AMERICAN SAMOA POWER AUTHORITY

STANDARD WATER TANK SPECIFICATIONS

JANUARY 2018

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SECTION 00410

POTABLE WATER STORAGE TANK - BOLTED STEEL

PART 1 – GENERAL

1.01 SCOPE OF WORK

This section includes furnishing and erecting a RTP (rolled, tapered panel) bolted steel reservoir and all necessary piping and appurtenances, per AWWA D-103 specifications. For tank replacement projects, the contractor shall demolish the existing tank and preserve the existing foundation to be used for the new tank if suitable.

1.02 DRAWINGS AND SPECIFICATIONS

A. Construction shall be governed by the Owner's drawings and specifications showing general dimensions and construction details. There shall be no deviation from the drawings and specifications, except upon written order from the Engineer.

B. The bidder is required to furnish, for the approval of the Engineer and at no increase in contract price, 5 sets of complete specifications and construction drawings for all work not shown in complete detail on the bidding drawings stamped by a U.S. licensed Professional Engineer. A complete set of structural calculations shall be provided for the tank structure and foundation stamped by a USA licensed Professional Structural Engineer.

C. When approved, two sets of such prints and submittal information will be returned to the bidder marked **"APPROVED FOR CONSTRUCTION"** and these drawings will then govern the work detailed thereon. The approval by the Owners Engineer of the tank supplier's drawings shall be an approval relating only to their general conformity with the bidding drawings and specifications and shall not guarantee detail dimensions and quantities, which remains the bidder's responsibility.

1.03 MEASUREMENT AND PAYMENT

Payment shall be based on the items as shown in the bid form which may be classified either as unit bid items or lump sum items.

1.04 QUALIFICATION OF TANK SUPPLIER

A. The Engineer's selection of a Fusion Bond powder coated bolted steel tank is predicated on a thorough examination of design criteria, construction methods, and optimum coating for resistance to internal and external tank corrosion. Deviations from the specified design, construction or coating details will not be permitted.

B. The bidder shall offer a new tank structure as supplied from a manufacturer specializing in the design, fabrication and erection of factory applied Fusion Bond coated, bolt together tank systems. The manufacturer shall fabricate and coat the tank in the same facility, which it owns and operates.
C. The tank shown on the contract drawings and specified herein shall be a LIQ Fusion 7000 FBE™ powder-coated, RTP bolted tank as manufactured by Tank Connection or other approved manufacturer.
D. Erection of the structure is to be by the tank manufacturer. The contractor shall be fully responsible for the entire installation including tank erection, and the ultimate water tightness of the complete installation.
E. Strict adherence to the standards of design, fabrication, erection, product, quality, and long-term performance, established in this Specification will be required by the Owner and Engineer.
F. Tank suppliers wishing to pre-qualify shall submit the following to the Engineer/Owner for consideration:
    a. Typical structure drawing(s)
    b. List of tank materials, appurtenances and tank coating technical specifications.
    c. Resume of job installation superintendent.
    d. The contractor shall have the experience and knowledge necessary to furnish and erect the highest quality tank possible. Under no circumstances shall an inexperienced contractor be awarded the project. The contractor shall be fully responsible for the entire installation including appurtenances and the final product.
    e. If an aluminum geodesic dome roof system is required, the dome erector must have installed, and had in satisfactory service, at least one clear span aluminum dome with a diameter equal to or larger than the unit specified, and shall submit evidence of such with his bid proposal and/or pre-bid submittal.
    f. The components of the tank that come in contact with stored water shall be certified to meet ANSI/NSF Additives Standard No. 61.

1.05 DESIGN CRITERIA

A. The materials, design, fabrication and erection of the bolt together tank shall conform to the AWWA Standard for “Factory-Coated Bolted Steel Tanks For Water Storage” – ANSI/AWWA D103, latest addition.
B. The tank coating system shall conform solely to Section 10.6 Thermoset Powder Coatings of ANSI/AWWA D103, latest addition.
C. All materials furnished by the tank manufacturer, which are in contact with stored water, shall be certified to meet ANSI/NSF Additives Standard No. 61. Certification of a coating type alone will not be sufficient to meet this requirement. Certification of a distributor, and not the tank or coating manufacturer, will not be accepted.

D. The RTP (rolled, tapered panel) bolted tank design shall have lap joint connections on both vertical and horizontal shell seams. American Petroleum Institute (API 12B) flanged panel tank design will not be acceptable.
E. The following information is provided for the proper design of the tank:

Job Site Location:	Utulei
Product to be stored:	Drinking water
Specific Gravity:	1
PH of Product:	6.8~7.5
Temperature of Product:	23~35˚C
Nominal Capacity (Gallons):	200,000
Nominal Diameter (Feet):	30
Nominal Height (Feet):	40
Tank Base Elevation (Feet):	227.10
Min. Freeboard Space (Feet):	1.5
Design Pressure:	Atmospheric
Deck Live Load:	25 psf
Wind Speed:	200 mph
Seismic Zone:	3
Wind Speed:	200 mph
Seismic Zone:	3

1.06 REFERENCES

AWWA D103-97 – Bolted steel tank fabrication and erection

AWWA C652 – Disinfection of Water Storage Facilities

AWWA D102 – Standard for Painting Steel Water Storage Tanks

ANSI- American National Standards Institute

ASTM- American Society of Testing Of Material

SSPC- Steel Structure Painting Council

NSF- Additives Standard No. 61

NSF- Additives Standard No. 60

1.07 DESIGN SUBMITTALS FOR REVIEW

After award of the contract but prior to the start of any construction activity, the contractor shall submit five (5) complete sets of shop drawings and calculations to the Owner for approval.
All shop drawings and design calculations shall be certified by a United States Professional Civil Engineer.
Shop Drawings:

1) Storage Tank: Tank height and diameter, plate thickness and material requirements, structural details, weld joint details, anchor bolt and tank tie-down details (if applicable)and tank accessories details. Include erection drawings, elevations, and details where applicable. Submit paint color charts to the Owner for selection of inside and outside tank colors.
2) Foundation: Show size and location of all structural elements and reinforcements and type and location of splices of reinforcement.
3) Design Calculations: All calculations shall clearly state the external loading criteria and assumptions; show the resulting moments and stresses; and detail resulting cross-section area. The design calculations shall be provided by the Supplier/Contractor.

No deviation will be made from the approved submittal drawings without written approval from the Owner.

PART 2 – MATERIAL SPECIFICATIONS

2.01 STEEL

A. Plates and sheets used in the construction of the tank shell, tank floor and tank roof, shall comply with the minimum standards of AWWA D103.Design requirements for plate and sheet steel shall be ASTM A36; or ASTM A1011 Grade 40, 50, 60; or A572 Grade 50, 60; or A656 Grade 50, 60 or 70with minimum yield strength of 40,000 psi. Minimum thickness shall be 3/16” (0.1875 inches).
B. Rolled Structural Shapes: Rolled structural shapes shall conform to ASTM A36, A572 Grade 50, A992 or ANSI 1010. Other grades of carbon steel that meet or exceed these standards may be utilized.

2.02 BOLTS

A. Bolts used in tank lap joints shall be ½ - 13 UNC-2A rolled thread, and shall meet the minimum requirements of AWWA D103, Section 4.2.
B. Bolt material shall be SAE J429 Grade 8 150,000 psi min.
C. Bolt Finish – JS500 electro-plated.
D. Bolt Head Encapsulation

1. High impact polypropylene copolymer encapsulation of entire bolt head up to the splines on the shank.
2. Resin shall be stabilized with an ultraviolet light resistant material such that the color shall appear black. The bolt head encapsulation shall be certified to meet the ANSI/NSF Standard 61 for indirect additives.

E. All bolts on the vertical tank wall shall be installed such that the head portion is located inside the tank, and the washer and nut are on the exterior.
F. Bolt lengths shall be sized to achieve a neat and uniform appearance. Excessive threads extending beyond the nut after torquing will not be permitted.
G. Other bolts shall conform to or at least be equal to the latest revision of ASTM A307 or ASTM A325.
H. Anchor bolts shall meet or exceed the requirements of ASTM A36 or ASTM A325.

2.03 GASKET& SEALANTS

A. The lap joint sealant shall be a one component, moisture cured, polyurethane compound. The sealant shall be suitable for contact with potable water and shall be certified to meet ANSI/NSF Additives Standard 61 for indirect additives.
B. The sealant shall be used to seal lap joints and bolt connections and edge fillets for sheet notches and starter sheets. The sealant shall cure to a rubberlike consistency, have excellent adhesion to the Fusion Bond coating, low shrinkage, and be suitable for interior and exterior use.
C. Sealant curing rate at 73°F and 50% RH
D. Tack-free time: 6 to 8 hours
E. Final cure time: 10 to 12 hours
F. Neoprene gaskets and tape type sealer shall not be used in liquid contacting surfaces.

2.04 COATING

All metal plates, supports, members, and miscellaneous parts, except bolts, certain accessories, and appurtenances, shall be factory coated in accordance with AWWA D102 and the provisions of these specifications. Field coating, except for touch-up will not be permitted. The color of the external surface shall be forest green.

2.05 APPLICATION PROCEDURES FOR FACTORY COATING

A. Cleaning
    1. Following the fabrication process, sheets and tank components shall be thoroughly washed and rinsed.

a. Washing shall be with DuBois 626 E detergent (or equivalent). Concentration shall be 2% to 3% and the water temperature shall be 130 to 140 degrees F.
b. The PH level shall be monitored and maintained at 10 to 12.
c. Rinsing shall be in a two stage booth and ambient temperature freshwater in the second stage.
d. All water shall be removed from sheets and tank components with forced air at ambient temperature.

B. Surface Preparation
1. Sheets and tank components shall be blasted using steel shot S-230.
2. Sheets and tank components shall be blasted on both sides providing a surface profile of SSPCSP10. Anchor profile shall be 1.0 mil minimum.

C. Powder Coating System
1. After cleaning and blasting, the sheets and tank components shall receive a Fusion Bond powder coating on both sides of steel. The powder coating shall be applied with an electrostatic process. The thermoset powder coat system shall be as specified:

LIQUID STORAGE	FUSION SYSTEM	DFT*	Range (min/max)
Interior Lining	LIQ Fusion 7000 FBE™	7mils	6-9 mils
Exterior Primer	EXT Fusion 5000 FBE™	3mils	3-5 mils
Exterior Topcoat	EXT Fusion SDP™	3 mils	3-5 mils

**DFT – Nominal dry film thickness*

2. Interior lining, LIQ Fusion 7000 FBE™ will be applied at 7 mils nominal DFT,with a min/max range from 6-9 mils.
3. Exterior prime coat, EXT Fusion 5000 FBE™ will be applied at 3 mils nominal DFT, with a min/max range from 3-5 mils.
4. Coating thickness shall be maintained by the use of PLC controlled automatic spray guns preset for the application.
5. Visual inspection for coverage shall be made after powder application and before the first oven cure. Areas with light coverage shall be re-sprayed with a manual spray gun.

D. Powder Curing
1. Sheets and tank components shall then be heated in an oven to achieve a metal temperature of 375° and held for 15 minutes.
2. After oven curing, the sheets and tank components shall cool down to a metal temperature of 125° or less.

3. Both visual inspection and dry film test shall be randomly performed before the application of the top coat.

E. EXT Fusion SDP™ Top Coat (super durable polyester)
   1. SDP top coat shall be applied on all exterior surfaces at 3 mils nominal DFT,with a min/max range from 3-5 mils.
   2. The SDP top coat shall provide excellent gloss retention and UV resistance. Color to be selected from standard colors (chart) with special formulated and premium colors as available options.
   3. Visual and wet mil thickness testing shall be randomly performed before the second oven curing.

F. Final Curing
   1. Sheets and tank components shall then pass through the final cure oven where the oven temperature ranges from 300° to 475° based upon the metal thickness.

G. Inspection
   1. During final cool down, sheets shall be randomly inspected for cure, adhesion, coating thickness and holidays.
   2. Cure shall be confirmed using MEK rub.
   3. Adhesion shall be confirmed using 100 squares test.
   4. Coating thickness shall be confirmed using dry film thickness gage.
   5. Holiday testing shall be performed with tinker & razor wet sponge.

H. Packaging
   1. After cool down and inspection, the sheets and tank components shall be unloaded and packaged for shipment.
   2. Sidewall sheets shall be stacked on wooden skids with paper placed between each sheet to prevent any scuffing. Skids shall be loaded to 5,600 pound maximum weight. Each skid shall be wrapped in heavy mil, black polyreinforced plastic and then steel banded.
   3. Roof sheets and hopper or bottom sheets as well as other tank components shall be packaged to prevent damage and then wrapped and banded.
   4. Material to be marked or tagged with part number and order number for field assembly requirements. Touch-up paint with instructions for application by erection personnel.

2.06 TANK STRUCTURE

A. Fusion Bond Powder-Coated Steel Floor
   1. The floor is to be a Fusion Bond powder-coated bolted steel floor. Bolted steel panels shall be placed over a compacted gravel base contained by a concrete ring wall. A non-extruding and resilient bituminous type filler, meeting the requirements of ASTM D1751, should be placed between the tank floor and concrete ring wall.

2. A plastic encapsulated nut shall be used to cover the bolt threads exposed on the inside of the floor.
3. Tolerance on finished foundations shall be level within +/- 1/8" within any 30 ft of circumference under the shell. The levelness on the circumference shall not vary by more than +/- ¼" from an established plane.

B. Alternative Embedded Base Setting Ring and Concrete Floor
1. The floor design is of reinforced concrete with an embedded fusion coated carbon steel starter sheet per the manufacturer's design and in accordance with AWWA D103, Sec. 13.4, Type 6.
2. A leveling assembly shall be used to secure the starter ring, prior to placement in concrete. Installation of the starter ring on concrete blocks or bricks, using shims for adjustment is not permitted.
3. Embedded base setting rings shall be level +/- 1/16 in within 10 feet of length and concentric +/- ¼ in.
4. Place one elastomer water stop seal strip on the inside surface of the starter ring below concrete floor line. Install materials in accordance with tank manufacturer's instructions.

C. Sidewall Structure
1. Field erection of the Fusion Bond powder-coated, bolted steel tank shall be in strict accordance with the procedures outlined by the manufacturer, using factory trained erectors.
2. Particular care shall be taken in handling and bolting of the tank panels and members to avoid abrasion of the coating system.
3. An electrical leak test shall be performed during erection using a wet sponge low voltage leak detection device. All electrical leak points found on the inside surface shall be repaired in accordance with manufacturer's published touchup procedures.
4. The placement of sealant on each panel may be inspected prior to placement of adjacent panels. However, the Engineer's inspection shall not relieve the bidder from his responsibility for liquid tightness.
5. No backfill shall be placed against the tank sidewall without prior written approval and design review of the tank manufacturer. Any backfill shall be placed according to the strict instructions of the tank manufacturer.

D. Roof Structure
1. Fusion Bond powder-coated steel deck.
    a. Tank shall include a sectioned roof fabricated from Fusion Bond powder-coated, bolted steel panels, as produced by the tank manufacturer, and shall be assembled in a similar manner as the sidewall panels. The roof shall be clear-span and self-supporting or post supported. Both live and dead loads shall be carried by the tank walls and any center supports.

E. Alternative Clear-span Aluminum Dome

1. The roof shall be constructed of non-corrugated triangular aluminum panels. Panels are sealed and firmly clamped in an interlocking manner to a fully triangulated aluminum space truss system of wide flange extrusions, thus forming a dome structure.
2. The dome shall be clear span and designed to be self-supporting from the periphery structure with primary horizontal thrust contained by an integral tension ring. The dome dead weight shall not exceed 3 pounds per square foot of surface area.
3. The dome and tank shall be designed to act as an integral unit. The tank shall be designed to support an aluminum dome roof including all specified live loads.
4. Materials:
    a. Triangulated space truss: 6061-T6 or 6005A-T6 aluminum struts and gussets.
    b. Triangulated closure panels: .050"t 3003-H16 aluminum sheet.
    c. Tension ring: 6061-T6 or 6005A-T6 aluminum.
    d. Fasteners: 7075-T73 anodized aluminum or series 300 stainless steel.
    e. Sealants and gaskets: gunnable silicone and neoprene rubber.
    f. Dormers, doors, vents and hatches: 6061-T6, 5086-H34 or 3003-H16aluminum.

2.07 APPURTENANCES

The contractor shall furnish and install the appurtenances as shown on the contract drawings and as specified below.

Unless otherwise noted, standard appurtenances shall be as follows:

1. Roof Hatch: The tank roof shall have a curbed, upward opening 24" square. The curb shall extend at least four inches above the tank. The hatch cover lip shall be hinged and provisions made for locking. The hatch cover lip should extend for a distance of two inches down on the outside of the curb with a rubber gasket to seal the gap between the lid and curb. The hatch shall be located near the outside tank ladder with railing. The hatch material shall be type 316 stainless steel or similar material as the water tank, whichever is more resistant to corrosion.
2. Inlet, Outlet, Overflow, Drain and Overflow Connections: Inlet, outlet, drain and overflow connections shall conform to the sizes and locations specified on the plan sheets.
3. Roof Vent: A properly sized vent assembly in accordance with AWWA D103 shall be furnished and installed above the maximum water level of sufficient capacity so that at maximum design rate of water fill or withdrawal, the resulting interior design pressure / vacuum will not exceed the tank's rated design pressure / vacuum.. The vent shall be so designed in construction as to prevent the entrance of birds and/or animals by including a 4 mesh (1/4" opening size) galvanize screen, plus a 16 mesh (1/16" opening size) screen to prevent the entrance of insects. The overflow pipe shall not be considered to be a tank

vent. The vent shall be stainless steel (type 316) and so designed and constructed as to prevent the entrance of birds, animals, and any possible contaminate to the potable water.

4. Outside Tank Ladder: An outside ladder with safety cage shall begin 6 feet above the level of tank bottom and at the location designated. Outside ladder and cage shall meet OSHA requirements. The ladder and the cage material shall be made of type 316 stainless steel or similar material as the water tank, whichever is more resistant to corrosion.
5. Interior Tank Ladder: An interior ladder with safety cage shall be installed below the roof hatch. The ladder material shall be made of type 316 stainless steel or similar material as the water tank, whichever is more resistant to corrosion.
6. Handrail and Toeboard: Handrail and toeboard around the deck perimeter shall be installed as specified on the plan sheets. These shall be made of type 316 stainless steel or similar material as the water tank, whichever is more resistant to corrosion.
7. Roof Walkway Handrail: For tanks with a bolted stainless steel roof, a non-skid roof walkway with handrails shall be provided to allow ready and safe access to the gravity vent. The walkway and handrails shall be type 316 stainless steel and meet OSHA requirements. For tanks with a dome roof, non-skid walkway and handrails are incorporated by the dome supplier.
8. Liquid Level Indicator: A liquid level indicator with stainless steel (type 316) float and target board shall be installed as detailed on the plans and to the tank manufacturer's specifications.
9. Internal Nozzle with Overflow Weir Cone: The internal nozzle with overflow weir shall conform to the size and location specified on the plan sheets.
10. Manway: Two 24" diameter manway shall be provided at a location to be determined by the Engineer. The manway shall include a reinforcing frame and cover plate with a hinged support for cover removal. The manway material shall be type 316 stainless steel or similar material as the water tank, whichever is more resistant to corrosion. The access door (shell manhole) and the tank shell reinforcing shall comply with AWWA D103.
11. Thrust Blocks: Concrete thrust block is required on the buried elbows, tees, and gate valves. The piping assembly shall be tested in accordance with ASPA's Acceptance Tests for Pressure Piping.
12. Flap Gate Valve: A flap gate valve shall be attached to the end of the drain pipe in the catch basin. A 16 mesh screen shall be installed inside the flap gate to prevent insects from entering the pipe and tank. The flap gate shall be a hinged gate with a neoprene seal to provide a positive seal.
13. Identification Name Plate: The Manufacturer's nameplate shall list the tank diameter, height, capacity, installation date, storage use and model/serial number. The nameplate shall be affixed to the tank exterior sidewall location approximately five (5) feet from grade elevation.

