standard Specification for Steel, Sheet, Hot Rolled, Carbon, Commercial, Structural, and High-Strength Low-Alloy, Produced by Twin-Roll Casting Process
22. ASTM C29 – Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate
23. ASTM C31 – Standard Practice for Making and Curing Concrete Test Specimens in the Field
24. ASTM C33 – Standard Specification for Concrete Aggregates
25. ASTM C39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
26. ASTM C94 – Standard Specification for Ready-Mixed Concrete
27. ASTM C109 – Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)
28. ASTM C127 – Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption for Coarse Aggregate
29. ASTM C128 – Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
30. ASTM C150 – Standard Specification for Portland Cement
31. ASTM C172 – Standard Practice for Sampling Freshly Mixed Concrete
32. ASTM C192 – Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
33. ASTM C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
34. ASTM C494 – Standard Specification for Chemical Admixtures for Concrete
35. ASTM C497 – Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile
36. ASTM C617 – Standard Practice for Capping Cylindrical Concrete Specimens
37. ASTM C618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
38. ASTM C1240 – Standard Specification for Silica Fume Used in Cementitious Mixtures

39. ASTM D75 – Standard Practices for Sampling Aggregate
40. ASTM D297 – Standard Test Methods for Rubber Products – Chemical Analysis
41. ASTM D395 – Standard Test Methods for Rubber Property – Compression Set
42. ASTM D412 – Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension
43. ASTM D572 – Standard Test Method for Rubber-Deterioration by Heat and Oxygen
44. ASTM D573 – Standard Test Methods for Rubber-Deterioration in an Air Oven
45. ASTM D2240 – Standard Test Method for Rubber Property – Durometer Hardness

C. American Concrete Pipe Association (ACPA)

1. Concrete Pipe Design Manual
2. Concrete Pipe Handbook

D. American Association of State Highway & Transportation Officials (AASHTO)

1. A Policy on Geometric Design of Highways and Streets

E. American Concrete Institute (ACI)

1. ACI 305R – Guide to Hot Weather Concreting

F. Canadian Standards Association (CSA)

1. Canadian Highway Bridge Design Code (CHBDC)

G. American Railway Engineering and Maintenance-of-Way Association (AREMA)

1. Manual for Railway Engineering

1.04 SUBMITTALS

A. Layout Documents

Submit tabulated laying schedule or drawings based on information as shown on project drawings. Laying schedule or drawings shall show code/piece numbers for all pipe, fittings and specials. These code/piece numbers shall correspond to markings on the pipe, fittings and specials. The location of all pipe, fittings and specials shall conform to the locations indicated on the drawings. Pipe supplied from inventory shall be approved by the Engineer.

B. Delivery Schedule

Submit anticipated delivery schedule.

C. Design Data

Submit design specification data sheets listing the following parameters:

1. Type of Pipe and Size

    a. Lined Cylinder (L-301)
    b. Embedded Cylinder (E-301)

2. Cylinder Data

    a. Thickness
    b. Diameter

3. Prestressing Wire Data

    a. ASTM Designation and Class
    b. Size
    c. Area
    d. Wire Spacing
    e. Minimum Ultimate Strength
    f. Wrapping Stress

4. Concrete Data

    a. Minimum Compressive Strength at Time of Wrapping
    b. Minimum Compressive Strength at 28 Days
    c. Core Thickness

5. Mortar Data

    a. Coating Thickness

D. Test Reports (If Required)

1. Steel
2. Cement
3. Gasket Rubber

1.05 QUALITY ASSURANCE

A. Qualifications

All prestressed concrete cylinder pipe, fittings and specials shall be furnished by a manufacturer with a minimum of five (5) years experience in the manufacture of prestressed concrete cylinder pipe. The pipe manufacturer shall be a member of the American Concrete Pressure Pipe Association and the manufacturing facility shall have a current Lloyd's Register Audit Certification for the manufacture of prestressed concrete cylinder pipe (AWWA C301). The pipe, fittings and specials shall be designed, manufactured and installed in accordance with industry standards and methods and shall comply with specification requirements as stated herein.

