

Section 13210

COMPOSITE ELEVATED WATER STORAGE TANK

Note to Contract Specifier

Specification clauses requiring revision or insert are high lighted and underlined. Specification notes are high lighted and italicized. Contact Landmark for technical assistance with project specific modifications and appurtenances not listed - phone 817 439 8888 or email info@ldmkusa.com.

PART 1 – GENERAL

1.01 Summary

A Work Included

This section includes the design, construction, testing, and commissioning of a Composite elevated tank and related work including foundations, [painting, electrical,] mechanical, [storage floor, control room], and appurtenances.

*** Spec Note – delete as required.*

B Related Documents

Drawings and the general provisions of this document, including General Conditions, Supplemental Conditions, Special Provisions and other Division 1 Sections apply to work in this section.

C Related Sections

Section 03300	Concrete
Section 09900	Coatings
Section 16000	Electrical

*** Spec Note – add or revise Sections as required.*

1.02 References

The latest version of the following Specifications, Codes and Standards are referenced in this section.

ACI 117	Standard Tolerances for Concrete Construction and Materials
ACI 304	Guide for Measuring, Mixing, Transporting and Placing Concrete
ACI 305	Hot Weather Concreting
ACI 306	Cold Weather Concreting
ACI 318	Building Code Requirements for Structural Concrete
ACI 347	Guide to Formwork for Concrete
AISC S335	Specification for Structural Steel Buildings

ANSI B16.5	Pipe Flanges and Flanged Fittings
ANSI ASCE 7	Minimum Design Loads for Buildings and Other Structures
API 650	Welded Steel Tanks for Oil Storage
ASTM A 123	Zinc Coatings on Iron and Steel Products
ASTM A 240	Stainless Steel Plate, Sheet and Strip for Pressure Vessels
ASTM A 285	Pressure Vessel Plates, Carbon Steel
ASTM A 774	Welded Stainless Steel Fittings
ASTM A 778	Welded Stainless Steel Tubular Products
AWWA D100	Welded Steel Tanks for Water Storage
AWWA D102	Coating Steel Water Storage Tanks
AWWA C652	Disinfection of Water Storage Facilities
FAA 70/7460-1H	Obstruction Marking and Lighting
NACE RP0178	
NFPA NEC	National Electric Code
NFPA 780	Standard for the Installation of Lightning Protection Systems
NSF 61	Standard for Drinking Water System Components
OSHA 29 CFR	Part 1926 Safety and Health Regulations for Construction
SSPC VIS-89	Visual Standard for Abrasive Blast Cleaned Steel

1.03 System Description

A Elevated Tank

The Composite elevated tank shall consist of the following: foundation, reinforced concrete support structure and a welded steel water tank. The support structure shall extend vertically from the foundation as a circular concrete wall. A domed concrete slab shall be provided as structural support for the steel tank within the perimeter of the wall. A reinforced concrete ring beam shall be provided to connect the steel tank, concrete dome and concrete support wall. The elevated tank shall be in accordance with the shape, dimensions and details required by these specifications and drawings.

B Operating Parameters

Minimum capacity within operating range	_____	gallon
Maximum operating range	_____	ft
Maximum fill rate	_____	gpm
Elevation - overflow/top capacity level	_____	ft
- grade slab	_____	ft
- final ground	_____	ft
Support wall diameter	_____ +/- 2	ft

**** Spec Note – contact Landmark for tank sizing information****

C General Design Standards

Structural design of the elevated storage tank shall conform to the following design standards except as modified by this section.

Foundations and Support Structure

ACI 318 and ASCE 7

D Design Loads

Design loads shall be in accordance with ASCE 7 for Category IV (essential facility) structure.

1. Dead load shall be the estimated weight of all permanent construction.
2. Water load shall be the weight of water when the tank is filled to overflow.
3. Roof live load in addition to snow load: none.
4. Roof snow load shall be the larger of 15 psf. or the snow load determined in accordance with ASCE 7. Ground snow load shall be determined from Figure 7-1 in ASCE 7.
5. Wind loads shall be in accordance with ASCE 7 for wind exposure category C, and basic wind speed of 90 mph. (see Figure 6-1 in ASCE 7)

*** Spec Note – basic wind speed will increase for hurricane coastal regions***

6. Horizontal and vertical seismic loads shall be in accordance with ASCE 7 and the Site Class as determined in the soil investigation report.

Importance factor $I = 1.50$.

Response Modification Coefficient $R = 3.0$ in accordance with ASCE 7

E Combination of Loads

The effect of combination of loads shall be considered in accordance with the following.

$$\begin{aligned}
 &1.4D + 1.6F + 1.6(L+S) \\
 &1.2D + 1.2F + L + 0.5S + 1.6W \\
 &1.2D + 1.2F + L + E \\
 &0.9D + 1.6W \\
 &0.9D + F + E
 \end{aligned}$$

- D = Effect of dead load.
 F = Effect of water load.
 E = Effect of horizontal and vertical seismic load.
 L = Effect of interior or roof live load.
 S = Effect of roof snow load.
 W = Effect of wind load.

F Foundation Design

The foundations shall be designed by the Contractor to safely support the structure based on the recommendations of the geotechnical report. Foundations shall be sized in accordance with AWWA D-100 subject to the following modifications:

- Allowable permanent capacity of soil or deep foundation element shall not be exceeded under $D + F$.
- Allowable short term capacity of soil or deep foundation element shall not be exceeded under $D + F + 0.7E$ or, $D + F + W$.
- No uplift under $D + W$ or $D + F + .75(0.7E)$ unless anchorage is provided
- No overturning under $D + 1.5W$ or $D + F + 1.5(0.7E)$.