The appurtenances shall be installed as shown on the Engineers drawings and as detailed in these specifications.

2.08 ACCESSORIES

1. Water Flow Meter: The flow meters shall be propeller turbine type furnished with fabricated carbon steel body, injection molded thermoplastic propeller and 12 to 15 mil NSF approved fusion bonded epoxy faced and drilled Class 150 ANSI or JIS flanged ends and shall be designed for 150 psi working pressure. Flow meter size shall be of the same size as indicated in the drawings. The meter body shall have the same nominal inside diameter throughout its length and shall be furnished with non-toxic liners. The meter accuracy shall register within plus or minus 1.5% or better of actual flow at normal flows and plus or minus 1.5% or better of low flow and shall have 6 digits totalizer. Registration shall be in 1,000s gallons. Sweep hand shall revolve once per 1,000 gallons. Meter shall be Sensus T2 or approved equal and conform to AWWA C701.
2. Altitude Valves: Altitude valves shall be of the hydraulically operated, pilot controlled, single seated, diaphragm type, globe valves (with resilient disc) and shall control the high water level in tanks and reservoirs without the need for floats or other devices. It shall be a non-throttling type valve and remain fully open until the "shut-off" point in the tank or reservoir is reached. The valve shall be designed as a two-way or one-way as shown in the drawings. The valve shall be manufactured by Cla-Val Co. or approved equal.

2.09 SHIPPING

All plates, supports, members and miscellaneous parts shall be packaged for shipment in such manner to prevent abrasion or scratching of the finished coating.

PART 3 – EXECUTION

3.01 FOUNDATION

A. The new tanks will be installed/constructed on the existing foundations.

3.02 ERECTION

A. Field erection of the bolted steel tank will be in strict accordance with manufacturer's procedures using factory trained and certified erectors.
B. Particular care will be taken to protect the baked-on powder coated panels from damage (i.e., scratches, abrasion) during field installation.
C. Tank to be constructed utilizing synchronized (hydraulic screw) jacking process, which keeps construction crews at grade level for safety and point access quality control.
D. Any coating damage will be repaired per manufacturer's recommendations.
E. No backfill shall be placed against the tank sidewall during or after the construction process.

3.03 TESTING

A. Following completion of erection and cleaning of the tank, the tank shall be tested for liquid-tightness by filling the tank to its overflow elevation.
B. Any leaks disclosed by this tank test shall be corrected by the contractor in accordance with the tank manufacturer's recommendation.
C. Water required for testing will be provided by the Owner. The contractor shall be responsible in conveying the water to the tank for testing.

3.04 DISINFFECTION

A. The tank shall be disinfected in accordance with Section 00500.
B. The tank structure shall be disinfected at the time of testing in accordance with AWWA Standard C652-02 "Disinfection of Water Storage Facilities" using chlorination method number two. Disinfection shall be performed by a competent water treatment contractor.
C. Disinfection shall not take place until tank sealant is fully cured.

3.05 GRAVEL COVER

A. The area within 10-ft around the tank perimeter shall be covered with a uniform 2-inch layer of 1 inch minus washed gravel.

3.06 SITE GRADIG AND CLEANUP

A. Upon completion of the tank, the Contractor shall clean the site of all rubbish and grade the earth to provide effective drainage away from the base of the tank. The slope shall be 5% extending from the base in all directions a distance of 10 feet away from the tank.

3.07 QUALIFICATIONS FOR TANK MANUFACTURERS AND TANK ERECTORS(Require information to be submitted with Contractor's bid):

A. Tank Manufacturer: Company specializing in the fabrication of bolted steel water tanks. All uncoiling, punching, radius rolling and glass-furnace operations shall be at one location. The manufacturer shall have fabricated and supplied, at least, ten (10) bolted steel tanks of comparable or larger capacity in the past 12 months. Provide a list of current year tanks shipped, with the owner's name, contact persons and phone numbers. This information shall be provided with bid.

B. Tank Erector: Company specializing in performing erection of bolted steel tanks shall have successfully erected a minimum of ten (10) comparable diameter or larger bolted steel tanks presently in full operational service in the United States. Provide a list complying tanks, owners' name, contact person and phone numbers. This information shall be provided with bid.

C. Installation Crew: Installation of the tank shall be under the direction of the tank erector's factory certified tank builder and shall maintain the same foreman andcrew from start to finish of work unless change is approved by Manager. Provide the names of the factory

certified tank builders for each of the 10 tanks listed above. This information shall be provided with bid.

3.08 WARRANTY

A. The tank manufacturer shall include a warranty on tank materials and workmanship for a specified period. The tank manufacturer shall warrant the tank against any defects in materials for a period of ten(10) years from date of shipment and the contractor shall warrant the tank system against any defects in workmanship for a period of ten(10) years from the date of final acceptance. If any such defect shall appear and is reported in writing to the Contractor during the warranty period, the Contractor shall make any necessary repairs without charge to the Owner.

END OF SECTION

SECTION 00420

POTABLE WATER STORAGE TANK – BOLTED STAINLESS STEEL

PART 1 – GENERAL

1.01 SCOPE OF WORK

The work to be performed under these specifications includes furnishing all labor, materials, tools and equipment necessary to design, fabricate, and construct the new 43,000 and 65,000 gallon bolted stainless steel water storage tanks, including all necessary accessories in accordance with AWWA D100 specifications, latest revision.

1.02 REFERENCE SPECIFICATIONS

The following reference specifications shall govern the work with regard to design materials and workmanship, where applicable.

ASTM A36 - Standard specification for structural steel.

ASTM A307 - Specification for carbon steel bolts.

ASTM A325 - Specification for high strength bolts for structural steel joints.

ASTM A240 - Specification for chromium-nickel stainless steel plate and sheet.

ASTM F593-98 - Standard specification for stainless steel bolts.

ASTM F594-98 - Standard specification for stainless steel nuts.

AISC - 89 - Specification for structural steel buildings.

And if required:

ANSI/AWWA D103 – 87 Factory coated bolted steel tanks for water storage.

ANSI/AWWA D103 – 97 Section 3, General design.

ANSI/AWWA C652 – 86 Disinfection of water storage facilities.

ANSI/AWWA D103 – 97 Section 5, Appurtenances as adapted for stainless steel.

ANSI/AWWA D103 – 97 Section 13, structurally supported aluminum dome.

ANSI/NSF STANDARD 61 - Drinking water system components.

1.03 SUBMITTAL DRAWINGS AND CALCULATIONS

Construction shall be governed by the Owner's plans and specifications showing general dimensions and construction details, after approval by the Engineer of submittal drawings and design calculations prepared by the manufacturer.

There shall be no deviation from these drawings and specifications, except upon written order or approval from the Engineer. The bidder is required to furnish, for review and approval by the Engineer, construction drawings for all work not shown in complete detail on the bidding drawings. A complete set of structural calculations shall be provided for the tank structure and foundation. All such submissions shall be stamped by a Registered Professional Engineer.

When approved, two sets of such prints and submittal information will be returned to the bidder marked "APPROVED FOR CONSTRUCTION" and these drawings will then govern for the work detailed thereon.

PART 2 – DESIGN

2.01 TANK SIZE LOADS

Job Site Location:	Utulei
Product to be stored:	Drinking water
Specific Gravity:	1
PH of Product:	6.8~7.5
Temperature of Product:	23~35˚C
Nominal Capacity (Gallons):	200,000
Nominal Diameter (Feet):	30
Nominal Height (Feet):	40
Tank Base Elevation (Feet):	227.10
Min. Freeboard Space (Feet):	1.5
Design Pressure:	Atmospheric
Deck Live Load:	25 psf
Wind Speed:	200 mph
Seismic Zone:	3

2.02 DESIGN STANDARDS

The design of the bolted tank shall conform to AWWA D100, latest revision.

PART 3 – MATERIAL

3.01 PLATES AND SHEETS

Plates and sheets used in the construction of the tank shall be Type 316 stainless steel.

3.02 ROLLED STRUCTURAL SHAPES

Rolled structural shapes shall be type 316 stainless steel. Material shall conform to minimum standards of ASTM A36.

3.03 HORIZONTAL WIND STIFFENERS

Wind stiffener at top of tank shall provide a flat, horizontal, continuous surface at tank rim level, compatible with geodesic dome or roof mounting and flashing. Design requirements for intermediate horizontal wind stiffeners shall be of the "web truss" design. Wind stiffeners shall be type 316 stainless steel. Material shall conform to minimum standards of ASTM A36.

3.04 BOLT FASTENERS

Bolts used in tank lap joints shall be type 316 stainless steel 1/2 - 13 UNC-2A rolled thread.
Lap joint bolts shall be installed such that the head portion is located inside the tank and the washer and nut are on the exterior. Lap joint bolts shall be properly selected such that threaded portions will not be exposed in the "shear plane" between tank sheets. Bolt lengths shall be selected to achieve a neat and uniform appearance. Excessive threads extending beyond the nut after tightening is not acceptable.
Lap joint bolts shall include a minimum of four splines on the underside of the bolt head at the shank in order to resist rotation during tightening.

3.05 SEALANT

The lap joint sealant shall be a one component moisture cured polyurethane compound. The sealant shall be used to seal lap joints and bolt connections and to isolate dissimilar metals.
The sealant shall cure to a rubber-like consistency and have excellent adhesion, have low shrinkage, and be suitable for interior and exterior exposure.
Neoprene gaskets and tape type sealer shall not be used.
The sealant shall be NSF certified.

PART 4 – APPURTENANCES

The contractor shall furnish and install the appurtenances as shown on the contract drawings and as specified below.
Unless otherwise noted, standard appurtenances shall be as follows:

1. Hatch: The tank roof shall have a curbed, upward opening 24” square. The curb shall extend at least four inches above the tank. The hatch cover lip shall be hinged and provisions made for locking. The hatch cover lip should extend for a distance of two inches down on the outside of the curb with a rubber gasket to seal the gap between the lid and curb. The hatch shall be located near the outside tank ladder with railing. The hatch material shall be type 316 stainless steel or similar material as the water tank, whichever is more resistant to corrosion.
2. Inlet, Outlet, Overflow, Drain and Overflow Connections: Inlet, outlet, drain and overflow connections shall conform to the sizes and locations specified on the plan sheets.
3. Vent: A mushroom-screened vent shall be furnished above maximum water level of sufficient size to accommodate normal inlet and outlet flow. The vent shall be so designed in construction as to prevent the entrance of birds and/or animals by including a 4 mesh (1/4” opening size) galvanize screen, plus a 16 mesh (1/16” opening size) screen to prevent the entrance of insects. The overflow pipe shall not be considered to be a tank vent. The vent shall be stainless steel (type 316) and so designed and constructed as to prevent the entrance of birds, animals, and any possible contaminate to the potable water.
4. Outside Tank Ladder: An outside ladder with safety cage shall begin 6 feet above the level of tank bottom and at the location designated. Outside ladder and cage shall meet OSHA requirements. The ladder and the cage material shall be made of type 316 stainless steel or similar material as the water tank, whichever is more resistant to corrosion.
5. Interior Tank Ladder: An interior ladder with safety cage shall be installed below the roof hatch. The ladder material shall be made of type 316 stainless steel or similar material as the water tank, whichever is more resistant to corrosion.
6. Handrail and Toeboard: Handrail and toeboard around the deck perimeter shall be installed as specified on the plan sheets. These shall be made of type 316 stainless steel or similar material as the water tank, whichever is more resistant to corrosion.
7. Roof Walkway Handrail: For tanks with a bolted stainless steel roof, a non-skid roof walkway with handrails shall be provided to allow ready and safe access to the gravity vent. The walkway and handrails shall be type 316 stainless steel and meet OSHA requirements. For tanks with a dome roof, non-skid walkway and handrails are incorporated by the dome supplier.
8. Liquid Level Indicator: A liquid level indicator with stainless steel (type 316) float and target board shall be installed as detailed on the plans and to the tank manufacturer’s specifications.
9. Internal Nozzle with Overflow Weir Cone: The internal nozzle with overflow weir shall conform to the size and location specified on the plan sheets.
10. Manway: Two 24" diameter manway shall be provided at a location to be determined by the Engineer. The manway shall include a reinforcing frame and cover plate with a hinged support for cover removal. The manway material shall be type 316 stainless steel or similar material as the water tank, whichever is more resistant to corrosion.

11. Thrust Blocks: Concrete thrust block is required on the buried elbows, tees, and gate valves. The piping assembly shall be tested in accordance with ASPA's Acceptance Tests for Pressure Piping.
12. Flap Gate Valve: A flap gate valve shall be attached to the end of the drain pipe in the catch basin. A 16 mesh screen shall be installed inside the flap gate to prevent insects from entering the pipe and tank. The flap gate shall be a hinged gate with a neoprene seal to provide a positive seal.
13. Identification Name Plate: The Manufacturer's nameplate shall list the tank diameter, height, capacity, installation date, storage use and model/serial number. The nameplate shall be affixed to the tank exterior sidewall location approximately five (5) feet from grade elevation.
14. PVC Liner: The tank shall be lined with a heavy duty PVC liner of thickness 0.51 mm or more with suitable protection layer. The PVC liner shall be manufactured for the purposes of lining potable water tanks and the manufacturer of the PVC shall guarantee its suitability for this purpose and that it meets all standards.

The appurtenances shall be installed as shown on the Engineers drawings and as detailed in these specifications.

PART 5 – BOLTED FLOOR – (OPTIONAL)

A bolted stainless steel floor is allowed as an option to the reinforced concrete floor.

5.01 CONSTRUCTION

The bolted floor construction would include sectional bolted stainless steel floor panels as produced by the tank manufacturer. The floor shall be erected similar to the sidewall panels using the same sealant and bolting techniques. The bolted floor shall be supported by compacted sand or placed upon a concrete sub-floor. If a concrete sub-floor is utilized, a 1 inch thick layer of fiber cane shall be placed on the concrete floor prior to placement of the bolted steel floor.

PART 6 – BOLTED ROOF

A bolted stainless steel roof is allowed for tank diameters up to 36ft.

6.1 CONSTRUCTION

The roof shall be constructed of radial sections of bolted stainless steel roof panels as produced by the tank manufacturer with a knuckle formed down that bolts to the upper shell ring.

The roof panels shall be erected similar to the sidewall panels using the same sealant and bolting techniques. The roof shall be self-supporting and shall clear the span of the tank. The roof shall transfer the live and dead loads to the sidewall.

PART 7 – ALUMINIUM DOMED ROOF

Tanks greater than 36 foot diameter shall be supplied with aluminum dome roofs or other more corrosion resistant material as approved by Owners engineer.

7.1 CONSTRUCTION

The dome shall be constructed of non-corrugated triangular aluminum panels on a fully triangulated aluminum space truss system of wide flange extrusions, thus forming a spherical dome structure. The dome shall be clear span and designed to be self-supporting from the periphery structure with primary horizontal thrust contained by an integral tension ring. The dome dead weight shall not exceed 3 pounds per square foot of surface area. The dome and tank shall be designed to act as an integral unit. The tank shall be designed to support an aluminum dome roof including all specified loads.

PART 8 – ERECTION

8.01 FOUNDATION

The new tanks will be installed/constructed on the existing foundations.

8.02 CONCRETE FLOOR

N/A

8.03 STARTER RING

N/A.

8.04 LAPPED JOINTS

All vertical, horizontal, shell to roof, and shell to bottom plates or sheets shall be field bolted. Sealant shall be used on all joints to ensure liquid tightness. Fillet sealant at all lapped joints to provide a neat and pleasing appearance.

8.05 SIDEWALL

Placing of sealant on each connection may be inspected by the Engineer prior to placement of adjacent member. However, the Engineer's inspection shall not relieve the erector of his responsibility for liquid tightness.

8.06PVC LINER

The PVC liner shall be placed and fasten to tank sides in accordance to manufacturer recommendations and an insulation layer shall be placed between liner and steel tank as recommended by manufacturer. The liner should extend over the sides of the tank for about 10 inches on the outside.

8.07 QUALIFICATIONS FOR TANK MANUFACTURERS AND TANK ERECTORS(Require information to be submitted with Contractor's bid):

Tank Manufacturer: Company specializing in the fabrication of bolted stainless steel water tanks. All uncoiling, punching, radius rolling and furnace operations shall be at one location. The manufacturer shall have fabricated and supplied, at least, ten (10) bolted steel tanks of comparable or larger capacity in the past 24 months. Provide a list of current year tanks shipped, with the owner's name, contact persons and phone numbers. This information shall be provided with bid.

Tank Erector: Company specializing in performing erection of bolted steel tanks shall have successfully erected a minimum of ten (10) comparable diameter or larger bolted steel tanks presently in full operational service in the United States. Provide a list complying tanks, owners' name, contact person and phone numbers. This information shall be provided with bid.

Installation Crew: Installation of the tank shall be under the direction of the tank erector's factory certified tank builder and shall maintain the same foreman and crew from start to finish of work unless change is approved by Manager. Provide the names of the factory certified tank builders for each of the 10 tanks listed above. This information shall be provided with bid.

PART 9 – LEAK TEST

Leak test shall not take place until joint sealant is fully cured (10 to 12 days at 73 degrees F).

9.01 HYDROTEST

The tank shall be hydro tested to ensure liquid tightness by filling the tank to its overflow elevation. Water and disposal of as required for this test shall be the responsibility of the Contractor.

PART 10 – ACCESSORIES

10.01 WATER FLOW METER

The flow meters shall be propeller turbine type furnished with fabricated carbon steel body, injection molded thermoplastic propeller and 12 to 15 mil NSF approved fusion bonded epoxy faced and drilled Class 150 ANSI or JIS flanged ends and shall be designed for 150 psi working

pressure. Flow meter size shall be of the same size as indicated in the drawings. The meter body shall have the same nominal inside diameter throughout its length and shall be furnished with non-toxic liners. The meter accuracy shall register within plus or minus 1.5% or better of actual flow at normal flows and plus or minus 1.5% or better of low flow and shall have 6 digits totalizer. Registration shall be in 1,000s gallons. Sweep hand shall revolve once per 1,000 gallons. Meter shall be Sensus T2 or approved equal and conform to AWWA C701.

