(THERMAL ENERGY STORAGE TANK –2-12-09)

SECTION 13.1
THERMAL ENERGY STORAGE TANK SYSTEM
PRECAST, PRESTRESSED, CONCRETE TANK
WITH STEEL DIAPHRAGM

PART 1.00 GENERAL

1.01 DESCRIPTION

A. Work Included

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1. This section specifies the design and construction of the precast, prestressed concrete circular thermal energy storage (TES) tank with steel diaphragm complete; including all site work, excavation, backfill, concrete work, reinforcing, diffuser, insulation, testing, and appurtenances directly related to the tank, unless otherwise specified.

2. The Contractor shall furnish all labor, materials, tools, and equipment necessary to design, construct, and test the precast, prestressed concrete tank and appurtenances as indicated on the drawings, and as specified.

B. Related Work Described Elsewhere

1. Rock Excavation

2. Piping

3. Instrumentation

{NOTE: Add items as necessary, i.e. earthwork, concrete formwork, cast-in-place concrete reinforcing, etc.}

C. Description of TES System

The TES tank shall consist of a cast-in-place reinforced concrete floor, a precast, prestressed concrete wall with a continuous mechanically bonded steel diaphragm, a precast or cast-in-place prestressed clear span concrete dome with no interior columns, a diffuser piping system, and insulation.

1.02 QUALITY ASSURANCE

A. Qualifications and Experience

1. Singular Responsibility: It is the intent of the specification to create singular responsibility for the design and construction of the prestressed concrete tank. The design and construction of all aspects of the foundation, floor slab, wall, prestressing, shotcrete, and dome roof of the prestressed concrete tank must be performed by the tank contractor. The tank contractor may subcontract labor for reinforcing steel installation and for concrete slab placement under the tank contractor's direct supervision.

2. All tank work shall be performed by a company that specializes in the design and construction of precast, wire-wound prestressed concrete tanks using the method of circumferential prestress wire reinforcing and with proven capability of meeting all the requirements of these specifications. No company is considered qualified unless it has designed and built in its own name at least twenty precast, wire-wound prestressed concrete tanks conforming to AWWA D110, Type III in the last ten years. At least ten of the above tanks shall have been in successful service for a minimum of five years.

3. The tank contractor shall have in its employ a design engineer with a minimum of ten years experience in the design of AWWA D110 Type III tanks. The design engineer shall have been the engineer of record for a minimum of ten AWWA D110 Type III tanks.

4. The tank contractor shall have in its employ for this project a team consisting of a tank superintendent, project manager, shotcrete foreman, wire-winding foreman, and precast erection foreman, each of whom shall have constructed a minimum of five (5) AWWA D110 Type III tanks having a capacity of 1.0 MG or greater.

5. Experience in the design and construction of AWWA D110 Type I, Type II, or Type IV tanks is not acceptable.

6. The plans and specifications included in the contract documents are typical of an AWWA D110, Type III wire wound, prestressed concrete tank.

B. Prequalification

1. All tank contractors are required to be prequalified. The bidder is required to state on the face of his sealed proposal the name of the prequalified tank contractor. Sealed proposals which do not state the name of the prequalified tank contractor will be returned to the bidder unopened.

2. Natgun Corporation, Wakefield, Massachusetts, and, *(NOTE: Add other prequalified tank contractors, if any)* are prequalified for precast, wire-wound

prestressed, concrete tank construction. Additional tank contractors seeking prequalification shall make a complete submittal to the Engineer for review and approval no later than ten (10) days prior to the date set for receipt of bid, in accordance with Section 1.03A. The submittal shall include detailed design drawings and calculations meeting the requirements of these specifications, the company's record of previous experience in the design and construction of circular precast, wire-wound prestressed concrete tanks constructed in their own name, conforming to AWWA D110 Type III, including the experience of the design engineer meeting the requirements of Section 1.02 A.3. and a project team meeting the requirements of Section 1.02 A.4. Within five (5) days prior to the date of receiving bids, the engineer will publish a list of additional prequalified tank contractors.

3. Experience in the design and construction of AWWA D110 Type I, Type II, or Type IV tanks is not acceptable.

4. All tank contractors not prequalified in accordance with Paragraph 1.02 will be rejected.

C. Codes & Standards

1. ACI 301 Specifications for Structural Concrete for Buildings

2. ACI 305 Hot Weather Concreting

3. ACI 306 Cold Weather Concreting

4. ACI 309R Guide for Consolidation of Concrete

5. ACI 318 Building Code Requirements for Reinforced Concrete and Commentary

6. ACI 350 Code Requirements for Environmental Engineering Concrete Structures and Commentary

7. ACI 350.3 Seismic Design of Liquid Containing Concrete Structures and Commentary

8. ACI 372R Design and Construction of Circular Wire- and Strand Wrapped Prestressed Concrete Structures

9. ACI 506R Guide to Shotcrete

10. ASTM A185 Specification for Steel Welded Wire, Fabric, Plain for Concrete

11. ASTM A416 Standard Specification for Steel Strand, Uncoated Seven- Wire for Prestressed Concrete

12. ASTM A475 Standard Specification for Zinc-Coated Steel Wire Strand

13. ASTM A615 or A615M Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

14. ASTM A821 Specification for Steel Wire, Hard Drawn for Prestressing Concrete Tanks

15. ASTM A1008/A1008M Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy With Improved Formability

16. ASTM C31 Standard Practice for Making and Curing Concrete Test Specimens in the Field

17. ASTM C33 Standard Specification For Concrete Aggregates

18. ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

19. ASTM C618, Type F Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

20. ASTM C920 Specification for Elastomeric Joint Sealants

21. ASTM D1056 Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber

22. ASTM D1556 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method

23. ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 Ft. - lbf/ft3) 2700 KN-M/M3)