1.04 Submittals

A Submit the following with the proposal:

A preliminary section view drawing of the tank proposed for this project. The drawing shall include sufficient detail to illustrate tank geometry, materials of construction, primary dimensions, support wall thickness and pour height, domed concrete slab thickness, the elevation of low and high water levels, interior wet, interior dry and exterior paint areas, and other information required to show compliance with the specification. If the proposed design does not comply with the specifications, the bid shall be rejected.

B Construction Drawings

Provide elevation, plan and sectional view drawings of the foundation, support structure, tank and all appurtenant equipment and accessories. Show the location, dimensions, material specifications, and finish requirements. The submission shall be sealed by professional engineer registered in the State of the project.

Foundation details shall include excavation, soil protection and backfill.

Reinforced concrete details shall include construction joints, openings and inserts. Reinforcement shall be clearly indicated on the structural drawings and identified by mark numbers that are used on the fabrication schedule. Location, spacing and splice dimensions shall be shown. Placement and fabrication details shall conform to ACI 318.

Steel tank details shall include weld joints and a layout showing all primary and secondary shop and field welds.

C Construction Procedures

Provide design, detail drawings and procedures for the support structure forming system. Details shall include location of form and construction joints, rustications and ties. Procedures shall include form removal criteria and minimum elapsed time for adjacent concrete placement.

Provide shop and field weld procedures for all structural joints on the steel tank.

D Design Data

Provide a table showing capacity of the tank in gallons at all levels in one foot increments.

Provide a summary of the design for the foundation, support structure, tank and other components. Include the design basis, loads and load combinations and results.

Provide a finite element analysis that accurately models the intersecting elements of the interface region. The interface region includes those portions of the concrete support structure and steel tank affected by the transfer of forces from the tank cone and the tank floor to the concrete support wall. The analysis shall provide results including the shear, moment, and compression or tension caused by the intersecting elements in the interface region.

E Product Data

Provide a separate concrete mix design for each concrete compressive strength required or specified.

Provide technical data and color samples of all coating products.

Provide manufacturers descriptive information for appurtenant equipment and accessories that are not detailed on the construction drawings.

F Reports/Certification

Provide documentation of all tests, inspections and certifications required by this section.

Provide qualifications of all welders.

Provide proof of insurance for Professional Liability with a minimum limit of \$2,000,000 each occurrence and aggregate.

G Operation/Maintenance

Provide operating instructions and maintenance procedures for the elevated tank and applicable appurtenant equipment, mechanical components and accessories.

1.05 Quality Assurance

A Experience Requirements of Tank Contractor

The work described in this section shall be performed by a company that specializes in the design and construction of composite elevated tanks. The tank contractor shall have the following qualifications:

1. A minimum of ten years experience in composite tank design and construction.
2. The design, construction and commissioning of a minimum ten Composite elevated tanks of equal or greater capacity, all in satisfactory operation for at least 5 years. These tanks shall be of the same design and constructed using forming systems as required by this specification.

B Pre-Qualification of Tank Contractor

Acceptable contractors pre-qualified to perform the work specified herein are: CB&I Constructors, Inc., and Landmark Structures.

Other contractors may be considered only if they meet the experience criteria and the specification requirements. A written request for pre-qualification must be received by the Engineer a minimum of fourteen days prior to bid date and must include the following minimum information.

1. A completed contracts summary demonstrating minimum ten years experience and listing a minimum of ten composite elevated tanks of equal or greater capacity in successful operation for at least five years. Provide the location, capacity, Owner contact with phone number, and year completed.
2. A preliminary section view drawing of the tank proposed for this project. The drawing shall include sufficient detail to illustrate tank geometry, materials of construction, primary dimensions, support wall thickness and pour height, domed concrete slab thickness, the elevation of low and high water levels, and other information required to show compliance with the specification.
3. Detail drawings and/or photographs of the equipment and systems to be used for construction of the concrete support structure and erection of the steel tank. Submittal shall describe the forming system, concrete placement method, rustications, ties, methods used to prevent grout leakage, steel erection method.
4. Written procedures for concrete and steel quality control including wall form alignment, segmented wall pour, and steel cone dimension control.
5. A sample finite element analysis of the tank interface region.
6. A written affidavit confirming that no exceptions are taken to the requirements and procedures described in the specifications.
7. Proof of insurance for Professional Liability with a minimum limit of \$2,000,000 each occurrence and aggregate.
8. Photographic evidence that the contractors concreting systems result in architectural concrete. Uniform color, uniform surface density and uniform alignment of rustication are primary measure. Photographs shall provide adequate detail to show absence of surface defects at construct joints and structure penetrations. Submit a photographic resume of ten projects with a minimum of four images each project proving the architectural concrete requirements have been attained.

The Engineer and /or Owner shall be the sole and final judge as to the acceptability of a tank contractor's qualifications. Bidders failing to obtain pre qualification will be considered non-responsive and their bid will not be opened.

C Quality Assurance

Elevated tank design, concrete support structure construction and steel tank construction shall not be subcontracted. These items shall be self performed by the contractor.

The contractor shall directly employ a full time professional engineer with a minimum five years cumulative experience in the design and construction of Composite elevated tanks. The engineer shall be registered in the State the work is being performed and shall be in responsible engineering charge of the work.

A qualified supervisor directly employed by the manufacturer shall be on site at all times during construction of the foundation, support structure and steel tank.

D Regulatory Requirements

The specifications, codes and standards referenced in paragraph 1.02 shall govern the work with regard to materials, design, construction, inspection and testing to the extent specified.

Personnel safety equipment shall be provided in accordance with OSHA requirements and manufacturers documentation.

