SECTION T457
GALVANIC CATHODIC PROTECTION JACKETS

T457-1 Description.

 **T457-1.1:** Furnish, fabricate, and install a galvanic cathodic protection integral pile and column jacket per the Contract Documents.

Refer to the Contract Documents for all cathodic protection (CP) and structural reinforcing steel details and requirements.

 **T457-1.2 Cathodic Protection:** Per the Contract Documents, CP pile jacket systems shall consist of embedded zinc anode(s) of expanded zinc mesh anodes pre-installed against the inside face of the fiberglass pile jacket forms. The Engineer or CP Specialist (CPS) can propose a system that uses as many bulk anodes as necessary to meet the Association for Materials Protection and Performance (AMPP) standards installed on each pile, receiving a CP jacket at a minimum elevation of two feet below the jacket system, or as the depth of water will allow providing full immersion of the bulk zinc anode at all times. Ensure that the ends of CP system wires with exposed copper are kept out of the water at all times, except when making negative connections to reinforcing steel underwater. Provide all necessary surveying to determine the specified elevations.

 **T457-1.3 Jacket Location and Length:** Install pile jacket to cover a minimum of two feet above and two feet below the major deficient area on the pile. In the case of damage all the way to the cap, terminate the jacket 4 inches from the cap to allow for proper filling of the annular space and bevel placement. Obtain the Engineer’s approval when a jacket needs to terminate at the bottom of the cap. The actual length of the jacket may be extended if a major deficiency of the pile extends beyond the limits shown in the Contract Documents, as determined by the Engineer. Immediately notify the Engineer if the above conditions are discovered prior to ordering the jackets. The minimum jacket length shown in the Contract Documents shall be maintained. The Engineer shall determine if the pile jacket length should be increased. Minor deficiencies will be repaired outside the pile jacket limits as directed by the Engineer.

Additional payment for increased pile jacket lengths will be given based on the pay items described in this Section.

 **T457-1.4 Incidental Work:** Excavation at the mud line may be necessary to install the jacket systems and is considered incidental work. Restore any excavation work at the mud line back to existing, as-found conditions immediately after the jacket system installation work is completed at each pile.

T457-2 Materials.

 **T457-2.1 Stay-In-Place Forms:** Use forms fabricated from fiberglass or carbon fibers and polyester or vinyl ester resins with an interlocking joint along one or two sides that permit the form to be assembled and sealed around the pile or column without damage to the system.. Provide jackets with a minimum thickness of 1/8 inch and a minimum thickness at the corners of 1/4 inch extending a minimum of 2 inches on both sides of the corner, and dimensions as shown in the Contract Documents. Ensure the form can maintain its original shape without additional support or damage when placed around a pile. Ensure the inside face of the form has no bond‑inhibiting agents in contact with the filler material. Provide the forms with bonded or bolted-on, non-metallic, adjustable standoffs to maintain the forms in the required positions. Sandblast or score the inside surface of the forms with an abrasive material to provide a rough surface texture and ensure a bond with the filler material. The Contractor shall install the forms with a temporary compressible sealing strip at the bottom which will effectively seal the annular space between the pile or column and the form. Non-metallic pumping ports shall be pre-installed on opposite faces of the jacket to ensure a monolithic fill with no voids or honeycombing. Fabricate the jacket form in a workmanlike manner and have it inspected and approved by the Engineer prior to placement. Remove from the project any jacket form that has been rejected.

