CATHODIC PROTECTION OF STEEL IN CONCRETE
(REV 10-26-2026)

The following new Section is added:

SECTION 457
CATHODIC PROTECTION OF STEEL IN CONCRETE

457-1 Description.

Furnish, fabricate, install, test, energize, and commission a Cathodic Protection (CP) system constructed in accordance with the Contract Documents.

457-2 Materials.

Portland Cement Concrete-Class IV*	Section 346
Reinforcement	Section 415
Epoxy Compounds	Section 926
Anodes	Section 939
Hybrid Anodes	Section 939
Monitoring Sensors	Section 939
Data Management System	Section 939
Cables (CP only)	Section 939
Conduit (CP only)	Section 939
Junction Boxes (CP only)	Section 939
Power Supplies System	Section 939
Transformer Rectifiers	Section 939
Stay-In-Place Forms	Section 939

*Use a mix design with a maximum surface resistivity of 15 kΩ-cm at 28 days, and a target slump of 8 inches ± 2 inches, use No. 89 stone coarse aggregate and do not use supplementary cementitious materials as directed by the Engineer.

457-3 Submittals and Qualifications.

457-3.1 Quality Control Plan: Develop a Quality Control(QC) Plan identifying all tasks to be performed by the Contractor. Develop the QC plan to ensure the service life of the specified CP system will be achieved. Include the items below, including but not limited to procedures, testing frequencies, documentation requirements, and acceptance criteria for the following:

1. Corrosion assessment report.
2. Locating reinforcing steel and other embedded metallic components.
3. Testing electrical continuity.
4. Correcting electrically discontinuous reinforcement.
5. Testing electrical isolation.
6. Installing and verifying anodes, structure grounds, reference cells, sensors, cables, junction boxes, and power equipment.
7. Detecting and correcting electrical shorts.
8. Measuring electrical resistance, current output, voltage, and reinforcing-steel potentials.
9. Preparing and testing production test sections.

Do Not Use Without CO Spec Authorization

10. Energizing, adjusting, and commissioning the CP system.

11. Recording and submitting installation and test data.

12. Qualifications and certifications for the CP Technologist, CP Technicians, equipment operators for thermally sprayed anodes, and other personnel performing specialized CP work.

13. Identify the instruments, reference cells, and testing equipment proposed for use. Include current calibration certificates.

The plan shall provide a comprehensive inventory of calibrated equipment and reference electrodes, accompanied by valid calibration certificates for all instrumentation. The plan shall specify procedures for measuring anode current output and reinforcing steel potentials, as well as the formal system activation process.

The QC Plan shall be prepared and executed by an independent Cathodic Protection Technologist secured under Contract by the Contractor. Submit the QC Plan to the Engineer for approval before any installation commences.

457-3.2 Personnel Qualifications: Provide qualified personnel for sampling, testing and inspection of materials and construction activities. Ensure that qualifications are maintained during the course of sampling, testing and inspection in accordance with Section 105.

Ensure all work associated with the CP system meets the following requirements.

457-3.2.1 Cathodic Protection Technician: Ensure all CP technicians who install, energize, and finish the CP system have a minimum of 2-years' experience working with CP electronics or equivalent instrumentation, a minimum of 2-years' experience in corrosion mitigation and control, or a minimum of 1-year experience of work involving corrosion control on marine structures.

457-3.2.2 Cathodic Protection Technologist: Provide CP technologist to oversee installation the CP system, including testing, corrections, commissioning, visual inspection, energizing, finishing and reporting, The CP technologist shall be an Association for Materials Protection and Performance (AMPP) CP3 certified cathodic protection technologist with a minimum of 2-years' experience in installing and maintaining CP systems, or have 10-years verifiable experience in installing and maintaining CP systems in marine environments.

457-3.2.3 Cathodic Protection Specialist: Provide a CP Specialist to design the cathodic protection (CP) system, including system design, plan modifications, materials evaluation, QC planning, and any work performed by a CP Technologist or Technician. The CP Specialist shall be an AMPP CP 4-certified Cathodic Protection Specialist with a minimum of two years of experience in designing and maintaining CP systems.

457-4 Construction.

457-4.1 Contractor Personnel Qualification: Use personnel trained and experienced in the work being performed. Provide information verifying that personnel installing any CP system have at least 2 years of experience operating the associated application equipment and have completed at least two projects of similar size within the previous 5 years.

457-4.2 Submittal: Provide Construction Plan obtain the Engineer's approval prior to installation. Construction Plan that includes, but is not limited to, the construction schedule, personnel qualifications, and shop drawings for the following:

1. Installation sequence and schedule.

2. Shop drawings showing CP zones and locations of anodes, structure grounds, reference cells, sensors, cables, conduits, junction boxes, power supplies, monitoring units, and other system components.