1.06 Delivery, Storage & Handling

A Handling and Shipping

The Contractor shall handle materials and fabricated components in a manner that will protect them from damage. Allow painted materials adequate cure time prior to stacking or shipping.

B Storage and Protection

Protect delivered materials and equipment from damage. Store in well drained areas and provide blocking to minimize contact with the ground.

1.07 Project Conditions

A Permits and Easements

Permits, licenses, and easements required for permanent structures, changes in existing facilities or advancement of the construction as specified shall be secured and paid for by the Owner prior to the start of construction. These include building permits, airspace authority approval, site access easements, highway crossing permits, etc.

Licenses or permits of a temporary nature required by specific trades shall be the responsibility of the Contractor.

B Existing Conditions

A geotechnical investigation has been carried out at the site and a report has been incorporated within these specifications. The net allowable bearing pressure of shallow foundations and/or the allowable capacity of deep foundation elements have been defined in this report. The Contractor shall be responsible for securing any further geotechnical information required beyond that provided in this report.

C Access

The Contractor shall provide access from public roads to the tank site unless otherwise specified.

D Working Conditions

1. Safety and Health - The Contractor shall comply with safe working practices and all health and safety regulations of OSHA, state and local health regulatory agencies and Material Safety Data Sheets (MSDS). Provide protective and lifesaving equipment for persons working at the site.

1.08 Sequencing and Scheduling

A Schedule

The Contractor shall provide a bar chart showing the anticipated schedule for design, submittals, site work and the major components of construction including foundation, support structure and steel tank. In addition, show tank painting, electrical installation and other significant activities. Update the schedule as required.

B Notification

The Contractor shall provide notification of the intent to start work at least seven days prior to commencing each major phase of work.

C Certifications

Provide certification from the engineer of record that the elevated tank has been designed in accordance with the requirements of the specification.

Provide certification that testing and inspection requirements of 3.07 have been performed and the results comply with the requirements of the specification.

1.09 Guarantees

The Contractor shall guarantee the structure, appurtenant equipment and accessories provided under this section against defective design, workmanship or materials for a period of one year from the date of substantial completion. If notified within this period, the Contractor shall repair any defects at no cost to the Owner. Defects caused by damaging service conditions are not covered.

All guarantees for materials, equipment and accessories provided under this section shall be obtained by the Contractor and submitted.

1.10 Insurance

In addition to any requirements specified in the General and/or Supplemental Conditions, the Contractor shall maintain Professional Liability insurance with a minimum limit of \$2,000,000 each occurrence and aggregate.

1.11 Contract Award

Contract award will be based on an evaluated bid analysis. Evaluations will consider capital cost and maintenance costs over a 60 year life cycle. The owner reserves the right to award the contract based on the evaluation criteria, not on the low bid. The Owner will be the sole and only judge in this evaluation.

Maintenance analysis will be performed by establishing the present value of future tank coating requirements based on industry standard repaint cycles and costs. A 3% inflation rate and a 5% interest rate shall be used in the life cycle cost analysis.

*** Spec Note – life cycle analysis shall be included for contracts considering alternate tank styles. Contact Landmark for life cycle analysis program.*

PART 2 - PRODUCTS

2.01 Materials

A Reinforced Concrete

Concrete materials and reinforcement shall comply with ACI 318, except as modified in this section.

B Steel Tank

Steel tank components, including steel plates, sheets, structural shapes and filler metals shall be in accordance with AWWA D100, Section 2, "Materials".

2.02 Concrete Foundation

The concrete foundation shall be designed in accordance with ACI 318. Minimum specified compressive strength shall be 4000 psi at 28 days. The service load reinforcement tension stress shall not exceed 30,000 psi under dead plus water load unless flexural cracking is otherwise controlled in accordance with ACI 318.

2.03 Concrete Support Structure

The concrete support structure shall be designed in accordance with ACI 318. The specified compressive strength of concrete shall be as required by design, but not less than 4000 psi at 28 days. The maximum specified compressive strength of concrete for the wall and dome shall be 5500 and 4500 psi respectively.

A Support Wall

Support wall shall be reinforced concrete with a minimum thickness of 8 inches exclusive of any architectural relief. Wall thickness shall be provided such that the average

compressive stress due to the weight of the structure and stored water is limited to 25% of specified compressive strength, but not greater than 1000 psi. A minimum total wall reinforcement of 0.15% vertically and 0.20% horizontally shall be distributed approximately equally to each face. A minimum of 0.75% vertical reinforcement shall be provided in the top 6 ft. of the wall extending into the concrete ring beam. Minimum concrete cover for interior / exterior faces shall be 1 inch and 1-1/2 inches respectively.

B Tank Floor

Tank floor shall be a reinforced concrete dome not less than 8 inches thick. The average compressive stress due to the weight of the structure and stored water shall not exceed 15% of the specified compressive strength, nor greater than 600 psi. Minimum total reinforcement in orthogonal directions shall be 0.40% distributed approximately equally to each face. Additional reinforcement shall be provided for stress caused by edge restraint effects.

C Openings

The effects of openings in the wall shall be considered in the design. Not less than 60% of the interrupted reinforcement in each direction shall be placed each side of the opening. Reinforcement shall extend past the opening not less than half the transverse opening dimension.

Openings wider than 3 ft. 6 in. shall be subjected to a rigorous analysis taking into account the stress concentrations and diminished lateral support that exist in the vicinity of such openings. Each side of the opening shall be designed as a column in accordance with ACI 318.