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| The forms shall meet the following physical property requirements of Table T457-1:

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| Table T457-1Physical Requirements of Stay-In-Place Forms |
| Property | Threshold |
| Water Absorption (ASTM D 570)\* | 1% maximum |
| Ultimate Tensile Strength (ASTM D 638)\* | 9,000 psi minimum |
| Flexural Strength (ASTM D 790)\* | 16,000 psi minimum |
| Modulus of Elasticity (ASTM D 790) | 700,000 psi minimum |
| IZOD Impact (ASTM D 256) | 15 pounds/inch minimum (unnotched specimen) |
| Barcol Hardness (ASTM D 2583) | 45 minimum number |
| Color | AMS Standard Color Chart Number 595A, AMS-STD 36373AMS-STD 36440AMS-STD 36463AMS-STD 36473AMS-STD 36492AMS-STD 36495AMS-STD 36559AMS-STD 36595AMS-STD 36622AMS-STD 36628 The color must be integral in the form gel coat. |

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| \* On original specimens whose flat surfaces are not machined to disturb the fiberglass. |

**T457-2.2 Anode Material:** Use expanded zinc mesh anodes pre-installed to the inside face of the form by the manufacturer. Use the anode type and configuration shown in the Contract Documents. Place the anodes in direct contact with the inside face of the form.

 The zinc mesh anode attached inside the pile jacket shall be an approved expanded zinc mesh with at least 98.0% zinc composition. Provide a mill certificate for the zinc mesh used in the jacket, listing the compositional elements and their percent by weight.

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

 Electrical conductivity = 28% minimum (in relation to copper)

 Solid zinc density = minimum of 0.26 pound per cubic inch

 Weight of expanded mesh = Mesh area times 1.6 pounds per square foot minimum

 Open area of expanded mesh = 53% (density)

 Solid zinc sheet thickness = 3/32 inch

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

 0.500 inch hexagonal pattern

 0.125 inch strand width in the short direction

 0.500 inch strand width in the long direction

 0.320 inch short opening

 0.750 inch long opening

 Provide an expanded zinc mesh anode with pre-installed connection wires, which shall extend to the designated connection box location as shown in the Contract Documents without splices.

 An anode manufacturer representative must be available for consultation with the Contractor or Engineer. The manufacturer representative must be available for field visits as needed.

 **T457-2.3 Bulk Zinc Anode:** Each bulk zinc anode shall be a 50-pound (nominal), 99% pure zinc (hull type) anode with a cast-in steel strap core conforming to ASTM B-418. The steel strap core shall be hot dip galvanized with sufficient thickness to be bolted or welded to the supporting channel. Holes at each end of the strap for mounting shall be pre-drilled prior to hot dip galvanizing and casting the anodes.

 **T457-2.4 Hardware:** All metal hardware for conduit, accessories, terminal boxes, and electrical connections shall be corrosion-resistant and provide service life compatible with the CP system.

 **T457-2.5 Portland Cement Concrete:** Meet the following requirements:

Coarse Aggregate............................................................Section 901

Fine Aggregate\*…..........................................................Section 902

Portland Cement and Blended Cement...........................Section 921

Water……………….......................................................Section 923

Admixtures \*\*……………….………………................Section 924

\*Use only silica sand, except as provided in Section 902.

\*\*Use products listed on the Department’s Approved Products List (APL) that contain no chlorides or other salts that are corrosive to metals.

 Do not use materials containing hard lumps, crusts, frozen matter, or contaminated with materials exceeding the specified limits in the above-listed Sections.

 Use a mix design with 28-day specified minimum compressive strength of 5,500 psi, a maximum surface resistivity of 15 kΩcm at 28 days, and a target slump of 7 to 9 inches ± 1.5 inches. Use a reduced-size coarse aggregate. Do not use mixes with fly ash, slag, or silica fume.

 **T457-2.6 Reinforcing Steel:** Use reinforcing steel meeting the requirements of Section 415 for all structural jackets, except when non-metallic reinforcement is specified.

 **T457-2.7 Reference Electrode:** Provide permanent silver/silver chloride (Ag/Ag Cl) electrodes manufactured to measure the potential of reinforcing steel in concrete compatible with CP. The electrode shall have a manufacturer-estimated service life of no less than 25 years and a maximum drift of no more than ± 3 mV in 24 hours. The electrode shall be provided with a steel ground wire for connection to the reinforcement at the location of the electrode. Ground and electrode wires shall be sufficient to extend to the connection box outside the jacket.

T457-3 Materials Certification and Testing.