PART 11 – WARRANTY

11.01 STRUCTURES

If within a period of ten (10) years from date of completion the water storage tank, or any part thereof, proves to be defective in material or workmanship upon examination by Manufacturer, the Manufacturer will supply replacement part to ASPA's Tafuna Campus, at its option will repair or allow credit for such part.

Manufacturer shall further warrant that, if within a period of ten (10) years from the date of completion of the stainless steel sheets placed in the storage tank fail due to corrosion as determined upon examination by the manufacturer or Owners representative, the manufacturer will supply replacement sheets to ASPA's Tafuna Campus, at its option will repair or allow credit for such sheets.

END OF SECTION

SECTION 00440

GLASS-FUSED TO STEEL STORAGE TANK

PART 1 – GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment, quality control inspection, fabrication, material testing and all other incidentals and labor required to design and construct a bolted, factory-applied, glass-fused-to-steel potable tank with an aluminum dome roof and all appurtenances, as specified herein.

B. Description of Tank:

1. The tank shall comply with AWWA D-103-97 and shall be a bolted glass-fused-to-steel design with nominal inside diameter and sidewall height as shown on the construction plans. The tank shall have a nominal capacity as shown on the construction plans. The tank shell panels shall be factory rolled to the required radius and shall be a flat panel design with bolted lap-joints using cured-in-place urethane sealant.

2. The tank roof greater than 36 foot diameter shall be an aluminum dome structure. The dome roof shall conform to AWWA D103-97, Section 13 and shall be a fully triangulated space truss complete with non-corrugated closure panels. The dome shall be clear span and self-supporting from the periphery structure with primary horizontal thrust contained by an integral tension ring.

3. The Contractor, in accordance with the minimum requirements shown on the Plans and specified, herein, shall provide the foundation. The tank shall be anchored to the foundation to resist seismic and wind forces. The foundation shall be as shown on the Plans and shall be designed by the tank manufacturer's engineering department. The foundation shall be AWWA D-103 Type 6.

4. All shell, floor and roof penetrations shall be adequately reinforced to transfer vertical, tangential and horizontal stresses, seismic load, and incidental differential settlement.

5. The following appurtenances shall be provided and located as indicated on the Plans (Unless noted otherwise; appurtenances in contact with the stored potable water shall be Type 316 stainless steel, appurtenances on tank exterior shall be Type 316 stainless steel). :

a. The Contractor shall supply an internal overflow with diameter area equal to the area of all inlet pipes. The overflow open end elevation

shall be the maximum water surface elevation, as shown on the Plans. Suitable Type 316 stainless steel pipe supports, at approximately 10' intervals, shall be provided to prevent overflow pipe from moving. Nozzles thru the tank wall, if required by the Plans, shall be Type 316 stainless steel, full-face flange. The overflow may pass thru the tank floor and connect underground with the drain or it may pass thru the tank wall to an exterior 316 stainless steel flap valve (exterior concrete splash pad shall be provided). Overflow pipe shall be Schedule 80 PVC or C905 PVC where in contact with product water.

b. Separate tank inlet, effluent and washout connections shall be provided in diameters and at locations as shown on the Plans.

c. At least, one (1) Type 316 stainless steel shell manway with a minimum diameter of 24 inches shall be provided in the sidewall of the reservoir. The manway shall be placed with the centerline approximately 3.0 feet above the reservoir bottom. Manway shall have a watertight seal and the openings shall be suitably reinforced.

d. One (1) umbrella-type air vent fabricated from aluminum shall be provided. The vent opening shall be sized that differential pressure remains less than 0.5 inches of water column at 1,500 CFM in or out with screens in place. The vent insect and bird screens shall be non-corrosive monofilament polyester, aluminum or type 316 stainless steel.

e. One (1) outside Type 6061 T-6 aluminum ladder with Type 316 stainless steel cage shall be provided. An aluminum shield gate shall be provided for controlled access to the outside ladder.

f. One (1) aluminum watertight, gasketed roof hatch as shown on the Plans and as described later in these specifications.

g. A tank manufacturer approved cathodic protection system, utilizing suspended sacrificial magnesium anodes, shall be provided to protect the interior wetted surfaces of the tank. The anodes shall be suspended from fiberglass deck mounts which shall be installed using silicone sealant to prevent leakage through the dome. A corrosion engineer shall design the system and submit the design calculations for review by the Engineer. The cathodic protection system shall be designed for 10-year protection prior to anode replacement, based on the conductivity of the water stored and the exposed metallic surfaces.

1.02 REFERENCE DOCUMENTS:

(Reference documents shall be the latest edition of the publication unless otherwise indicated.)

A. International Conference of Building Officials (ICBO)

1. Uniform Building Code (UBC)

B. American Concrete Institute (ACI)

1. ACI 318-05 Building Code Requirements for Structural Concrete

C. American Society for Testing Materials (ASTM)

1. Standard Specifications as referenced.

D. American Water Works Association (AWWA)

1. ANSI/AWWA C651-99 AWWA Standard for Disinfecting Water Mains.

2. ANSI/AWWA C652-92 AWWA Standard for Disinfection of Water-Storage Facilities.

3. ANSI/AWWA D103-06 AWWA Standard for Factory-Coated Bolted Steel Tanks for Water Storage.

E. (HIOSH)

1. HIOSH Chapter 72, work Areas and Working Surfaces

1.03 SUBMITTALS:

A. Shop and Erection Plans:

1. Submit shop and erection Plans along with structural design calculations, stamped by a registered Structural Engineer with current licensing from the State of Hawaii.

2. Submit foundation Plans along with structural design calculations, stamped by a registered Structural Engineer with current licensing from the United States.

3. Submit a statement by tank engineer approving foundation Plans.

B. Product Data: Provide data on tank and dome materials, construction and accessories. Submit manufacturer's descriptive literature including accessories,

components, and systems. Literature shall include detail specifications, available performance test data, and instruction for application and maintenance.

C. Tank Color: The exterior ceramic glass color shall be forest green. The interior tank color shall be titanium white. Manufacturer's color chart shall be submitted with the colors clearly identified.

D. Test Reports:

1. Furnish manufacturer's mil test reports for plate materials.

2. At conclusion of work, furnish a written report prepared by Contractor certifying that work was inspected in accordance with AWWA D103 Section 9. This report shall meet the requirements of Section 9 and cover hydrostatic test. Include in report a certification that construction conforms to approved Plans and specifications.

E. Certification: Submit a certificate signed by tank manufacturer's registered structural engineer providing the following information:

1. Description of structural design loading conditions used for design of entire tank including foundation.

2. Description of structural design method and codes used in establishing allowable stresses and safety factors applied in the design.

3. A statement verifying that structural design has been checked by experience engineers specializing in hydraulic structures.

4. A statement verifying that shop Plans have been checked by experienced engineers specializing in hydraulic structures to determine that they agree with design calculations, dimensions, and fabricating in member sizes, dimensions, and fabricating process as prescribed by ACI and AWWA standards.

F. Certificate for Microbiological Test: As required under item Testing and Disinfection.

G. Manufacturer's Installation Instructions: Indicate special procedures and installation instructions. Submit manufacturer's instructions for erection of tank. Instructions shall include, but not be limited to, bolt installation, sealant application, coating repair, foundation work and clean up.

H. Manufacturer's Certificate: Certify that products meet or exceed specified requirements and are suitable for intended use. Submit manufacturer's certification that tank has been manufactured in accordance with AWWA D103.

I. Report: Provide manufacturer's representative field observations.

1.04 PROJECT RECORD DOCUMENTS:

A. Submit project record documents to reflect actual installation conditions.

1.05 QUALIFICATIONS FOR TANK AND DOME MANUFACTURERS AND TANK ERECTORS (Require information to be submitted with Contractor's bid):

A. Tank Manufacturer: Company specializing in the fabrication of bolted, glass-fused-to-steel water tanks. All uncoiling, punching, radius rolling and glass-furnace operations shall be at one location. The manufacturer shall have fabricated and supplied, at least, ten (10) glass-fused-to-steel tanks of comparable or larger capacity in the past 12 months. Provide a list of current year tanks shipped, with the owner's name, contact persons and phone numbers.

B. Tank Erector: Company specializing in performing erection of glass-fused tanks with aluminum domes shall have successfully erected a minimum of ten (10) comparable diameter or larger glass-fused tanks with aluminum domes presently in full operational service in the State of Hawaii. Provide a list complying tanks, owners' name, contact person and phone numbers. This information shall be provided with bid.

C. Installation Crew: Installation of the tank shall be under the direction of the tank erector's factory certified tank builder and shall maintain the same foreman and crew from start to finish of work unless change is approved by Manager. Provide the names of the factory certified tank builders for each of the 10 tanks listed above. This information shall be provided with bid.

1.06 DESIGN CRITERIA:

A. Dimensions, elevations and location of penetrations and appurtenances shall be as located on the Plans and/or specified herein.

B. Design Loads

1. Dead load of the tank and its accessories, and live load of the contained static water, shall be as specified in AWWA D103-97. Design water depth shall be as shown on the Plans.

6. Roof Live Load: 25 psf uniform, in conformance with AWWA D103-97.

3. Wind Load: In accordance with AWWA D103-97, Base Wind Velocity 150 MPH or higher, if required on Plans.

4. Seismic Load: Design shall be in accordance with Section 12 of AWWA D103-97 using the effective mass approach in accordance with AWWA D103-97 Seismic Zone 3 or as indicated on the Plans.

C. Tank Design

1. Allowable design stress of steel for the tank shall be in accordance with AWWA D103-97.

2. No corrosion allowance shall be provided for shell plates. Cathodic protection shall be provided for wetted interior tank surfaces, as called for in these specifications.

D. Tank Foundation

1. The new tanks will be installed/constructed on a new foundations.

E. The following information is provided for the proper design of the tank:

Job Site Location:	Utulei
Product to be stored:	Drinking water
Specific Gravity:	1
PH of Product:	6.8~7.5
Temperature of Product:	23~35˚C
Nominal Capacity (Gallons):	200,000
Nominal Diameter (Feet):	30
Nominal Height (Feet):	40
Tank Base Elevation (Feet):	227.10
Min. Freeboard Space (Feet):	1.5
Design Pressure:	Atmospheric
Deck Live Load:	25 psf
Wind Speed:	200 mph
Seismic Zone:	3
Wind Speed:	200 mph
Seismic Zone:	3

1.07 TEST REPORTS:

A. The costs of all tests and reports shall be borne by the Contractor. Copies of the following tests shall be furnished:

B. Manufacturer's mil test reports for plate and roof framing materials.

C. Mil thickness test and holiday detection test for glass coating.

D. At the conclusion of the work, a written report prepared by the Tank Erector certifying that the work was inspected in accordance with Section 9 of AWWA D103-97. This report shall meet the requirement of Section 9 and also cover the hydrostatic test.

B. Microbiological tests in accordance with this section.

1.08 PRE-INSTALLATION CONFERENCE:

A. Attendance is to include Manufacturer's representative, Tank Erector, Contractor, Engineer, and representative of other trades affected by work of this Section.

1.09 MATERIAL HANDLING:

A. Deliver, store, protect and handle products with adequate protection against damage, and manufacturer's instructions.

B. Plates, members and miscellaneous parts shall be packaged for shipment in such a fashion to prevent abrasion or scratching of finished coating system.

C. Handle and store water storage tank systems, components, and parts to prevent distortions or other damages that could affect their structural or mechanical integrity. Store items that are subject to deterioration by exposure to elements off the ground, in a well-drained location, protected from weather, and accessible for inspection and handling.

D. Materials furnished for the water tank, which are found to be defective by the Owner's Representative, shall be rejected. All materials rejected must be removed from the project site immediately or within such time as allowed by the Owner's Representative and replaced with material of a quality acceptable to the Owner's Representative. Failure to reject any material or to require removal of any such rejected material shall not relieve the Contractor from responsibility as to the quality and character of material used or as any other obligations imposed upon him by the contract.

1.10 FIELD MEASUREMENTS:

A. Verify that field measurements are as indicated on shop Plans and as instructed by manufacturer.

1.11 COORDINATION

A. Coordinate work with work of others affected by work of this section.

1.12 SPECIAL WARRANTY:

A. Provide manufacturer's extended performance warranty stating that the wetted surfaces of the tank shall be free of corrosion, fish scaling and spalling for ten(10) years from date of installation.

PART 2 – PRODUCTS

2.01 TANK MATERIALS:

A. Bolted, Glass-Fused-to-Steel Tank:

1. Ceramic glass-fused tank
    i. The tank shall be for potable water storage and shall conform to AWWA D103-97 and the additional requirements specified herein.
    ii. Tank shall be an Engineered Storage Products Company Aquastore, Temcor or approved equal, with factory-applied glass-fused-to-steel components.
    iii. The exterior ceramic glass coating shall be forest green color and shall be a minimum of 11 mil in thickness.
    iv. It shall be free of holidays, fish scaling or other defects.
    v. The tank interior ceramic glass shall be titanium white color and shall be 7 to 11 mils in thickness.
2. Steel Sheet. After initial sheet preparation, all full height vertical wall sheets and all rectangular shaped floor sheets shall be beveled. A metal coating of 316 stainless steel shall then be applied to these edges by an ARC thermal spray of 1.5 to 5 mils (0.0015 to 0.005 inches). The coating shall have a tensile strength of >1500 psi (per ASTM C633-79).
3. Bolt Fasteners
    i. Bolts used in tank lap joints shall be ½" diameter hex head design.
    ii. Bolt Material shall be type 316 stainless steel, ASTM F593, Alloy Group 2, Condition CW1. Nuts and washers shall be type 316 stainless steel.
    iii. Where shear requirements cannot be satisfied with stainless steel bolting hardware, the bolts shall be ½" diameter – 13 UNC-2A rolled thread with galvanized coatings on bolt, nut and washer. These bolts shall meet the minimum requirements of AWWA D103, Section 2.2.
    iv. All bolts on the vertical tank wall shall be installed such that the head portion is located inside the tank, and the washer and nut are on the exterior.

v. Bolt lengths shall be sized as to achieve a neat and uniform appearance. Excessive threads extending beyond the nut after torquing will not be permitted.

4. Tank Sheet Sealant/Caulk. Tank sheet sealant shall be cured-in-place urethane: Manus Bond, Sika Flex 1A or approved equal. Sealant shall be NSF Standard 61 approved. Rolled gaskets of neoprene or EDPM shall not be acceptable.

B. Aluminum Dome Roof:

1. Tank shall have an aluminum dome roof from one of the following manufacturers, or approved equal:
   i. CST Storage, 345 Harvestore Drive, DeKalb IL 60115
   ii. CST Domes, 150 West Walnut Street, Gardena CA 90248
2. Dome roof shall be constructed of non-corrugated triangular aluminum panels that are sealed and firmly clamped in an interlocking manner to a fully triangulated aluminum space truss system of wide flange extrusions, thus forming a spherical dome structure.
3. The dome surface paneling shall be designed as a watertight system under all design load and temperature conditions. All raw edges of the aluminum panels shall be covered, sealed, and firmly clamped with batten bars in an interlocking manner to prevent slipping or disengagement under all load and temperature changes. The batten to panel sealing must be accomplished with an extruded gasket in full engagement with the formed panel and batten. The gasket engagement detail shall prevent any wiping action between the panel and gasket.
4. The dome shall be clear span and designed to be self-supporting from the periphery structure with primary horizontal thrust contained by an integral tension ring. The dome dead weight shall not exceed three (3) pounds per square foot of surface area.
5. The dome and tank shall be designed to act as an integral unit. The tank shall be designed to support an aluminum dome roof including all specified live loads.
6. Low rise: The dome shall be designed so that its total height above the tank ring shall not exceed 5’-0”.
7. Materials:
   a. Triangulated space truss: 6061-T6 aluminum struts and gussets.
   b. Triangular closure panels: .050"t 3003-H16 aluminum sheet.
   c. Tension ring: 6061-T6 aluminum.
   d. Fasteners: 7075-T73 anodized aluminum or Series 300 stainless steel.
   e. Sealant and gaskets: 100% Silicone rubber.
8. Roof Vent:
   a. A properly sized vent assembly in accordance with AWWA D103 shall be furnished and installed above the maximum water level of sufficient capacity so that at maximum possible rate of water fill or

withdrawal, the resulting interior pressure or vacuum will not exceed 0.5" water column.

b. The overflow pipe shall not be considered to be a tank vent.

c. The vent shall be constructed of aluminum such that the hood can be unbolted and used as a secondary roof access.

d. The vent shall be so designed in construction as to prevent the entrance of birds and/or animals by including an expanded aluminum screen (2 inch) opening. An insect screen of 23 to 25 mesh polyester monofilaments shall be provided and designed to open should the screen become plugged.

7. Roof Hatch:

a. Roof hatch shall be 30” square and shall be located as shown on the construction plans.

b. Roof hatch shall be aluminum, shall include a lockable hasp and shall be mounted on a 4” curb with a 2” overhang. A gasket shall be provided to prevent entry of rainwater.

8. Safety Handrail:

a. Handrail shall be 1½” diameter, schedule 40 aluminum pipe. Handrail shall be in compliance with OSHA and ASPA requirements.

b. Handrail shall include a 4” high toe plate at the base of the stanchions.

9. Roof Access:

a. Roof service area shall be coated in a non-skid material to provide a safe walking surface for maintenance personnel.

b. Access from the exterior ladder to the roof shall include an aluminum checker plate gangway.

C. Concrete:

1. Concrete for the ring wall footing shall be in accordance with Manufacturers design standard to meet AWWA requirements.

2. Concrete floor coating. If AWWA D-103-97 Type 1 foundation is selected, tank floor shall be cleaned, acid etched and coated with potable water grade, NSF 61 approved Tnemec Elasto-Shield Series 264 modified polyurethane (minimum 50 mil DFT) or approved equal. N/A

D. Work Specified in this Section:

1. The work to be performed under this section shall include the following:

a. Furnish all labor, tools, equipment and materials necessary to complete all concrete work, complete in place, as shown on the plans.

b. Coordinate work with all trades.

c. Install bolts, anchors, metal frames and covers, and other inserts furnished by other trades. All anchors and inserts shall be installed using template.

E. Vapor barrier shall be 6 mil thick plastic sheets.

F. Base course under tank concrete slab shall conform to current Water System Standards.

G. Tank Accessories and Assemblies:

1. Ladders, Manway, Roof Hatch and Vent: Ladders, manway, roof hatch and vent shall be as shown on the plans.

2. All components shall conform to AWWA D103-97, with the ladders and cage meeting all OSHA requirements. Exterior ladder shall have a lockable gate at the bottom as shown in drawings.

C. Pipe straps shall be Type 316 stainless steel for interior straps and for exterior straps, unless indicated otherwise on the plans. Straps shall be placed at maximum intervals indicated on the plans and be of sufficient size for the pipe it supports.

PART 3 – EXECUTION

3.01 CONSTRUCTION:

A. Construct tank in accordance with AWWA D103-97 and in strict accordance with manufacturer's instructions. Install liquid level indicator and all other components as shown on the plans and in accordance with manufacturer's instruction, as may be amended by Owner's Representative as part of shop drawing review. Install vapor barrier in accordance with the manufacturer's instructions.