Openings 8 ft. 0 in. or wider used for vehicle access shall be strengthened against vehicle impact and local buckling by means of an internal buttress located on each side of the opening. The buttress shall consist of a thickened, reinforced concrete wall section that is integrally formed and placed with the support wall. The buttress section shall be not less than 3 ft. 0 in. wide and 6 in. thicker than the nominal wall dimension.

2.04 Concrete Support Structure / Steel Tank Interface

A Interface Region

The interface region includes those portions of the concrete support structure and steel tank affected by the transfer of forces from the tank cone and the tank floor to the concrete support wall. This includes a ring beam and connection details. The Contractor shall provide evidence that a thorough review of the interface region has been performed. Finite element and finite difference analyses are the required methods for examining such local stresses in detail.

The geometry of the interface shall provide for positive drainage and not allow either condensate or precipitation to accumulate at the top of the concrete wall or ring beam.

B Ring Beam

The ring beam shall be reinforced concrete with a nominal width and height of at least two times the support wall thickness. Minimum radial and circumferential reinforcement

shall be 0.25%. For direct tension, reinforcement shall be provided such that the average service load stress in tension reinforcement due to the weight of the structure and stored water does not exceed 12,750 psi.

Ring beam design shall consider unbalanced forces from the steel tank cone and concrete dome, load conditions varying with water level, eccentricity of loads resulting from design geometry, and allowance for variations due to construction imperfection and tolerance.

2.05 Steel Tank

A General

The steel tank shall be all welded construction and shall be designed in accordance with applicable sections of AWWA D100. The required capacity and dimensions of the tank are noted on the drawings and in this section of the specifications. All exposed lap joints shall be fully seal welded on both sides.

B Plate Thickness

All members shall be designed to safely withstand the maximum stress to which they may be subjected during erection and operation. The minimum thickness of any steel plate shall be 1/4 in., except that plate used as a membrane over the structural concrete floor shall have a minimum thickness of 3/16 in.

C Roof Support

All structural members supporting the roof of the steel tank shall be flat bar or sealed square tubular sections. I-beams or other sections with horizontal projections may be used if the nominal depth is 10 in. or greater. Support beams shall be seal welded to the underside of the roof plate along the entire length of the beam.

D Cone

Conical sections of the tank that support water shall be designed in accordance with AWWA D100.

2.06 Appurtenances and Accessories

A General

Accessories shall comply with the minimum requirements of the Specifications, Codes and Standards listed in 1.02, current applicable safety regulations, and the operating requirements of the structure.

B Ladder Access

Ladders shall be provided from the slab on grade inside the base of the support wall to the upper walkway platform located below the tank floor. The tank floor manhole shall be provided with ladder access from the upper platform. A ladder shall extend from the

upper platform, through the access tube interior to the roof. A ladder mounted on the access tube exterior shall be provided for access to the tank interior, extending from the roof manhole to the tank floor.

Ladders that terminate at platforms or landings shall extend a minimum of 48 in. above the platform elevations. A safety extension shall be provided at the top of the ladder under hatch(s). The safety extension shall be a Ladder Up Safety Post as manufactured by Bilco or equal. The post shall extend 42-inches above the top of the ladder and be constructed of hot dip galvanized steel. Mounting hardware shall be galvanized.

Ladders located in the concrete support structure and access tube interior shall be galvanized steel. Tank interior ladders shall be coated in accordance with the tank interior coating system.

Ladder side rails shall be a minimum 3/8 in. by 2 in. with a 16 in. clear spacing. Rungs shall be minimum 3/4 in. diameter, spaced at 12 in. centers and plug welded into holes drilled in the side rails. Tank interior ladders shall be provided with 1 in. diameter rungs and 1/2 in. x 2 in. side rails and shall be fully seal welded.

Ladder shall be secured to the adjacent structure by brackets located at intervals not exceeding 10 ft. Brackets shall be of sufficient length to provide a minimum distance of 7 in. from the center of rung to the nearest permanent object behind the ladder. Ladder brackets located on the access tube exterior shall be reinforced at the access tube shell so that potential ice damage is confined to the ladder and bracket and not the access tube shell.

C Safe Climbing Device

High strength aluminum, rigid rail safe climbing devices shall be provided on all ladders. Rails shall be center mounted and extend from 3 ft. above the ladder bottom to the top of the ladder section. Mounting brackets, fasteners and splice bars shall be provided as required for a rigid installation.

Three trolleys with snap hooks shall be provided that are designed to be operated with the aluminum rail. A safety body harness with front and side rings shall be supplied for each trolley.

A caution sign shall be provided at the lowest point of access to the ladder requiring safe climbing devices. The sign shall read "CAUTION – Safety Equipment Required When Climbing Ladder". The sign shall be secured to the wall.

D Rest Platforms

Rest platforms shall be provided at maximum 50 ft. intervals along the support wall ladder. Platforms shall be minimum 3 ft. by 5 ft. and complete with handrails, mid rails and toe plates in accordance with OSHA requirements. Grating shall be used for the walking surface and shall be suitably hinged at the ladder penetration. Platforms shall be arranged for straight run ladder and operable without removing fall prevention equipment. All components shall be galvanized steel.

E Platforms

A 4 ft. wide upper walkway platform shall be located at the top of the support wall to provide access from the support wall ladder to the roof access ladder located on the interior of the access tube. Platforms shall be provided with handrails, mid rails and toe plates in accordance with OSHA requirements. Grating shall be used for the walking surface. All components shall be galvanized steel.

