SECTION 13414
PRESTRESSED CIRCULAR CONCRETE TANK

PART 1 - GENERAL

1.1 Scope of work

A. This section covers the work necessary for the design, submittals, construction, and testing of the prestressed concrete tank.

B. Furnish all labor, materials, equipment, tools, scaffolding, and incidentals required to construct a prestressed concrete water storage tank as shown on the drawings and as specified herein.

C. The prestressed concrete tank shall have a wire-wound prestressed corewall with a steel shell diaphragm encased the full height. All prestressing shall be done with high tensile wire permanently bonded to the tank wall. The tank floor shall be reinforced concrete. The tank roof shall be a free span concrete dome.

D. The intent of the Specification is to create a singular responsibility for the design and construction of the prestressed concrete tank. The design and construction of all aspects of the floor, wall, prestressing, shotcrete cover, and dome roof of the prestressed concrete tank must be performed by the tank contractor.

E. The entire tank, including all portions of the floor, wall, and roof shall be built by a specialty tank contractor using its own trained personnel and equipment.

F. The tank shall be designed, constructed, and tested in accord with ANSI/AWWA D110 with a Type II corewall.

1.2 References

A. ACI 301 – Specifications for structural concrete.

B. ACI 304 - Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete.

C. ACI 350/350R - Code Requirements for Environmental Engineering Concrete Structures.

D. ACI 506R – Guide to Shotcrete.

E. ASTM A185 - Standard Specification for Welded Steel Wire Fabric for Concrete Reinforcement.

F. ASTM A416 – Uncoated Seven-Wire, Stress-Relieved Strand for Prestressed Concrete

G. ASTM A615 - Standard Specification for Deformed and Plain Carbon- Steel Bars for Concrete Reinforcement.

H. ASTM A821 - Standard Specification for Steel Wire, Hard-Drawn for Prestressing Concrete Tanks.

I. ASTM C881/C 881M – Standard Specification for Epoxy-Resin-Base Bonding system for Concrete.

J. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy.

K. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized).

L. ANSI/AWWA C652 - Disinfection of Water Storage Facilities.

M. ANSI/AWWA D110 – Wire- and Strand- Wound, Circular Prestressed Concrete Water Tanks.

N. CRD - C572 - Specification for PVC Water-stop - Corps of Engineers.

O. ASCE Standard 7 – Minimum Design Loads for Buildings and Other Structures.

P. ACI 372R – Guide to Design and Construction of Circular Wire- and Stand- Wrapped Prestressed Concrete Structures.

Q. NACE 6/SSPC 13 – Surface Preparation of Concrete

1.3 Submittals

A. Submit detailed design drawings sealed by a professional engineer registered in the state for the project location.

B. Submit design calculations sealed by a professional engineer registered in the state for the project location.

C. Submit concrete and shotcrete mix designs.

D. Submit coating data sheets.

E. Submit tank warranty document.

1.4 Quality assurance

A. The tank construction company shall be a specialist in the design and construction of wire-wound circular prestressed concrete tanks. The tank contractor shall have had at least five (5) years of experience in ANSI/AWWA D-110 Type II corewall tank construction and have built, completely in its current name, no less than ten (10) prestressed concrete tanks with a Type II corewall of comparable size demonstrating satisfactory service.

B. The tank construction company's staff shall include a full-time professional engineer having no less than five (5) years of experience in the design and field construction of ANSI/AWWA D110 circular prestressed concrete tanks with a Type II corewall. This professional engineer shall have been the engineer of record for a minimum of ten (10) similar prestressed concrete tanks now in

service. All working drawings and design calculations shall carry the seal of this registered professional engineer.

