Special Specification 4037
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 in accordance with the details 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:

- Review and endorse shop plan submittal including detailed drawings and installation procedures of the zinc mesh integral pile packets with bulk zinc anodes.
- Train personnel on testing and installation of cathodic protection system.
- Verify and certify effectiveness of negative connections for the first two installations.
- Re-train personnel as directed by the Engineer when needed.
- Near the completion of the project, perform the following test on cathodically protected members as directed and present findings in a written report:
  - Electrical continuity between elements;
  - Current output; and
  - Polarization decay & polarization development.
- Test 10 existing pile jackets for:
  - Current output; and
  - Polarization decay and polarization development.

3. MATERIALS

Provide materials meeting the following physical property requirements:

3.1. **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. Epoxy seal joints and holes for stand-offs. Fabricated forms from fiberglass and polyester resins. The form dimensions shown in the plans are minimum dimensions permitted. The Engineer may approve minor variations. Use forms with a minimum thickness of 1/8 in. Upon installation, use watertight forms 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.

Use jacket forms such that the inside face has no bond inhibiting agents in contact with the cement grout or the mesh anode. Provide forms with bonded on or bolted on, nonmetallic standoffs, which will maintain the forms in the required position. Sandblast or score the inside surface of the form with an abrasive material to provide a texture equal to a sandblasted surface. Prepare the inside at the factory.

Use watertight forms, 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. Use sealing strip 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:

- Water absorption (ASTM DS70) – 1% Max
- Ultimate Tensile Strength (ASTM D638) – 9 ksi Min
- Flexural Strength (ASTM D796) – 16 ksi Min
- Flexural Modulus of Elasticity (ASTM D790) – 700 ksi Min
- IZOD Impact (ASTM D256) – 15 lb./in. Min
- 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.

3.2. **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 will 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.

3.3. **Zinc Mesh Anode**. The zinc mesh anode attached inside the jacket will be an expanded zinc mesh conforming to ASTM A-190 with the following metal composition:

- Pb 0.003% wt. Max
- Fe 0.001% wt. Max
- Cd 0.003% wt. Max
- Cu 0.7 – 0.9% wt. Max
- Al 0.001% wt. Max
- Ti 0.001% wt. Max
- Zn balance

Additionally, use mesh anode with the following physical properties:

- Electrical conductivity = 28% Min
- Solid zinc density = 0.28 lb. per cu. in. Min
- Weight of expanded mesh = 1.60 psf Min
- Open area of expanded mesh = 53% (density)
- Solid zinc sheet thickness = 3/32 in. Min

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

- 1/2 in. Hex pattern
- 1/8 in. Strand width in the short direction
- 9/16 in. Strand width in the long direction
- 5/16 in. Short opening
- 3/4 in. Long opening

3.4. **Bulk Zinc Anode**. Provide 48 lbs. minimum 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 in. Location and size of the holes as shown in the plans. Clamp the anode onto the pile using two 2 in. galvanized steel channels with the flanged side facing the concrete surface (as shown in the plans) using galvanized hardware.

4. CONSTRUCTION

Provide continuity of the prestressing steel, dowel bars, and ties by brazing, metallizing or other approved method.

4.1. **Existing Jacket Removal**. Remove existing pile jacket as directed. Notify engineer prior to removal. Obtain the services of a CPS to witness condition of various components of Cathodic Protection Jacket system during removal.

4.2. **Cathodic Protection Jacket Installation.** Provide the necessary equipment to expose the steel in the piling as required to perform the testing.

Provide safe access for the Engineer and inspection personnel to inspect all aspects of the construction. Supply to the Engineer the required test equipment and 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. Sound test areas to receive jackets and the surrounding concrete surfaces 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 will 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. Do not leave exposed steel unprotected for a period greater than 96 hr. after sandblasting. Wash down clean pile surfaces 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.

Provide the expanded mesh anode with a connection wire that extends a minimum of 9 in. above the top of the jacket to perform the connection to the reinforcing steel inside the system connection box as shown in the plans.

Install the Cathodic Protection Jackets 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 hr., remove all temporary form supports and/or bracing, and clean the exterior of the form of any filling material which may have been deposited. Slope the top of the filling material as shown in the construction drawings.

Place the bulk anode 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, excavate around the pile to provide the proper elevation unless otherwise directed by the Engineer. Restore excavation to original profile after completing the system installation. The Contractor is responsible for any necessary surveying work to determine the correct elevation on each pile.