B. Pipe Handling and Inspection

Care shall be taken during storage, loading and transporting to prevent damage to the pipe, fittings, specials or coatings.

PART 2 PRODUCTS

2.01 MATERIALS

Unless otherwise specified herein, materials and workmanship shall be governed by AWWA C301. Core and coating thickness shall be as specified in AWWA C301.

A. Concrete and Mortar

1. Portland Cement

Portland cement shall conform to ASTM C150, Type II. Cement shall be stored in a dry, well-ventilated location protected from the weather. If the temperature of the cement exceeds 150°F, it shall not be used until cooled to less than 150°F, or the measures recommended in ACI 305R are applied to control the effect of high temperature.

Note: Other types of portland cement may be required based on specific job conditions.

2. Cement Replacement Material

Fly ash, natural pozzolan or silica fume may be used as a partial cement replacement. The replacement material shall conform to ASTM C618 or ASTM C1240. Storage requirements for cement replacement material shall be the same as portland cement.

3. Aggregates

Aggregates shall conform to ASTM C33.

4. Water

Water used in mixing and curing concrete and mortar may be fresh or recycled and shall be clean and free from deleterious amounts of oil, acids, alkalies and organic material.

5. Admixtures

Admixtures conforming to ASTM C494 may be used unless otherwise specified. The use of admixtures containing chlorides is prohibited.

6. Concrete for Pipe Core

The proportions of portland cement, cement replacement material (if specified), fine aggregate, coarse aggregate and water used in the concrete for pipe cores shall be determined and controlled to provide a uniform, dense and durable mix. Concrete shall have a portland cement content of not less than 560 pounds per cubic yard, except that up to 20 percent by weight of the cement may be replaced by an approved fly ash or natural pozzolan or up to ten (10) percent by weight of the cement may be replaced by an approved silica fume. The water-soluble chloride ion (Cl^-) content of the concrete mix, expressed as a percentage of the weight of cementitious material, shall not exceed 0.06 percent.

The minimum compressive strength of concrete at the time of prestressing shall be 3,000 psi for pipe cores produced by vertical casting and 4,000 psi for pipe cores produced by the centrifugal method or radial compaction, or 1.82 times the initial compression induced in the concrete core, whichever is greater. The minimum 28-day concrete compressive strength shall be 4,500 psi for pipe cores produced by vertical casting and 6,000 psi for pipe cores produced by the centrifugal method or radial compaction, or as required by the pipe design, whichever is greater.

To satisfy the 28-day strength requirements, a set of at least two (2) standard test cylinders shall be made each day from the mixed concrete for pipe cores. In addition, for determining the strength of concrete in the cores prior to prestressing, two (2) standard test cylinders shall be made each day for each 50 cubic yards of concrete for each mix design placed in a day, or two (2) standard test cylinders per pipe core, whichever requires the lesser number of cylinders. The concrete shall be removed from the mix in accordance with ASTM C172. Test cylinders shall be made in conformance with ASTM C31. The initial curing of the test cylinders shall be at the same temperature, for the same total length of time and by the same means (accelerated cure, water or combination) as applied to the pipe. After initial curing, cylinders made for the determination of strength for prestressing shall be stored in the same environment as the pipe cores. All test cylinders shall be tested in accordance with ASTM C39.

The moving average strength of any ten (10) consecutive strength tests of cylinders representing the 28-day strength for each mix design shall be equal to or greater than the required strength. Not more than two (2) of ten (10) strength tests shall have less than the required results. In no case shall the strength of any cylinder tested be less than 80 percent of the specified strength.

Note: Under certain design conditions, other types of cementitious materials may need to be considered.

7. Cement Mortar for Coating

Cement mortar used for coating shall consist of one (1) part of cement to not more than three (3) parts of fine aggregate by weight and a minimum water content of seven (7) percent of the total dry weight of cement and aggregate. Cement mortar rebound not to exceed ¼ of the total mix weight may be used as a sand replacement; however, the resulting mix proportions shall be a minimum of 1:3. Rebound not used within one (1) hour shall be discarded. The soluble Cl^- content of the mortar-coating mix, expressed as a percentage of the weight of cement, shall not exceed 0.06 percent.