24. ASTM D2000 Classification System for Rubber Products in Automotive Applications

25. ASCE Standard 7-05 Minimum Design Loads for Buildings and Other Structures

26. AWWA C652 Standard for Disinfection of Water-Storage Facilities

27. AWWA D110-04 Wire and Strand Wound, Circular, Prestressed Concrete Water Tanks, Type III.

28. US Army Corps of Engineers Specification CRD-C-572, Specification for PVC Waterstop

D. Design Criteria

1. The prestressed concrete TES tank shall be designed and constructed in accordance with the provisions of AWWA D110 Standard for Wire-Wound Circular Prestressed-Concrete Tanks, Type III: Precast-Concrete with a Steel Diaphragm.

2. Horizontal prestressing shall be continuous. Discontinuous prestressing tendons or strands will not be allowed.

3. The Contractor shall use the following loadings and requirements in the design calculation:

a. Capacity: ____ ton hours.

b. Chilled Water Supply Temperature: ___ºF.

c. Chilled Water Return Temperature: ___ºF.

d. Maximum Flow Rate: ____ gpm.

e. Maximum Heat Gain in a 24-hour period at Ambient Dry-Bulb Temperature ___ºF: 2% of rated TES capacity

f. Maximum Pressure Drop through the Tank from the Inlet Flange to the Outlet Flange: 3 psi.

g. Dimensions ____ft. diameter; ____ ft. water depth.

h. Dead Load: shall be the estimated weight of all permanent construction and fittings. Unit weight of concrete 150 pounds per cubic foot; steel 490 pounds per cubic foot.

i. Live Load: shall be the weight of all the liquid when the reservoir is filled to overflowing. Unit weight of liquid water 62.4 pounds per cubic foot.

j. Total Roof Live Load shall be as required by ASCE 7-05.

k. Backfill Pressure: earth loads shall be determined by rational methods of soil mechanics. Backfill pressure shall not be used to reduce the amount of required prestressing.

l. Foundation Loads: the tank foundation shall be proportioned so that soil pressure shall be less than the allowable soil bearing capacity. The allowable soil bearing capacity is ____ psf.

m. Seismic Criteria:

i. AWWA D110 Seismic Zone ____

ii. IBC Site Class ____

n. Wind Loads: shall be as required by ASCE 7-05.

4. The prestressed TES tank wall shall be designed as a composite concrete wall with an embedded, mechanically bonded steel diaphragm in combination with vertical mild steel reinforcement.

a. The prestressed TES tank wall shall be considered as a cylindrical shell with partial edge restraint.

b. The prestressed TES tank wall shall be reinforced vertically by deformed steel reinforcing rods and welded wire fabric. The continuous, mechanically bonded steel diaphragm can be taken as effective vertical reinforcing.

c. The prestressed TES tank wall shall be of precast construction. Shotcrete or cast-in-place concrete core walls are not permitted.

d. A suitable stress plate shall be required at all locations where prestress wires are displaced 24 inches or greater. The stress plate shall be designated to transfer stress across the opening.

e. Minimum precast wall thickness shall be four inches.

f. No reduction in ring compression or tension in the wall will be taken due to restraint at the bottom.

5. The floor slab shall be designed as a membrane floor not less than six inches thick and shall be placed monolithically. No construction joints will be allowed unless otherwise approved by the engineer. Minimum ratio of floor reinforcement area to concrete area shall be 0.5 percent for tanks with diameters less than 100 feet, 0.6 percent for tanks with diameters 100 to 150 feet, and 0.8 percent for tanks with diameters over 150 feet. Wall footings may be above or below floor grade, but shall be placed monolithically with the floor.

6. The dome roof shall have a rise to span ratio within the range of 1:8 to 1:14. The minimum concrete thickness shall be four inches for a precast dome and three inches for a cast-in-place dome. The dome shall be fixed to the tank wall. Columns or

interior supports will not be allowed. Dome design shall be based on elastic spherical shell analysis.

1.03 SUBMITTALS

A. Prequalification Submittals Ten Days Prior to Bid Date

1. Tank contractors not previously prequalified shall submit preliminary design drawings and calculations showing the dimensions of the tank, details of the type of construction, wire-wound prestressing methods, and sizes of principal members. The drawings and calculations shall be of sufficient detail to show compliance with the specification and all required standards and shall be signed and sealed by an Engineer registered in the state the tank is to be constructed. The registered Engineer shall certify the design is in conformance with AWWA D110, Type III.

2. Tank contractors not previously prequalified shall submit a complete experience record for the tanks they have designed and built in their own name. The record shall include the contractor's experience in the design and construction of precast, wire-wound, prestressed concrete tanks conforming to AWWA D110, Type III. The record shall also indicate the size of the tank, the name and address of the Owner, the year of construction, and the name of the Engineer for each project.

