SPECIAL SPECIFICATION
4900
Sacrificial Cathodic Protection Pile Jacket

1. Description. This Item shall govern for the furnishing, installing and energizing a sacrificial anode cathodic protection system, including connection to the reinforcing steel, materials, testing and ensuring continuity between all embedded steel components on designated piles of the Queen Isabella Causeway in accordance with the details on the plans and this Item.

The Cathodic Protection system consists of expanded zinc mesh anodes suspended inside integral pile jackets and installed on the piles at the locations and elevations shown in the plans. It also includes bulk zinc anodes installed on each pile shown in the plans.

2. Materials. Material furnished for the pile jacket forms shall meet the following physical property requirements.

(a) Water absorption (ASTM DS70) – one percent maximum
(b) Ultimate Tensile Strength (ASTM D638) – 90 ksi minimum
(c) Flexural Strength (ASTM D796) – 16 ksi minimum
(d) Flexural Modulus of Elasticity (ASTM D790) – 700 ksi minimum
(e) IZOD Impact (ASTM D256) – 392 lb/in (un-notched)
(f) Barcol Hardness (ASTM D2583) 45 minimum

Portland cement grout filler material shall consist of a mixture of Portland cement, fine aggregate, water and approved admixture. The use of fly ash in the mix is not allowed for this mix. The filling material shall contain 1000 lb. of cement per cubic yard with sufficient water to produce a workable mix. Fine aggregate shall be silica sand meeting the requirements of Item 421. Portland cement shall meet the requirements of Item 421. Admixtures shall contain no chlorides or other salts corrosive to metals and shall comply with the requirements of Item 437. Final acceptance of the fill material shall be made based on compressive strength results meeting or exceeding those established by the approved design mix. Testing of the Portland Cement Grout fill material shall be per ASTM C109, “Standard Test Method for Compressive Strength of Hydraulic Cement Mortars”.

Contractor shall be responsible for providing six, 2-inch x 2-inch, test cubes for each batch of grout filling material used and four 6-inch x 3-inch, compression test cylinders for each batch used.

The zinc mesh anode attached inside the jacket shall be an expanded zinc mesh conforming to ASTM A-190 with the following metal composition:
(a) Pb 0.005% wt. max.
(b) Fe 0.010% wt. max.
(c) CD 0.005% wt. max.
(d) Cu 0.7 – 0.9 % wt. max.
(e) Al 0.001 % wt. max.
(f) Zn balance

Additionally, the mesh anode shall have the following physical properties:

(a) Electrical conductivity = 28 % min.
(b) Solid zinc density = 0.28 lb/in2 min.
(c) Weight of expanded mesh = 1.60 lb/sf min.
(d) Open area of expanded mesh = 53 % (density)
(e) Solid zinc sheet thickness = 3/32 inch min.

The expanded mesh anode shall also conform to the following nominal geometry to allow proper mortar encapsulation:

(a) ½ inch Hex pattern
(b) 1/8 inch Strand width in the short direction
(c) 9/16 inch Strand width in the long direction
(d) 5/16 inch Short opening
(e) ¾ inch Long opening

The bulk zinc anode shall be 50 lb. min., 99% pure zinc anode (hull type anode) with a steel strap core, conforming to ASTM B-418. The steel strap shall be plated or galvanized with a minimum zinc thickness of 1/128 inch. A hole shall be drilled at each end of the strap for mounting. Such hole shall be fabricated prior to galvanizing. Location and size of the holes shall be as shown in the plans. The anode shall be clamped onto the pile using two, two-inch galvanized steel channels with the flanged side facing the concrete surface (as shown in the plans) using galvanized hardware.

3. **Construction Methods.** Continuity of the prestressing steel, dowel bars, and ties shall be provided by brazing, metallizing or other approved method.

Prior to commencing the cathodic protection installation, the Contractor shall submit for approval, shop drawings indicating equipment, materials, details and procedures for installing the cathodic protection system. Include details on the following: the negative connections to the steel, continuity check and correction procedures, and anode system fabrication, including bulk anode and hardware, and expanded zinc mesh anode jackets.

Contractor shall also restore to original dimensions minor concrete delaminations and/or spalls on the piles that may be present (above the MLW line) outside the limits of the cathodic protection jackets as directed by the Engineer.
The Contractor shall inspect all piles and locate all deteriorated concrete areas on the pilings that are to receive cathodic protection. Areas to receive jackets and the surrounding concrete surfaces shall be sound tested by the Contractor to determine the actual dimensions of the deteriorated concrete to be removed. Each jacket should encompass the entire problem areas within the specified jacket limits. The Engineer reserves the right to add or delete piling repair and protection as required. Dimensions of the spalled areas shall be recorded by the Contractor and verified by the Engineer. A final report detailing locations and size of the spalls and/or cracks shall be provided by the Contractor at the end of the project. All delaminated, cracked or unsound concrete shall be removed by the Contractor from the areas, which are hollow sounding when tested, or areas with visible cracks. Light duty pneumatic concrete chippers may be used. Sound cracked concrete (up to 1/64 inch wide), may not need to be removed as directed by the Engineer.