B. Anchor bolts shall not be driven but shall be set at time the concrete is placed and in the locations indicated on the approved shop Plans. This is required to limit corrosion impacts to concrete reinforcement.

3.02 SITE WORK:

A. Description:

1. This item of work shall include the furnishing of all labor, materials, tools, and equipment, necessary for completing this item of work as called out in the plans and specifications, and as supplemented hereinafter.

B. Excavation:

1. Excavation for structures shall not be carried below the elevations and beyond the dimensions shown. Over-excavation under structures and appurtenances shall be filled with lean concrete (BWS 2000) or compacted structural fill at no cost to the Owner, as directed by the Owner's Representative. Measurements for structure excavations shall be measured to dimensions of a neat structure line.

2. Bottom of footing trenches shall be compacted before pouring any concrete.

3. Foundation Testing. The contractor is responsible for performing all the foundation preparation and probing called for by the Geotechnical Investigation prepared for this tank and per specifications.

3.03 TESTING AND DISINFECTION:

A. Scope: Except as otherwise provided herein, furnish all equipment, labor and materials required for testing and disinfecting the water tank and all new pipelines, including valves and appurtenances. Water for testing and disinfecting shall be provided by the Owner. Disinfection shall be accomplished by chlorination in accordance with applicable AWWA procedures. All chlorinating and testing operations shall be done in the presence of the Owner's Representative. Disinfection operations shall be scheduled by the Contractor as late as possible during the contract time period so as to assure the maximum degree of sterility of the facilities at the time the work is accepted by the Owner's Representative. Results of the bacteriological testing shall be satisfactory with the Owner and the Utility Contractor. Release of water from structures and pipelines, after testing, disinfecting and neutralization of disinfected water have been completed, shall be approved by the Owner's Representative prior to release.

B. Execution:

1. Preliminary Cleaning and Flushing: Prior to both testing and disinfecting, the tank shall be cleaned by thoroughly hosing down all surfaces; all pipelines shall be thoroughly flushed or blown out, using a high volume of water or a cleansing pig.

2. Testing of Tank:

a. General: Testing shall not be performed until construction of the tank has been completed and shall be in accordance to AWWA D103-97. The test shall consist of filling the tank with water to the maximum operating water surface. After testing has been completed, water shall be disposed of as directed by the Owner's

Representative. If suitable, water may be utilized in Owner's system.

b. Leakage Test and Repairs: After the tank has been filled, the leakage test shall be performed as follows: An initial water level reading shall be made. The tank shall be considered to have passed the test if water loss during the 72 hour period, as computed from the two water level readings, does not exceed 0.75 percent of the total volume of water in the tank. Should the tank fail to pass the test, the test shall be repeated for up to three additional test periods. If, at the end of 28 days, the tank still fails to pass the leakage test, the Contractor shall empty the tank as directed by the Owner's Representative and shall examine the interior for evidence of any condition that might be responsible for the leakage. Any evidence of leakage shall be repaired. Following these operations, the Contractor shall again test the tank.

3. Disinfection of Tank:

a. After all other work, including testing and painting, has been completed; the interior of the reservoir shall be thoroughly cleaned and disinfected in accordance with an appropriate method as included in AWWA C652-92. Disinfection shall not take place until tank sealant is fully cured (e.g. 5 to 8 days at 73E F /50% Relative Humidity).

b. Prior to starting any disinfection work, the Contractor shall submit to the Engineer a detailed outline of the procedures proposed, the coordination and sequence of operation, and the manner of filling and flushing the reservoir. All procedures shall be acceptable to the Engineer.

c. Corrections, when required, shall be in accordance with the requirements of this Specification.

d. The Contractor shall furnish all labor, materials, equipment and incidentals necessary for the cleaning and disinfecting operations. Water shall be supplied as described in the Special Conditions.

e. All water used in cleaning and disinfecting the reservoir and which is to be wasted shall be disposed of in a manner acceptable to the Engineer and in accordance with all local regulatory requirements.

f. After the reservoir has been filled, after disinfection, samples will be taken by the Engineer for bacteriological or aesthetic quality; the

reservoir shall be completely drained and re-disinfected by the Contractor.

END OF SECTION

SECTION 00500

DISINFECTION OF POTABLE WATER TANKS

PART 1 – GENERAL

1.01 SUMMARY

This section describes the requirements for disinfecting a water tank or reservoir.

1.02 REFERENCES

AWWA C652-92-Disinfection of Water Storage Facilities

1.03 MEASUREMENT AND PAYMENT

This work is incidental to the erection of the tank, and the Contractor shall not receive any extra payment for this work. Compensation shall be included in the price stipulated in the contract.

PART 2 – EXECUTION

2.01 PREPARATION AND TEMPORARY PROVISIONS

Injection Points: Provide temporary saddle and corporation stop for the purpose of injecting chlorinated solution (if chlorination method 1 is chosen).

Sample Tap: Install a corporation stop saddle and sampling bib in the check valve vault for bacteriological sampling. Consult with the Project Engineer regarding the placement of the saddle.

2.02 DISINFECTION

Chlorination Method: Choose one of the following methods of AWWA C652-92 for disinfecting the water tank.

1) **CHLORINATION METHOD 1**:

   Fill the tank to the overflow level with potable water with chlorine added to bring the free chlorine residual to a level that will result in 10 mg/l.

   If the water was chlorinated continuously during filling, the retention period shall be 6 hours. If the water was chlorinated by adding sodium or calcium hypochlorite within the tank, the retention period shall be 24 hours.

   After the chlorination period, the free chlorine residual shall be decreased below 2mg/l via dilution with potable water and tested for bacteriological safety.

2) **CHLORINATION METHOD 2**:

Apply a solution of 200 mg/l available chlorine directly to the interior surfaces of the reservoir, including the inlet and outlet piping interior.

Application Methods: Apply with suitable brushes or spray equipment.

Retention: Ensure that the surfaces remains continuously wetted with the required solution for at least 30 minutes.

Bacteriological Testing: Fill the tank with potable water to bring the free chlorine residual below 2mg/l, and then sample for bacteriological safety.

3) BACTERIOLOGICAL TESTING RESULTS

If, after disinfection activities are complete, a positive bacteriological result is obtained, consult with the Project Engineer as to whether re-chlorination is necessary.

Provide two negative bacteriological results to demonstrate that a positive bacteriological problem has been remedied.

4) DISPOSAL OF CHLORINATED WATER

Waste flushed disinfection water in an environmentally safe manner and AS-EPA approved. In no case shall direct disposal to surface water be permitted.

Check the chlorine residual at time of disposal.

If disposal to a community sewer system is available, neutralize the chlorine residual if the free residual is above 10 mg/l.

If disposal is to the ground surface or ditch, neutralize the chlorine residual if the free residual is above 1 mg/l.

Use the following neutralization chemical schedule:

a) Sodium Dioxide at 0.8 lb/100,000 gals/mg/l of free chlorine.
b) Sodium Bisulfite at 1.2 lb/100,000 gals/mg/l of free chlorine.
c) Sodium Sulfite at 1.4 lb/100,000 gals/mg/l of free chlorine.
d) Sodium Thiosulfate at 1.2 lb/100,000 gals/mg/l of free chlorine.

END OF SECTION

SECTION 00600

CATHODIC PROTECTION FOR WATER TANK

(SACRIFICIAL ANODE - TANK INTERIOR)

PART 1 – GENERAL

1.01 SECTION INCLUDES

1. Requirements for sacrificial anode cathodic protection systems for the interior submerged surfaces of steel water storage tanks.
2. Specifications for anodes, wiring, test station and long life reference electrodes.
3. Requirement that all materials in contact with the water or exposed to the interior of the tank to be classified in accordance with ANSI/NSF 61 - Drinking Water System Components.
4. Reference to the National Electrical Code (latest edition) which is part of this specification.

1.02 RELATED SECTIONS

1. Section 01110 – Summary of Work.
2. Section 01330 – Submittal Procedures.
3. Section 01351 – Environmental Safety and Worker Protection.
4. Section 13113 – Cathodic Protection for New Tank Bottoms.
5. Section 13201 – Welded Steel Water Storage Tanks.

1.03 UNIT PRICES

1. There is no separate measurement and payment for work performed under this Section. Include the cost for this work in the contract bid price for work of which this is a component part.
2. Payment will be full compensation for all labor, equipment, materials and supervision for the installation of the cathodic protection system, complete in place including anodes, reference cells, wiring, and all field welding, connections, adjustments, testing, cleanup, and other related work necessary for construction as shown on the Drawings and specified herein.

1.04 REFERENCES

1. ANSI/NSF 61 - Drinking Water System Components.
2. ASTM D1248 – Polyethylene Plastics Extrusion Material for Wire Cable.
3. AWWA D100- Standard for Welded Steel Tanks for Water Storage.

4. AWWA D102 – Standard for Painting Steel Water-Storage Tanks.
5. National Electrical Code.
6. NEC 70 - National Electrical Code (latest revision).
7. DOT 199 – Federal Substance Abuse and Testing Regulations.
8. UL 83 - Thermoplastic-Insulated Wires.
9. UL 467 - Bonding and Grounding Equipment.
10. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors.

1.05 SUBMITTALS

1. General: Submittals to conform to the requirements of this specification.
2. Design Drawings and Computations: Prepare all computations and drawings by or under the direct supervision of a Corrosion Engineer who is a Professional Engineer, registered in the United States with a minimum of ten years' experience in cathodic protection design for water storage tanks. Design the system to provide effective corrosion control in accordance with the criterion for protection which is a tank-to-water potential, IR drop free, within a range of -0.850 volts to -1.050 volts relative to copper-copper sulfate reference electrode. Measure this potential free of the effect of voltage gradients (IR drops).
   The Corrosion Engineer to base system capacity on:
   i. Total surface area of the tank. Total surface area includes to the high water level (HWL) in bowl and wet risers in elevated tanks, which are 30 inch diameter or larger.
   ii. High quality interior coating.
   iii. Protection of bare steel surfaces due to coating deterioration of up to 20% of the total submerged surface area.
   iv. Chemical analysis of water including resistivity.
   v. Minimum anode system life of twenty (20) years.
3. Provide certificate, signed and sealed by Professional Engineer stating that computations and Drawings are in conformance with these design criteria.
4. Catalog Cuts: Submit manufacturer's catalog cuts for the system which demonstrates classification in accordance with ANSI/NSF 61 - Drinking Water System Components.
5. Operating and Maintenance Manual: Submit five (5) operating, monitoring and maintenance manuals for the cathodic protection system. Include operating instructions, maintenance data, product data and test procedures in the manuals.
6. Drawings: Maintain as-built Drawings of the corrosion system during installation and construction. Revise drawings to show exact locations of all wiring, connections and terminal boxes. Properly identify all items of equipment and material. Submit the original as-built Drawings to the Owner representative.

1.07 QUALITY CONTROL

1. Certification: Provide manufacturer's certification that all components of the cathodic protection system meet the requirements of the Drawings and specifications.
2. Drawings: The Drawings for the cathodic protection systems are diagrammatic. Do not scale the Drawings for exact locations unless scales are explicitly stated on the specific drawing. Determine exact locations by field conditions and non-interference with mechanical and structural features.
3. Inspection: All materials, fabrication and installations are subject to inspection and testing by the Owner or its designated representative.

1.08 QUALIFICATIONS

A minimum of five years' experience installing and servicing the types of system described in this specification is required of the Cathodic Protection Contractor. Install the system by employees of the Cathodic Protection Contractor who have experience in the installation of water tank systems. All personnel subject to Federal Substance Abuse and Testing Regulations as required by the Owner.

1.09 RECOMMENDED CONTRACTOR

Corrpro US, Houston Office, 7000 B Hollister, Houston, TX 77040; www.corrpro.com

PART 2 – PRODUCTS

All materials in contact with the water or exposed to the interior of the tank are to be classified in accordance with ANSI/NSF 61 "Drinking Water System Components".

2.01 ANODES

1. General: Anode material to be high potential magnesium, having a diameter of 2.024 ±0.024 inches, extruded on a solid, 1/8 inch steel core with nominal length of 10 feet for each anode.
2. Composition: High potential magnesium alloy to conform to the following:

i.	Element	% by Weight
ii.	Silicon	0.05 maximum
iii.	Copper	0.01 maximum
iv.	Nickel	0.001 maximum
v.	Iron	0.002 maximum
vi.	Aluminum	2.5 – 3.5
vii.	Zinc	0.7 – 1.3
viii.	Manganese	0.2 minimum

ix.	Other	0.3 maximum
x.	Magnesium	Remainder

3. Anode Lead Wire: Use No. 8 AWG stranded copper wire with medium density, high molecular weight polyethylene (HMW/PE) insulation. Polyethylene to conform to ASTM D 1248, Type I, Class C, Grade 5.
4. Connection: Connect the anode-to-wire with a Thomas & Betts, C tap, crimp connector sized for No. 8 AWG stranded copper conductor. First crimp the wire to the 1/8-inch anode core and then silver solder to ensure electrical continuity and strength.
5. Anode Eye Ring: Drill and tap the end of the anode to a depth of 1-1/2 inches adjacent to the core wire. Screw a 3/8-inch diameter eye ring with a 3-inch shaft and a 1-inch inside diameter eye loop, 1-½ inches into the anode.
6. Encapsulation: Encapsulate the crimped connection and the shaft of the eye ring in epoxy. See Drawings.

2.02 MONITORING STATION

1. Enclosure: Use a NEMA 4X enclosure for the cathodic protection system monitoring station.
2. Meter: Cathodic protection potential/anode current DC voltmeter to have a push to read button connecting the permanent reference cell to the digital voltmeter with an internal resistance of not less than 1,000,000 ohms/volt and a minimum full scale of 1999 mV.
3. Shunt: Place a calibrated shunt in the anode circuit wired to the DC voltmeter for measuring DC current.
4. Resistor: Equip the monitoring station with a variable resistor (rheostat) sized not less than a 100 watt, 100 ohm, connected between the anode header cable and the tank lead wire.
5. Tank Negative Lead: Use No. 8 AWG stranded copper with THHW insulation for the system ground.
6. Test Lead: Install independent structure test lead not smaller than No. 18 AWG stranded copper TW or THHW insulation on the potential test circuit.
7. Tank Connections: Space the anode system structure and test structure connections six (6) or more inches apart on ladder stand-off welded to tank shell. Connect with brass bolts as shown on Drawings.
8. Monitoring Station Mounting: Locate the monitoring station on the exterior of the tank for convenient operator serviceability approximately five (5) feet off the ground near the ladder.

2.03 REFERENCE ELECTRODES

1. General: Install two (2) copper-copper sulfate electrodes, manufactured with 99.99% pure copper coiled element. Cells are to remain stable (plus or minus 10 mV) in fresh water for a minimum of ten years.

2. Lead Wires: Use No. 14 AWG stranded copper wire with blue, medium density, high molecular weight polyethylene (HMW/PE) insulation for the reference cell lead wire. Polyethylene to conform to ASTM D 1248, Type I, Class C, Grade 5.
3. Encapsulation: Encapsulate the reference electrode to lead wire connection in epoxy to prevent water penetration.

2.04 ANODE SUSPENSION SYSTEM

1. Cord: Suspend the anode from a minimum 5/16 inch diameter polyester cord, tied to the anode eye ring and anchored to the roof of the tank as shown on the Drawings.
2. Lead Wires: Do not use the anode lead wire to support the weight of the anode.

2.05 ANODE HEADER CABLE

1. General: Use No. 8 AWG stranded copper, HMW/PE insulated cable. Install header cable without cutting any strands of copper and run from each anode completing a full 3600 circle. Extend both ends of the anode header cable to the monitoring station where one end will terminate on a variable resistor. Connect the other end of the resistor to the tank with a No. 8 AWG copper wire. Terminate the other end of the header cable with a wire nut.
2. Interior Wiring: Insulate all wiring within the tank to prevent copper conductor contact with the potable water.
3. Exterior Wiring: Use stranded copper conductors, run in rigid, galvanized steel conduit for all wiring on the exterior of the tank.

2.06 ANODE CONNECTIONS

1. Connectors: Use a Thomas & Betts, C tap, crimp connector for a No. 8 AWG stranded to No. 8 AWG stranded copper wire connection for the anode lead wire to header cable splices.
2. Sealant: Seal splices between anode lead wires and collector cable with Scotchfill Insulation Putty, Scotch 130C Rubber Tape, and Scotch Super 88 Plastic Tape as manufactured by 3M. Coat the completed splice with Scotchkote.

2.07 HARDWARE

All hardware used in conjunction with the system to be provided with a protective coating to protect against corrosion

PART 3 - EXECUTION

3.01 PERFORMANCE

1. Perform all work in accordance with the following requirements:

2. General: Install components of the cathodic protection system in the manner and at the locations shown on the Drawings prepared by the Corrosion Engineer.
3. Inspection: Prior to installation, have the Owner or its designated representative, inspect materials and equipment. Replace any defective materials or components that do not satisfy the requirements of this specification.
4. Tank Attachments: All attachments to the interior, wetted surfaces of the tank should be constructed of non-metallic materials or mild steel that is provided with the same protective coating system as the tank shell. Where stainless steel accessories are used, such as ladders or safety rails, the stainless steel shall be electrically isolated from the tank.
5. Welding, Cutting and Coating: Follow AWWA Standards D 100 and D 102 for welding, cutting, and coating.
6. Electrical Continuity: Assure continuity by spot welding all sections of bolted or riveted tanks. Tank Construction Contractor to perform the welding.
7. Wiring: Handle and install lead wires to prevent damage from abrasion.
8. Connections: Seal electrical connections within the tank to prevent water penetration.
9. Monitoring Station: Mount the monitoring station at a convenient height (eye level) above grade for monitoring and service purposes.
10. Disinfection: The Tank Construction Contractor is responsible for disinfection.
11. Workmanship: Complete the work in a clean and safe manner.
12. Tank Closure: Security of all tank access locations (e.g. hatches) is the responsibility of the Owner.

3.02 ENERGIZING SYSTEM

1. General: After the system is installed and the tank is filled, provide startup service, which includes energizing, testing, and adjusting the system for optimum performance.
2. Prior to native state, polarized potential testing and commissioning of the system, give a minimum of 48 hours notice to the Owner, Engineering Project Manager to facilitate observation of the tests by an Owner Representative.
3. Method: Record all tank-to-water potential measurements with a calibrated, portable, copper-copper sulfate reference electrode and a portable, high impedance voltmeter. Measure native state, current “on” and “instant off” potentials at a minimum of five locations within the tank. Record potential and current measurements at the monitoring station.
4. Report: Review and evaluation of all test data is the responsibility of the Corrosion Engineer. In addition to the startup service, submit “as-built” drawings and an Operations and Maintenance Manual in accordance with Section 1.05.

SECTION 00610

CATHODIC PROTECTION FOR WATER TANK

(EXTERNAL CATHODIC PROTECTION OF ON-GRADE CARBON STEEL STORAGE TANK BOTTOMS)

SECTION 1: GENERAL

1.1 This section includes:

1. Guidelines for the design, installation, operation and maintenance of cathodic protection for the exterior bottoms of on-grade carbon steel storage tanks.