C. Approved tank construction companies:
   1. Precon Corporation.
   2. Crom Corporation.

1.5 Design Data

A. The tank shall be designed in accordance with applicable portions of ACI 372R – Guide to Design and Construction of Circular Wire- and Stand- Wrapped Prestressed Concrete Structures, ANSI/AWWA D110 – Wire- and Strand- Wound, Circular Prestressed Concrete Water Tanks, and standard industry practice per the following criteria:

   1. Capacity: _____ gallons
      a. Inside Diameter: __'-__"
      b. Water Depth: __'-__"
   2. Liquid unit weight: 62.4 lb/ft^3
   3. Wind loads per ASCE 7
   4. Seismic design per AWWA D-110 & ASCE 7
   5. Dome live load per AWWA D-110 & ASCE7
   6. Backfill loads, both uniform and differential.

1.6 Warranty

A. The tank construction company shall provide a warranty for workmanship and materials on the entire tank structure for a period of five (5) years from date of acceptance of the work. In case leakage or other defects appear within the five (5) year period, the tank construction company shall proceed to make repairs promptly upon written notice by the owner that such defects have been found. The Owner will make the tank available to the tank construction company for inspection and repairs. Leakage as defined by AWWA D-110 section 5.12. The tank construction company shall not be responsible for any subsurface condition.

PART 2 - PRODUCTS

2.1 Concrete

A. Materials shall meet the requirements of ACI 301. Cement shall be Portland Type I/II or IL. Up to 25% of cement may be replaced by fly ash (Type C/F) or slag.

B. Mix proportions shall be in accordance with ACI 301.

C. Maximum concrete temperatures at time of placement shall be 95°F per ACI 301.

D. Per requirements outlined below.

Mix	Compressive Strength psi	Slump	Aggregate Size	Air Content	Maximum W/C Ratio
Floor	4,000	3-5"	57/67	5%±1.5%	0.45
Dome	4,000	3-5"	89/78	5%±1.5%	0.45
Pipe	2,500	---	57/67	---	---

2.2 Shotcrete

A. Materials shall meet the requirements of ACI 506. Cement shall be Portland Type I/II or IL. Fly ash (Type C/F) or slag may be added as directed by the tank designer up to 25%. Additional fly ash may be added to facilitate pumping.

B. Wet mix process referred to in ACI 506 for shotcrete shall be used.

C. Wire coat used for covering intermediate layers of prestressing wire shall consist of not more than three parts fine aggregate to one part cement.

D. Mix proportions shall be in accordance with ACI 301. Shotcrete in direct contact with prestressed reinforcement shall not contain chloride ions more than 0.06 percent of the weight of the cement in the mix.

E. Slump may be increased on site when necessary to facilitate encasement of reinforcing steel and prestress wires.

F. Admixtures, including but not limited to hydration stabilizers, mid-range water reducers, air-entrainers, and fibers may be added as necessary to maintain slump, workability, material temperature and overall material quality.

G. Maximum shotcrete temperatures at time of placement shall be 95˚F per ACI 301.

H. Per requirements outlined below.

Mix	Compressive Strength psi	Slump	Aggregate Size	Air Content	Maximum W/C Ratio
FA Shotcrete	4,000	2-5"	sand	4-7%	0.42
CA Shotcrete	4,000	2-5"	89/78	4-7%	0.42

2.3 Reinforcing steel

A. New billet steel grade 60 meeting the requirements of ASTM A615.

B. Welded wire fabric shall conform to ASTM A185.

2.4 Prestressing steel

A. Steel shall be cold drawn, high carbon wire, meeting the requirements of ASTM A821, having a minimum ultimate tensile strength of 231,000 psi. Wire size may be 6- or 8-gauge.

B. The allowable design tensile stress before losses, f_{si} shall be 145,600 psi or no greater than 0.64 f_u, where f_u is defined as the ultimate strength of the wire.

C. Splices shall be ferrous material and shall be compatible with the prestressing steel.

2.5 Steel diaphragm

A. Shall conform to ASTM A653 or ASTM A1008 and shall be a minimum of 26-gauge thickness. It shall be vertically ribbed with reentrant angles which provide a mechanical keyway within the wall.

B. Panels shall extend the full height of the corewall with no horizontal joints.

C. All vertical seams between panels shall be sealed watertight by epoxy injection. The epoxy injection procedure shall have been used successfully on a minimum of ten (10) similar tanks currently in service.

