SPECIAL SPECIFICATION

4533

Sacrificial Cathodic Protection Jacket

1. **Description.** Furnish, install, and energize a sacrificial anode cathodic protection system, including connection to the reinforcing steel, materials, testing and ensuring continuity between all embedded steel components on designated prestressed concrete piling and other reinforced concrete members of the Nueces Bay Causeway in accordance with the details on shown on the plans and this Item.

The sacrificial cathodic protection system consists of expanded zinc mesh anodes suspended inside integral pile and column jackets and installed at the locations and elevations shown on the plans. It also includes bulk zinc anodes installed at the location and elevations shown on the plans.

2. **Qualifications.** Secure the services of a qualified individual to offer instruction and train the personnel to insure the Cathodic Protection System is properly installed for the first eight pile jacket installations and to perform follow-up testing. Submit the individual’s name and qualifications to the Engineer for approval. As a minimum, the individual must be either an independent specialist with a National Association of Corrosion Engineers (NACE) with cathodic protection specialist (CPS) certification or an independent Licensed Professional Engineer proficient in cathodic protection of steel in concrete. The specialist’s/Engineer’s services must include, at a minimum (but be not limited to), the following:

   A. Review and endorse shop plan submittal including detailed drawings and installation procedures of the zinc mesh integral pile packets with bulk zinc anodes.
   B. Train personnel on testing and installation of cathodic protection system.
   C. Conduct strand continuity tests and certify results of the first eight installations of the zinc mesh integral pile jackets with bulk zinc anodes.
   D. Verify and certify effectiveness of negative connections for the first eight installations.
   E. Re-train personnel as directed by the Engineer when needed.
   F. Near the completion of the project, perform the following test on forty cathodically protected piling on twenty different bents as directed and present findings in a written report:
      - Electrical continuity between elements
      - Current output
      - Polarization decay & polarization development
3. **Materials.** Provide materials meeting the following physical property requirements:

**A. Exterior Form.**

Provide forms 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 or column. 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 installation, 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 column/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.

Provide jacket forms meeting the following:

(a) Water absorption (ASTM DS70) – one percent max.
(b) Ultimate Tensile Strength (ASTM D638) – 9 ksi min.
(c) Flexural Strength (ASTM D796) – 16 ksi min.
(d) Flexural Modulus of Elasticity (ASTM D790) – 700 ksi min.
(e) IZOD Impact (ASTM D256) – 15 lb/inch min.
(f) Barcol Hardness (ASTM D2583) 45 min.

Provide form jackets with a minimum number of pumping ports to accomplish complete filling of annual space without damaging jacket by excessive pressure. Replace or repair by approved method any cracked or damaged form jackets.

**B. Fill Material.** Submit mix design and testing results for filler material meeting the following:

Filler material for non-structural jackets Portland cement grout filler material shall consist of a mixture of portland cement, fine aggregate, water and approved admixtures. The use of fly ash, slag, or silica fume in the mix is not allowed for this mix.
Provide a workable mix containing 1000 lbs. of cement, fine aggregate (sand), potable water, and necessary non-chloride admixtures per cubic yard in accordance with Item 421, “Hydraulic Cement Concrete”. A minimum 28-day compressive strength of 5,000 psi is required per ASTM C109, “Standard Test Method for Compressive Strength of Hydraulic Cement Mortars”.

Provide three 3-in. x 6-in. cylinders for each day’s placement of grout fill material.

C. Zinc Mesh Anode.

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 0.003% wt. max.
(b) Fe 0.001% wt. max.
(c) Cd 0.003% wt. max.
(d) Cu 0.7 – 0.9 % wt. max.
(e) Al 0.001 % wt. max.
(f) Ti 0.001% wt. max.
(g) Zn balance

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

(a) Electrical conductivity = 28 % min.
(b) Solid zinc density = 0.28 lb/in^3 min.
(c) Weight of expanded mesh = 1.60 lb/ft^2 min.
(d) Open area of expanded mesh = 53 % (density)
(e) Solid zinc sheet thickness = 3/32 in min.

The expanded zinc mesh anode shall allow proper mortar encapsulation with approximate dimensions (or similar as approved):

(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

D. Bulk Zinc Anode. Provide 48 lbs. min. bulk zinc anode of 99% pure zinc anode (hull type anode) with a steel strap core, conforming to ASTM B-418 Type I. Fabricate steel strap with mounting holes at each end and galvanize strap with a minimum zinc thickness of 1/128 inch. Location and size of the holes as shown in the plans. Clamp the anode 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.

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

Provide the necessary equipment to expose the steel in the piling as required to perform the testing.
The Contractor shall provide safe access for the Engineer and inspection personnel to inspect all aspects of the construction. The Contractor shall supply to the Engineer the required test equipment, multi-purpose voltmeter, if the specialist is not retained for the installation of all pile jackets.

Prior to commencing the cathodic protection installation, 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.

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, in accordance with Item 429, “Concrete Structure Repair.”

Inspect and identify all piles and columns and locate all deteriorated concrete areas on the supports 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 repair and protection as required. Dimensions of the spalled areas shall be recorded by the Contractor and verified by the Engineer.

Perform the following surface preparation for surfaces to be encased:

Ensure that all exposed steel is cleaned to a white metal condition and all debris removed from spalled areas and all other concrete surfaces within the jacket limits by sandblasting prior to installing the protective 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.

Mechanical scrape and water blast to remove all marine growth from the area below water to receive the protective jacket.

Remove all residue or marine growth on the surface of the columns and piles at the elevation where the cathodic protection jackets will be installed. Additionally, remove the marine growth from the supports to the extent necessary to facilitate the installation of the bulk anode. Propose method for cleaning and debris removal to the Engineer for approval.

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 supports 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 concrete deficiency and/or avoid the various structural members at specific locations.
Pump filling material into from the bottom. Continue pumping after initial filling until no water is present at the highest discharge point of the jacket and a uniform grout consistency is achieved.

After the filling material has cured for a minimum 72 hours, all temporary form supports and/or bracing shall be removed, 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. 6 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. 6 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 ¼ 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 ¼ 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 stainless steel conforming to ASTM A-555 and F-593.

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 structural supports 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 or columns where discontinuous strands are found on two or more faces, 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. Where cathodic protection jackets are placed adjacent to zinc spray cathodic protection systems, additionally connect the embedded zinc mesh to the zinc spray connection plate by No. 6 AWG copper strand wire with HMWPE insulation.

5. **Measurement.** This Item will be measured by the each unit of Sacrificial Cathodic Protection Jacket and Bulk Zinc Anode.

6. **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 for “Sacrificial Cathodic Protection Jacket” and “Bulk Zinc Anode”. This shall be full compensation for furnishing all materials, providing access for inspection, surface preparation, removal of unsound concrete, removal of all residue or marine growth on the surface of the concrete at the elevations where cathodic protection will be installed, installation of forms and cathodic protection, filling annular space with portland cement grout filler, securing and attaching bulk zinc anode, continuity tests and corrections, anode to steel connections, electrical work, initial energizing report, securing services of cathodic protection specialist, follow-up testing, and all other incidentals necessary to make the cathodic protection system operate as designed.