Note: Under certain design conditions, other types of cementitious materials may need to be considered.

B. Steel

1. Prestressing Wire

Wire for circumferential prestressing shall conform to ASTM A648, Class III, with

amendments to the standard as described in the following sections. The wire shall be protected at all times from physical damage or deterioration.

a. Minimum Wire Diameter

Prestressing wire shall be a minimum No. 6 gauge (nominal diameter 0.192 inch).

b. Tensile Test

A tensile test shall be made on a specimen taken from each coil of wire. The maximum tensile strength shall not exceed the minimum required tensile strength by more than 30 ksi. The tension tests shall be made in accordance with methods and definitions of ASTM A370, Supplement IV.

c. Reduction of Area Test

Reduction of area shall be determined on each tensile test specimen. The reduction of area shall not be less than 35 percent for No. 6 gauge wire and 30 percent for ¼-inch and $^{5}/_{16}$-inch diameter wire. The reduction of area shall be determined in accordance with the methods and definitions of ASTM A370, Supplement IV.

d. Torsion Test

A continuous torsion test shall be made on a specimen taken from one (1) of five (5) coils or fraction thereof in a lot. A lot is the number of coils of the same heat number. The tests shall be made at rotational speeds of 10-20 rotations per minute and with an end load of 0.5 to two (2) percent of the load that would produce the minimum breaking strength of the wire. Failure of the test sample is defined as separation of the sample into two (2) or more pieces. Torsion test shall be made in accordance with methods and definitions of ASTM A938. The number of turns to failure shall be commensurate with the following table:

Nominal Wire Size	Minimum Turns per Foot
6 gauge	8
¼-inch	7
$^{5}/_{16}$-inch	6

***Note**: Minimum turns as shown above are for 12-inch sample lengths. Other sample lengths may be used with minimum turns proportioned to that specified for a 12-inch sample length.*

e. Hydrogen Embrittlement Test

Prestressing wire shall meet the hydrogen embrittlement testing requirements of ASTM A648, Supplemental Requirement S1 and ASTM A1032.

f. Chemical Requirements

The chemical analysis of the steel used in manufacturing the wire shall conform to the requirements of ASTM A648 as specified in the following table:

Chemical	Class III
Carbon %	0.50-0.85
Manganese %	0.60-1.00
Silicon %	0.10-0.35
Phosphorus – maximum %	0.30
Sulfur – maximum %	0.30

2. Steel Cylinders

Steel sheet for pipe cylinders shall have minimum yield strength of 36,000 psi, minimum elongation at rupture of 15 percent (2-inch gauge length) and shall meet the requirements of ASTM A659, ASTM A1011, ASTM A1018 or ASTM A1039.

Steel plate for pipe cylinders and fittings shall conform to ASTM A36, ASTM A283 or ASTM A285.

3. Joint Rings

Steel for joint rings shall have minimum yield strength of 33,000 psi and minimum elongation of 20 percent (2-inch gauge length).

Steel strip for bell rings shall conform to ASTM A1011 or ASTM A1018.

Steel plate for bell rings or special shapes for spigot rings shall conform to ASTM A36, ASTM A283, ASTM A576 (Grade 1012 or 1015) or ASTM A675 (Grade 50, leaded steel excluded). Merchant quality bars conforming to ASTM A575 (Grade M1012 or M1015) or ASTM A663 (Grade 50) may be used, provided the surface finish is satisfactory.

C. Gaskets

Gaskets for the joints shall be continuous solid rings made of a composition of natural or synthetic polyisoprene rubber. The cross section of gaskets shall be circular with a diametral tolerance of plus or minus 0.015 inch. Surfaces of gaskets shall be smooth and free from pits, cracks, blisters and other imperfections. The rubber compound shall be dense, homogeneous and free from porosity and air pockets, and shall contain no rubber substitute, reclaimed rubber or deleterious substance.