D. All tanks shall incorporate a waterstop at the floor/wall joint. The diaphragm panels shall be sealed to the waterstop to form a watertight seal around the bottom perimeter of the tank.

2.6 PVC waterstop

A. Extruded from an elastomeric plastic material of which the base resin is virgin polyvinyl chloride and shall meet the requirements of CRD-C-572.

B. Splices shall be made in accordance with the manufacturer's recommendation.

2.7 Seismic tendons

A. Shall be seven-wire strand per ASTM A882 with a fusion bonded, grit-impregnated epoxy coating or galvanized strand per ASTM A475.

B. The minimum yield strength shall be 270,000 psi.

2.8 Epoxy

A. Epoxy for sealing the diaphragm panels shall be per ASTM C 881, 100% solids, and suitable for bonding concrete, shotcrete, PVC waterstop, and steel reinforcing.

B. Bonding epoxy shall be per ASTM C881, 100% solids, and suitable for bonding newly poured concrete with hard concrete.

2.9 Accessories

A. The tank contractor shall furnish and install those accessories shown on the drawings.

B. Wall Manhole shall be fabricated of 316 stainless steel frame, cover, stainless steel bolts and neoprene gasket. Internal dimensions to be 17 ½" tall x 51" wide.

C. Exterior Ladder shall be fabricated of 6061-T6 aluminum and shall conform to OSHA requirements.

D. Interior Ladder shall be fabricated of fiberglass and shall conform to OSHA requirements.

E. Ventilator shall be all fiberglass construction with minimum 3/16" thickness located in the center of the dome. The ventilator shall be fastened with stainless steel bolts. Openings shall be covered with polyester screen.

F. Aerator shall be fiberglass construction cascade type aerator per specification 13415. Sizing and enclosure layout per plans.

G. Overflow vents shall be precast concrete positioned three inches above the design high water level. The combined opening size of all overflows shall be three times the area of the largest pipe. The openings shall be covered with removable screen and shall function as additional ventilators.

H. Thru wall pipes shall be 316 stainless steel or ductile iron and shall be sealed to the diaphragm with epoxy.

I. Hatch cover shall be constructed of fiberglass. Hatch shall have a thirty-six-inch square minimum opening.

J. Liquid level indicator shall have a half travel board with an interior float. The board shall be fabricated of fiberglass. The remaining components shall be fabricated from aluminum, stainless steel, or PVC pipe.

K. The baffle curtain shall be 8130 XR-3PW as manufactured by the Seaman Corporation and NSF 61 approved per layout on the plans.

L. Block wall baffles to be designed by tank manufacturer per layout on the plans.

M. Aluminum staircase shall be fabricated of 6061-T6 aluminum and shall conform to OSHA requirements.

N. Aluminum handrail shall be fabricated of 6061-T6 aluminum and shall conform to OSHA requirements. Handrail shall have a "mill" finish.

O. Dome probes shall be PVC pipes with a concrete collar.

P. All fasteners shall be 316 stainless-steel.

2.10 Coatings

A. All concrete surfaces shall be prepared per NACE 6/SSPC 13 prior to coatings being applied.

B. Exterior coatings shall consist of the following:
   1. One coat of Sherwin-Williams Loxon XP or Tnemec 156 (6 mils DFT).
   2. One coat of Sherwin-Williams SuperPaint or Tnemec 1026 (1.5 – 2.5 mils DFT)

C. Interior coatings shall consist of the following: (wall & underside of dome).
   1. Surfacer either Sherwin-Williams Duraplate 2300 or Tnemec 218 Mortar Clad (1/16" - 1/8") shall be applied to dome surface.
   2. First coat of Sherwin-Williams Macropoxy 5500 or Tnemec N140 (4 -6 mils DFT)
   3. Second coat of Sherwin-Williams UHS or Tnemec 22 (10 - 12 mils DFT).