Surface preparation for piles shall be as follows:

(a) **Above water deficiencies:** The Contractor shall ensure that all exposed steel is cleaned to a gray metal condition and all debris removed from spalled areas and all other concrete surfaces within the jacket limits by sandblasting prior to installing the pile jacket. Exposed steel shall not be left unprotected for a period greater than 96 hours after sandblasting. Cleaned pile surfaces shall be washed down with fresh (non-saline) water immediately prior to jacket installation.

(b) **Below water deficiencies:** Mechanical scraping and water blasting will be required to remove all marine growth from the area to receive the pile jacket.

An approved latex modified concrete or underwater repair mortar shall be used for patching spalled areas outside the limits of the cathodic protection jackets as required. Concrete removal and restoration within the limits shown on the plans but outside the jacket limits or the bulk anode location shall be considered incidental to the concrete restoration operation and shall be included in the cost of the Sacrificial Cathodic Protection Pile Jacket System.

Contractor shall remove all residue or marine growth on the surface of the piles at the elevation where the cathodic protection jackets will be installed. Additionally, the Contractor will be responsible for removing marine growth from the piling to the extent necessary to facilitate the installation of the bulk anode. This may be achieved by sandblasting, hydro-blasting or other methods as approved by the Engineer.

The expanded mesh anode shall be provided with a connection wire which shall extend a minimum of 9 inches above the top of the jacket to perform the connection to the reinforcing steel inside the system connection box as shown in the plans.

The Cathodic Protection jackets shall be installed on the designated piles starting at the elevation detailed in the construction plans, and extending upward to the required elevation also shown in the construction plans. Adjustments to these
Elevations may be required to encompass pile deficiency and/or avoid the pile caps at specific locations.

Jackets longer than six feet will require staged pumping ports. Filling material shall not be dropped into the form from elevations greater than six feet or into forms containing water. Filling material for jackets extending below water level shall be pumped from the bottom. The pumping shall continue after initial filling until no water is present at the highest discharge point of the jacket and a uniform grout consistency is achieved.

The forms shall be composed of a durable, inert corrosion resistant material with an interlocking joint along two opposite sides that will permit the form to be assembled and sealed in place around the pile. Joints and holes for stand-offs shall be epoxy sealed. Forms shall be fabricated from fiberglass and polyester resins. The form dimensions shown in the plans are minimum dimensions permitted. The Engineer may approve minor variations. The minimum thickness of the forms shall be 1/8 inch. Upon placing around a pile, the forms shall be watertight, and capable of maintaining their shape without assistance or damage. Temporary lateral supports and/or bracing may be required to avoid deformation of the jacket during placement of the Portland cement grout filling. Jacket stand-offs may require field fabrications after removal of unsound concrete to assure proper alignment of the jacket during fill material placement.

The inside face of the jacket forms shall have no bond inhibiting agents in contact with the cement grout or the mesh anode. The forms shall be provided with bonded on or bolted on, nonmetallic standoffs, which will maintain the forms in the required position. The inside surface of the form shall be sandblasted or scored with an abrasive material to provide a texture equal to a sandblasted surface. Inside preparation shall be done at the factory.

The forms shall be watertight, equipped with a compressible sealing strip at the bottom, which will provide a positive seal of the annular space between the pile and the form. The sealing strip shall be capable of resisting slight vibration that may be required for adequate consolidation of the filling material as determined by the Engineer.

After the filling material has cured for a minimum 72 hours, all temporary form supports and/or bracing shall be removed from the piles and the exterior of the form shall be cleaned of any filling material which may have been deposited. The top of the filling material shall be sloped as shown in the construction drawings.

The bulk anode shall be placed at an angle at the depth shown in the construction drawings. If the ground level is higher than the installation elevation shown in the drawings, the Contractor shall excavate around the pile to provide the proper elevation unless otherwise directed by the Engineer. Excavation shall be restored to original profile after completing the system installation. The Contractor shall be responsible for any necessary surveying work to determine the correct elevation on each pile.
A No. 8 AWG copper strand wire with HMWPE insulation shall be connected to the anode via a 3/8 inch diameter round steel bar welded to the anode strap. The No. 8 AWG wire shall be brazed to the bar, and the bar-wire connection shall be permanently encased in a 1 ¼-inch diameter by 8-inch long PVC pipe filled with epoxy. The remaining wire shall be routed to the jacket inside a ¾ inch diameter PVC pipe. All required fabrication shall be done prior to the anode installation. The wire insulation shall be protected from heat during the welding and brazing operation. Special precautions may be necessary to protect the wiring insulation and splice during anode installation. The ¾ inch pipe shall extend to an elevation of approximately two inches inside the bottom of the cathodic protection jacket. No conduit will be required on the portion of the wire inside the jacket. Inside the jacket, the wire shall be routed upward along the closest corner and positioned between the fiberglass form and the zinc mesh anode. At the top of the jacket, the wire shall be routed in conduit to the PVC connection box located immediately above the jacket. At this location, the bulk anode wire shall be connected to the zinc mesh anode wires and routed via connection to a 5/16 inch diameter stainless steel bolt to the reinforcing steel connection wire as shown in the construction drawings. No conduit will be allowed for wires running inside the cathodic protection jacket. However, temporary conduit for the purpose of routing the wire to top of the jacket may be permitted as approved by the Engineer. Bulk anode installation shall be performed prior to placement of the filling material for the cathodic protection jacket.