3. Tank contractors not previously prequalified shall submit the resume of the tank designer, currently in its employ, and his/her experience as the designer of record for AWWA D110 Type III tanks, meeting the requirements of Section 1.02 A.3.

4. Tank contractors not previously prequalified shall submit the resumes for each member of the project team including the tank superintendent, project manager, shotcrete foreman, wire-winding foreman, and precast erection foreman that will be used for this project, meeting the requirements of Section 1.02 A.4.

5. Experience in the design and construction of AWWA D110 Type I, Type II, or Type IV tanks is not acceptable.

B. Design Submittal after Execution of Contract

1. Design calculations and shop drawings in quadruplicate, showing details and procedures of construction, shall be submitted to the Engineer for approval after execution of the Contract. After approval by the Engineer, one set of the drawings and calculations will be returned to the Contractor, and any changes found necessary by the Engineer shall be made by the Contractor.

2. Approval by the Engineer of the drawings and calculations submitted by the Contractor will not in any way relieve the Contractor of full responsibility for the accuracy and completeness of the drawings and calculations.

3. Design calculations and shop drawings shall be stamped by a Professional Engineer experienced in the design of AWWA D110, Type III wire-wound, prestressed concrete tanks and registered in the state of _____.

C. Construction Submittals for Review Prior to Use

1. Design proportions for all concrete and shotcrete. Concrete strengths of trial mixes.

2. Admixtures to be used in the concrete or shotcrete and their purpose.

3. Reinforcing steel shop drawings showing fabrication and placement.

4. Catalog cuts or shop drawings of all appurtenances, i.e. hatch, vent, ladders, waterstops.

1.04 GUARANTEE

The Contractor shall guarantee the structure against defective materials or workmanship for a period of one year from the date of completion. If any materials or workmanship prove to be defective within one year, they shall be replaced or repaired by the Contractor at the Contractor's expense.

PART 2.00 MATERIAL

2.01 CONCRETE

A. Concrete shall conform to ACI 301.

B. Cement shall be Portland cement Type I or Type II.

C. Admixtures, other than air-entraining and water reducing admixtures, will not be permitted unless approved by the Engineer.

D. Concrete for tank wall and dome construction shall have a minimum compressive strength of 4,000 psi at 28 days. All wall and dome concrete shall be air-entrained.

E. Concrete for the tank floor, footings, pipe encasement, and all other work shall have a minimum compressive strength of 3,500 psi at 28 days and shall not be air-entrained. The course and fine aggregate shall meet the requirements of ASTM C33. Course aggregate shall be No. 467 with 100% passing the 1-1/2 inch sieve. Superplasticizer and water-reducing admixtures shall be incorporated into the floor concrete. Polypropylene fibers shall be included in the floor concrete. Fibers shall be Microfiber by Grace, Fibermesh 150 by Propex, or equal. Fiber lengths shall be a maximum of 3/4 inches. The amount of polypropylene fibers added to the concrete mix shall conform to the manufacturer's recommendations.

F. Proportioning for concrete shall be in accordance with ACI 301.

G. Concrete or shotcrete in contact with prestressing steel shall have a maximum water soluble chloride ion concentration in the concrete or shotcrete of 0.06 percent by weight of cement.

2.02 SHOTCRETE

A. Shotcrete shall conform to ACI Standard 506, except as modified herein.

B. Wet mix process shall be employed for shotcreting.

C. Shotcrete used for covering prestressed wire shall consist of not more than three parts sand to one part Portland cement by weight. Additional coats of shotcrete shall consist of not more than four parts sand to one part Portland cement by weight. Shotcrete shall have a minimum strength of 4,500 psi at 28 days.

2.03 MORTAR FILL AND NON-SHRINK GROUT

Mortar fill and non-shrink grout shall have a minimum compressive strength of 4,000 psi at 28 days.

2.04 REINFORCING STEEL

A. Reinforcing steel shall be new billet steel Grade 60, as shown on the drawings, meeting the requirements of ASTM A615. Welded wire fabric shall conform to ASTM A185.

B. Reinforcing steel shall be accurately fabricated and shall be free from loose rust, scale, and contaminants which reduce bond.

C. Reinforcing steel shall be accurately positioned on supports, spacers, hangers, or other reinforcements and shall be secured in place with wire ties or suitable clips. Rebar chair supports may be either steel or plastic.

D. When required by design, the tank designer shall use base restraint cables to resist earthquake loads. Seismic base restraint cables shall be hot-dipped galvanized seven-wire

strand and shall be manufactured in accordance with ASTM A416 prior to galvanizing, and ASTM A475 after galvanizing.

2.05 STEEL DIAPHRAGM

A. The steel diaphragm shall conform to ASTM A1008 and shall be a minimum thickness of 0.017 inches. It shall be vertically ribbed with reentrant angles. The back of the channels shall be wider than the front, thus providing a mechanical keyway anchorage with the concrete and shotcrete encasement.

B. The steel diaphragm shall extend within one inch of the full height of the wall panel with no horizontal joints. Vertical joints within a wall panel shall be roll seamed or otherwise fastened in a fashion which results in a firm mechanical lock. Joints between wall panels that are not roll seamed shall be edge sealed with polysulfide or polyurethane sealant.