F Support Wall Doors

1. Personnel Door - Door frames shall be 16-gauge with concealed reinforcement at hardware locations. Expansion type anchors for existing openings shall be installed near the top, bottom and intermediate point of each jamb to rigidly secure the frame. Doors shall be 1 3/4 in. thick insulated, reinforced, full, flush type with 18-gauge face sheets and concealed reinforcement at hardware locations. All edges shall be finished flush with watertight seams. Shop applied finish for the frame and door shall be baked on rust inhibitive primer. Field finish shall be compatible with the tank exterior. Standard hardware shall be stainless steel and include three 4 1/2 in. by 4 1/2 in. hinges, industrial duty closer and lockset.

Quantity and location of personnel door(s) shall be as shown on the drawings.

2. Overhead Vehicle Door - Door installation shall be on the interior face of the support wall. The door frame shall be a steel plate fabrication suitably detailed, fastened and reinforced to accept the door. Operation shall be manual with a chain hoist. The curtain shall be formed of 22-gauge steel interlocking slats with end locks and wind locks designed for a wind loading of 20 psf. Torsion springs shall be mounted on a solid torsion rod, which is attached to an exterior mounted spring tension adjustment wheel. A 24-gauge steel hood shall be provided with a weather seal to protect the assembly. Steel brackets shall be installed to the interior face of the wall with expansion anchors which enclose and support the counterbalance assembly with sealed bearings. Steel curtain guides are mounted to the brackets. The curtain, bottom bar, brackets, guides, hood, pipe and chain shall be galvanized. Provide with locking device.

Size, quantity and location of vehicle door(s) shall be as shown on the drawings.

G Tank Openings

1. Floor - Provide a 30 in. diameter manhole through the tank floor. The manhole shall be operable from a ladder located on the upper platform and shall be designed to withstand the pressure of the tank contents without leakage. The manhole assembly shall include a stainless steel hand wheel operator and threaded components.
2. Roof - Provide two 30 in. square weather proof access hatches on the roof of the tank. One hatch shall allow egress from the access tube to the roof. The second hatch, located adjacent to the first, shall allow access to the interior of the tank via the ladder mounted on the exterior of the access tube. The opening shall have a minimum 4 in. curb. Provide aluminum covers with a 2 in. down turned edge, stainless steel hardware, hold open arm and a locking mechanism.

H Access Tube

Provide a minimum 48 in. diameter centrally located access tube through the steel tank to provide access to the tank roof from the upper walkway platform. The access tube shall incorporate a 2 in. by 2 in. channel to collect condensation that may form on the interior surface. A flexible 3/4 in. PVC hose complete with backflow preventer shall drain the channel to the overflow pipe.

I Roof Railing

A 42 in. high roof handrail shall be provided to enclose all centrally located roof accessories. The roof railing shall be a minimum of 18 ft. in diameter.

J Rigging Access

Provide a 24 in. x 36 in. opening at the top of the support wall. This opening shall be accessible from a platform and shall provide access to the exterior rigging rail located at the tank/support wall intersection. The access opening shall be provided with a hinged stainless steel cover or a removable vent in accordance with 2.06.M.2.

A minimum 24 in. diameter opening shall be provided on the tank roof to provide access to the tank interior rigging rail.

K Rigging Rails

Provide permanently installed rigging rails suitable for rolling trolleys at the interior of the tank at the wall/roof and access tube/roof connections. Provide an exterior rigging rail at the base of the tank adjacent to the support structure.

L Piping

1. Inlet/Outlet Pipe - Provide a _____ inch diameter inlet/outlet pipe that extends from the base of the support structure to the tank floor elevation. Provide a minimum 6 in. high removable silt stop where the inlet/outlet pipe enters the tank. The bottom capacity level of the tank's operating range shall be at or above the elevation of the top of the silt stop. Pipe material within the support structure shall be Schedule 10S Type 304L stainless steel. Piping below the grade slab shall be flanged cement lined ductile iron suitably restrained to prevent movement.

The inlet/outlet pipe shall be designed to support all related static and dynamic loads. Suitable galvanized steel brackets, guides and hangers shall be provided on the support wall and tank floor at intervals not exceeding 20 feet.

The inlet/outlet pipe shall be designed and constructed to accommodate any differential movement caused by settlement and by thermal expansion and contraction over the range of extreme temperature differences expected for the support wall and pipe. The required flexibility shall be provided by an expansion joint located near grade in the vertical section of pipe.

2. Overflow Pipe - Provide a _____ inch diameter overflow. The top of the overflow shall be located within the tank at the overflow elevation. It shall run vertically beside the central access tube and extend through the tank floor, at which point it shall turn 90° and run under the tank floor to the support wall. This horizontal run shall be sloped to drain. The pipe shall then turn 90° and run vertically beside the support wall to grade. A base elbow shall direct the overflow through the support

wall, where the pipe shall be terminated with a flap valve. Pipe material within the support structure shall be Type 304L (minimum 11 gauge) stainless steel. If the top of overflow is located above top capacity level, the tank shall be designed for the additional capacity provided by the difference.

*** Spec Note – contact Landmark for minimum pipe sizing to satisfy maximum fill rate.***

The entrance to the overflow pipe shall be designed for the maximum inlet flow rate specified in 1.03B. The design shall be based on the water level cresting within 6 in. above the overflow elevation. A conical weir shall be provided if the entrance capacity of the overflow pipe diameter is not adequate. A vortex prevention device shall be used.

The overflow shall be designed to support all related static and dynamic loads. Suitable galvanized steel brackets, guides and hangers shall be provided on the support wall and tank floor at intervals not exceeding 20 ft. The overflow pipe and weir section within the tank shall be carbon steel and supported by the central access tube.

The overflow pipe shall be designed and constructed to accommodate any differential movement caused by settlement and by thermal expansion and contraction over the range of extreme temperature differences expected for the support wall and pipe. A layout with sufficient upper offset to accommodate differential movement is acceptable. If this method is not applicable, the required flexibility shall be provided by an expansion joint located near grade in the vertical section of pipe.