The Contractor shall install an electrical negative connection on each pile receiving cathodic protection. The connection shall be performed by brazing two No. 10 AWG THWN copper strand wires to different areas of reinforcing steel at the elevation shown in the construction drawings. A sufficient length of wire shall be used such that the wires can be routed to the connection box mounted on the pile without any splices. This location shall be maintained constant at every pile unless otherwise approved by the Engineer and the Cathodic Protection Specialist. The brazed part of the negative connection wire (at reinforcing steel) shall receive a coat of 100% solids, non-conductive epoxy such that no wire or brazing material will be in contact with the concrete when patching. The wire shall be brazed to a minimum length of tie of one inch. All connection lead wires shall be routed to the PVC connection box located immediately above the expanded zinc mesh CP jacket system as shown in the drawings. The negative lead shall be connected to the wire originating at the CP jacket mesh anode and to the bulk anode wire at the terminal box. Soldered electrical ring connectors shall be used for the connection. Connection between the ring connectors shall be made using stainless steel bolts, nuts, and washers. The connection shall be properly insulated after completion. Wire splices and connections insulating method and materials shall be submitted for approval prior to performing this work.

The terminal box placed above the jackets to house the anode steel connections shall be 6 inch x 6 inch x 4 inch or other suitable size with weather tight cover and shall be attached to the concrete with four stainless steel fasteners per box. All
PVC components shall be schedule 80, sunlight resistant. All hardware for the installation of the PVC conduit and terminal box shall be 316 stainless steel. Elevation of the terminal box shall be maintained constant throughout the project.

Concrete removal to expose the reinforcing ties shall be performed inside the jacket limits. Dimensions of excavation shall be kept to a minimum but not exceed 4 inch x 4 inch. Routing wires outside the excavation to the conduit system shall be performed inside the jacket to the conduit attached to the terminal connection box. The Contractor shall submit details of the intended method for this operation and material specifications for approval by the Engineer. The Contractor shall verify continuity between the connection and the ties prior to coating with epoxy.

Any connection testing discontinuous shall be repaired by the Contractor at no extra cost. After connection is approved, the excavation shall be filled with an approved mortar prior to the jacket installation. Prior to installing the jackets, the Contractor shall perform an electrical continuity test between all strands, ties, and dowel bars (if present) on all the piles receiving cathodic protection. The Contractor shall certify such tests correct and detailed report shall be provided to the Engineer at the end of the project.

Strands and dowels for continuity test shall be exposed by drilling a ¾ inch diameter hole to each strand and/or dowel in the concrete and measuring inter-strand (or dowel) voltage using a high impedance voltmeter. Drill holes in a staggered pattern within the limits of the jacket. Use existing exposed steel for continuity testing when possible. Some additional chipping may be necessary to expose the dowels. Where continuity correction is required, additional concrete excavation will be necessary. Size of continuity correction excavation shall be maintained at the minimum required to expose the discontinuities to a continuous adjacent strand as shown in the construction plans or as approved by the Engineer based on the minimal concrete removal alternative. On piles where discontinuous strands are found on two or more faces of the pile, saw-cut a 3-inch wide groove at an elevation of no less than six inches below the top of the jacket. Continuity shall then be provided to all strands inside the groove. Any hole and/or concrete removal for continuity testing shall be filled with an approved concrete repair mortar prior to placing the jackets. Special care shall be observed to avoid damage to any of the strands or ties during the drilling or saw cutting operation.

Continuity shall be provided by brazing, metallizing or welding two continuous solid steel wires to each strand requiring continuity correction inside the excavation. Continuity shall be re-tested on all strands after this operation is completed. All connections shall be approved by the Engineer. Continuity connections shall receive a coat of 100% solids, non-conductive epoxy such that no wire in contact with the concrete when patching. Intended equipment and procedure for continuity corrections shall be included and submitted for approval in the shop drawings prior to performing this work.

4. **Measurement.** This Item will be measured by the unit (Each)
5. **Payment.** The work performed and the materials furnished in accordance with this Item and provided under “Measurement” will be paid for at the unit price bid “Sacrificial Cathodic Protection Pile Jacket”. This shall be full compensation for furnishing installation of Portland cement grout filler, surface preparation, removal of unsound concrete, removal of all residue or marine growth on the surface of the piles at the elevations where cathodic protection will be installed, installation of fiber glass forms and cathodic protection, continuity tests and corrections, anode to steel connections, electrical work, initial energizing report, spall size and location report and all other incidentals necessary to make the cathodic protection system operate as designed.