C. No punctures will be permitted in the diaphragm except those required for pipe sleeves, temporary construction openings, or special appurtenances. Details of such openings, as are necessary, shall be approved by the Engineer. All such openings shall be completely edge sealed with polysulfide or polyurethane sealant.

D. Diaphragm steel may be considered as contributing to the vertical reinforcement of the wall.

2.06 PRESTRESSING STEEL

A. Steel for prestressing shall be cold drawn, high carbon wire meeting the requirements of ASTM A821 having a minimum ultimate tensile strength of 210,000 psi.

B. Splices for horizontal prestressed reinforcement shall be ferrous material compatible with the reinforcement and shall develop the full strength of the wire. Wire splice and anchorage accessories shall not nick or otherwise damage the prestressing.

2.07 ELASTOMERIC MATERIALS

A. Nine inch minimum waterstop with centerbulb shall be polyvinyl chloride meeting the requirements of the Corps of Engineers Specification CRD-C 572. Splices shall be made in accordance with the manufacturer's recommendations subject to the approval of the Engineer. Waterstop shall be manufactured by Greenstreak Plastic Products Company, Inc., or equal.

B. Bearing pads shall be natural rubber or neoprene.

1. Natural rubber bearing pads shall contain only virgin natural polyisoprene as the raw polymer and the physical properties shall comply with ASTM D2000 Line Call-Out M 4 AA 414 A1 3.

2. Neoprene bearing pads shall have a hardness of 40 to 50 durometer, a minimum tensile strength of 1500 psi, a minimum elongation of 500%, and a maximum compressive set of 50 percent. Pads shall meet the requirements of ASTM D2000 Line Call-Out M 2 BC 410 A1 4 B14 for 40 durometer material.

C. Sponge filler shall be closed-cell neoprene or rubber conforming to ASTM D1056, Type 2, Class A, and Grade 1. Compression deflection limited to 25 percent at 2 to 5 psi.

D. Polysulfide or polyurethane sealant will be a two or three component elastomeric compound meeting the requirements of ASTM C920. Sealants must have permanent characteristics of bond to metal surfaces, flexibility, and resistance to extrusion due to hydrostatic pressure. Air cured sealants shall not be used.

2.08 DECORATIVE COATING

A. Decorative coating shall be applied to the exterior dome surface using one coat of a cementitious based damp-proofing product such as "Tamoseal" or equal, and one coat of a non-cementitious, high build, 100 percent acrylic resin polymer such as "Tammscoat" smooth textured protective coating or equal. A decorative coating shall be applied to the exterior wall surfaces using two coats of a non-cementitious, high build, 100 percent acrylic resin polymer such as "Tammscoat Smooth" textured protective coating or equal.

2.09 APPURTENANCES

B. The Contractor shall provide and install all appurtenances as shown on the drawings. Appurtenances shall include the following:

1. Insulation (see Section 13.2)

2. Diffuser Piping (see Section 13.3)

3. Overflow Weir and Piping

4. Roof Hatch: A 48" minimum square aluminum hatch with lockable, hinged cover and curb frame. The hatch shall have a lift handle, padlock tab, padlock and a cover hold open mechanism. All hardware shall be aluminum or stainless steel. Locate hatch as shown on drawings.

5. Roof Ventilator: Fiberglass or Aluminum, with fiberglass insect 20 x 20 screen, minimum diameter 2-ft 0-in.

{NOTE: If the liquid depth is 40 feet or greater and a Wall Access Manway is not provided, an Interior Ladder shall be added}

6. Interior Ladder: An aluminum ladder shall extend from the hatch to the floor. The ladder shall have a fall prevention device attached consisting of a sliding, locking mechanism and safety belt and complying with applicable OSHA standards. Location as shown on the drawings.

{NOTE: If the distance from final grade to the top of the dome ring is greater than 30'-0", an exterior ladder may be added.}

7. Exterior Ladder: An aluminum ladder shall extend from eight feet above the final grade to the tank roof. The ladder shall have an OSHA-approved fall prevention device (if required) consisting of a sliding, locking mechanism and safety belt. Location as shown on the drawings.

{NOTE: If the distance from final grade to the top of the dome ring is greater than 40 feet, and an Interior Ladder is not provided, an access manway shall be added.}

8. Access Manway: A circular 25 inch diameter Type 304 stainless steel wall manway with a hinged cover. A Type 304 stainless steel grab bar and an aluminum ladder shall be installed at the manway location. Locate access manway as shown on drawings.

{NOTE: If a Wall Access Manway is not provided, a Temporary Access Manway shall be added}

9. Temporary Access Manway: The tank contractor may elect to include a rectangular or circular, Type 304 stainless steel temporary wall manway and cover in the tank wall. The minimum temporary manway opening shall be 30" in each direction and the location for the temporary wall manway shall be determined by the tank contractor.

10. Floor Sump: A minimum of one 2'-0" square x 6" deep sump shall be provided in the tank floor. The sump may be at a drain pipe, outlet pipe or separate from the floor piping. The location of the sump shall be as shown on the drawings.

11. Temperature Sensor Sleeve: Ten inch (10") diameter S.S. or D.I. pipe with flange end extending above and below the tank roof top and bottom surfaces a minimum of 4 inches.

12. Temperature Sensor Protector: Ten inch (10") diameter perforated PVC pipe installed vertically inside the TES tank attached to the tank wall (minimum 3 feet from wall) to receive the individual sensors.