Connect a No. 6 AWG copper strand wire with HMWPE insulation to the anode via a 3/8 in. diameter round steel bar welded to the anode strap. Braze the No. 6 AWG wire to the bar, and permanently encase the bar-wire connection in a 1-1/4 in. diameter by 8 in. long PVC pipe filled with epoxy. Rout the remaining wire to the jacket inside a 3/4 in. diameter PVC pipe. Do all required fabrication prior to the anode installation. Protect the wire insulation from heat during the welding and brazing operation. Special precautions may be necessary to protect the wiring insulation and splice during anode installation. Extend the 3/4 in. pipe to an elevation of approximately 2 in. inside the bottom of the cathodic protection jacket. No conduit is required on the portion of the wire inside the jacket. Inside the jacket, rout the wire upward along the closest corner and position between the fiberglass form and the zinc mesh anode. At the top of the jacket, rout the wire in conduit to the PVC connection box located immediately above the jacket. At this location, connect the bulk anode wire to the zinc mesh anode wires and routed via connection to a 5/16 in. 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. Perform bulk anode installation prior to placement of the filling material for the cathodic protection jacket.

Install an electrical negative connection on each pile receiving cathodic protection. Perform the connection by brazing two No. 10 AWG THWN copper strand wires to different areas of reinforcing steel at the elevation shown in the construction drawings. Use a sufficient length of wire such that the wires can be routed to the connection box mounted on the pile without any splices. Maintain this constant location 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) will receive a coat of 100% solids, non-conductive epoxy such that no wire or brazing material is in contact with the concrete when patching. Braze the wire to a minimum length of tie of one inch. Route all connection lead wires to the PVC connection box located immediately above the expanded zinc mesh CP jacket system as shown in the drawings.

Connect the negative lead to the wire originating at the CP jacket mesh anode and to the bulk anode wire at the terminal box. Use soldered electrical ring connectors for the connection. Use stainless steel bolts, nuts, and washers as the connection between the ring connectors. Properly insulate the connection after

completion. Submit wire splices and connections insulating method and materials for approval prior to performing this work.

The terminal box placed above the jackets to house the anode steel connections will be 6 in. x 6 in. x 4 in. or other suitable size with weather tight cover and will be attached to the concrete with four stainless steel fasteners per box. Use schedule 80, sunlight resistant, PVC components. Use stainless steel hardware for the installation of the PVC conduit and terminal box conforming to ASTM A-555 and F-593.

Perform concrete removal inside the jacket limits to expose the reinforcing ties. Keep dimensions of excavation to a minimum but do not exceed 4 in. x 4 in. Routing wires outside the excavation to the conduit system will be performed inside the jacket to the conduit attached to the terminal connection box. Submit details of the intended method for this operation and material specifications for approval by the Engineer. Verify continuity between the connection and the ties prior to coating with epoxy.

Repair any connection testing discontinuities at no extra cost. After connection is approved, fill the excavation with an approved mortar prior to the jacket installation. Prior to installing the jackets, perform an electrical continuity test between all strands, ties, and dowel bars (if present) on all the structural supports receiving cathodic protection. Certify such tests correct and provide a detailed report to the Engineer at the end of the project.

Expose strands and dowels for continuity test by drilling a 3/4 in. 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. Maintain size of continuity correction excavation 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 in. wide groove at an elevation of no less than six inches below the top of the jacket. Provide continuity to all strands inside the groove. Fill any hole or concrete removal for continuity testing with an approved concrete repair mortar prior to placing the jackets. Take special care to avoid damage to any of the strands or ties during the drilling or saw cutting operation.

Provide continuity by brazing, metallizing or welding two continuous solid steel wires to each strand requiring continuity correction inside the excavation. Re-test continuity on all strands after this operation is completed. The Engineer will approve all connections. Coat continuity connections with 100% solids, non-conductive epoxy such that no wire comes in contact with the concrete when patching.

Include and submit intended equipment and procedure for continuity corrections 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 each unit of Sacrificial Cathodic Protection Jacket, Bulk Zinc Anode, Remove Existing Jacket, and Test Existing Jacket System.

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," "Bulk Zinc Anode," "Remove Existing Jacket," and "Test Existing Jacket System." This will 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.