Two (2) splices in each gasket will be permitted, provided the length of gasket between splices is at least 24 inches. Gaskets shall be stored in a cool, dry area and protected from

direct sunlight.

2.02 BASIS OF DESIGN

A. Pipe

Pipe shall be designed in accordance with AWWA C304, using the design parameters as specified herein. These parameters shall also be used in the design of any fittings and specials that include an interior and exterior coating of portland cement mortar on the steel cylinder.

1. Internal Pressure

   a. Design Working Pressure (P_w) shall be ___ psi.

   ***Note**: AWWA C304 requires the actual system working pressure for design purposes. The working pressure should not be increased as AWWA C304 utilizes appropriate safety factors.*

   b. Transient (surge) Pressure (P_t) shall be ___ psi.

   ***Note**: Transient pressure is the pressure that can occur over and above the working pressure during a transient (surge) event. In the absence of a design transient pressure (P_t) specified by the purchaser, AWWA C304 requires using a transient pressure of 40 percent of the working pressure or 40 psi, whichever is greater. In gravity flow conditions, the transient pressure will be zero (0).*

   c. Field Test Pressure (P_{ft}) shall be ___ psi.

   ***Note**: AWWA Manual M9 recommends a field test pressure of 120 percent of the working pressure.*

2. External Loading

   a. Earth Loads

   Earth loads shall be computed using Marston equations for trench conditions based on the following:

   1) Depth of cover as shown on project plans
   2) Trench width as shown on project plans

***Note**: Typically, the most economical pipeline projects are achieved by minimizing trench widths. ACPPA recommends the following trench widths for proper placement of the pipe and bedding material:*

Pipe Diameter (inches)	*Trench Width*
16 – 48	*Outside Pipe Diameter + 2.0 feet*
54 – 72	*Outside Pipe Diameter + 2.5 feet*
84 – 96	*Outside Pipe Diameter + 3.5 feel*
102 – 120	*Outside Pipe Diameter + 4.0 feet*
126 – 144	*Outside Pipe Diameter + 5.0 feet*

b. Olander Coefficients

Olander coefficients shall be based on the following:

1) TYPE R___ Bedding

> ***Note**: The five (5) bedding details for PCCP are contained in AWWA C304 and AWWA Manual M9. For most installations, R3 or R4 bedding is sufficient.*

2) Bedding Angle = ___ Degrees

> ***Note**: The recommended bedding angle for R3 is 60 degrees. The recommended bedding angle for R4 is 90 degrees.*

> ***Note**: Unlike flexible pipe materials such as steel, ductile iron, fiberglass and plastic, PCCP is designed as a rigid structure that does not rely on soil side support to resist external loads. The bedding and backfill details on the project plans should reflect this benefit in order to obtain the most economical design for the client.*

3) Unit Soil Weight = 120 pounds per cubic foot

c. Live Loads

Live loads shall be computed in accordance with ACPA Concrete Pipe Design Manual or Concrete Pipe Handbook, based on the following:

1) AASHTO HS-20 or CHBDC CL-625, Section 3.8.3.2 for two (2) trucks passing
2) AREMA Cooper E-80 for pipe within a railroad right-of-way and not in a tunnel liner or casing

3. Thrust

In areas where the pipe alignment will be subject to unbalanced hydrostatic thrust forces (i.e., at bends, tees, bulkheads, wyes or valves), the unbalanced forces shall be addressed in accordance with AWWA Manual M9.

Where pipe restraint is required, lengths of restrained joint pipe and cylinder thickness shall be computed using the method contained in Chapter 9 of AWWA Manual M9. Acceptable types of restrained joints shall be as shown in AWWA Manual M9.

> ***Note**: ACPPA's Thrust Restraint Design Program shall be used to compute pipe restraint.*

4. Core Thickness

The minimum design thickness of the core shall be 1/16 of the nominal pipe diameter.

5. Core Thickness Tolerance

   The core thickness, except at the joints, shall not be less than that shown on the drawings by more than five (5) percent or by more than 0.125 inch for pipe up to 36 inches in diameter, by more than 0.188 inch for 42-inch through 48-inch pipe, by more than 0.25 inch for 54-inch through 72-inch pipe, or by more than 0.375 inch for pipe larger than 72 inches, whichever is greater.