13. Level Sensor Sleeve: Six inch (6") diameter S.S. or D.I. pipe with flange end extending above and below the tank roof top and bottom surfaces a minimum of 4 inches.

PART 3.00 - CONSTRUCTION

3.01 CLEARING, GRUBBING, AND STRIPPING

A. All trees, shrubs, brush, stumps, roots, and other unsuitable material shall be removed to a minimum distance of 12 feet outside the edge of the tank foundation, plus additional areas necessary for the tank construction. The limits of clearing shall be as shown on the drawings and/or as approved by the Engineer.

B. No burning will be allowed unless approved by the Engineer and local authorities. All trees and vegetation shall be disposed of off site, unless approved otherwise by the Engineer.

C. All topsoil shall be stripped from the proposed construction work area and stockpiled on site.

3.02 EXCAVATION AND BACKFILL

A. The Contractor shall excavate to such depths and widths to provide adequate room for tank construction. A minimum working area of ten feet beyond the circumference of the tank foundation at an elevation six inches below the top of the tank foundation shall be provided. Excavated material may be used as suitable backfill material and stockpiled on site as required.

B. The excavation shall be dewatered as required during construction. The dewatering method used shall prevent disturbance of the tank foundation soils.

C. The Contractor shall excavate rock, if encountered, to the lines and grades indicated on the drawings, or as directed by the Engineer. Rock excavation shall be measured separately and paid for by the unit price item for rock excavation indicated in the bid. The pay limit for rock in the area of the tank shall be carried out to ten feet beyond the circumference of the tank foundation and at an elevation of one foot below the tank foundation.

D. In the event the subgrade material is disturbed or over excavated by the Contractor during excavation, it shall be removed and replaced with compacted select fill, at the Contractor's expense.

E. If, in the opinion of the Engineer, the subgrade is unsuitable for the foundation, the Engineer shall direct that it be removed by the Contractor and replaced with compacted select fill. Unsuitable material and compacted select fill shall be measured separately and paid for by the unit price indicated in the bid.

F. After excavation is complete, the bottom of the excavation shall be proof rolled and leveled as directed by the Engineer before the compacted select fill is placed. The Engineer shall inspect the subgrade for conformance with the original geotechnical report and its suitability for the tank foundation. Before any select fill is to be placed against rock surfaces, the rock shall be relatively free of all vegetation, dirt, clay, boulders, scale, excessively cracked rock, loose fragments,

ice, snow, and other objectionable substances. All free water left on the surface of the rock shall be removed.

G. A leveling base material consisting of a minimum six inch thick layer of compacted select fill shall be placed beneath the entire tank foundation. A non-woven geotextile fabric such as Mirafi 1100N, Propex 4545, or equal, shall be placed between the subgrade and leveling base material as shown on the drawings or directed by the tank builder. Select fill shall consist of a clean, well graded angular or subangular material having not more than 8 percent by weight passing the No. 200 sieve. The maximum size stone shall be 1½ inch. Select fill shall be placed in layers not exceeding twelve inches and compacted to a minimum density equal to 95 percent of the maximum laboratory density in accordance with ASTM D1557. Field testing for density achieved shall be in accordance with ASTM D1556 or D2922. If directed by the tank builder, a uniformly graded ¾ inch minus crushed stone shall be used as the leveling base material. The crushed stone shall be ¾ inch sieve size with 100 percent passing the one inch. If uniformly graded crushed stone is used for the leveling base material, compaction performance criteria shall be used to gauge the degree of compaction. Crushed stone shall be placed in layers not exceeding 9 inches and compacted with at least two passes in each direction with vibratory roller compaction equipment. Compaction shall be inspected and verification of compaction effort shall be documented by an approved testing laboratory.

H. The surface elevation of the leveling base shall be fine graded to a tolerance of plus zero inches to minus ½ inch over the entire foundation areas. Fine grading tolerances for floor pipe encasements shall be plus zero inches to minus six inches.

I. The tank shall be backfilled and rough graded to the contours shown on the drawings. Unless other material is specified by the Engineer, materials used for backfilling shall be suitable on site material.

J. Frozen material shall not be used for backfill nor shall fill material be placed on snow, ice, or frozen material. Rock or concrete spoils (greater than six inches) shall not be used in backfill within two feet of the tank wall.

K. Crushed stone material shall consist of clean, hard, durable, crushed particles or fragments of stone or ledge rock of uniform quality reasonably free of thin or elongated pieces. The materials shall be free from ice, snow, rubbish, sods, roots, and other deleterious or organic materials and shall conform to the following gradation requirements meeting ASTM C 33 stone size No. 67.

SIEVE SIZE	PERCENT PASSING BY WEIGHT
1 inch	100%
3/4 inch	90% - 100%
3/8 inch	20% - 55%
No. 4	0% - 10%
No. 8	0% - 5%

L. Compacted granular fill should consist of sandy gravel or gravelly sand free of ice, snow, rubbish, sods, roots and other deleterious or organic materials and should be well graded within the following limits.

SIEVE SIZE	PERCENT FINER BY WEIGHT
1.5 inch	100%
No. 4	30% - 90%
No. 40	10% - 50%
No. 200	0% - 8%

3.03 FLOOR

A. The floor and wall footings shall be constructed to the dimensions shown on the Approved Shop Drawings.

B. Prior to placement of the floor, a six mil polyethylene moisture barrier shall be placed over the subbase. Joints in the polyethylene shall be overlapped a minimum of six inches.