Do Not Use Without CO Spec Authorization

3. Installation procedures for each CP system included in the Work.

4. Procedures for concrete removal, surface preparation, patching, overlay placement, and jacket-filler placement.

5. Procedures for installing, routing, identifying, connecting, and protecting electrical cables.

6. Procedures for installing forms, temporary supports, access systems, and work platforms.

7. Procedures for preparing and testing production test sections.

8. Procedures for waste containment and environmental protection.

9. Procedures for protecting CP system components before concrete placement, overlay placement, backfilling, or energization.

10. Procedures for correcting deficient or damaged work.

457-4.3 Preparation: Prepare existing concrete surfaces before installing anode materials, cementitious materials, overlays, or other CP components when the Contract Documents require specific bond, durability, or performance criteria.

457-4.3.1 Surface Preparation: Ensure the cleaned concrete surface has an acceptable texture that achieves a Concrete Surface Profile (CSP) rating of CSP 5 to CSP 7 as defined by the International Concrete Repair Institute. Remove all oil, grease, dirt, broken concrete, marine growth, oyster beds, and any other deleterious material that could impact proper application of repair or CP in that area. Apply the accepted surface profile to all production surfaces receiving the associated material.

Remove metallic items that may create an electrical short between the anode and reinforcement. Cut or grind metallic items that remain in place to at least 1/2 inch below the concrete surface and electrically isolate them using two coats of 100 percent solids epoxy.

Maintain prepared surfaces in the accepted condition until installation of the anode, binder, overlay, jacket, or other CP component.

457-4.3.2 Concrete Repair: Repair spalled concrete areas in accordance with Developmental Specifications 401 and 930. Notify the Engineer at least 48 hours prior to placing any concrete. Inspect proposed cathodic protection application areas and surrounding concrete surfaces to identify deterioration extending beyond the limits shown in the Contract Documents. Notify the Engineer when deterioration extends beyond the specified limits.

457-4.3.3 Reinforcing Preparation: Perform reinforcing preparation work in accordance with Developmental Specification 401. Exposed steel above and underwater shall not be unprotected for more than 72 hours after cleaning. Reclean reinforcing steel when contamination or corrosion occurs before placement of repair material.

457-4.3.4 Excavation and Patching: Patch concrete repair areas and excavations for structure-ground connections, continuity bonds, reference cells, wire-routing trenches, and other CP components in accordance with Contract Documents. Use cementitious repair materials free of metallic fibers.

457-4.4 Electrical Continuity: Complete continuity testing and required continuity corrections before installing the anode system or covering the tested reinforcement.

457-4.4.1 Continuity Testing: Perform all electrical continuity testing and certify the final test results with the Engineer.

Do Not Use Without CO Spec Authorization

457-4.4.1.1 CP Systems: Wire tie all rebars exposed in repair areas. For embedded discrete anodes and surface applied systems over repaired and limited adjacent areas, test each reinforcing bar exposed within each repair area after completing wire tying.

For surface applied and distributed systems installed test continuity of all reinforcement throughout applicable limits. Continuity can be checked on rebars exposed in repairs after they are wire tied and by exposing rebars that are not accessible in or from repair areas. Test reinforcement added within repair areas for continuity with the existing steel and when a reinforcement mat or cage is added. Test reinforcing mats and cages to verify continuity between individual bars. When a pile splice occurs within a CP application area, test continuity between the pile sections above and below the splice.

Test continuity using a calibrated, high-impedance multimeter with an input impedance greater than 10 MΩ and resolutions of 0.1 Ω and 0.1 mV. Do not use a multimeter calibrated more than 180 days before testing.

Two metallic components are electrically continuous when the forward resistance and reverse resistance are each less than 1 Ω and the voltage difference is less than 1 mV.Record and submit test locations, forward and reverse resistance, voltage difference, corrective work, and final test results. Submit all continuity test data in the CP Report.

457-4.4.1.2 Pile Jackets: Perform pile jacket continuity testing using standard Direct Current (DC) resistance with normal and reverse polarity, DC millivolt difference test methods, and a high-impedance multi-meter as directed by CP technologist or CP Technician.

The Engineer shall verify continuity between the system's negative connections and the spiral tie prior to coating with epoxy. After a connection is deemed satisfactory by the Engineer, 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 not more than 3 days.

Prior to installing the jackets, the Engineer 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 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 Engineer. The Engineer should 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 3/4-in. diameter hole in the concrete to the depth of the steel. Stagger drilled holes at 1-ft. intervals within the jacket limits. Unless otherwise approved, do not drill hole elevations less than 1 ft. above the MHWEL per the Engineer 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 methods in accordance with Contract Document. Intended equipment and procedures to install

Do Not Use Without CO Spec Authorization

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. Locate all concrete excavations made to install continuity corrections within the jacket limits. Unless otherwise approved, do not perform excavations for continuity corrections less than 1 ft. above the MHWEL per the CP technologist 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 at no additional cost to the Department.