6. Lengths

   The manufacturer shall designate the standard length to be furnished, and all standard pipes shall be uniformly of that length. To meet special requirements as approved by the Engineer, pipe sections may be furnished shorter than the standard length.

B. Joints

Each length of standard pipe shall have a steel bell ring and a steel spigot ring welded to the steel cylinder. The spigot ring shall have a groove in its exterior for the purpose of retaining the solid O-ring rubber gasket, which shall seal the joint under normal conditions of service.

Gaskets shall be of sufficient volume to substantially fill the space provided when the joint is assembled and will function solely to seal the joint.

C. Fittings

Steel plate thickness of all fittings shall be designed in accordance with Chapter 8 of AWWA Manual M9. Fittings shall be designed for the same internal pressure and external load conditions as the adjacent pipe.

D. Prestressing

1. Wrapping Stress

   The design gross wrapping stress in the prestressing wire shall be 75 percent of the specified minimum tensile strength of the wire.

2. Wire Spacing

   The design center-to-center spacing of wires shall not be less than 2.75 wire diameters for lined cylinder pipe and 2.00 wire diameters for embedded cylinder pipe. The maximum center-to-center spacing shall not exceed 1.5 inch, except for lined cylinder pipe with ¼ inch or larger wire, the maximum center-to-center spacing shall not exceed one (1) inch. The number of wraps of prestressing wire along any 2-foot length of core shall not be less than required by the design.

3. Cover

   The minimum cover provided by the cement-mortar coating shall be 0.75 inch over the prestressing wire.

2.03 MANUFACTURING

A. Equipment

The manufacturer shall furnish necessary plant, storage facilities, forms and equipment for manufacturing and curing the pipe and testing the components.

B. Steel Cylinders

1. Forming

The steel sheets or plates shall be formed into cylinders having transverse, longitudinal or helical-welded seams. Seams may be butt-welded, offset lap-welded or lap-welded.

2. Testing

Each cylinder with joint rings attached shall be hydrostatically tested to produce a circumferential stress at the bottom of the cylinder of at least 20,000 psi, but not more than 25,000 psi. If leaks develop during the hydrostatic test, the cylinder shall be repaired by welding and retested until all leaks have been eliminated. Outlet collars and wrappers, when required, shall be welded to cylinders prior to hydrostatic test. Cylinders heavier than No. 10 gauge, which may occasionally be required for special design situations, shall be tested to the pressure required for 10-gauge cylinder.

C. Joint Rings

1. Forming

The bell stock and special spigot shape shall be rolled and butt-welded to form round steel rings. Resistance or electric arc welding shall be used. Welds on gasket contact surfaces shall be ground smooth and flush with the adjacent surfaces. Joint rings shall be sized by expansion beyond their elastic limits. Joint rings shall be attached to the steel cylinders by electric arc welding. Minimum throat dimensions of the joint band fillet weld shall be equal to the thickness of the steel cylinder.

2. Coating

Prior to pipe shipment, exposed portions of the steel joint rings on the completed pipe shall be cleaned and protected with a shop-applied rust-inhibiting primer or metalized zinc coating.

D. Pipe Cores

1. Concrete

Fine aggregate, coarse aggregate, cement and cement replacement material, if specified, shall be batched by weighing. Water used in the mix shall be metered or weighed, and allowance shall be made for any free moisture present in the aggregates. All materials shall be mixed to a homogeneous mixture. No water may be added to the

mix once the concrete has been discharged from the mixer. The temperature of the mix shall not be less than 40°F at the time of placement.

2. Casting

Pipe core shall be produced by the centrifugal, radial compaction or vertical casting method.