 **T457-3.1 Certification:** Submit certified test results of the chemical composition of the zinc mesh and bulk zinc anodes. Submit a manufacturer certification stating that the dimensions and physical characteristics of the zinc mesh anode meet the Contract Document requirements prior to the delivery of CP jackets.

 No test report for tests made more than two years prior to shipment will be accepted for the fiberglass jacket form and anode materials.

 **T457-3.2 Sampling and Testing of Jacket Filler Materials:** Sample and test materials following the requirements for concrete in Section 346. Perform sampling and testing using Quality Control (QC) technicians meeting the requirements of Section 105. Conduct tests at a frequency of one set of tests per LOT. The maximum LOT size for concrete materials is 50 cubic yards or one day’s production, whichever is less.

 Conduct a field demonstration of the mixing operations prior to commencing the jacket installation.

T457-4 Quality Assurance (QA) / Quality Control (QC).

 **T457-4.1 QA:** Secure the services of a Cathodic Protection Specialist (CPS) having one or more of the following qualifications:

 1. Association for Materials Protection and Performance (AMPP) certification in cathodic protection accredited CP-4.

 2. A Florida registered Professional Engineer with a minimum of five years of verifiable experience designing, installing and testing galvanic CP systems to protect steel reinforced concrete structures.

 3. A corrosion engineering practitioner with at least 10 years of verifiable experience installing and testing galvanic CP systems to protect reinforced concrete structures.

 The qualifying candidate shall have performed (QC) and performance testing of galvanic CP systems for concrete structures in a minimum of three projects within the past five years.

 The CPS shall be an independent entity and shall not be an employee or affiliated in any way with the Contractor, the Contractor’s organization or operation, a project subcontractor, the anode distributor or manufacturer, or their representative.

 Submit in writing the qualifications and experience records of the individual selected for the Engineer’s approval. Acceptance of the CPS shall be subject to the approval of the Engineer.

 No CP work will be allowed if, at any time, an approved CPS is not active or otherwise involved in the project.

 **T457-4.1.1 Cathodic Protection Technician (CPT):** An AMPP-certified CPT with a minimum of five verifiable project experiences in the last five years in CP may perform field measurements on behalf of the CPS. Submit, in writing, the qualifications of the individual satisfying these requirements for the Engineer’s approval. Acceptance of the CPT shall be subject to the approval of the Engineer.

 Submitted experience from the CPT shall include projects in which the CPT was performed QA/QC of CP systems installation and monitoring. Each project reference shall include the project name, scope of work, dates performed, and project reference with contact information. All project references must be regarding the CP of steel reinforced concrete structures.

 **T457-4.2 Quality Control:** Include the work under this Section in the Contractor (QC) General Requirements set forth in Section 105 of the FDOT Specification. The portion of the QC plan covering the cathodic protection jacket installation shall be reviewed and approved by the CPS and submitted to the Department for approval prior to commencing the CP system installation.

 The QC Plan covering the CP work shall describe tasks to be executed by the Contractor as well as those to be executed by the CPS, including, but not limited to, method and frequency of QC testing, methods of measuring electrical continuity, methods for locating existing steel for continuity testing, details regarding all electrical continuity testing to be performed, anode installation testing, alternating current (AC) resistance measurements, anode current output measurements, rebar potential measurements, and activation procedure. It is recommended that the Contractor discusses the intended installation schedule with the CPS prior to preparing his bid to ensure that the Contractor’s schedule is consistent with the plan.

 **T457-4.3 QA Tasks:** The CPS shall conduct the following QA tasks as a minimum:

 1. Review all CP-related submittals before they are submitted to the Department for approval.

 2. Inspect all CP system materials and personally supervise every phase of the installation of the CP systems.

 3. Perform all the continuity testing, inspect, and test all the continuity corrections, inspect and test all negative connections, inspect all CP system wiring and wire connections, and perform the initial energizing on all of the piles, including anode-cathode AC resistance measurements, anode current output measurements and static and energized reinforcing steel potential measurements (on and instant-off a minimum of four hours after the CP systems are initially activated).