SECTION 2: DEFINITIONS.

Amphoteric Metal: A metal that is susceptible to corrosion in both acid and alkaline environments.

Anode: The electrode of an electrochemical cell at which oxidation occurs. Electrons flow away from the anode in the external circuit. Corrosion usually occurs and metal ions enter the solution at the anode.

Backfill: Material placed in a hole to fill the space around the anodes, vent pipe, and buried components of a cathodic protection system.

Cathode: The electrode of an electrochemical cell at which reduction is the principal reaction. Electrons flow toward the cathode in the external circuit.

Cathodic Protection (CP): A technique to reduce the corrosion of a metal surface by making that surface the cathode of an electrochemical cell.

Cell: See *Electrochemical Cell.*

Current Density: The current to or from a unit area of an electrode surface.

Deep Groundbed: One or more anodes installed vertically at a nominal depth of 15 m (50 ft) or more below the earth's surface in a drilled hole for the purpose of supplying cathodic protection.

Differential Aeration Cell: An electrochemical cell, the electromotive force of which is due to a difference in air (oxygen) concentration at one electrode as compared with that at another electrode of the same material.

Electrical Isolation: The condition of being electrically separated from other metallic structures or the environment.

Electrochemical Cell: A system consisting of an anode and a cathode immersed in an electrolyte so as to create an electrical circuit. The anode and cathode may be different metals or dissimilar areas on the same metal surface.

Electrolyte: A chemical substance containing ions that migrate in an electric field.

External Circuit: The wires, connectors, measuring devices, current sources, etc., that are used to bring about or measure the desired electrical conditions within an electrochemical cell. It is this portion of the cell through which electrons travel.

Foreign Structure: Any metallic structure that is not intended as a part of a system under cathodic protection.

Galvanic Anode: A metal that provides sacrificial protection to another metal that is more noble when electrically coupled in an electrolyte. This type of anode is the electron source in one type of cathodic protection.

Groundbed: One or more anodes installed below the earth's surface for the purpose of supplying cathodic protection. For the purposes of this standard, a groundbed is defined as a single anode or group of anodes installed in the electrolyte for the purposes of discharging direct current to the protected structure.

Impressed Current: An electric current supplied by a device employing a power source that is external to the electrode system. (An example is direct current for cathodic protection).

On-Grade Storage Tank: A tank constructed on sand or earthen pads, concrete ring walls, or concrete pads.

Oxidation: (1) Loss of electrons by a constituent of a chemical reaction. (2) Corrosion of a metal that is exposed to an oxidizing gas at elevated temperatures.

Piping: For the purposes of this standard, this term refers to all piping associated with the transfer of products in and out of storage tanks.

Reduction: Gain of electrons by a constituent of a chemical reaction.

Reference Electrode: An electrode whose open-circuit potential is constant under similar conditions of measurement, which is used for measuring the relative potentials of other electrodes.

Stray-Current Corrosion: Corrosion resulting from current through paths other than the intended circuit, e.g., by any extraneous current in the earth.

SECTION 3: PRELIMINARY EVALUATION and DETERMINATION OF THE NEED FOR CATHODIC PROTECTION

3.1. GENERAL

1. This section outlines the information that should be considered prior to designing a cathodic protection system to protect on-grade carbon steel storage tank bottoms in contact with an electrolyte.

3.2 Site Assessment Information

1. Prior to designing a cathodic protection system, the following information should be obtained:
   (a) Tank, piping, and grounding construction drawings, including dimensions, etc.
   (b) Site plan and layout
   (c) Date of construction
   (d) Material specifications and manufacturer
   (e) Joint construction (i.e., welded, riveted, etc.)
   (f) Coating specifications
   (g) Existing or proposed cathodic protection systems in the area
   (h) Location of electric power sources
   (i) Electrochemical properties of the tank bedding or padding material
   (j) History of the tank foundation (i.e., whether the tank has been jacked up/leveled, etc.)
   (k) Unusual environmental conditions

(l) Operating history of the tank, including leak information (internal and external)
(m) Maintenance history of the tank
(n) Containment membranes/impervious linings
(o) Secondary bottoms
(p) Water table and site drainage information
(q) Liquid levels maintained in the tank
(r) Nearby foreign structures
(s) Type of liquid stored
(t) Operating temperature
(u) Electrical grounding

3.3 Predesign Site Appraisal

1. Determining the Extent of Corrosion on Existing Systems
   1.1 Information regarding the degree of tank-bottom corrosion is useful because considerable bottom damage may require extensive repairs or replacement prior to the installation of cathodic protection.
   1.2 Field procedures for determining the extent of existing corrosion may include:
   (a) Visual inspection
   (b) Tank bottom plate-thickness measurements
   (ultrasonic testing, coupon analysis, etc.)
   (c) Estimation of general corrosion rates through the use of electrochemical procedures
   (d) Determination of the magnitude and direction of galvanic or stray current transferred to or from the tank through piping and other interconnections
   (e) Determination of soil characteristics including resistivity, pH, chloride ion concentration, sulfide ion concentration, and moisture content
   (f) Estimation of the degree of corrosion deterioration based on comparison with data from similar facilities subjected to similar conditions
   1.3 Foundation characteristics are also important factors in the assessment of the extent of existing corrosion. The pad material of construction, thickness of ring walls, and water drainage should all be considered.
   1.4 Data pertaining to existing corrosion conditions should be obtained in sufficient quantity to permit reasonable engineering judgments. Statistical procedures should be used in the analysis, if appropriate.

3.4 Electrical Isolation

1. Electrical isolation facilities must be compatible with electrical grounding requirements conforming to applicable codes and safety requirements. If the tank bottom is to be cathodically protected, the use of alternative electrical grounding materials, such as galvanized steel and galvanic anodes, should be considered.
2. The designer of a cathodic protection system should consider the possible need for electrical isolation of the tank from piping and other interconnecting structures. Isolation may be necessary for effective cathodic protection or safety considerations.
3. Electrical isolation of interconnecting piping can be accomplished through the use of isolating flanges, dielectric bushings or unions, or other devices specifically designed for this purpose. These devices shall be rated for the proper operating pressure and be compatible with the products being transported.

4. Polarization cells, lightning arresters, grounding cells, and other decoupling devices may be useful in some situations for maintaining isolation under normal operating conditions and providing protection for an isolating device during lightning strikes, power surges, and other abnormal situations.
5. Tests to determine tank electrical characteristics include:
   (a) Tank-to-earth resistance tests
   (b) Tank-to-grounding system resistance and potential tests
   (c) Tank-to-electrolyte potential tests
   (d) Electrical continuity tests for mechanical joints in interconnecting piping systems
   (e) Electrical leakage tests for isolating fittings installed in interconnecting piping and between the tanks and safety ground conductors

3.5 Cathodic Protection Type, Current Requirements, and Anode Configuration

1. Soil resistivity tests should be performed in sufficient quantity as to aid in determining the type of cathodic protection (galvanic or impressed current) required and the configuration for the anode system. Figure 1 illustrates the four-pin method of soil resistivity testing.
2. Resistivities can be determined using the four-pin method described in ASTM[(1)] G 57, [1] with pin spacings corresponding to depths of at least that expected for the anode system, or by using an equivalent testing method (in very dry environments, electromagnetic conductivity testing may be used to measure resistivities). [2] The resistivity measurements should be obtained in sufficient detail to identify possible variations with respect to depth and location. As a general guideline, resistivity data should be obtained at a minimum of two locations per tank.

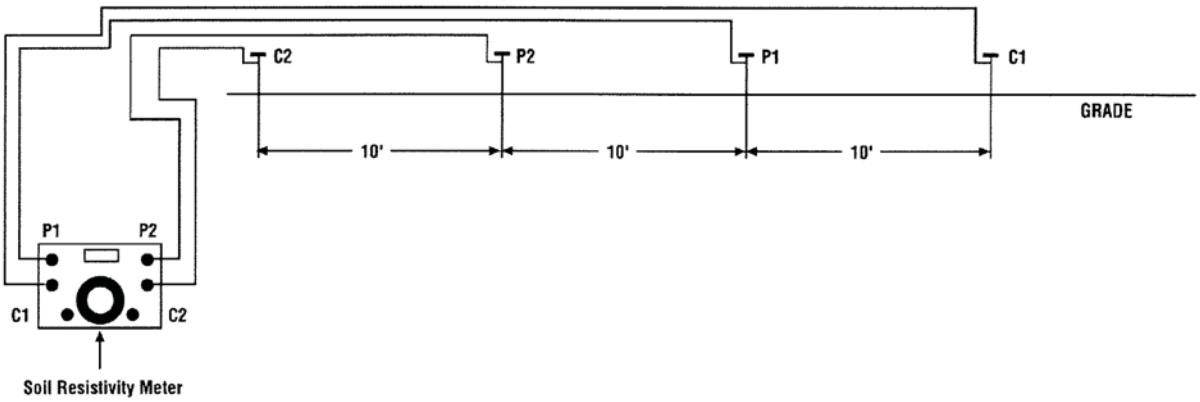

Figure 1: Soil Resistivity Testing (Four-Pin Method)
Note: a = Depth of interest for the soil resistivity measurement.

(1) American Society for Testing and Materials (ASTM), 100 Barr Harbor Dr., West Conshohocken, P.A. 19428.

3. If deep groundbeds are considered, resistivities should be analyzed using procedures described by Barnes3 to determine conditions on a layer-by-layer basis. On-site resistivity data can be supplemented with geological data including subsurface stratigraphy, hydrology, and lithology. Sources for geological information include water

well drillers, oil and gas production companies, the U.S. Geological Survey Office,(2) and other regulatory agencies.

4. Cathodic protection current requirements can be estimated using test anode arrays simulating the type of groundbed planned. Test currents can be applied using suitable sources of direct current. Test groundbeds can include driven rods, anode systems for adjacent cathodic protection installations, or other temporary structures that are electrically separated from the tank being tested. Small- diameter anode test wells may be appropriate and should be considered if extensive use of deep anode groundbeds is being considered. Figure 2 illustrates a temporary groundbed for current requirement testing.

3.6 Stray Currents

1. The presence of stray earth currents may result in cathodic protection current requirements that are greater than those required under natural conditions. Possible sources of stray current include DC-operated rail systems and mining operations, other cathodic protection systems, welding equipment, and high-voltage direct current (HVDC) transmission systems.
   - 1.1 Field tests to determine whether stray currents are a concern include those that provide tank-to-electrolyte and structure-to-electrolyte potential measurements on adjacent structures, earth gradient measurements, and current flow measurements on tank piping and safety grounding conductors.
   - 1.2 Possible interference effects caused by adjacent cathodic protection systems should be determined by interrupting the current output using a known timing cycle. Structure-to-electrolyte potentials and other parameters should be monitored over a minimum 24-hour period in areas where dynamic stray currents or transient effects are expected to be a concern. Recording instruments can be used for this purpose. Figure 3 illustrates stray current corrosion.
   - 1.3 Cathodic protection designs should incorporate every practical effort to minimize electrical interference on structures not included in the protection system. Predesign test results can be analyzed to determine the possible need for stray current control provisions in the cathodic protection system.

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(2) U.S. Geological Survey Office, P.O. Box 25046. Federal Center, Denver, CO 80225.

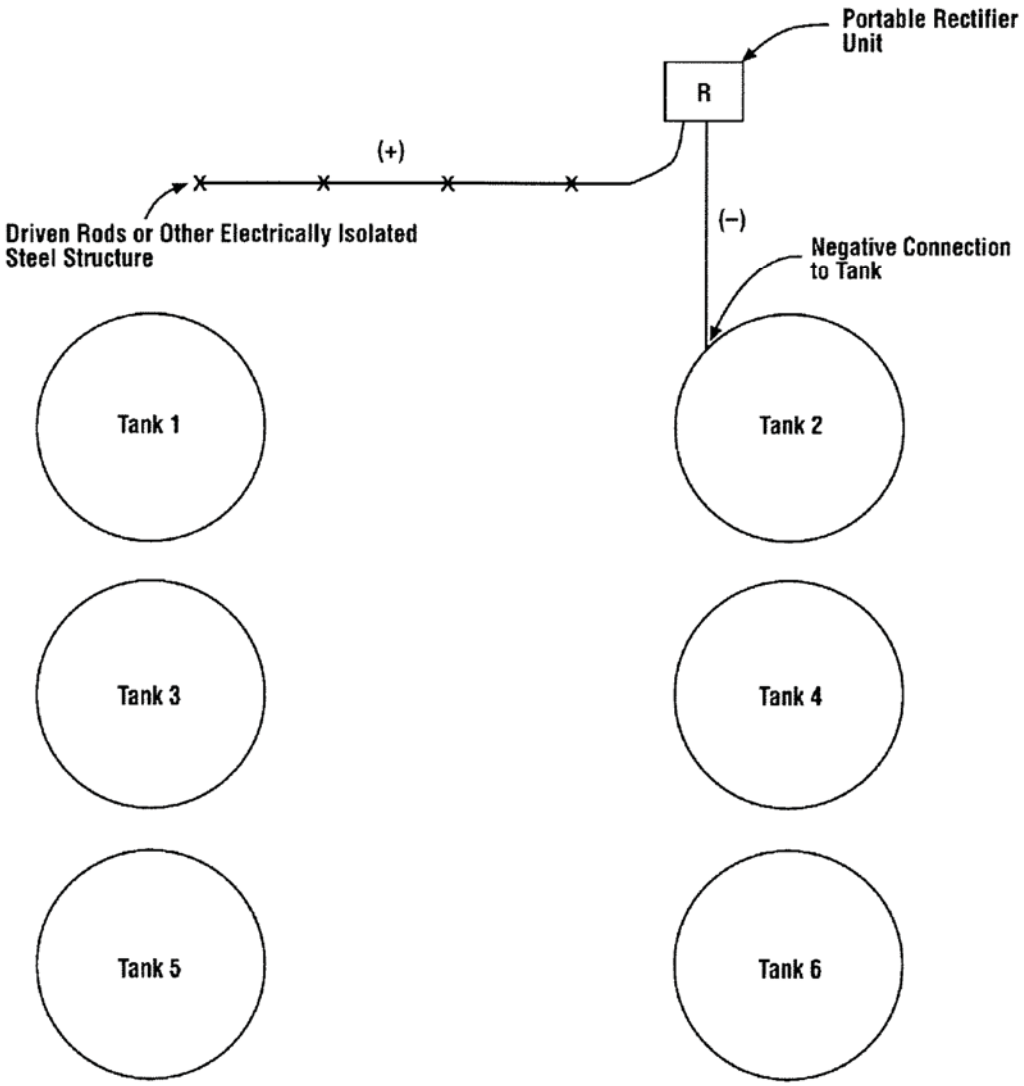

Figure 2: Temporary Groundbed for Current Requirement Testing

SECTION4: CRITERIA FOR CATHODIC PROTECTION

4.1 GENERAL

1. This section lists criteria for cathodic protection that, if complied with either separately or collectively, indicate that cathodic protection of an on-grade carbon steel storage tank bottom has been achieved.

   1.1 The objective of using cathodic protection is to control the corrosion of an on-grade carbon steel storage tank bottom in contact with an electrolyte. The selection of a particular criterion for achieving this objective depends, in part, on prior experience with similar tank bottoms and environments in which the criterion has been successfully used.

   1.2 The criteria in Paragraph 4.3 were developed through laboratory experiments or were determined empirically by evaluating data obtained from successfully operated cathodic protection systems. It is not intended that personnel responsible for corrosion

control be limited to operating under these criteria if it can be demonstrated by other means that the control of corrosion has been achieved.

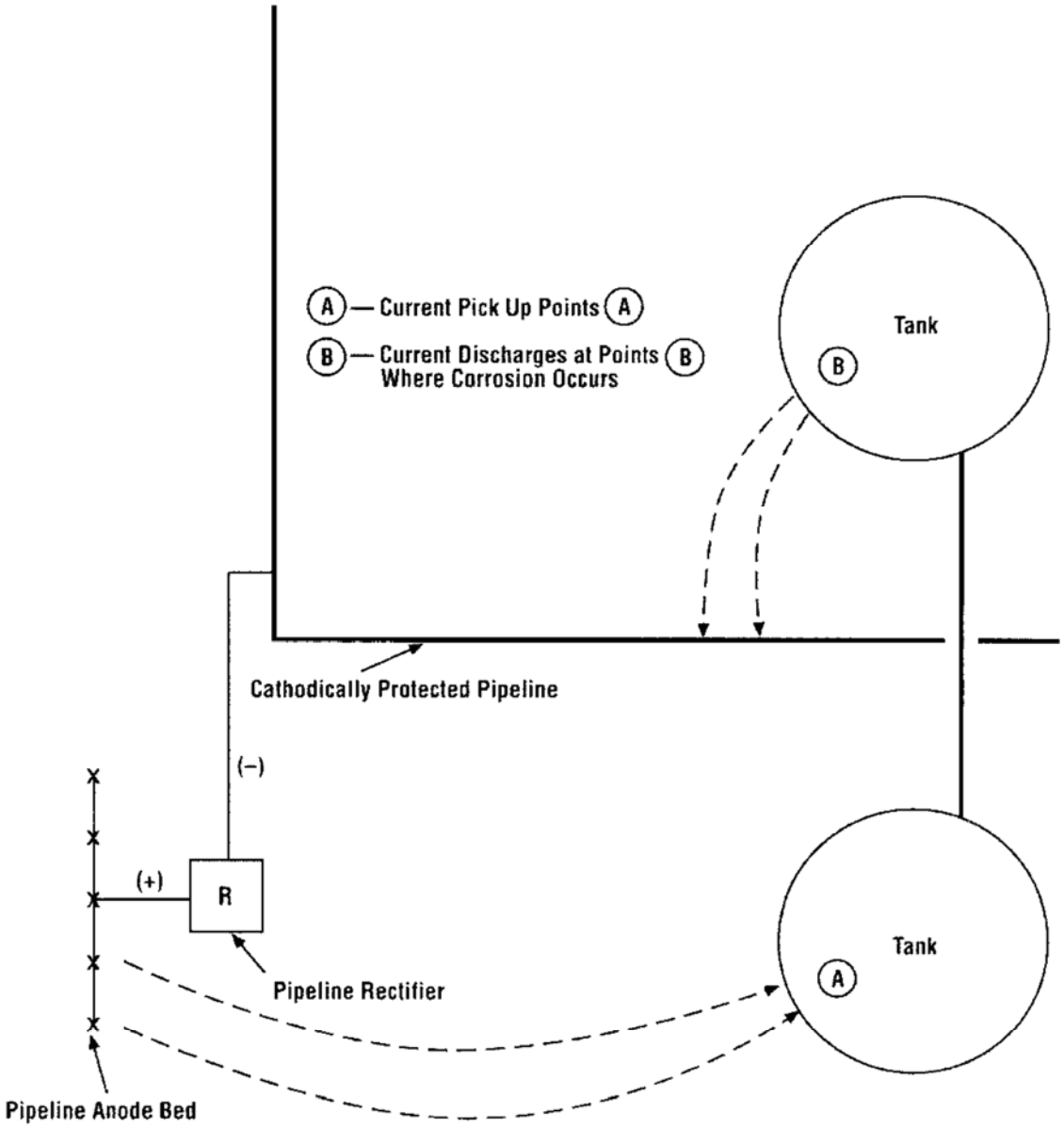

Figure 3: Stray Current Corrosion

2. Potential measurements on storage tanks shall be made with the reference electrode located as close as possible to the tank bottom. On most tanks, measurements should be taken at the perimeter, near the center of the tank bottom, and at various points in

between. Consideration must be given to voltage drops other than those across the structure-to electrolyte boundary, the presence of dissimilar metals, and the influence of other structures. These factors may interfere with valid interpretation of potential measurements. Also, measurements made with a reference electrode located on asphalt pavement or a concrete slab or outside the concrete wall may be in error.