3. Curing

The pipe core shall be initially cured by accelerated or water curing methods, as described in the following paragraphs, or by a combination of these methods. Ambient curing of the pipe core shall be continued until the required compressive strength at time of prestressing is obtained. Concrete test cylinders made and tested in accordance with Section ___ shall verify the required compressive strength.

a. Accelerated Curing

As soon as practical after completion of casting, the pipe core shall be enclosed within a suitable curing chamber that protects the pipe core from outside drafts. Enclosures shall allow full circulation around the inside and outside of the pipe core. Until four (4) hours after final placement of concrete, the ambient temperature within the enclosure shall not be less than 40°F and shall not be raised above 95°F by introducing heat. After four (4) hours, the temperature shall be increased at a rate not to exceed 40°F per hour, and thereafter maintained at a temperature between 90°F and 125°F for a minimum of eight (8) hours, except for the time required to remove the casting forms. The total curing period, consisting of the 4-hour delay period, the accelerated cure and the ambient cure, shall be sufficient to produce the concrete strength required by design. The ambient temperature in the curing chamber shall be thermostatically controlled and continuously recorded. Exposed concrete surfaces shall be kept continuously moist, either by maintaining an atmosphere in the curing chamber with a relative humidity of not less than 85 percent, by the presence of free water in contact with the exposed surfaces or by sealing exposed concrete surfaces with a concrete curing compound suitable for potable water. The forms shall not be removed until at least six (6) hours after the start of curing. As soon as practicable after removal of the forms, the pipe core shall again be enclosed and curing continued.

For that part of the cure after removal of the forms, the curing facility shall provide a moist atmosphere about the entire pipe core with a relative humidity of not less than 85 percent.

b. Water Curing

Water curing may be substituted on a time-ratio basis of four (4) hours of water curing to one (1) hour of accelerated curing for any part of the cure after removal of the forms. The pipe core may be water cured by a system of perforated pipe,

sprinklers, porous hose or other means that keeps the outside and inside of the pipe continuously moist.

E. Prestressing

After the concrete has attained the required compressive strength, the prestressing wire shall be helically wound around the core under measured and recorded tension at the design spacing. At the ends of the pipe, the wire shall be securely anchored to the pipe core. Anchorages of the wire at the ends of the core shall be capable of resisting a force equal to 75 percent of the specified minimum tensile strength of the wire.

Tension at each anchor shall not be less than half of the specified tension, and the tension shall increase to the full specified amount in the first wrap around the core adjacent to each anchor. Prior to prestressing, any voids of 0.375 inch in depth and diameter or greater and offsets greater than 0.125 inch on the exterior surface of the pipe core shall be repaired.

Wire splices shall be capable of withstanding a force equal to the specified minimum tensile strength of the wire.

During the circumferential prestressing operation, a portland cement slurry shall be applied to coat the wire bearing surface. The slurry shall consist of one (1) sack of portland cement to not more than eight (8) gallons of water. A retarder may be used in the mix.

F. Cement Mortar Coating

1. Batching

Fine aggregate and cement for the cement-mortar coating shall be batched by weighing, and all water used in the mix shall be metered or weighed. All materials shall be mixed thoroughly. The moisture content of the mortar mix shall be a minimum of seven (7) percent of the total dry weight. The temperature of the mortar mix shall not be less than 40^{o}F at the time of placement.

2. Applying

Immediately prior to application of the cement mortar coating, a slurry consisting of one (1) sack of portland cement to not more than eight (8) gallons of water shall be applied uniformly over the wire wrapped surface of the core at a rate of not less than one (1) gallon per 100 square feet. A retarder may be used in the mix.

The cement mortar shall be mechanically impacted against the pipe to form a coating of the required thickness. The finished coating shall be dense and firm throughout and shall be in intimate contact with the core and the prestressing wire.