 4. Conduct a minimum of two QA visits to the job site per month and update the Engineer directly (verbally and in writing) on the status and quality of the work.

 5. Test for electrical shorts between the anode and all steel components in the piles and notify the Engineer and the Contractor for correction as necessary. Also, continuously monitor the development of electrical shorts while filler material is placed into the jackets.

T457-5 Cathodic Protection Report (CP Report).

 **T457-5.1 CP Report:** Submit an original final construction report produced by the CPS for the CP system to the Department after the completion of the project. The report shall describe the general characteristics of the CP systems, installation sequence, and all test data collected during the project, including, but not limited to, continuity testing and corrections (for existing steel reinforcement, new steel reinforcement, and all negative connections), anode to steel AC resistances, anode current outputs, and static and energized potentials (on and instant-off a minimum of four hours after the CP systems are initially activated) for each CP system. Measure potentials with a portable Ag/Ag Cl reference electrode placed in the water and the monitoring access port. The report and all collected data shall be typed and a digital version of the report shall be provided. The report shall include the following statement signed and notarized by the CPS:

 “I hereby certify that the cathodic protection work and facilities constructed under Financial Project Number xxxxxx-x-xx-xx has been completed and is functionally complete. I further certify that construction proceeded substantially per the Contract Documents or that any deviations noted below will not prevent the system from functioning in compliance with the intent of the Contract Documents when properly operated and maintained. These determinations are based upon my on-site observation of construction, scheduled and conducted by a project representative under my direct supervision or me, to determine if the work proceeded in compliance with the Contract Documents.”

Submit the report for approval:

State Materials Office (SMO)

Corrosion and Materials Durability

Field Operations

5007 NE 39th Avenue
Gainesville, Florida 32609
sm-corrosionfieldops@dot.state.fl.us

T457-6 Preparation.

 **T457-6.1 Inspection/Report:** Inspect all piles and locate all deteriorated concrete on the pilings where jacket systems are to be installed prior to ordering the jackets. Clean the concrete element within jacket limits prior to inspection. If deterioration extends beyond jacket limits, continue cleaning until sound pile concrete is reached. Sound test areas to receive jackets and the surrounding concrete surfaces to determine the actual dimensions and locations of the deteriorated concrete to be removed. Verify that the specified jacket lengths will encompass all major cracked, delaminated, and spalled areas. Remove all cracked, delaminated, or otherwise damaged concrete. Before ordering jackets, the dimensions of all deficiencies (e.g., deteriorated or damaged concrete) shall be recorded, verified, and approved by the Engineer.

 The Department reserves the right to add or delete piling repair and protection, as needed.

 Provide a final report detailing locations and sizes of cracks, delamination, and spalls at the end of the project as an addendum to the CPS report.

 **T457-6.2 Forms, Construction Methods, and Materials:** Submit shop drawings, manufacturer’s drawings, and certifications to the CPS and SMO prior to ordering the jackets and commencing the jacket installation for approval indicating form design, filling mix and other materials and procedures for construction. Include all details for equipment, materials, and procedures for the jacket and bulk zinc anode installations, negative connections to the reinforcing steel, reinforcing steel cages (including dowels), all continuity testing and correction work for the reinforcing steel, anode system shop fabrication including bulk anode and related hardware and expanded zinc mesh anode jackets.

 Submit chemical composition and technical data sheet for the zinc mesh anode and the bulk zinc anode prior to ordering materials for approval by the SMO.