The overflow pipe shall penetrate the support wall approximately 1 ft. above grade and discharge through a flap valve onto a 5 ft. wide x 15 ft. concrete splash pad.

3. Stainless Steel Requirements - Pipe and fittings shall be Type 304L stainless steel fabricated from material meeting the requirements of ASTM A-240. Fabrication, inspection, testing, marking and certification of pipe and fittings shall be in accordance with ASTM A-778 and A-774 respectively. All fittings less than 18 inches shall be smooth flow, fittings larger than 18 inches may be of five section mitre construction. Backing flanges shall be in accordance with ASTM A285-C drilled to ANSI B16.5 Class 150. Pipe, fittings and welds shall be cleaned and passivated.

Pipe, fittings and flange thickness shall be in accordance with the manufacturers certified pressure rating for the applicable service pressures. The design pressure rating shall be minimum 125 psi for piping located within closed or valve sections.

4. Tank Drain – A tank drain shall be provided to completely drain the tank contents if the inlet/outlet pipe does not intersect the low point of the tank. A four inch drain pipe located at the low point of the tank floor shall be fitted with a threaded plug and tee handle. Flexible stainless steel piping shall connect and drain to the overflow pipe.

M Ventilation

1. Tank Ventilation - A tank vent shall be provided, located centrally on the tank roof above the maximum weir crest elevation. It shall consist of stainless steel or aluminum components, including a support frame, screened area and cap. The support shall be fastened to a flanged opening in the tank roof. The vent cap shall be provided with sufficient overhang to prevent the entrance of wind driven debris and precipitation. A minimum of 4 in. shall be provided between the roof surface and the vent cap.

The tank vent shall have an intake and relief capacity sized to prevent excessive pressure differential during the maximum flow rate of water, either entering or leaving the tank. The overflow pipe will not be considered as a vent. The maximum flow rate of water entering the tank is specified in 1.03B. The maximum flow rate of water exiting the tank shall be calculated assuming a break in the inlet/outlet at grade when the tank is full. The vent shall be provided with an insect screen. Vent capacity shall be determined based on open area provided by the screen.

In addition to the tank vent, a pressure/vacuum relief mechanism shall be provided that will operate in the event of vent failure. The mechanism shall be designed to return automatically to its original position after operation. The pressure/vacuum relief mechanism shall be located on the tank roof above the maximum weir crest elevation, and may be incorporated in the vent assembly.

2. Support Structure Ventilation - Ventilation within the support structure shall comply with the governing building code requirements, based on occupancy classification. As a minimum, one louvered vent shall be provided at the top of the support wall. This vent shall be accessible from the upper platform and may also be designed to provide access to the exterior rigging rails located at the tank/support wall intersection. Vents shall be accessible from the interior ladders, platforms or floors provided. Vents shall be stainless steel or aluminum and provided with a removable insect screen.

N Interior Floors

1. Slab on Grade - Provide a 6 in. thick, 3500 psi concrete floor slab in the base of the support structure. The slab shall be supported on compacted granular fill and shall be reinforced with #4 reinforcing steel at 12 in. centers each way. Provide 1/2 in. expansion joint between floor slab and support wall and at pipes and supports that extend through the floor. Place cap strip and sealant over the expansion joint. The slab shall be sloped at 0.5% toward the truck door for drainage.
- [2. *Structural Floor – Provide a composite construction structural floor located ft. above the slab on grade. The design shall comply with the applicable requirements of AISC S335. It shall be designed for a minimum uniform live load of 125 psf. The floor shall consist of a concrete slab supported by a galvanized formed steel deck and galvanized steel girders.*

The structural floor shall be a clear span design supported entirely by the concrete support wall. All loads transferred from the structural floor to the support wall shall be considered in the design. The wall shall be strengthened as required in the vicinity of connections causing point load or eccentric conditions. Loads transferred

from the structural floors to the foundation shall be considered in the design of the foundation.

Unless structural floor and supports are isolated from the wall, loads on the wall caused by thermal stresses in these members shall be considered. An analysis of the lateral loading condition shall be performed and the wall strengthened accordingly.

Provide a galvanized steel access stairway adjacent to the support wall. Access openings through the structural floor shall be protected with 42 in. high galvanized steel handrails.]

**** Spec note – remove Clause #2 if storage floor not required.****

O Level Monitoring

1. General - Provide three 3/4 in. couplings welded to the inlet/outlet pipe 5 ft. above grade. Each coupling shall be provided with a stainless steel nipple and an isolation valve.
2. Pressure Gauge - Provide a pressure gauge in accordance with ASME B40.1 Grade 2A. The dial shall be 4 1/2 in. diameter with black markings on white background. Pressure range is 0-100 psi.

P Lightning Protection

Provide a lightning protection system for the elevated tank structure and any roof mounted equipment that may be damaged by lightning.

Minimum requirements include two 28 strand by 14 gauge copper conductors bonded to the steel tank 180 degrees apart. The conductors shall be fastened to the interior support wall at 3 foot minimum spacing, and shall terminate with buried 5/8 inch diameter by 8 foot long copper clad ground rods.

Lightning protection for obstruction lights shall consist of an air terminal mounted on the support and formed to fit around the fixture. The 1/2 inch diameter copper air terminal shall extend a minimum of 10 inches above the light fixture and shall connect to a copper conductor that terminates in a bonding plate secured to the tank roof.