4.2 Criteria for Corrosion Control of Carbon Steel Tank Bottoms

1. Corrosion control can be achieved at various levels of cathodic polarization depending on environmental conditions. However, in the absence of specific data that demonstrate that cathodic protection has been achieved, one or more of the following must apply to the system:

   1.1 A negative (cathodic) potential of at least 850 mV with the cathodic protection current applied. This potential shall be measured with respect to a saturated copper/copper sulfate reference electrode (CSE) contacting the electrolyte. Consideration must be given to voltage drops other than those across the structure-to-electrolyte boundary for valid interpretation of this voltage measurement.

   1.2 Consideration is understood to mean the application of sound engineering practice in determining the significance of voltage drops by methods such as:

   (a) Measuring or calculating the voltage drop(s),

   (b) Reviewing the historical performance of the cathodic protection system,

   (c) Evaluating the physical and electrical characteristics of the tank bottom and its environment, and

   (d) Determining whether or not there is physical evidence of corrosion.

   1.3 A negative polarized potential of at least 850 mV relative to a CSE.

   1.4 A minimum of 100 mV of cathodic polarization between the carbon steel surface of the tank bottom and a stable reference electrode contacting the electrolyte. The formation or decay of polarization may be measured to satisfy this criterion.

4.3 Reference Electrodes

1. Other standard reference electrodes may be substituted for the CSE. Two commonly used reference electrodes are listed below. The voltages given are equivalent (at 25°C [77°F]) to a negative 850 mV potential referred to a CSE:

   (a) Saturated silver/silver chloride reference electrode: a negative 780 mV potential

   (b) High-purity zinc (99.99%): a positive 250-mV potential (see Paragraph 7.3.4)

2. Stationary (permanently installed) reference electrodes may assist in measuring potentials under the tank. Stationary electrodes may be encapsulated in an appropriate backfill material.

4.4 Special Considerations

1. Special cases, such as stray currents and stray electrical gradients, that require the use of criteria different from those listed above may exist.
2. Coupons and electrical resistance probes may be useful in evaluating the effectiveness of the cathodic protection system.
3. Conditions in which cathodic protection is ineffective or only partially effective sometimes exist. Such conditions may include the following:

   (a) Elevated temperatures

   (b) Disbonded coatings

   (c) Shielding

   (d) Bacterial attack

(e) Unusual contaminants in the electrolyte
(f) Areas of the tank bottom that do not come into contact with the electrolyte
(g) Dry tank cushion

4. Rocks, clay deposits, or clumps under tank bottom plates can promote the formation of localized corrosion activity, which is difficult to monitor or evaluate.

4.5 APPLICATION

1. Cathodic protection shall be installed to protect new or existing tanks, but cannot protect carbon steel surfaces that are not in contact with an electrolyte.
2. Cathodic protection shall be applied to welded, bolted, and riveted carbon steel tanks that are either field- or shop-fabricated.
3. Cathodic protection may be used alone or in conjunction with protective coatings.
4. All cathodic protection systems should be installed with the intent of conducting uninterrupted, safe operations.
5. Cathodic protection should be operated continuously to maintain polarization.

SECTION 5: DESIGN CONSIDERATIONS

5.1. GENERAL:

1. The current industry standards.
2. Corrosion control must be a consideration during the design of on-grade carbon steel storage tanks.
3. Recognition of hazardous conditions prevailing at the site and the selection and specification of materials and installation practices that ensure safe installation and operation.
4. Compliance with all applicable governmental codes and owner requirements.
5. Avoid excessive levels of cathodic protection, which may cause coating disbondment and possible damage to high-strength and special alloy steels.
6. If amphoteric metals are involved (i.e., lead, tin, aluminum), avoiding high or low pH conditions that could cause corrosion.
7. Presence of secondary containment systems.
8. The preferred method of determining the current requirements for achieving a given level of protection on an existing tank bottom is to test the tank bottom using a temporary cathodic protection system. Alternately, a current density can be used for design purposes based on a current density successfully used at the same facility or at a facility with similar characteristics.
9. Current requirements on new or proposed tank bottoms may be established by calculating surface areas and applying a protective current density based on the size of the tank, the electrochemical characteristics of the environment, the service temperature, and the parameters of the groundbed. Current densities of 10 to 20 mA/m2 (1 to 2 mA/ft2) of bare tank bottom surface are generally sufficient. Systems exposed to chemistry involving chlorides, sulfides, or bacteria or to elevated service temperatures require more current. The history of other tanks in the same environment should be considered when choosing a design current density.

10. Care must be exercised to ensure that anode type and placement result in uniform distribution of protective current to the tank bottom surfaces.
11. Liquid levels within tanks to ensure that the entire tank bottom is in intimate contact with an electrolyte while establishing current requirements and testing applied protection levels.
12. Cathodic protection shall not create shielding conditions.
13. The presence of sulfides, chlorides, bacteria, coatings, elevated temperatures, shielding, pH conditions, treated tank padding material, soil/groundwater contamination, dissimilar metals, and pad/concrete/metal interface at the ring wall, as well as any heating or refrigeration coils under tank bottoms. Clean, fine sand is the preferred tank pad material.

5.2. IMPRESSED CURRENT CATHODIC PROTECTION.

1. Impressed Current Anode Systems
2. Impressed current anodes shall be connected with an insulated cable, either singularly or in groups, to the positive terminal of a direct current source such as a rectifier or DC generator. The tank bottom shall be electrically connected to the negative terminal. Cable insulation should be selected based on the anticipated environmental conditions and should be resistant to oil and water.
3. Anode groundbed configurations may be vertical, angled, deep, or horizontal, as illustrated in Figures 1 through 4. Anodes may be installed in a distributed fashion under tank bottoms. The selection of anode configuration is dependent on environmental factors, current requirements, the size and type of tank bottom to be protected, whether the tank is of new or existing construction, and whether it is a single- or double-bottom tank.

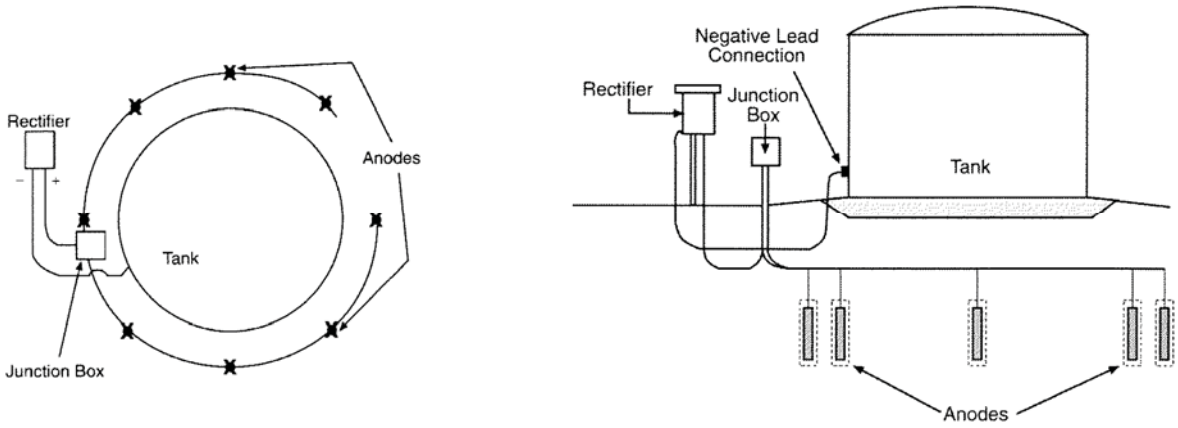

Figure 4: Vertically Drilled Anode CP System

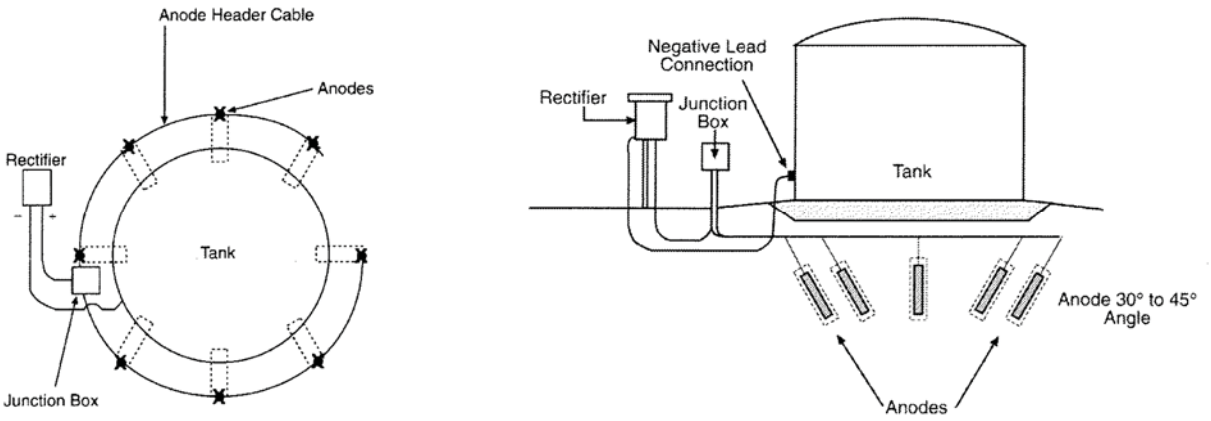

Figure 5: Angled Anode Cathodic Protection System

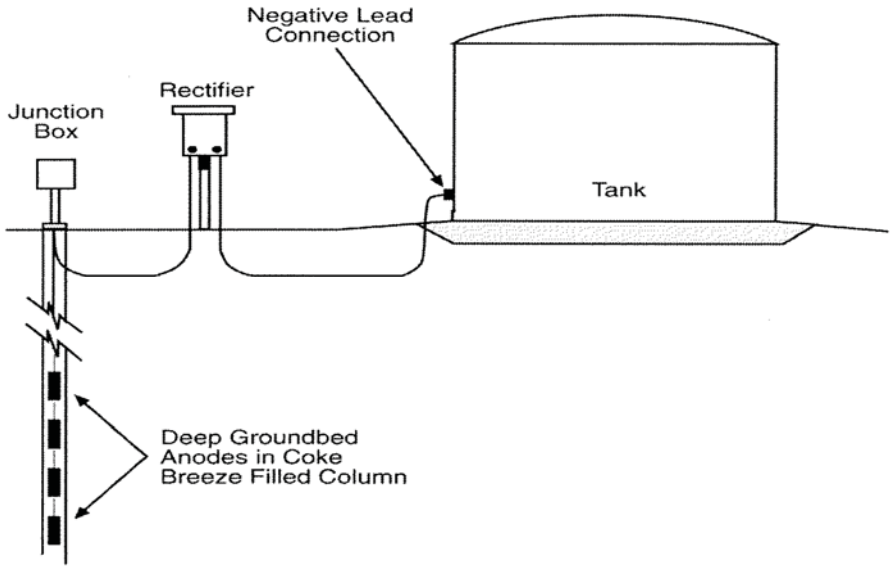

Figure 6: Deep Anode Groundbed

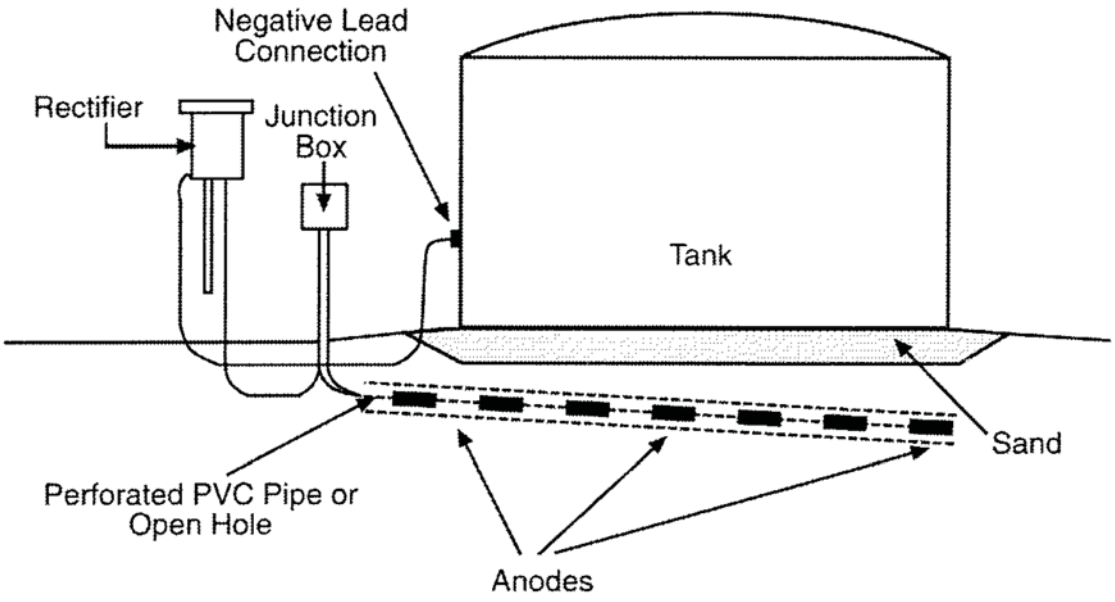

Figure 7: Horizontally Installed Anode Groundbed

4. Deep anode systems should be designed and installed in accordance with NACE Standard RP0572.4.
5. Anode materials have varying rates of deterioration when discharging current. Therefore, for a given output, the anode life depends on the environment, anode material, anode weight, and the number of anodes in the cathodic protection system. Established anode performance data should be used to calculate the probable life of the system.
   NOTE: Platinized niobium (columbium) and polymeric anodes should not be used in hydrocarbon contaminated environments.
6. The useful life of impressed current anodes can be lengthened by the use of special backfill around the anodes. The most commonly used backfill materials are metallurgical coal coke and calcined petroleum coke. Because coke is noble compared to carbon steel, coke should not be allowed to come into contact with the tank bottom.
7. In the design of an extensive, distributed-anode impressed current system, the voltage and current attenuation along the anode and the anode-connecting (header) cable should be considered. In such cases, the design objective should be to optimize anode system length, anode size and spacing, and cable size in order to achieve effective corrosion control over the entire surface of each tank bottom.
8. Suitable provisions for venting the anodes should be made in situations in which it is anticipated that entrapment of gas generated by anodic reactions could impair the ability of the impressed current groundbed to deliver the required current. Venting systems must be designed to prevent contaminants from getting into the venting system.
9. All impressed current systems must be designed with safety in mind. Care must be taken to ensure that all cables are protected from physical damage and the possibility of arcing.

10. Rectifiers and junction boxes must meet regulatory requirements for the specific location and environment in which they are installed. Such locations shall be determined by reviewing regulatory agency and prevailing industrial codes.
11. Consideration should be given to locating isolating devices, junction boxes, and rectifiers outside hazardous areas in case sparks or arcs occur during testing.
12. When cathodic protection systems are turned off, sufficient time must be allowed for depolarization before opening connections. Bonding cables must be used when parting piping joints.

5.3. CONSIDERATIONS FOR GALVANIC ANODE CATHODIC PROTECTION.

1. If the carbon steel surface area is exposed to the electrolyte, the surface area size, power source or impressed current source availability.
2. Galvanic anodes should be connected to the tank bottom through a test station so that anode performance and voltage drops can be monitored.
3. The effectiveness in soil environments.
4. The current requirements of the tank bottom, the soil conditions, the temperature of the tank bottom, and the cost of the materials.
5. Ensure that the anodes meet the requirements of ASTM B 4185 Type II anode material.
6. Zinc anodes should not be used if the temperature of the anode environment is above 49°C (120°F). Higher temperatures can cause passivation of the anode. The presence of salts such as carbonates, bicarbonates, or nitrates in the electrolyte may also affect the performance of zinc as an anode material.
7. Galvanic anodes (except for rebar-type anodes) should be supplied with adequate lead wire attached by the anode supplier.
8. Lead wire should be at least 2 mm in diameter (#12 AWG [American Wire Gauge.]) Cable insulation should be selected based on the anticipated environmental conditions and should typically be resistant to oil and water.

5.4. Cathodic Protection for Tanks with Replacement Bottoms or Release-Prevention Barriers

1. Release-prevention barriers and replacement tank bottoms can be used together or separately.
2. Release-prevention barriers and/or secondary carbon steel tank bottoms may shield the carbon steel surface of the primary tank bottom from the flow of cathodic protection current, resulting in a lack of adequate cathodic protection.
3. Any impact (i.e., corrosiveness) that the fill material beneath or between the tank bottoms could have on the cathodic protection system.
4. Impervious membranes or liners constructed of a nonconductive material used as a release-prevention barrier. Anodes must be placed between the barrier and the carbon steel tank bottom so that current flows to the surfaces requiring protection. If release-prevention barriers made of conductive material are used with a cathodic protection system with anodes outside the space contained by the barrier, the barrier must maintain a resistance low enough for sufficient cathodic protection current to flow to the tank bottom.

5. Stationary reference electrodes and/or portable reference electrode insertion tubes location.
6. If a replacement tank bottom is installed in an existing tank over an original bottom.
7. The anodes and reference electrodes or nonconductive reference electrode insertion tubes must be placed in the electrolyte between the two bottoms. Figure 5 illustrates a typical double-bottom cathodic protection layout.
8. If the original tank bottom is removed and replaced with a new bottom, the cathodic protection design should be that utilized for a standard, single bottom tank.