 **T457-6.3 Surface Preparation:** Provide surface preparation by hydro demolition or mechanically removing all unsound concrete within the repair area to sound concrete. Chip back unsound concrete to sound concrete. Provide surfaces sound, clean, and free of contaminants in all areas. Remove all delaminated, cracked, and unsound concrete from the areas that are hollow sounding when tested or areas with visible cracks. Additionally, sound concrete will require removal to obtain the ¾ inch to 1 inch behind the existing reinforcing steel to achieve a mechanical bond. Use a 15-pound chipping hammer (maximum size) to remove the spalled and behind bars concrete unless otherwise approved by the Engineer. Thoroughly clean all element surfaces that the jackets will cover. Remove all oil, grease, dirt, broken concrete, marine growth, and other deleterious material that could prevent proper bonding. Chip concrete substrate to obtain a surface profile of 1/16 inch to ⅛ inch in depth with a new fractured aggregate surface. Sandblast exposed steel to a near white condition per The Society for Protective Coatings (SSPC) report number 10 (SP 10). No rust, mill scale, epoxy, or other contaminants shall be present after sandblasting or similar or mechanical cleaning approved by the Engineer. Special attention shall be observed to ensure proper cleaning and preparation of the backside of exposed reinforcement. Add new rebars where reinforcement with over 25% of cross-section loss is determined as indicated in the Plans. Exposed steel above and under water shall not be unprotected for more than 72 hours after cleaning.

 Exercise great care to prevent damage to reinforcing steel and sound concrete not intended for removal. Stop work and submit to the Engineer the report of the concrete and reinforcing steel damages due to the Contractor’s operation. Submit a repair method for the damaged area(s) for the Engineer’s approval prior to continuing the concrete removal and restoration work.

 Clean existing concrete surfaces by media blasting, wet blasting, wire brushing, water laser, or other methods approved by the Engineer, which will yield an equivalent result. Cleaned pile surfaces above water shall be washed down with fresh water immediately prior to jacket installation. Do not place the form until the Engineer has approved the surface preparation.T457-7 Negative Connections: Install redundant electrical negative connections on each pile where CP systems are to be installed. The connections shall be performed by brazing two number 10 AWG THNN copper strand wires with black insulation to different areas of a spiral tie at the elevation shown in the Contract Documents for the existing piles. Connect two number 10 AWG THNN copper strand wires with white insulation to two different bars and any supplementary reinforcement for each cage reinforcing when Section 415 reinforcement is used. Use sufficient lengths of wire such that the wires can be routed to the connection box, mounted at locations shown in the Contract Documents, without any splices.

 The brazed part of the negative connection wires at the ties and reinforcing steel shall receive a coat of 100% solids, non-conductive epoxy, such that no exposed copper or brazing material will be in contact with the concrete when patching or filling. Braze each wire to a minimum length of 1 inch onto the ties or reinforcing steel.

 For connections located underwater, braze the system negative wires to steel tabs and then weld underwater to a spiral or provide a mechanical connection device approved by the Engineer.

 Route all connection lead wires to the terminal box as shown in the Contract Documents. Connect the negative leads to the wires originating at the CP jacket mesh anode and the bulk anode wire at the terminal box. Use connectors as shown in the Contract Documents for all wire connections. The connection between the connectors shall be made as shown in the Contract Documents. After completion, properly insulate all connections with a heat shrink connector.

 The terminal box placed above the jackets to house the anode to steel connections shall be per Contract Documents. Each terminal box shall have a weather-tight cover. Box cover screws shall be Type 316 Stainless Steel. Use Schedule 80, sunlight-resistant PVC, for all PVC components as applicable. Fabricate the terminal box to accept 1/4-inch diameter Type 316 Stainless Steel bolts which will connect the system wires inside the box, as shown in the Contract Documents. Use Type 316 Stainless Steel hardware to install PVC conduit and connection boxes. The location of the connection boxes shall be as shown in the Contract Documents.

 Perform the concrete excavation to expose the spiral tie inside the upper jacket limits and, when possible, at a minimum of 5 feet above the Mean High Water Elevation Level (MHWEL). Route the connection wires inside the jacket to the connection box via the conduit attached to the connection box. Submit details of the intended method for this operation and material specifications for approval by the Engineer.

T457-7 Continuity Reporting.

 **T457-7.1 Continuity Testing and Corrections:** Perform continuity testing using standard Direct Current (DC) resistance with normal and reverse polarity, DC millivolt difference test methods, and a high-impedance multi-meter.