2.07 Electrical and Lighting

Electrical work shall be in accordance with Division 16

[Obstruction lighting shall be provided in accordance with FAA standards. The obstruction light shall be centrally located on the roof of the tank above all permanent installations. It shall be a steady burning, dual fixture type with a lamp-out relay switch. The fixture shall be weather sealed, corrosion resistant, with aluminum base and housing. Red globes with 116-watt clear traffic signal lamps rated at 8000 hour life shall be provided. A pilot light located near the electrical panel shall be provided to indicate when the primary bulb has failed.]

*** Spec note – remove Paragraph 2 if obstruction lighting not required***

2.08 Steel Tank Painting

Refer to Section 09900 for tank coatings. Galvanized, stainless steel and concrete surfaces are not coated.

2.09 Source Quality Control

A Tests

Review mill test certifications of all steel plate, structural components and reinforcement to ensure compliance with specification requirements.

B Inspections

Provide inspection of shop fabricated components in accordance with AWWA D100.

PART 3 - EXECUTION

3.01 Foundation

A Excavation

The foundation bearing surface and excavation shall be inspected by a representative of the geotechnical engineer prior to foundation construction. Verification of the applicable design and construction recommendations is required. The geotechnical engineer shall be retained by the Contractor. After verification of the foundation bearing surface, provide a 2 in. thick concrete working slab within the lower excavation limits. Grade the site to prevent runoff from entering the excavation.

B Concrete Construction

For shallow foundations, reinforcement placed adjacent to a concrete working slab shall have a 2 in. minimum cover, and shall be supported by precast concrete block, metal or plastic bar supports.

The sides of foundations shall be formed using any suitable system conforming to ACI 318. Earth cuts shall not be used as forms for vertical surfaces. Forms shall be provided on top sloping surfaces steeper than 2.5 horizontal to 1 vertical. Straight form panels may be used to form circular foundation shapes. The minimum design radius shall be maintained at all sections.

C Finish

Formed surfaces shall have a smooth form finish when exposed and a rough form finish when not exposed.

Unformed surfaces shall have a troweled finish when exposed and floated finish when not exposed.

3.02 Concrete Support Structure

A Architectural Concrete Construction

The exposed exterior surface of the concrete support wall is designated architectural concrete. The concrete and formwork requirements of this section shall be strictly enforced to ensure concrete of the highest practicable architectural standard. Formwork design, installation and removal shall comply with the minimum requirements of ACI 318, ACI 117 and the applicable requirements of ACI 347, except as modified by this Section.

Attention shall be given to ensure the same concrete design mix is used throughout the support wall. The proportion, type and source of cement and aggregates shall not be changed. Uniform moisture content and placing consistency shall be maintained.

Placement is crucial to achieving architectural concrete. All wall concrete shall be placed vertically and directly inside the reinforcement cage with drop chutes to prevent form splatter and the resulting surface finish variations. Placement methods that introduce concrete horizontally through wall reinforcement are strictly prohibited. Vertical pour rate shall be a minimum of 15 feet per hour.

Support wall reinforcement shall be installed with plastic supports. Maximum spacing of supports for welded wire fabric shall be 5 ft. centers, horizontal and vertically. Forming systems shall be designed with the provision of ties and bracing such that concrete components conform to the correct dimensions, shape, alignment and elevation. Embedded items shall be properly positioned and secured. Form surfaces shall be thoroughly cleaned of concrete residue and coated with a release agent prior to placing reinforcement. Do not allow excessive release agent to accumulate on the form surface. Steel forms shall be coated with a non-staining, rust preventative form oil or otherwise protected. Rust stained steel formwork shall not be used.

The forming system for the pedestal wall shall be fully engineered and detailed with procedures to meet the increased demands of architectural concrete. The support wall shall be constructed with a jump form process using form segments prefabricated to match the wall curvature. Concrete pour height shall be a minimum of 6 ft. and a maximum of 10 ft. Form panels shall extend the full height of the concrete pour using only vertical panel joints. Form system shall be designed to lap and be secured to the previous wall pour. The space between the form and the previous pour shall be sealed to prevent grout leakage. Wall forms shall incorporate a positive means of adjustment to maintain dimensional tolerances specified. Wall forms shall be adjusted for vertical plumb and circularity and locked into position with through wall form ties prior to concrete placement. Panels shall be designed for lateral pressures associated with full height plastic concrete head, and support and bracing shall be provided for construction related impact loads and wind loads. Working platforms that allow safe access for inspection and concrete placement shall be provided. Form surfaces shall be steel, plastic or fiberglass coated material.

The form system shall incorporate a uniform pattern of vertical and horizontal rustications to provide architectural relief to the exterior wall surface. Rustication strips

shall be sealed to the form face to eliminate the grout leakage that results in broken corners, color variations and rock pockets. Broken edges and chamfers will not be accepted. All construction joints and panel joints shall be located in rustications. Vertical panel joints shall be sealed using closures which combine with the form pattern to eliminate grout leakage and panel joint lines. All joints shall be grout tight. The vertical and horizontal rustications shall be proportioned and combined to impart a symmetrical architectural pattern to the completed structure. Form ties shall be located in a uniform pattern. No architectural form treatment is required on the interior surface.

Support wall concreting shall incorporate segmented placement procedures. Temporary vertical bulkheads shall divide the wall pour into segments corresponding to a single batch (truckload) of concrete. The bulkheads shall be located at rustications, braced rigid and tight to maintain vertical alignment under concrete load without grout leakage. Wall segment concrete shall be placed continuously to full form height from a single load. Placement from multiple batches is not permitted. Temporary bulkheads shall not be removed until adjacent concrete is placed. Support wall concreting operations shall occur a maximum of once per day. Multiple form movements and concrete placements within a day are not permitted.