PART 3 - EXECUTION

3.1 Floor

A. Shall be reinforced concrete construction and shall be designed as a membrane slab in accord with ACI 350.

B. Thickness shall be 4 inches thick with 0.6% reinforcing steel in each direction.

C. Reinforcing shall be supported on plain, uncoated steel bar supports, CRSI Class 3.

D. Thickness shall be 8 inches over all pipe encasements. Additional reinforcing shall be used over the encasement to maintain the 0.6% reinforcement. This additional mat shall extend a minimum of 2 feet into the adjacent floor.

E. A 6-mil plastic sheeting per ASTM D4397 shall be placed on the sub-grade prior to placing reinforcing.

F. Shall be vibratory screeded to consolidate concrete and obtain encasement of floor reinforcing steel.

G. Shall be given a light broom or trowel finish.

H. Shall be water-cured.

3.2 Corewall

A. Shall be constructed of shotcrete encasing a continuous steel shell diaphragm. The thickness of the corewall shall be designed to accept the initial compressive forces applied by prestressing, backfill, and other applicable loads. The wall may taper uniformly on the outside face from top to bottom as required by design computations. In no case shall the corewall be less than 3-½ inches thick as established by wall pins, line wires, or other positive means of controlling wall

thickness. Horizontal sections of the wall shall form true circles without flats, excessive bumps, or hollows.

B. The wall shall be designed for bending, shrinkage, and temperature stresses.

C. The interior wall finish shall be a light broom finish with the ripple pattern of the steel diaphragm being acceptable.

D. Interior and exterior surfaces of the wall shall be water cured.

3.3 Steel Diaphragm

A. Shall be embedded in the prestressed wall to form a water barrier, extend the full height and circumference of the corewall, and composed of vertical panels.

B. Shall be fabricated with vertical re-entrant ribs that key the wall on each side of the diaphragm together. Steel diaphragm with vertical ribs may be used for vertical reinforcement.

C. Shall be encased and protected with shotcrete no less than 1 inch thick.

D. Shall be sealed to a water-stop in the floor/wall connection.

E. All vertical laps and joints between the diaphragm sheets shall be sealed with a method used successfully on minimum of ten (10) tanks currently in service.

F. No horizontal splices of the diaphragm will be allowed.

G. No nail or other holes shall be made in the steel shell except for inserting pipe sleeves, reinforcing steel, bolts, sheet fastening or other special appurtenances. All penetrations shall be sealed with epoxy.

3.4 Shotcrete

A. Shall be wet mix and in accordance with ACI-506 and shall be applied by or under direct supervision of experienced nozzlemen.

B. The nozzle shall be held as near as practical to the application surface. Shotcrete shall be applied in such a way that it flows into position. No air pockets shall form, and a good bond shall develop between reinforcement and shotcrete. Any deposit of loose sand shall be removed prior to placing of succeeding layers.

C. Each layer shall be broomed prior to final set to effect satisfactory bonding of the following layer.

D. Shall be placed only when the temperature is 35 degrees F and rising. Shotcrete shall not be placed when the temperature is 40 degrees F and falling unless protective measures are taken. Shotcrete shall not be placed on a frozen surface where frost or ice is present.

3.5 Dome roof

A. Shall be constructed of cast in place reinforced concrete and shall be of thin shell design.

B. Shall be a spherical shape and have a rise of one tenth of the tank diameter. The dome roof shall be supported by the tank wall and be free span with no interior columns or supports.

C. Dome reinforcement shall consist of wire mesh or reinforcing bars with a minimum 0.25% reinforcing.

D. The dome ring girder shall be prestressed with sufficient wire to withstand the dome dead load and design live loads. The ring girder shall have a cross section suitable to accept the applied prestressing forces. All concrete surfaces in the wall-dome ring girder joint shall be coated with bonding epoxy prior to placing fresh concrete.

E. The high-water level in the tank shall be permitted to encroach on the dome shell no higher than the upper horizontal plane of the dome ring girder.

F. Wire fabric and reinforcing bars shall be supported with plastic chairs. Wire ties shall be galvanized.

G. The exterior dome surface shall be given a light broom finish.

H. Shall be wet cured.

3.6 Horizontal prestressing

A. Shall be achieved by the application of cold-drawn, high-carbon steel wire placed under high tension. An allowance shall be made for prestressing losses due to shrinkage and plastic flow in the shotcrete and due to relaxation in the prestressing steel.