The CPS or CPT under their direction shall verify continuity between the system’s negative connections and the spiral tie prior to coating with epoxy. Repair any connection that tests discontinuous or is otherwise found deficient at no additional cost. After a connection is deemed satisfactory by the CPS or CPT, cover the correction area with epoxy and fill the excavation with an approved filler. Use an approved epoxy mortar if the excavation is located underwater. Connections above water shall be exposed for 14 days at maximum, and connections underwater shall be exposed for at most 3 days.

 Prior to installing the jackets, the CPS or CPT shall perform an electrical continuity test between all pre-stressing strands, ties, reinforcing steel, dowels, and any other reinforcing steel components inside the piles and within the jacket limits on all of the piles where CP systems are to be installed. On piles where a pile splice is detected before, during, or after surface preparation, continuity shall be tested and provided between both pile sections if found discontinuous.

 Continuity tests and any necessary continuity corrections testing shall be performed and certified correct by the CPS. The CPS or CPT shall perform continuity tests prior to removing any concrete for continuity corrections. Steel to be tested that is not exposed after the concrete removal process is completed shall be exposed for testing purposes by drilling a ¾-inch diameter hole in the concrete to the depth of the steel. Stagger drilled holes at one-foot intervals within the jacket limits. Request the Engineer’s approval for drilled hole elevations less than two feet above the MHWEL per the CPS recommendation.

 Due to the elevation on some of the piles, continuity checks, corrections, and negative connection installations will need to be performed underwater. Include details for performing the underwater testing and work in the QC Plan.

 Install continuity corrections on all steel components that are found to be discontinuous. Provide continuity corrections by resistance welding or other approved method(s). Intended equipment and procedures to install continuity corrections shall be included and submitted for approval in the shop drawings prior to performing this work. Each continuity correction shall consist of welding two continuous solid steel wires with no insulation between discontinuous steel and the nearest continuous steel. Determine the proper wire gauge and the resistance welder output for this operation. Where continuity correction is required, additional concrete excavation will be necessary.

 The size of each concrete excavation made to install continuity corrections shall be as small as possible and shall be approved by the Engineer before the excavation is made. Locate all concrete excavations made to install continuity corrections within the jacket limits. Request the Engineer’s approval for excavation less than two feet above the MHWEL per the CPS recommendation. Observe care to avoid cutting steel inside the pile when drilling holes or preparing excavations. Repair any damage to the steel caused by the Contractor using materials and methods approved by the Engineer at no additional cost.

 On piles where a continuity correction is installed, the CPS or CPT shall repeat the continuity testing on all steel after the corrections are made to ensure that all steel is continuous. The Engineer shall approve all continuity correction welds. Each weld shall receive a coat of 100% solids non-conductive epoxy. Fill all drilled holes made for continuity testing purposes and all excavations made to install continuity corrections with an approved material prior to installing the jacket. Drilled holes and excavations above water shall be exposed for at most 14 days and drilled holes and excavations underwater shall be exposed for at most 3 days.

 Before coating with epoxy, the CPS shall verify the continuity between the negative connections and the new reinforcing steel inside the jackets. The Contractor shall repair any connection that tests discontinuous or is otherwise found deficient at no additional cost to the Department. The CPS shall verify that negative connections on ties are discontinuous from negative connections on new reinforcing steel inside the jackets. Correct any problems identified by this testing at no additional cost. Negative connections above water shall not be left exposed longer than 14 days, and connections underwater shall not be left exposed longer than 3 days.

 For structural CP jackets with new steel reinforced cage, conduct electrical continuity testing on all new reinforcing steel bars inside the jackets. The CPS shall train Contractor personnel to conduct this electrical continuity testing. The training shall include test procedures, equipment, recording of test data, and data interpretation. Tighten existing steel tie wires and install a minimum of two additional steel tie wires on any new structural reinforcing steel that is found to be electrically discontinuous. Repeat the electrical continuity testing on all the reinforcing steel to ensure that all new reinforcing steel is continuous. Continuity test data obtained by the Contractor shall be submitted to the CPS for review and approval prior to installing jackets. The CPS or CPT shall verify electrical continuity test results on the new reinforcing steel on every pile.