C. Prior to placement of the floor, all piping that penetrates through the floor, shall be set and encased in concrete.

D. The vertical waterstop shall be placed and supported so that the bottom of the center bulb is at the elevation of the top of the footing. The waterstop shall be supported without puncturing any portion of the waterstop, unless it is manufactured with holes for tying. The waterstop shall be spliced using a thermostatically controlled sealing iron and each splice shall be successfully spark tested prior to encasement in concrete.

E. The floor shall have a minimum thickness of six inches and be poured monolithically. There shall be no construction joints in the floor or between the floor and footing. Floors over 30,000 sq.ft. in surface area may, at the option of the Contractor, have one or more construction joints. Such construction joints shall be approved by the Engineer prior to placement.

F. The floor shall be cured by applying one coat of curing compound and flooding with water, and shall remain saturated for a period of seven days.

3.04 PRECAST PANEL CONSTRUCTION AND ERECTION

A. The precast wall shall be constructed with a continuous waterproof steel diaphragm embedded in the exterior of the precast panel. Horizontal joints in the diaphragm will not be allowed.

B. No holes for form ties, nails, or other punctures will be permitted in the wall.

C. Temporary wall openings may be provided for access and removal of construction materials from the tank interior subject to the approval of the Engineer.

D. Wall and dome panel beds shall be located around the periphery of the tank as required. The beds shall be constructed to provide finished panels with the proper curvature of the tank.

E. Polyethylene sheeting shall be placed between successive pours to provide a high moisture environment and a long slow cure for the concrete.

F. The erection crane and lifting equipment shall be capable of lifting and placing precast panels to their proper location without causing damage to the panel.

G. The precast panels shall be erected to the correct vertical and circumferential alignment. The edges of adjoining panels shall not vary inwardly or outwardly by more than 3/8 inch and shall be placed to the tank radius within + 3/8 inch.

H. Joints between precast wall panels shall be bridged with a 10 gauge steel plate, edge sealed with polysulfide, and filled with mortar as shown on the drawings. No through-wall ties will be permitted.

I. Minimum dome and wall panel thickness shall be four inches.

3.05 CONCRETE

A. All concrete shall be conveyed, placed, finished, and cured as required by pertinent ACI standards.

B. Weather Limitations

1. Unless specifically authorized in writing, concrete shall not be placed without special protection during cold weather when the ambient temperature is below 35 degrees Fahrenheit and when the concrete is likely to be subjected to freezing temperatures before final set has occurred and the concrete strength has reached 500 psi. Concrete shall be protected in accordance with ACI 306R. The temperature of the concrete shall be maintained in accordance with the requirements of ACI 301 and 306R. All methods and equipment for heating and for protecting concrete in place shall be subject to the approval of the Engineer.

2. During hot weather, concreting shall be in accordance with the requirements of ACI 305R.

3. Placement of concrete during periods of low humidity (below 50 percent) shall be avoided when feasible and economically possible, particularly when large surface areas are to be finished. In any event, surfaces exposed to drying wind shall be covered with polyethylene sheets immediately after finishing, or flooded with water, or shall be water cured continuously from the time the concrete has taken initial set. Curing compounds may be used in conjunction with water curing, provided they are compatible with coatings that may later be applied, or they are degradable.

C. Finishes

The tank shall be given the following finishes:

1. The floor slab shall be given a bull float and/or fresno finish.

2. The interior of precast wall panels shall be given a light broom finish.

3. The exterior of precast dome panels, dome slots, and cast-in-place domes shall be given a light broom finish.

4. Exterior shotcrete shall be given a fine texture gun finish.

D. Curing

Concrete shall be cured using water methods, sealing materials, or curing compounds. Curing compounds shall not be used on surfaces to which mortar or shotcrete is to be applied. Curing compounds used within the tank shall be suitable for use with potable water.

E. Testing

1. For concrete placed in precast panels or wall slots, a set of three cylinders shall be made for each truck load of concrete placed. For concrete placed in the floor,

dome ring, or dome slots, two sets of three cylinders for the first 50 cubic yards, and one set of three cylinders for every 100 cubic yards thereafter placed in the same day. One cylinder shall be tested at seven days, one at 28 days, and one held as a spare.

2. Slump, air content and temperature testing shall be performed on each truck where cylinders are taken.

3. All concrete testing shall be in accordance with ASTM C-31 and C-39, at the Contractor's expense, and shall be conducted by an independent testing agency approved by the Engineer.

3.06 SHOTCRETING

A. Weather Limitations

1. Shotcrete shall not be placed in freezing weather without provisions for protection of the shotcrete against freezing. Shotcrete placement can start without special protection when the temperature is 35 degrees Fahrenheit and rising, and must be suspended when the temperature is 40 degrees Fahrenheit and falling. The surface to which the shotcrete is applied must be free from frost. Cold weather shotcreting shall be in accordance with ACI 301 and ACI 306R.

2. Hot weather shotcreting shall be in accordance with the requirements of ACI 301 and ACI 305R.

B. Shotcrete Coating Over Steel Diaphragm

1. The steel diaphragm shall be covered with a layer of shotcrete at least ½ inch thick prior to prestressing.

2. Total minimum coating over the steel diaphragm shall be 1-1/2 inches including diaphragm cover, wire cover, and finish covercoat.