Wall forms shall not be disturbed or removed until the concrete has attained sufficient strength to prevent forming operations or environmental loads from causing surface damage or excessive stress. Form removal shall be based on early age concrete strength testing. The minimum concrete strength shall be established by the Contractor, based on an analysis of stress at critical stages throughout the forming and concrete operations. Early age concrete testing shall be in accordance with ACI 228.1R-95. Pull Out testing in accordance with ASTM C 900-99, Maturity Method testing in accordance with ASTM C 1074-93, or field cured cylinders compressive strength tested in accordance with ASTM C 172 are the acceptable methods to determine early concrete strength.

The formwork system for the domed structural floor shall be designed to support all construction loads. Adequate shoring and bracing shall be provided to transfer loads without appreciable movements. Form surfaces shall be steel, plastic or fiberglass coated material. Shoring and forms for the structural dome slab shall remain in place until the concrete has gained sufficient strength to carry the floor weight without damaging deflections.

Concrete surfaces shall be protected in accordance with the recommendations of ACI 306 until the component attains 35% of the specified compressive strength. At this time, protection may be removed subject to the allowable temperature differential. A reasonable temperature differential shall be defined, based on component thickness and restraint conditions.

B Finish

Provide a smooth form finish without rub for the interior and exterior support wall. Tie holes shall be plugged using grout on the interior and manufactured plugs on the exterior which match the color of the cured concrete as closely as possible. Provide a light sandblast to the exposed exterior concrete support wall surface.

Provide a smooth form finish without rub for the interior dome slab. The unformed surface shall have a floated finish.

C Dimensional Tolerances

Support structure concrete construction shall conform to the following:

Variation in thickness:

wall.....-3.0% to +5.0%

dome.....-6.0% to +10%

Support wall variation from plumb:

in any 5 feet of height3/8 inch

in any 50 feet of height1 inch

maximum in total height2 inches

Support wall diameter variation.....0.4%

not to exceed3 inches

Dome floor radius variation.....1.0%

Level alignment variation:

from specified elevation.....1 inch

from horizontal plane.....1/2 inch

Offset between adjacent pieces of formwork:

exterior exposed surfaces.....1/8 inch

interior exposed surfaces.....1/4 inch

D Mock Up Panel

A mock up panel shall be constructed using the proposed form work, concrete and placement methods. Minimum size will be 4 ft wide by 6 ft high. This panel shall be agreed upon by the Contractor and Engineer as the reference standard with which to judge surface quality, appearance and uniformity of texture and color.

Review and acceptance of formed concrete surface must be made immediately upon form removal. Succeeding pours shall not be placed until the most recent wall pour has been stripped and the form surface approved. The Contractor shall be responsible to inform the Engineer as to pour schedule. The Engineer shall not delay the Contractor by lack of attendance. Non-attendance by the Engineer will be understood by the Contractor to mean acceptance of the lift by the Engineer.

Concrete with surface defects exceeding limitations specified herein or not meeting the standard represented by the mock-up panel shall be repaired to meet that standard, or removed.

3.03 Steel Tank

A Welding

Welding procedures and general welding requirements shall be in accordance with AWWA D100, Section 8, "Welding".

No structural welding is permitted to any steel embedded in hardened concrete, unless the weld is at least 2 ft. from the embedment interface.

Grinding of weld contour shall approximate Condition "D" of NACE Standard RP0178.

B Fabrication

Layout, cutting, forming, edge preparation and workmanship for steel tank components and fabrications shall be in accordance with AWWA D100, Section 9, "Shop Fabrication".

C Tank Erection

Steel tank erection procedures and general requirements shall be in accordance with AWWA D100, Section 10, "Erection".

D Tolerances

Steel tank tolerances shall be in accordance with the requirements of API 650, Section 5.5.

Steel cone shall be constructed to the following tolerance. The deviation from the theoretical conical surface shall not exceed $0.032 \sqrt{RT}$, when measured in the radial direction over length $4\sqrt{RT}$, where R is the radius normal to the plate surface at the point of consideration, and T is the plate thickness.

E Grouting

The interface between the steel tank floor plate and the supporting structural concrete slab shall be constructed with a minimum 1 in. void. Subsequent to testing, the void shall be filled with a flowable grout mix.

3.04 Field Quality Control

A Concrete Testing and Inspection

The evaluation and acceptance of concrete shall be in accordance with Section 03300 of this specification.

The support wall radius, plumb and thickness shall be verified for each concrete lift at all vertical form panel joints and at a minimum of 60 degree intervals. Vertical alignment and radius shall be checked using a visible beam laser. Measurement shall be made to the outside form surface. Daily measurements shall be provided to resident inspector. An inspection report certified by the tank designer shall be provided to the Owner at project completion.

B Steel Tank Testing & Inspection

Inspection procedures for the steel tank shall be as required by AWWA D100, Section 11, "Inspection". Radiographic inspection of full penetration butt-welded joints shall be made by an independent inspection company retained by the Contractor.

Erection tolerance of the steel cone in the radial direction shall be measured. Provide field measurements at 30 degree intervals.

Weld joints of plate over the structural concrete floor shall be tested for leaks by vacuum box / soap solution testing, or equivalent method prior to grouting.

3.05 Cleaning

A Site

The project site shall be kept in a clean and safe condition at all times. The Contractor shall remove all construction equipment and debris at project completion.

B Tank Disinfection

Water and sufficient pressure for flushing, cleaning, initial testing and disinfection shall be supplied by the Owner at no cost to the Contractor. Disinfection shall be in accordance with AWWA C652. Tank leakage test shall be performed during disinfection.

END OF SECTION