T457-8 Pile Spalls outside Jacket Limits.

 Restore the concrete per Technical Special Provision T401as applicable.

T457-9 Construction.

 **T457-9.1 Shop Drawings:** Submit shop drawings and obtain approval prior to field installation. Submit shop drawings showing locations of standoff spacers, method of fastening jacket form to piling, method of sealing the form after assembly, and method for bracing during filler placement. Include details of access holes, fiberglass caps, securing anode from movement, placing the filler, and sealing the pumping ports. Show alternating pumping port elevations and locations on the manufacturer’s drawings.

 **T457-9.2 Form Placement:** Locate the MHWEL and its elevation on each pile and obtain approval of these locations from the Engineer before installing jackets and reinforcing steel based on the CPS recommendation.

 Place the fiberglass form in position around the pile. Secure and seal the interlocking joints, seal the bottom of the form against the pile surface with the compressible seal, and coat the compressible seal with an APL-listed epoxy mastic suitable for underwater application. Adjust standoffs to prevent misalignment and install temporary hard backing to prevent jacket deformation. Place a temporary plastic wrap around the form prior to placement of the hard backing to protect the gel coat.

 **T457-9.3 Bulk Zinc Anode Installation:** Provide and install a bulk zinc anode with each CP jacket or as determined appropriate by the Engineer. The bulk anode shall be placed at an angle guaranteeing the entire length of the anode is in contact with the surface of the pile or jacket and at the depth shown in the Contract Documents. Perform bulk anode installation prior to placement of the filling material for the CP jacket. Each bulk anode and associated hardware shall make up one anode assembly.

 Clamp the anode onto the pile or jacket using two 2-inch hot dip galvanized steel channels with the flanged side facing the concrete or jacket surface using galvanized hardware. Connect a number 8 AWG copper strand wire with HMWPE insulation to the anode via a 3/8-inch diameter round steel bar welded to the anode strap. The number 8 AWG wire shall be brazed to the bar, and the bar-wire connection shall be permanently encased in a 1.25-inch diameter by an 8-inch-long PVC pipe filled with epoxy. Complete all required fabrication prior to the anode installation. Protect the wire insulation from heat during the brazing operation. Special precautions may be necessary to protect the wiring insulation and splice inside the PVC pipe during anode installation.

 Connect a 1.25-inch diameter PVC pipe to a 3/4-inch PVC pipe. Extend the 3/4‑inch pipe approximately 2 inches inside the bottom of the CP jacket. No additional conduit shall be used on the portion of the wire inside the jacket. Inside the jacket, route the wire upward along the closest corner and position it between the fiberglass form and the zinc mesh anode. At the top of the jacket, route the wire in the conduit to the PVC connection box. At this location, connect the bulk anode wire to the zinc mesh anode wires and the reinforcing steel negative connection wires. A temporary conduit to route the wire to the top of the jacket may be permitted as approved by the Engineer.

 **T457-9.4 Filler Placement:** Wet to saturate the surface of the existing concrete immediately prior to placing the filler. Place the filler in one continuous pour no more than 72 hours after the final surface preparation. No cold joints shall be permitted.

 Fill the annulus between the prepared surface and jacket form following the jacket manufacturer’s instructions and the Contract Documents. Do not drop filler material into forms higher than 5 feet or forms containing water. Prevent contamination of the filler during placement and provide vibration to ensure proper consolidation. Fill the jacket to approximately 1 inch from the top during the pumping process. Prior to the fill material fully hardening, apply a 45-degree chamfer bevel that is neat, straight, and free of cracking from the top lip of the jacket. The chamfer should have the same mix design used for filling the jacket. The chamfer bevel is to provide positive drainage of the pile rainwater runoff.