C. Shotcrete Coating Over Prestressing Wire

1. Each prestress wire shall be individually encased in shotcrete. Shotcrete wire coat thickness shall be sufficient to provide a clear cover over the wire of at least ¼ inch.

2. A finish coat of shotcrete shall be applied as soon as practical after the last application of wire coat. The total thickness of shotcrete shall not be less than 1 inch over the wire.

D. Placement of Shotcrete

1. Shotcrete shall be applied with the nozzle held at a small upward angle not exceeding five degrees and constantly moving during application in a smooth motion with the nozzle pointing in a radial direction toward the center of the tank. The nozzle distance from the prestressing shall be such that shotcrete does not build up or cover the front face of the wire until the spaces behind and between the prestressing elements are filled.

2. Total shotcrete covercoat thickness shall be controlled by shooting guide wires. Vertical wires shall be installed under tension and spaced no more than 2 feet apart to establish uniform and correct coating thickness. Wires of 18 or 20 gauge high tensile strength steel or a minimum 100 lb. monofilament line shall be used. Wires shall be removed after placement of the shotcrete covercoat and prior to finishing.

E. Curing

Shotcrete shall be cured using water curing methods, sealing materials, or curing compounds at the option of the Contractor.

F. Testing

1. Testing of shotcrete shall be in accordance with ACI 506, except as specified herein. One test panel shall be made for each of the following operations: corewall, cove, wire cover, and covercoat. Test panels shall be made from the shotcrete as it is being placed, and shall, as nearly as possible, represent the material being applied. The method of making a test sample shall be as follows: A frame of wire fabric (one foot square, three inches in depth) shall be secured to a plywood panel and hung or placed in the location where shotcrete is being placed. This form shall be filled in layers simultaneously with the nearby application. After 24 hours, the fabric and plywood back-up shall be removed and the sample slab placed in a safe location at the site.

2. The sample slab shall be moist cured in a manner identical with the regular surface application. The sample slab shall be sent to an approved testing laboratory and tested at the age of 7 days and 28 days. Nine three inch cubes shall be cut from the sample slab and subjected to compression tests in accordance with current ASTM Standards. Three cubes shall be tested at the age of 7 days, three shall be tested at the age of 28 days, and three shall be retained as spares. Testing shall be by an independent testing laboratory, approved by the Engineer and at the Contractor's expense.

3.07 PRESTRESSING

G. Prestressing wire will be placed on the wall with a wire winding machine capable of consistently producing a stress in the wire within a range of –7 percent to +7 percent of the stress required by the design. No circumferential movement of the wire along the tank wall will be permitted during or after stressing the wire. Stressing may be accomplished

by drawing the wire through a die or by another process that results in uninterrupted elongation, thus assuring uniform stress throughout its length and over the periphery of the tank.

H. Each coil of prestressing wire shall be temporarily anchored at sufficient intervals to minimize the loss of prestress in case a wire breaks during wrapping.

I. Minimum clear space between prestressing wires is 5/16 inch or 1.5 wire diameters, whichever is greater. Any wires not meeting the spacing requirements shall be respaced. Prestressing shall be placed no closer than two inches from the top of the wall, edges of openings, or inserts, nor closer than three inches from the base of walls or floors where radial movement may occur.

J. The band of prestressing normally required over the height of an opening shall be displaced into circumferential bands immediately above and below the opening to maintain the required prestressing force. Bundling of wires shall be prohibited.

K. A stress plate shall be used at all permanent wall penetrations above grade that results in displacement of wire equal to or greater than 24 inches in height. The stress plate shall accommodate a portion of the prestressing wires normally required for the height of the opening. The remaining prestress wires normally required shall be displaced into circumferential bands immediately above and below the penetration. The effect of banded prestressing shall be taken into account in the design.

L. Ends of individual coils shall be joined by suitable steel splicing devices capable of developing the full strength of the wire.

M. The Contractor shall furnish a calibrated stress recording device, which can be recalibrated, to be used in determining wire stress levels on the wall during and after the prestressing process. At least one stress reading per vertical foot or one stress reading for every roll of wire - whichever is greater - shall be taken immediately after the wire has been applied on the wall. Readings shall be recorded and shall refer to the applicable height and layer of wire for which the stress is being taken. A written record of stress readings shall be kept by the Contractor. All stress readings shall be made on straight lengths of wire. If applied stresses fall below the design stress in the steel, additional wire will be provided to bring the force on the corewall up to the required design force. If the stress in the steel is more than 7 percent over the required design stress, the wrapping operation should be discontinued, and satisfactory adjustment made to the stressing equipment before proceeding.

3.08 LIQUID TIGHTNESS TEST

Upon completion, the tank shall be tested to determine liquid tightness. The tank shall be filled with water to the maximum level. Water will be furnished to the tank by the owner. The test shall be in accordance with AWWA D-110-04, Section 5.13 excluding allowable leakage. The net liquid loss shall be zero.

3.09 CLEAN-UP

The premises shall be kept clean and orderly at all times during the work. Upon completion of construction, the Contractor shall remove or otherwise dispose of all rubbish and other unsightly material caused by the construction operation. The Contractor shall leave the premises in as good a condition as it was found.