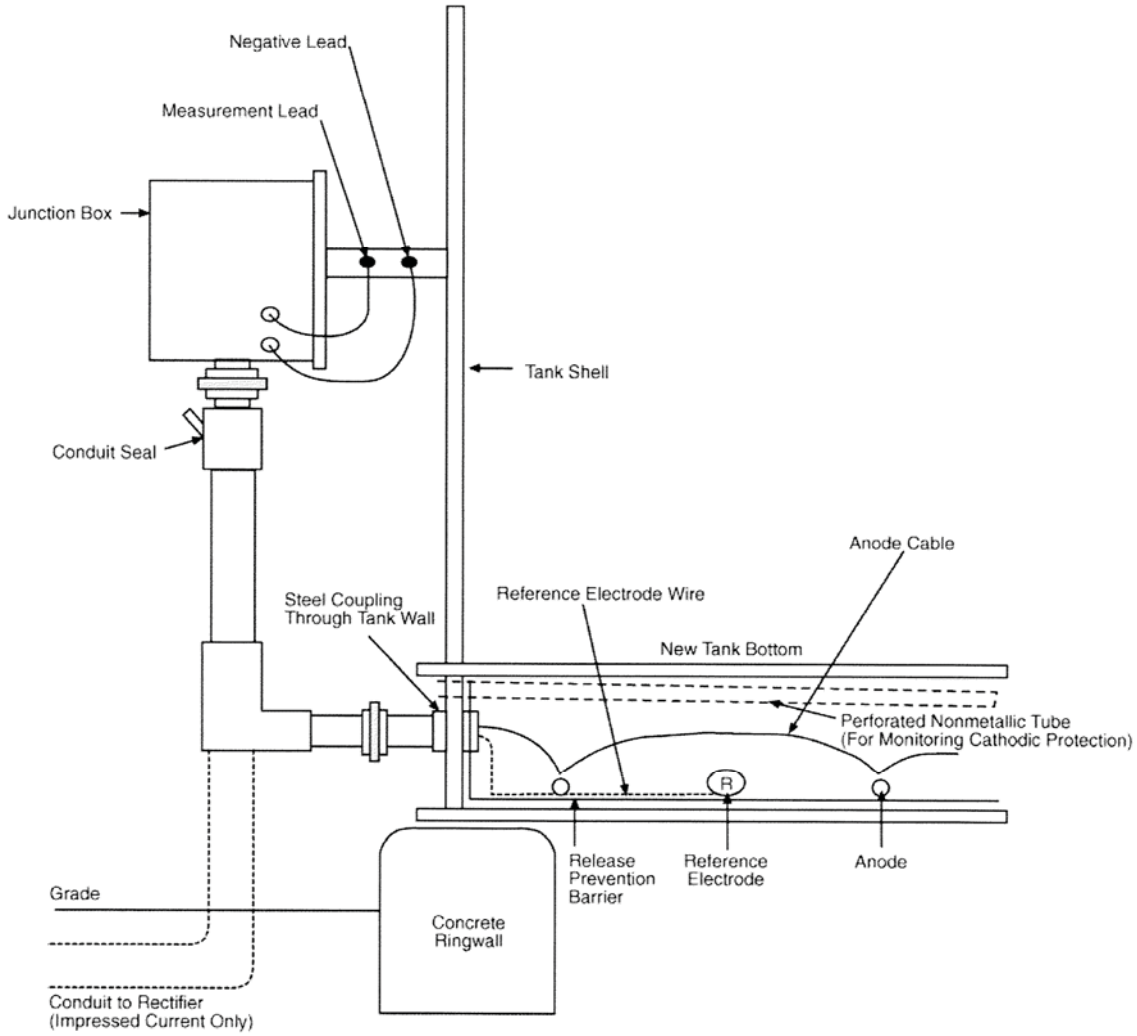

Figure 8: Typical Double-Bottom Cathodic Protection Layout (Impressed or Sacrificial)

9. Either impressed current or galvanic anode cathodic protection may be used. Galvanic anodes may be magnesium or zinc. Figure 6 illustrates a typical double-bottom galvanic anode design.
10. Anode materials that may be used for impressed current systems include mixed-metal

oxides, polymer carbon, graphite, high-silicon chromium-bearing cast iron, platinized niobium (columbium), platinized titanium, scrap metal, and below-grade metallic structures that have been removed from service. Figure 7 illustrates a typical new tank or double-bottom impressed current anode design.

11. Due to the depolarizing effect of oxidation by-products (typically chlorine, oxygen, or carbon dioxide) migrating from the anode to the steel cathode, the current density for protection with an impressed current system may be higher than that required for a galvanic anode system.
12. The space between bottoms, close anode spacing may be required to improve current distribution. Impressed current anodes must not contact the carbon steel surfaces of the tank.
13. Anodes must be installed in a conductive electrolyte. The electrolyte must be sufficiently compacted as to prevent settlement of the replacement tank bottom.

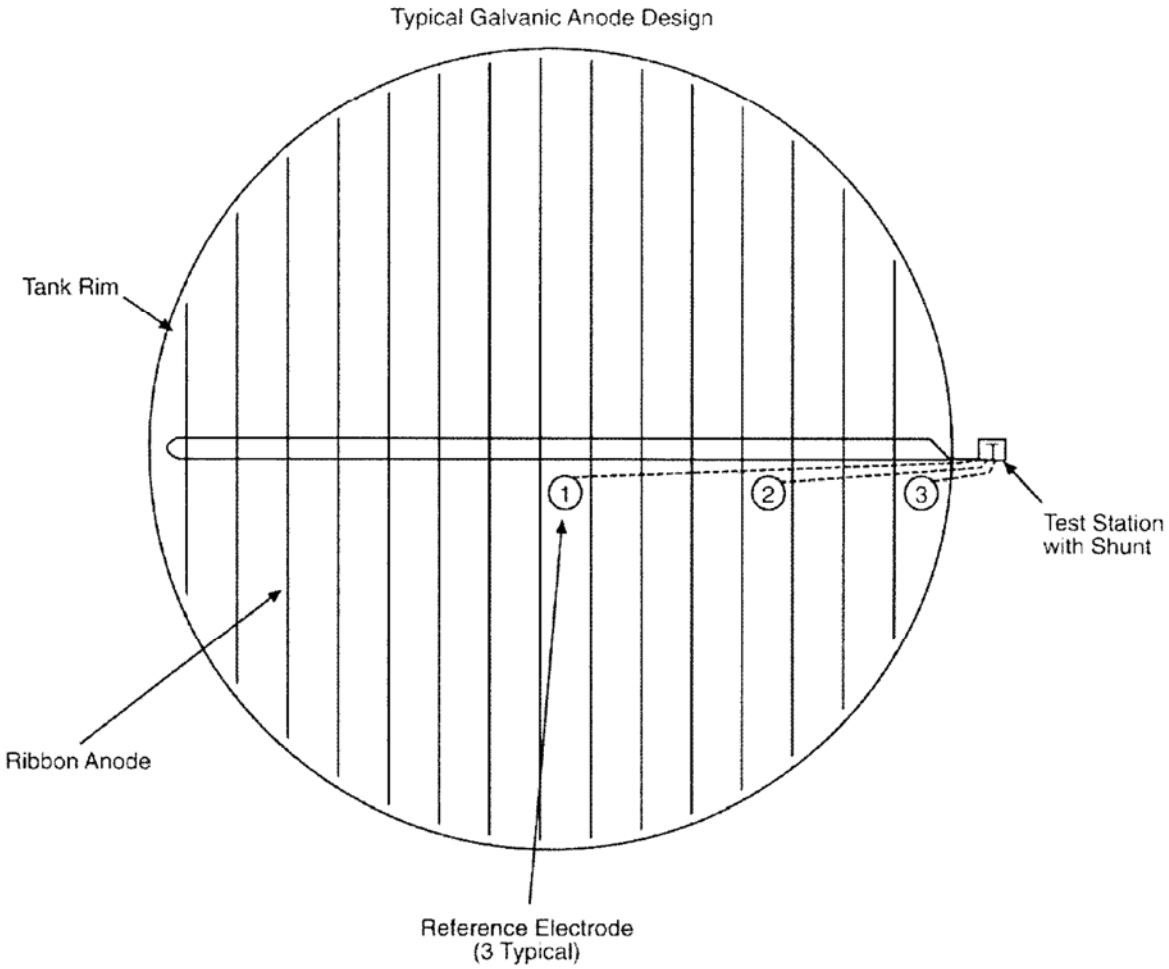

Figure 9: Typical Double-Bottom Galvanic Anode Design

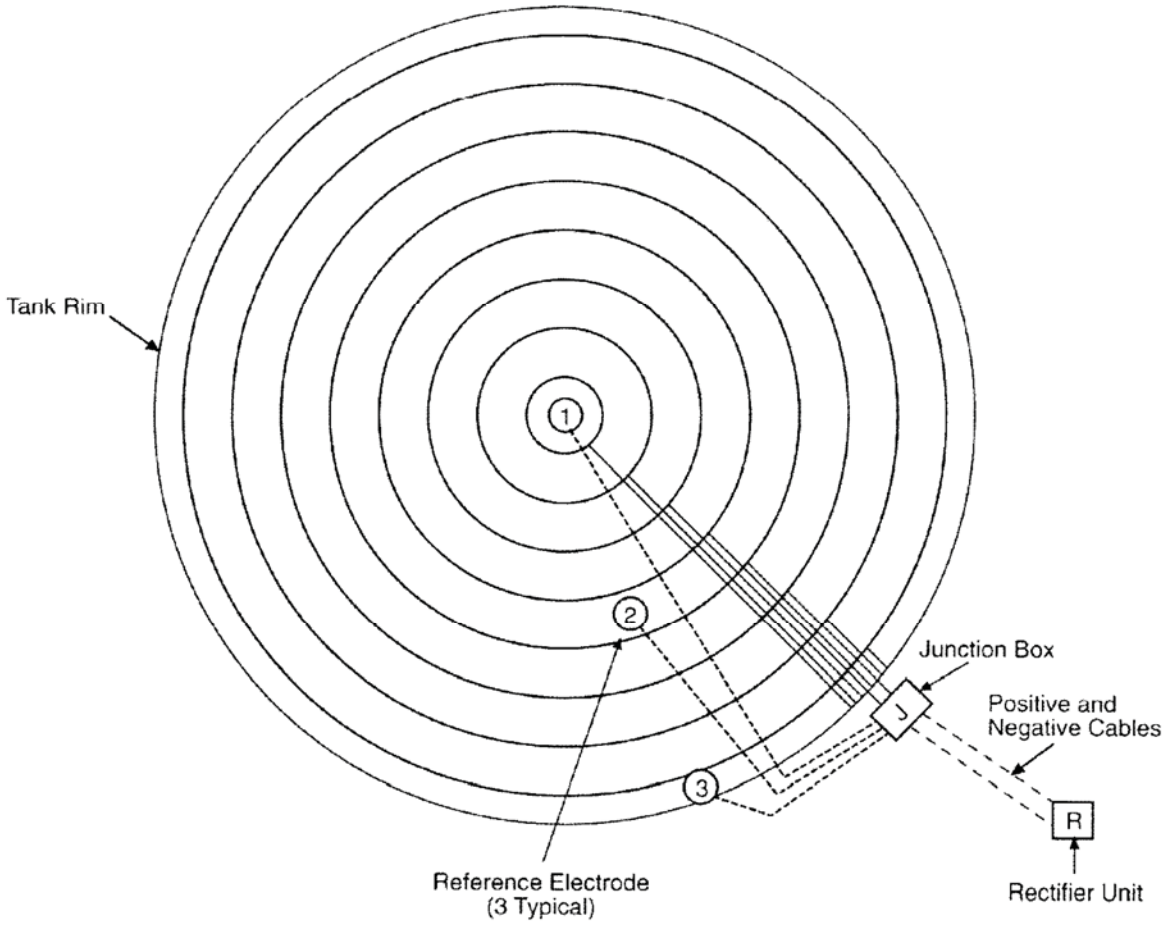

Figure 10: Typical New Tank or Double-Bottom Impressed Current Anode Design

SECTION 6: INSTALLATION.

6.1. GENERAL

1. This section recommends elements to consider during the installation of cathodic protection systems for on-grade carbon steel storage tank bottoms.

6.2. PREPARATION

1. Materials should be inspected prior to installation in order to ensure that specifications have been met.
2. Installation practices shall conform to all applicable regulatory agencies codes and requirements.
3. Anodes should be installed as designed. Care must be taken to ensure that the anodes do not come into electrical contact with any piping or tankage during installation.

4. Slack should be allowed in the anode lead wires to avoid possible damage due to settlement of the tank and surrounding soils. Anodes, lead wires, and connections should be handled with care to prevent damage or breakage.
5. The anode lead wires should be extended to the side of the tank away from the construction to minimize possible damage. After the tank foundation has been prepared and the tank set in place, the wires should be terminated in a test station or junction box, which may include shunts for measuring anode current outputs.
5. Stationary reference electrodes or nonconductive, perforated tubes for temporary installation of a portable reference electrode should be installed under all tanks regardless of the groundbed type and location.
6. Stationary reference electrodes may be prepackaged in a backfill and placed in the soil under the tank bottom or positioned inside the perforated reference electrode access piping. Reference electrodes placed inside access piping should be surrounded with a backfill material designed to provide contact between the electrode and the electrolyte outside the pipe. If practical, provisions should be made for future verification of all stationary reference electrode potentials with portable reference electrodes.
7. Reference electrode access piping must have some means of contact with the electrolyte and should have at least one end accessible from outside the tank shell. This contact can be through the use of holes, slits, or not capping the end of the piping beneath the tank. Perforations and slots should be designed to minimize entry of tank pad material. Portable reference electrodes shall be inserted through the inside diameter of the access pipe with a nonmetallic material such as small-diameter polyvinyl chloride (PVC) pipe. Inserting a reference electrode with metallic tape, bare wires, etc., may adversely affect potential readings. If necessary, water should be injected inside the access pipe to establish continuity between the electrode and the electrolyte. Deionized water should be used for double-bottom tanks or tanks with secondary containment.
8. For existing tanks, reference electrode access piping should be installed under the tank with horizontal drilling equipment capable of providing guidance and directional control to prevent tank bottom damage and to ensure accurate placement of the piping. Consideration must be given to the structural aspects of the tank padding and foundation to ensure that support capabilities are not adversely affected. Figure 8 illustrates the placement of perforated pipe installed for a reference electrode.

   NOTE: Special consideration must be given during the design and installation of access pipes to assure that any tank-containment system is not breached.
   CAUTION: Extreme caution must be exercised when boring or water jetting under tanks.

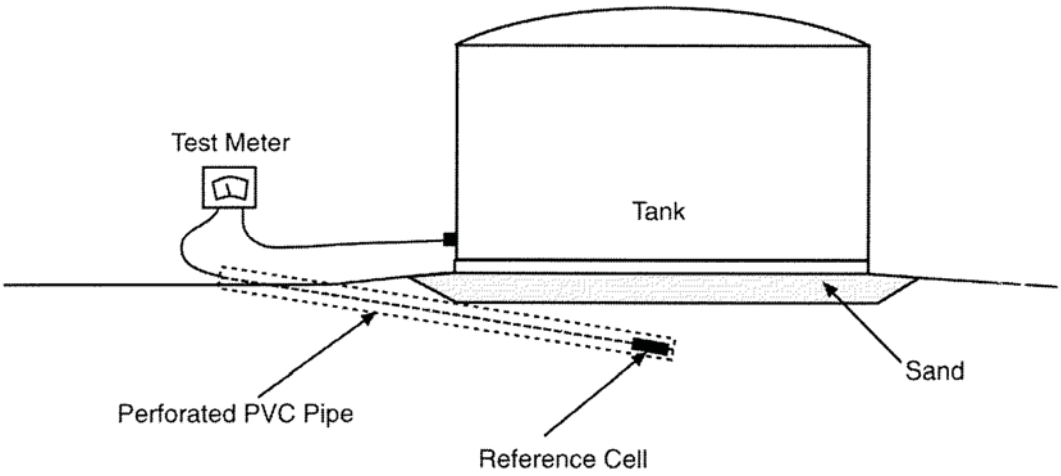

Figure 11: Perforated Pipe Installed for Reference Electrode

9. A constant distance should be maintained from the tank bottom to the reference electrode. Increasing space between tank bottom and reference electrode increases the voltage drop.
10. Test Stations and/or Junction Boxes for potential and current measurements should be provided at sufficient locations to facilitate cathodic protection testing.
11. The test station or junction box should be mounted on or near the side of the tank in an area that is protected from vehicular traffic.
12. The test station or junction box should allow for disconnection of the anodes to facilitate current measurements and potential measurements for voltage drop as required to evaluate the protection level. If desired, test leads from buried reference electrodes can be terminated in the same test station as tank bottom test wires.
13. Junction boxes can be used to connect continuity bonds or protective devices.
14. The test station or junction box in a galvanic system may be equipped with calibrated resistors (shunts) in connections between the anodes and the tank to measure the anode current output and thus the estimated anode life. Shunts are typically rated between 0.001 and 0.1 ohm.
15. The test station or junction box should be clearly marked and accessible for future monitoring of the tank bottom and, if possible, should be attached to the tank.
16. All lead wires to the test station or junction box should be protected from damage by a minimum 46-cm (18-in.) burial and/or placement within a conduit. Warning tape may be installed over direct-buried cables to prevent the possibility of damage during future excavation.
17. Safety Considerations

    17.1 All personnel to be involved in the installation of the cathodic protection system should participate in a thorough safety-training program.

    17.2 All underground facilities, including buried electric cables and pipelines in the affected areas, should be located and marked prior to digging.

17.3 All utility companies and other companies with facilities crossing the work areas should be notified and their affected structures located and marked prior to digging.
17.4 All areas with low overhead wires, pipelines, and other structures should be located and noted prior to any construction.
17.5 Operations and maintenance personnel should be notified of pending construction to coordinate necessary shutdowns or emergency considerations.

SECTION 7: ENERGIZING AND TESTING

7.1. GENERAL

1. This section discusses factors that should be considered when energizing and testing a cathodic protection system for on-grade carbon steel storage tank bottoms. If the tank has a secondary containment system, suitable access ports through the ringwall must be provided for testing.

7.2. DESIGN PARAMETERS

1. Knowledge of the performance criteria considered during the design of a cathodic protection system as well as the operational limits of cathodic protection devices and hardware should be available to the personnel setting operating levels for the cathodic protection system.
2. Initial Data
   2.1. Verification of cathodic protection devices and hardware, such as the following, should be done prior to energizing:
   (a) Location of anodes
   (b) Ratings of impressed current sources
   (c) Location of reference electrodes
   (d) Location of test facilities
   (e) Location of cathodic protection system cables
   2.2. Prior to energizing the cathodic protection system, the following data and information should be collected:
   (a) Tank bottom-to-electrolyte potentials
   (b) Pipe-to-electrolyte potentials on connected piping
   (c) Verification of dielectric isolation
   (d) Foreign structure-to-electrolyte potentials
   (e) Test coupon data
   (f) Fluid level in the tank during testing, and
   (f) Corrosion-rate probe data.
   2.3. All initial baseline data should be documented and the records maintained for the life of the cathodic protection system or the on-grade storage tank. Any deviations from the design or asbuilt documentation should be noted and included with the initial baseline data.
   2.4. When measuring the structure-to-electrolyte potential, the portable reference electrodes should be placed at sufficient intervals around the perimeter and

under the tank to ensure the potentials measured are representative of the entire tank bottom. The potential measured at the perimeter of a large diameter tank does not represent the potential at the center of the tank.