 Cure the filler for a minimum of 72 hours before removing any external bracing and temporary bottom form including the compressible sealing strip. Wet cure the chamfer section of the jacket as needed to prevent any shrinkage cracks. Curing compound for this purpose may be used if the Engineer approves based on performance. Remove any filler or other extraneous material from the exterior surface of the form and clean the form without damaging the fiberglass or gel coat resin.

 **T457-9.5 Monitoring Port:** After removal of temporary supports around the jacket, core drill 1.5-inch diameter access holes through the jacket to the depth of the original pile surface on one face of the pile at an elevation of six inches above the MHWEL, or as shown on the Contract Documents. The inside surface of access holes (except for the pile surface) shall be PVC shielded with a thorough coat of approved epoxy applied on the outside surfaces of the PVC pipe. Epoxy shall not cover the pile concrete surface at the back of access holes. Once the filler material has been set, cap off all pumping ports with an approved PVC screw-on cap.

 **T457-9.6 Reference Electrode Installation:** Install one reference electrode per pile bent at the same elevation but on the opposite pile face of the monitoring port. Excavate the original pile concrete to place the electrode and fill the excavation immediately after placement of the electrode with an approved filler. Do not allow any direct contact between the electrode and the reinforcement. Braze the electrode ground wire to a nearby reinforcement and seal the brazed connection with non-conductive epoxy. Route both wires inside the jacket to the connection box above the jacket and connect them to the designated monitoring terminals in the box.

 **T457-9.7 Pumping Ports:** Place the jacket filler beginning at the bottom pumping port and moving upward to the next port as the filler reaches the next port. Complete the filler placement, moving to the next port on the opposite face of the jacket. Do not place all the filler material from one side of the jacket. Ensure that the filler material displaces any standing water inside the jacket without mixing with the filler.

 **T457-9.8 Structural Jacket Reinforcing Steel:** Install the reinforcing as shown in the Contract Documents.

T457-10 Energizing and Acceptance.

 CP system energization testing for each pile shall include verification that no electrical short exists, verification of proper continuity between negative connections, anode to steel AC resistance measurements, individual and combined anode current outputs, and static and energized potentials (on and instant-off potentials) a minimum of four hours after the CP systems are initially activated. Potentials shall be measured with a portable Copper Sulfate Electrode (CSE) reference electrode placed in the water and the monitoring access hole. Additional potential measurements shall be obtained using the permanent Ag/Ag Cl electrode and reported. Submit the CPS report and the Contractor’s concrete deficiencies report for approval per T457-4. The project shall not be considered complete until the Engineer approves these reports.

T457-11 Durability of Galvanic CP Systems.

 Use materials included explicitly in the Contract Documents or previously approved by the Engineer. Galvanic CP systems shall have a maintenance-free service life of three years and shall provide CP per AMPP SP0216 and SP0408 as determined by potential measurements at the monitoring ports above the MHWEL.

T457-12 Method of Measurement.

 The quantities to be paid for will be based on the linear feet of galvanic CP jackets, measured from bottom to top of forms, furnished and installed, completed, certified operational, and accepted.

 Galvanic CP jackets with misalignments not exceeding 3/4-inch may be accepted at a reduced price not exceeding 60% of the unit price for the entire jacket length.

 Galvanic CP jackets with the anode shorted to the pile or column reinforcement or the new structural steel inside the jacket, besides jackets that are misaligned beyond the limits noted in this article, deformed, or positioned at an improper elevation shall not be measured but shall be removed and replaced at no additional cost to the Department.

T457-13 Basis of Payment.

 Price and payment will be full compensation for all work specified in this Section. No separate payment will be made for reinforcing steel or filler material. Include payment for anode material, anode connection accessories, testing, and activation in the price per foot for CP jackets.

 Payment will be made under the following:

Item No. T457- 1 – Galvanic Cathodic Protection Jacket - per foot.

Item No. T457- 2 – Galvanic Cathodic Protection Jacket (Structural) - per foot.