SECTION 13.2
THERMAL ENERGY STORAGE TANK INSULATION

A. Furnish all materials and services necessary to insulate the chilled water storage reservoir as shown on the Drawings.

B. Complete installation of the diffuser system hanger rods that penetrate the dome roof concrete prior to applying insulation, if insulation is required.

C. Clean and prime all concrete surfaces to receive insulation prior to applying insulation.

D. Apply insulation to the exterior of the roof if required and the tank wall a minimum of two feet below the tank backfill.

E. Do not apply insulation if the concrete surface is wet, or if the ambient temperature is fifty degrees Fahrenheit and falling.

F. Insulation shall be spray-on polyurethane foam insulation or finish coated polystyrene board, or an approved equal.

1.01 SPRAY-ON POLYURETHANE FOAM INSULATION

A. Polythane Systems' PSI-SH200-30 or approved equal two-component polyurethane foam material.

B. Dry thickness shall be determined by heat gain calculations.

C. Three pound per cubic foot density or as required.

D. Formulated with HCFC-141. Formulations using CFC-11 are prohibited.

E. Surface profile texture shall be orange peel to coarse orange peel. Popcorn or tree bark surface profile textures are unacceptable.

1.02 BASE COAT OF PROTECTIVE COVERING

A. Chem-Elast 5501 or 5511, Elasto-Bond 801/801FS or approved equal butyl rubber elastomer, colored black or gray.

B. Apply within forty-eight hours after foam application.

C. Apply two coats to all foam surfaces, a minimum two gallons per 100 square feet application rate.

D. Each completed coat is to be a minimum of nine dry mils thickness, total thickness of eighteen dry mils.

1.03 TOP COAT OF PROTECTIVE COVERING

A. Chem-Elast 2820, Futura-Flex 550, Futura-Thane 5650, or approved equal aliphatic urethane-based top coat, color to be selected by owner prior to material approval.

B. Apply top coat after the base coat is properly cured (dry).

C. 1.3 gallon per 100 square feet application rate.

D. Completed top coat to be a minimum of ten dry mils thickness.

1.04 FINISH INSPECTION

Inspect finished application for holidays, pinholes, and dry mil thickness. Caulk any defects with the same color aliphatic urethane-based caulking material.

2.01 EXTERIOR FINISH COATED POLYSTYRENE BOARD

A. Polystyrene board (expanded/extruded) manufactured to ASTM C578-87a, Type I or Type IV requirement.

B. Thickness shall be determined based on heat gain calculations (Provide minimum R-10).

C. Two pound per cubic foot density or as required to provide minimum R-10.

2.02 ADHESIVE AND BASE (GROUND) COAT

A. Copolymer based waterproof adhesive or equal applied to concrete or shotcrete to surface up to 1/8 inch thick.

B. Copolymer based ground coat applied to the polystyrene with spray-on or toweled equipment to a uniform thickness of 1/16 inch thick.

2.03 REINFORCEMENT MESH

A. Coated, interwoven fiberglass mesh used as base (ground) coat reinforcement; or

B. Heavy duty, interwoven fiberglass mesh for impact resistance.

2.04 FINISH COAT

A. Ready mixed acrylic-based synthetic plaster coating; weather, mildew, and crack resistant; washable and fade resistant.

B. Texture shall be pebbled or stucco or sandblast or freeform or combination of the above.

C. Color shall be uniform waterbased acrylic, selected by owner.

2.05 SAMPLES

A. Two foot square samples of the finish coat system for each finish texture and color on the appropriate substrate shall be submitted prior to selection by the owner/engineer.

B. After selection of sample, one sample shall remain at the job site and the other shall be retained by the owner/engineer.

SECTION 13.3
DIFFUSER PIPING

A. The diffuser piping shall be designed in accordance with the provisions of the publication design guide for cool thermal storage ASHRAE 90369 "Stratified Chilled-Water Storage Design Guide," utilizing an upper and lower octagonal diffuser piping array:

Capacity ____ ton hours.

Maximum Flow rate ____ gpm.

Chilled Water Supply Temperature: ___ºF.

Chilled Water Return Temperature ____ºF.

TES tank dimensions ___-ft diameter, ____-ft. water depth.

B. Furnish all labor, material, and equipment to install the diffuser piping arrays, including:

1. All diffuser and distribution piping will comply with ASTM-D2241 PVC Plastic Schedule 40 or SDR 41 pressure pipe, or approved equal.

2. All diffuser and distribution fittings will comply with ASTM-2466 or D2467 Schedule 40 PVC 1120 pressure fittings either molded or prefabricated.

3. Diffuser slots may be inspected and approved by the Project Engineer prior to installation.

4. All weld joints will be socket-type and set with PVC solvent cement (IPS "Weld-On" 306-719 or approved equal heavy bodied highly thixotropic medium set cement conforming to ASTM-D2564), and/or "Van Stone" flanges. Diffuser pipe installation to be joined with PVC solvent cement after the roof is completed, the cement is temperature sensitive. Provide adequate ventilation while joining diffuser pipe inside the tank.

5. All diffuser pipe hangers, supports, stands, and accessories (washers, nuts, bolts, rods, etc.) shall be stainless steel or fiberglass. Non-corrosive anchors shall be used for securing stands and/or hangers.