3. Current Adjustment
   3.1. The desired operating level of a cathodic protection system must often be determined by a series of trial tests at various operating levels. The specific operating level depends on the criterion for cathodic protection used for the on-grade storage tank(s). Section 4 defines the various criteria for achieving cathodic protection of on-grade carbon steel storage tank bottoms. Time required to achieve polarization on a bare tank bottom can be different from tank to tank.
   3.2. When the operating levels of cathodic protection systems are adjusted, consideration must be given to the effect of stray current on adjacent structures. Owners of these structures should be notified of the installation of a new cathodic protection system.
      3.2.1. Among the structures that should be considered as being possibly affected by stray current are:
         (a) On-grade and buried storage tanks
         (b) Piping separated from the tank(s) by high resistance fittings
         (c) Buried electric facilities
         (d) Buried fire-protection piping
         (e) Buried water piping
         (f) Transmission or distribution piping serving storage tank(s)
         (g) Municipal or public utility structures serving the facility in which a storage tank(s) is located
         (h) Fencing
      3.2.2. Structures that may contain discontinuous fittings or joints, such as cast iron systems, ductile iron piping systems, or piping with mechanically connected fittings, require special attention to ensure that stray current effects are detected and mitigated.
   3.3. The final operating level of a cathodic protection system should be established to achieve the cathodic protection criterion established by the design documents as set forth in Section 4, or by the operating policies of the facility owner.
4. Documentation
   4.1. Documentation of all operating parameters should be completed after the system is energized. Those parameters should include:
      (a) Initial baseline data
      (b) As-built drawings
      (c) Operating currents
      (d) Locations of test facilities
      (e) Key monitoring locations
      (f) Equipment manuals
      (g) Tank fluid level
   4.2. All collected data should be recorded and documented for future reference.
5. Error Sources: Consideration must be given to sources of error when potential readings are made on aboveground storage tank (AST) bottoms. Some of these error sources include:

5.1. Measurement Circuit IR Drop: The soil or fill under a tank bottom can be dry and have a high electrolyte resistance. Under these conditions, an IR drop error occurs in the measuring circuit if a low input impedance meter is used. This error can be minimized using a meter with an input impedance greater than 106 ohms.

5.2. Tank Bottom Flexing: When product level is low, the tank bottom can shift upward, affecting the measurement circuit and changing the area of the tank bottom being monitored. This may result in misleading readings. This error can be minimized by ensuring that there is sufficient product level in the tank during measurements.

5.3. Measurements Made from Grade Wall (single-bottom tanks): Potential measurements made from grade are strongly influenced by the potentials at the perimeter of the tank bottom or outside the ringwall (if present). To measure the potentials correctly in the center of the tank bottom, it is necessary to use either a stationary reference electrode, or to have an access tube located under the tank bottom.

SECTION 8: DELIVERABLES AND RECORDKEEPING

8.1 GENERAL

1. This section recommends pertinent information that should be recorded and filed for future information and reference.
2. Tank information should include, but not be limited to, the information outlined in Paragraph 3.2.
3. Design and installation records for cathodic protection systems should be kept, including the following information:
   (a) Design calculations and considerations
   (b) Power source capacity, circuit breakers, panels, etc.
   (c) Number of anodes
   (d) Anode material and expected life
   (e) Anode installation details
   (f) Type, quantity, and location of stationary reference electrodes
   (g) Soil resistivity
   (h) Date of energizing and initial current and voltage settings
   (i) Cost of system
   (j) Fluid level in the tank during survey
   (k) As-built drawings of the installation
4. Operation and maintenance records for cathodic protection systems should be kept, including the following information:
   (a) Tabulations of bimonthly readings of impressed current power source
   (b) Reports of periodic or annual inspections
   (c) All adjustments, repairs, and additions
   (d) Costs of maintenance
   (e) Test equipment calibration records

SECTION 9. REFERENCES

1. ASTM G 57 (latest revision), “Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method” (West Conshohocken, PA: ASTM).
2. F.W. Hewes, “Prediction of Shallow and Deep Groundbed Resistance Using Electromagnetic Conductivity Measurement Techniques,” CORROSION/87, paper no. 130 (Houston, TX: NACE International, 1987).
3. H.E. Barnes, “Electrical Survey Detects Underground Rock,” Pipeline Industry, April 1959.
4. NACE Standard RP0572 (latest revision), “Design, Installation, Operation, and Maintenance of Impressed Current Deep Groundbeds” (Houston, TX: NACE).
5. ASTM Standard B 418 (latest revision), “Standard Specification for Cast and Wrought Galvanic Zinc Anodes” (West Conshohocken, PA: ASTM).

END OF SECTION

SECTION 00700

WATER PIPES AND FITTINGS

REFERENCES

A. ANSI/AWWA C104/A21.4 – Cement-Mortar Lining for Ductile Iron Pipe and Fittings for Water

B. AWWA C105 – Polyethylene Encasement for Ductile-Iron Piping for Water and Other Liquids.

C. ANSI/AWWA C110/A21.10 – Ductile Iron and Gray Iron Fittings, 3 Inch Through 48 Inch, for Water and Other Liquids

D. ANSI/AWWA C111/A21.11 – Rubber-Gasket Joints for Ductile Iron and Gray Iron Pressure Pipe and Fittings

E. ANSI/AWWA C150/A21.50 – Thickness Design of Ductile Iron Pipe

F. ANSI/AWWA C151/A21.51 – Ductile Iron Pipe, Centrifugally Cast, for Water or Other Liquids

G. ANSI/AWWA C153/A21.53 – Ductile Iron Compact Fittings, 3 Inch Through 16 Inch, for Water and Other Liquids

H. ANSI/AWWA C502 – Dry Barrel Fire Hydrants

I. AWWA C503 – Wet-Barrel Fire Hydrants

J. AWWA C504 – Rubber-Sealed Butterfly Valves

K. ANSI/AWWA C509 – Resilient Seat Gate Valves for Water and Sewerage Systems

L. ANSI/AWWA C515 – Reduced Wall, Resilient Seated Gate Valve for Water Supply Service

M. ANSI/AWWA C600 – Installation of Ductile Iron Water Mains and Their Appurtenances

N. ANSI/AWWA C605 – Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water

O. ANSI/AWWA C651– Disinfecting Water Mains

P. ANSI/AWWA C900 – Polyvinyl Chloride (PVC) Pressure Pipe, 4 Inch Through 12 Inch, for Water Distribution

Q. AWWA C901 – Polyethylene (PE) Pressure Pipe, Tubing, and Fittings, ¾ inch through 3 inch, for Water.

R. ASTM D 1785 – Poly (VinylChloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

S. ASTM D 2241 – Poly (VinylChloride) (PVC) Plastic Pipe (SDR-PR).

T. ASTM D 2466 – Poly (VinylChloride) (PVC) Plastic Pipe Fittings, Schedule 40.

U. ASTM D 2855 – Making Solvent-Cememted Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.

V. ASTM D 2239 – Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter.

W. ASTM D 3139 – Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

X. ASTM F 477 – Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

Y. Standard Methods for Examination of Water and Wastewater

Z. NSF 60 - Drinking Water Treatment Chemicals

AA. NSF 61 - Drinking Water System Components

1.5 SUBMITTALS

A. Method of Disinfection

B. Water Testing Lab

C. Method of Connection to Existing Distribution System

D. Method of Pressure Testing

E. Pressure Test Certification Forms

1.6 DEFINITIONS

A. Fully Restrained: Pipe installed with or including:

1. Certalok C900 joined pipe (or equal)
2. Pipe with Flanged connections
3. Pipe with mechanical joints

1.7 QUALITY ASSURANCE

A. Water testing shall be done by a State certified laboratory.

B. Pipe: Perform work in accordance with manufacturer's recommended procedures.

C. Pressure testing shall be done in accordance with the Project Engineer's requirements in Section 3.11

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and protect products to site.

1.9 ACCEPTANCE

A. Work covered by this section will not be accepted until the backfilling and testing has been completed satisfactorily.

B. Any section of water main that is found defective in material, alignment, or joints before acceptance shall be corrected to the satisfaction of the Project Engineer at contractor's expense.

PART 2 – PRODUCTS

2.1 WATER PIPE

A. Manufacturers: Certainteed, Diamond Plastics, Johns Manville or equal.

B. PVC-O Pipe: AWWA C900, elastomeric-gasket couplings, Class 100, 150, or 200 as shown on the drawings or bid schedule.

1. Fittings: AWWA C111, rubber-gasket joints, Cast-Iron

2. Joints: ASTM D3139 compression gasket ring.
3. Tracer Wire: Magnetic detectable conductor, plastic covering, imprinted with "Water Line" in large letters.

C. PVC-O Pipe: ASTM D2241, SDR-21 or 26 as shown on the drawings or bid schedule:

1. Fittings: ASTM D2466, PVC.

2. Joints: ASTM D2855, solvent weld.
3. Trace Wire: Magnetic detectable conductor, plastic covering, imprinted with "Water Line" in large letters.

D. Ductile Iron Pipe: AWWA C151, pressure class 350, centrifugally cast in metal molds or sand-lined molds, or C104, cement-mortar lining, as shown on the drawings or bid schedule.

1. Fittings: Ductile iron, standard thickness.

2. Joints: AWWA C111, rubber-gasket joints with rods.

3. Jackets: AWWA C105 polyethylene encasement, double layer, half lapped, ½-inch polyethylene tape.

E. Joint Thrust Restraint

1. Concrete Thrust Blocks:

a. One part Portland cement, 2 ½ part of fine aggregate, 3 ½ parts coarse aggregate and just enough water for a workable consistency.

b. #4 deformed rebars.

2. Spatial Anchoring Retainer Glands for Mechanical Joints:

a. PVC: Equal to

i) EBAA Iron Series 2000PV

ii) Romac Industries Grip Ring

2.2 GATE VALVES

A. Manufacturers: American Darling, Mueller, Clow, or Waterous, or equal.

B. Meet or exceed either AWWA C509 or C515, resilient seated gate valves 2 inch through 12 inch NPS, ductile iron body, trim, non-rising stem with square nut, single wedge, mechanical joint, flanged, or slip-on ends as specified in drawings, control rod, and extension box.

C. Furnish one valve key per contract or delivery order as applicable.

2.4 COMBINATION AIR/VACUUM RELIEF VALVE

2.4.1 APCO, Combination Air Valve, 100 kPa, 150 psi, C.I., Model 143C single body, double orifice, cast iron

2.4.2 **PLAST-O-MATIC Thermoplastic Air Release Valve Model ARV100EPI-PV** manufactured by Plas-O-Matic Valves, Inc. in Cedar Grove, New Jersy, USA or ASPA approved equal.

2.5 GATE VALVE BOX

A. Manufacturer: Tyler Pipe or equal.

B. Two piece slip style valve box

C. 5 ¼-inch nominal diameter

D. Length: Sufficient for depth of bury indicated on plans

E. Cover: Locking with pentagon nut and clearly marked as “water”

F. Acceptable Products: Equal to the following

1. Tyler Pipe 6855 valve box and lid
2. Rich 920 or 925 valve box and lid

G. Cast iron and of the sliding type, sized for use with the appropriate valve. Box shall extend from the body of the valve to the finished grade.

END OF SECTION.

SECTION 00800

PORTLAND CEMENT CONCRETE PAVING

PART 1 – GENERAL

1.1 SECTION INCLUDES

Concrete sidewalks, stair steps, integral curbs, gutters, parking areas, and roads.

1.2 MEASUREMENT AND PAYMENT

A. Measurement: By square foot of concrete/pavement in place.

B. Basis for Payment Includes: saw cutting of existing pavement; removal and disposal of existing pavement; preparation of base; installation of rebars, dowels; pouring of concrete, curing and testing.

1.3 REFERENCES

A. ACI 301 - Specifications for Structural Concrete for Buildings.

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

C. ASTM A185 - Welded Steel Wire Fabric for Concrete Reinforcement.

D. ASTM A497 - Welded Deformed Steel Wire Fabric for Concrete Reinforcement.

E. ASTM A615 - Deformed and Plain Billet-Steel for Concrete Reinforcement.

F. ASTM C33 - Concrete Aggregates.

G. ASTM C94 - Ready Mix Concrete.

H. ASTM C150 - Portland Cement TYPE II

I. ASTM D1751 - Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction.

J. ASTM D1752 - Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

1.4 PERFORMANCE REQUIREMENTS

Paving: Designed for parking light duty commercial vehicles, residential streets, main street arteries and movement of trucks up to 30,000 lbs.

1.5 SUBMITTALS FOR REVIEW

Product Data: Provide data on joint filler, admixtures and curing compounds.

1.6 QUALITY ASSURANCE

A. Perform work in accordance with standards of the American Samoa Public Works Department.

B. Obtain cementitious materials from same source throughout.

1.7 REGULATORY REQUIREMENTS

Conform to applicable standards for paving work on public property.

1.8 ENVIRONMENTAL REQUIREMENTS

Do not place concrete when base has standing water.

PART 2 – PRODUCTS

2.1 REINFORCEMENT

A. Reinforcing Steel and Wire Fabric: ASTM A615, yield grade; deformed billet steel bars; unfinished, galvanized or epoxy coated finish.

B. Welded Steel Wire Fabric: Plain type, ASTM A185 or Deformed type, A497; in flat sheets or coiled rolls; unfinished or galvanized.

2.2 CONCRETE MATERIALS

A. Concrete Materials: ASTM C150, Normal - Type II, Portland type, grey, buff or white in color.

B. Fine and Coarse Mix Aggregates: ASTM C33.

C. Water: Not detrimental to concrete.

2.3 CONCRETE MIX - BY PERFORMANCE CRITERIA

A. Mix and deliver concrete in accordance with ASTM C94.

B. Select proportions for normal weight concrete in accordance with ACI 301 .

C. Use set retarding admixtures during hot weather only when approved by Engineer.

2.4 SOURCE QUALITY CONTROL AND TESTS

A. Submit proposed mix design to Engineer prior to work.

B. Tests on cement and aggregates will be performed to ensure conformance with specified requirements.

C. Test samples in accordance with ACI 301.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify base conditions and verify compacted sub-grade, granular base and/or stabilized soil is acceptable and ready to support paving and imposed loads.

B. Verify gradients and elevations of base are correct.

3.2 PREPARATION

A. Moisten base to minimize absorption of water from fresh concrete.

B. Coat surfaces of manholes, catch basins and frames with oil to prevent bond with concrete pavement.

C. Notify Engineer minimum 24 hours prior to commencement of concreting operations.

3.3 FORMING

A. Place and secure forms to correct location, dimension, profile, and gradient.

B. Assemble formwork to permit easy stripping and dismantling without damaging concrete.

3.4 REINFORCEMENT

Place reinforcement as indicated.

3.5 PLACING CONCRETE

A. Place concrete in accordance with ACI 301.

B. Ensure reinforcement, inserts, embedded parts and formed joints are not disturbed during concrete placement.

3.6 FINISHING

Finish as indicated on Plans.

3.7 PROTECTION

A. Immediately after placement, protect pavement from premature drying, excessive hot or cold temperatures, and mechanical injury.

B. Do not permit vehicular traffic over pavement until 75 percent design strength of concrete has been achieved.

3.8 SCHEDULES

A. Concrete Sidewalks and Median Barrier: 3,000 psi 28 day concrete, 4 inches thick, buff color Portland cement, exposed aggregate finish.

B. Parking Area Pavement: 4,000 psi 28 day concrete, 6 inches thick, - 6 x 6 inch mesh reinforcement, wood float finish.

END OF SECTION

SECTION 00900

SECURITY FENCE SPECIFICATIONS

1. CHAIN LINK FENCING:

(a) General.

Unless stated otherwise, all materials for chain link fencing and gates above and below ground shall be PVC coated galvanized as specified in the current ASTM F 668.

(b) Post.

All posts shall be of sufficient length to provide a 36-inch minimum setting in concrete footings and at a depth as specified on the plans. Posts shall be set at a maximum spacing of 10' o.c. Posts shall be in proper alignment so that there is a minimum of 4" on all sides of the post. No material shall be installed on the post nor shall the post be disturbed in any manner within 7 days after the individual post footing is completed. Should rock be encountered at a depth less than the planned footing depth a hole 2" larger than greatest dimension of the post shall be drilled to a depth of 12". No extra compensation shall be made for rock excavation.

(1) All posts. PVC coated Galvanized steel, 35 percent minimum carbon content, 60,000 pounds per square inch minimum tensile strength (Schedule 40).

(2) Line Posts. 2-3/8 inch O.D. pipe weighing 3.65 pounds per linear foot or 2 inch x 2-1/4 inch H section weighing 4.10 pounds per linear foot unless otherwise specified on drawings.

(3) End, Corner and Pull Posts. 2-7/8 inch O.D. pipe weighing 5.79 pounds per linear foot unless otherwise specified on drawings.

(4) Gate posts. For single gate or one leaf of double gates:

(aa) Up to 6 feet wide. 3 inch O.D. pipe weight 5.79 pounds per linear foot unless otherwise specified on drawings.

(ab) 6 feet to 15 feet wide. 4 O.D. pipe weighing 9.11 pound per linear foot.

(5) Post Tops. Tubular post tops designed to prevent moisture from entering posts and to support top rail.

(c) Top Rails.

(1) 1-1/2 inch I.D. PVC coated galvanized steel pipe weighing 2.27 pounds per linear foot.

(2) Provided with PVC coated galvanized, outside sleeve, self-centering 7-inch long couplings approximately every 20 feet.

(d) Horizontal Braces.

(1) Braces shall be 1-1/2 inch I.D. PVC coated galvanized steel pipe weighing 2.27 pounds per linear foot with plain ends.

(e) Diagonal Braces.

(1) Diagonal braces shall be 3/8 inch diameter PVC coated galvanized steel rods or as specified on drawing.

(2) Diagonal braces shall be provided with heavy galvanized iron turnbuckles to adjust the tension.

(f) Fence Fabric.

(1) Wire. 9 gauge PVC coated galvanized steel wire, of medium high carbon quality, minimum tensile strength of 70,000 pounds per square inch, interwoven into 2 inch diamond mesh.

(2) Fabric. 72 inches wide, selvage shall be knuckled at bottom and twisted and barbed at top.

(g) Barbed Wire

PVC coated barbed wire shall be 10 gauge with 10 gauge barbs. All barbs shall be 4 points and spacing of barbs shall be 4 to 6 inches.

(h) Fabric Connections and Installation.

(1) Terminal post shall be fastened by 3/16 inch x 3/4 inch stainless steel stretcher bars with 11 gauge stainless steel or aluminum bands unless otherwise specified on drawings.

(2) All line posts shall be fastened with 9 gage stainless steel or aluminum wire clips unless otherwise specified on drawings.

(3) All top rails shall be fastened with a 9 gage stainless steel or aluminum tie wires.

(4) The bottom edge of the fabric shall be fastened by 1/8 inch PVC coated galvanized tension bars with 11 gage stainless steel or aluminum bands unless otherwise specified on drawings.

(5) The fence shall generally follow the contour of the ground, with the bottom of the fence no more than 2" from ground surface. At locations of small natural swales and where it is not practical to have the fence conform to the general contour of ground surface, longer post may be used and multiple strands of barbed wire stretched there on to span the opening below fence. Vertical clearance between strands of barbed wire shall be 4" or less.

(i) **Concrete.**

Concrete shall be of a commercial grade with a min 28-day compression strength of 2500psi. All concrete shall be placed against solid, undisturbed or re-compacted fill materials. All aggregates shall comply with latest ACI requirements. Cement shall be Type II Portland. Concrete Mix Design (Proportion) shall be submitted to ASPA for approval prior to any concrete placement.

END OF SECTION