B. Shall be accomplished by a machine capable of continuously inducing a uniform initial tension in the wire. Tension in the wire shall be generated by methods not dependent upon the cold working or redrawing of the wire.

C. To be in a continuous and uniform helix of such pitch as to provide in each lineal foot of corewall height an initial force and unit compressive stress equivalent to that shown on the drawings. The clear space between adjacent wires is to be no less than one and a half wire diameters.

D. Anchor each reel of prestressing wire to minimize the loss of wire in case of a wire break. Join prestressed wires by splices that will develop the full strength of the wire.

E. Do not bundle or drape wires around pipe or manhole openings. Spread wire falling in such areas over a predetermined area above and below such wall openings in conformance with the above wire spacing requirements.

F. Only the aggregate force of all stressed wires per foot shall be considered rather than the force per individual wire, and such aggregate force shall not be less than required design values. No circumferential movement of the wire along the tank will be permitted during or after stressing of the wire.

G. The tank contractor shall provide stress-measuring equipment capable of measuring stress in the wire after it is in place. The equipment shall be field calibrated for the wire being placed.

H. The initial design stress shall be 145,600 psi or a maximum of 0.63 times the ultimate strength of the wire.

I. The working stress in the wall shall be 115,000 psi or 0.55 times the ultimate strength of the wire.

J. The working stress in the dome ring shall be a maximum of 120,000 psi.

3.7 Exterior covercoat

A. After circumferential prestressing wires have been placed, they shall be protected by encasement in shotcrete. This shotcrete encasement shall completely encapsulate each wire and shall permanently bond the wire to the tank wall. The final layer of shotcrete shall have a thickness of no less than one inch over all wires. When multiple layers of wire are required, each layer of circumferential prestressing shall be encased in shotcrete.

B. Total covercoat thickness shall be controlled by shooting gauge wires or screed boards.

C. Vertical wires shall be installed to establish uniform and correct thickness. Wires shall be removed after placement of the cover coat and prior to finishing.

D. All above grade wall finishes shall be a float finish or a light broom texture.

3.8 Coatings

A. All exposed exterior concrete surfaces of the wall and dome shall be coated.

B. The concrete surface to be coated must be clean, free of all dirt, grease, and foreign material. All bug holes, voids, and imperfections shall be filled or repaired.

C. Painting shall be performed by skilled personnel. The manufacturer's application instructions shall be followed.

D. Color shall be selected by the Owner.

3.9 Disinfection and testing

A. Disinfection of the completed tank shall be in accord with AWWA C652.

B. Fill the tank with water to the designed high-water level and let stand for at least 24 hours.

C. Record the water level over the next 72 hours to determine any change in liquid level. Evaporation losses shall be measured and deducted from any level change to determine any net liquid loss. The net liquid loss over a 24-hour period shall not exceed 0.05 percent of the tank capacity.

D. If the liquid loss exceeds the maximum allowable, the test may be extended to ta total of 120 hours. If at the end of the 120-hour period, the liquid loss does not exceed the average daily maximum, the test shall be considered satisfactory. If the net liquid loss exceeds the allowable, the tank shall be repaired and retested until the net liquid loss is within the allowable.

E. Damp spots on the exterior wall surface and measurable leakage of flowing water at the wall base shall not be permitted. Damp spots are defined as spots where moisture can be picked up on a dry hand. Damp spots and puddles on the footing are permissible

3.10 Material testing

A. Strength testing of concrete and shotcrete shall be confirmed by sets of 4-inch by 8-inch cylinders (or 6-inch by 12-inch cylinders) for each 50 cubic yards of concrete/shotcrete. Test specimens shall conform to ASTM C31 for making and curing test cylinders.

B. Compression tests shall be performed in accordance with ASTM C39.

C. Submit mill test reports certifying that the prestressing steel meets ASTM standards.