3. Curing

The cement mortar coating shall be cured by accelerated or water curing methods, as described in the following paragraphs, or by a combination of these methods.

a. Accelerated Curing

As soon as practical after completion of coating, the pipe shall be enclosed within a suitable curing chamber that will protect the pipe from outside drafts. Enclosures shall allow full circulation around the outside of the coated pipe. Until one (1) to four (4) hours after placement of the cement mortar, the ambient temperature within the enclosure shall not be less than 40°F; and shall not be raised above 95°F by introducing heat. After the 1- to 4-hour delay period, the temperature shall then be increased at a rate not to exceed 40°F per hour, and thereafter maintained at a temperature between 90°F and 125°F for a minimum period of 12 hours. The 1- to 4-hour delay period to attain initial set may be included as part of the 12 hours. The ambient temperature in the curing chamber shall be thermostatically controlled and continuously recorded. The curing facility shall provide a moist atmosphere about the outside of the pipe with a relative humidity not less than 85 percent.

b. Water Curing

After six (6) hours of accelerated cure, water curing may be substituted on a time-ratio basis of eight (8) hours of water curing to one (1) hour of accelerated curing. The coating shall be kept moist by a system of intermittent sprinklers, porous hose or other approved means that keeps the coating moist for a minimum period of four (4) days. Water curing may be used only if the ambient temperature is above 40°F. The curing period shall be extended one (1) hour for each hour in the first 24 hours, during which the ambient temperature is less than 50°F.

G. Testing

For completed pipe in which the cylinders have already been tested in accordance with Section 2.03.B.2, additional testing shall not be required.

H. Repairing

Repairs to damaged pipe may be made, so long as they are compatible with the method of pipe making. All repairs shall be subject to approval of the Engineer.

I. Marking

Each length of standard pipe and special pipe shall have the manufacturer's identification marks and date of casting plainly marked inside one end of the pipe. Each pipe shall be sufficiently identified to show its proper location in the pipeline by reference to layout drawings or schedules. Beveled pipe shall be marked at the spigot end to show the degree of bevel and the point of maximum pipe length.

PART 3 EXECUTION

3.01 GENERAL

A. Pipe Care

Pipe shall be handled carefully during unloading and stored in a manner designed to prevent damage to any part of the pipe, fittings, specials or coatings.

B. Inspection and Acceptance

Minor imperfections shall be repaired in the field in accordance with the manufacturer's procedures.

Damaged pipe, fittings or specials shall be repaired in the field if permitted by the Engineer or returned to the pipe plant for repairs or replacement. All repairs shall be in accordance with the manufacturer's procedures. All materials used for repair shall be approved by the Engineer and pipe manufacturer. Repairs shall be carefully inspected before installation of the pipe.

Damaged pipe discovered after installation shall be repaired in place if permitted by the Engineer and pipe manufacturer. All repairs shall be in accordance with the manufacturer's procedures. If in-place repairs are not permitted, the damaged pipe shall be removed and replaced.

C. Live Loads

The Contractor shall regulate and control equipment and construction operations such that live loads on the pipe do not exceed the design loads for the pipe. If longitudinal cracks caused by construction equipment or other loads exceed those allowed by AWWA C304, the pipe shall be repaired in accordance with the manufacturer's procedures as approved by the Engineer.

D. Pipe Manufacturer's Field Service Representative

The pipe manufacturer shall provide a qualified Field Service Representative, who shall be available to be on the project site upon proper notice.

1. Experience

The Field Service Representative, who shall be an employee of the pipe manufacturer, shall have experience as a representative of the manufacturer in the area of providing such field services.

2. Onsite Services

Installation of the pipeline shall be performed in accordance with specified standards and manufacturer's recommendations. The Contractor shall ensure the manufacturer's Field Service Representative will be onsite to provide the following services:

a. Perform initial pipe pre-installation training
b. Evaluate problems and provide advice during pipe installation

3.02 INSTALLING PIPE AND FITTINGS

A. General

Prestressed concrete cylinder pipe, fittings and specials shall be installed in accordance with AWWA Manual M9, except as otherwise required herein. A firm, even support shall be provided along the entire pipe length by tamping the bedding material in the haunch areas and at the sides of the pipe to achieve the required bedding support angle. Blocking shall not be permitted.

B. Pipe Interior

All pipe, fittings and specials shall be thoroughly cleaned before installation and shall be kept clean until used in the work. The pipe interior shall be maintained dry and broom clean throughout the construction period.

C. Pipe Installation

Installation of pipe, fittings and specials shall conform to the lines and grades shown on the drawings. When installation is not in progress, the open ends of the pipe shall be closed by watertight plug or other means approved by the Engineer to prevent unauthorized entrance of people, animals, dirt, debris or water into the pipeline already installed.

D. Joint Deflections

Angular changes in pipe alignment shall be formed by deflecting joints, straight pipe with beveled ends, fittings or a combination of these techniques. Joints may be deflected to form curves, to span angle points or to correct alignment. The deflections at joints shall not exceed the amount recommended by the pipe manufacturer.

E. Jointing

Gasket, gasket groove and bell sealing surfaces shall be cleaned and lubricated with a lubricant furnished by the pipe manufacturer. The lubricant shall be approved by the Engineer for use in potable water and shall be harmless to the rubber gasket. Pipe is normally installed with bell ends facing the direction of laying. The method of pipe jointing shall be in accordance with AWWA Manual M9 and the pipe manufacturer's recommendations. Once the joint is made, the position of the gasket in the spigot ring groove shall be checked with a feeler gauge provided by the pipe manufacturer. If the gasket is found to be displaced, the joint shall be removed, a new gasket installed, the joint re-laid and the gasket position rechecked.

F. Joint Protection

1. Interior

Exposed surfaces of steel joint rings shall be protected by methods compatible with the pipe manufacturer's production processes and in accordance with AWWA Manual M9.

***Note**: Consult ACPPA or your local pipe manufacturer for recommended methods of joint protection.*

2. Exterior

The grout band (diaper) shall consist of a Typar synthetic fabric layer and a layer of closed cell foam. These layers are sewn together along with a pair of steel bands at each edge which are used to secure the diaper to the pipe exterior. Only grout bands supplied by the pipe manufacturer shall be used. A stretching tool is used to tighten the steel bands. Once the steel bands are pulled tight, a steel clip is crimped around the bands to hold them in position. It is important that the grout band be carefully placed against the exterior surface of the pipe to ensure that it is flush with no gaps or gathers. The closed cell foam surface is to be placed against the pipe exterior.

The wet grout shall flow down to the bottom of the grout band and begin to bulge it out. Bedding material (or sandbags) shall be placed directly under the grout band at the bottom to support the weight of the wet grout. Care shall be taken not to push excessive amounts of bedding material under the grout band such that the grout band is pushed up into the joint recess impeding the flow of wet grout.

The grout shall be mixed using one (1) part ASTM C150 Type I or Type II portland cement to not more than three (3) parts clean sand with sufficient water to achieve a pourable consistency. The grout should look and pour like a thick cream. The mixed grout shall be poured carefully into the gap at the top of the diaper. As the pouring proceeds, the workers shall inspect the grout band around the joint periphery to ensure the grout is flowing all around. Once the grout band is full and wet grout is puddling at the gap at the top, the workers shall apply a stiffer mix the consistency of wet brick mortar to fill the gap at the top ensuring all steel components of the joint are properly covered.

***Note**: Other types of portland cement may be required based on specific job conditions.*

3.03 CLEANING

At the conclusion of installation and prior to post-construction hydrostatic testing, the pipeline shall be flushed with water or other method approved by the Engineer to remove all dirt, stones and debris which may have entered the pipeline during construction.

3.04 TESTING

The completed pipeline (or completed sections of the pipeline) shall be bulkheaded, filled with water and pressure tested to 120 percent of the internal working pressure as measured at the

low point of the pipeline. After the line is filled with water, and prior to pressure testing, the pipe shall be allowed to soak under low pressure for a minimum of 48 hours so the pipe walls can absorb water and the temperature can stabilize. When filling the line, the Contractor shall properly bleed off any trapped air to avoid adversely affecting the leakage test results.

During hydrostatic testing, the contractor shall use a calibrated meter or other device approved by the Engineer to accurately measure the quantity of water necessary to maintain the test pressure on the gauge. The pipeline will be accepted when the measured quantity is less than ten (10) gallons per inch of diameter per mile of pipeline per 24-hour test period.

Visible leaks shall be repaired using a procedure approved by the Engineer regardless of measured leakage.

END OF SECTION