On piles where a continuity correction is installed, the CP technologist or CP Technician 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 APL-listed 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 CP technologist 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 CP technologist shall verify that negative connections on ties are continuous from negative connections on new reinforcing steel inside the jackets. Correct any problems identified by this testing at no additional cost to the Department. 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 CP technologist 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 electrical 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 CP technologist for review and approval prior to installing jackets. The CP technologist or CP Technician shall verify electrical continuity test results on the new reinforcing steel on every pile.

457-4.4.2 Continuity Corrections: Correct reinforcement that does not satisfy the continuity criteria.

When 30% or more of the reinforcing bars on the face of an element are discontinuous, expose and bond the reinforcing bars in each direction using a No. 2 American Wire Gauge (AWG) steel pencil rod, No. 10 AWG solid steel wire, reinforcing bar, or another method approved by the Engineer. Submit the proposed trench layout to the Engineer after review and approval by the Engineer.

Do Not Use Without CO Spec Authorization

For epoxy-coated reinforcing steel, cut trenches in each required direction to expose the reinforcing bars within the mat receiving CP. Remove the epoxy coating from each connection area before installing continuity corrections. Repair the epoxy coating after completing and accepting the connection.

Perform continuity testing after completing continuity corrections. Do not proceed with subsequent work until the Engineer verifies and accepts the corrected continuity. For reinforced concrete elements that are in the splash zone, continuity checks, corrections, and negative connection installations may need to be performed underwater.

457-4.4.3 Continuity Bonds: Establish electrical continuity between two reinforcing bars using steel wire ties where practical. Install each tie to provide direct electrical contact with the reinforcing steel. Test continuity after installing the wire ties. Where wire ties do not establish continuity, install a continuity bond.

Provide continuity bonds consisting of two No. 10 AWG solid steel wires, a steel pencil rod, reinforcing bar, or another connection approved by the Engineer. Weld or mechanically connect the continuity bond to the discontinuous components. Route continuity bonds through excavation or trenches and embed them in concrete or approached repair material.

457-4.4.4 Exothermic Welds: Clean the reinforcing steel and connection materials before exothermic welding. Remove oil and grease using a suitable solvent and clean cloth. Remove slag from completed welds. After completing the weld, strike the weld with a 2 lb. hammer. Remove and replace welds that disintegrate or otherwise fail the test. Apply two coats of 100% solids epoxy to completed welds and exposed copper. Allow the first coat to cure before applying a second coat. Allow both coats to cure before placing concrete or repair material.

Use alternative welded or mechanical connection only when approved in writing by the Engineer. Coat connections embedded in concrete with 100% solids epoxy. Do not leave weld material or copper exposed

457-4.4.5 Structure Ground Installation: Install structure grounds by connecting structure-ground wires to the reinforcement using exothermic welds, or by another method approved in writing by the Engineer. Install 2 Structure Grounds in each CP zone. Where a CP zone includes more than one concrete element, including footings, columns, struts, or caps, install two structure grounds in each element unless otherwise shown in the Contract Documents. Where a reinforcement mat or cage is installed within a jacket, install two grounds on the new reinforcement mat or cage. Test continuity between concrete elements. Where continuity exists between elements, combine structure ground wires only when permitted by the Contract Documents or approved by the Engineer. Where continuity does not exist, route all structure-ground wires from each element to the junction box shown in the Plans. Route at least two structure grounds to the junction box shown in the Plans. Provide each structure ground wire as a continuous wire without splices. Coordinate splicing with requirements of 457-3.6. Test continuity between structure grounds within the same element and CP zone by the CP Technologist. Correct discontinuities before installing the anode system.

457-4.4.6 Reference Cells: Verify each field reference cell against an approved standard reference cell before installation. Place the field and standard reference cells in water and measure the DC potential difference. Do not install a field reference cell having a potential difference greater than 10mV from the standard reference cell. Do not permanently install the standard reference cell used for verification.

Do Not Use Without CO Spec Authorization

Locate reference cells as shown in the Contract Documents. Where the Contract Documents do not establish the final location, perform a half-cell potential survey in accordance with ASTM C876 and install the reference cell within the most active area of the applicable CP zone, as approved by the Engineer.

Install reference cells within excavations measuring at least 3 inches wide by 12 inches long and extending at least 1 inch below the reinforcing bar. Provide at least 1/2 inch of clearance around the reference cell and reinforcing bar for placement of repair material. A vertically drilled installation may be used when approved by the Engineer.

Connect the reference-cell ground wire to the reinforcement using an approved exothermic weld or another method approved in writing by the Engineer. Route the reference-cell wire through an approved trench, cementitious embedment, or conduit to the designated junction box. Connect the reference-cell wires as shown in the Contract Documents.

Test continuity between the reference-cell ground and structure ground. Correct discontinuities before covering the installation.

457-4.5 Anode Installation: Complete the applicable surface preparation, concrete removal, steel repairs, preparation, continuity testing and corrections, structure-ground installation, reference-cell or sensor installation, and inspection before installing the applicable anode system. Install each anode type at the locations and limits shown in the Plans and in accordance with the Contract Documents and manufacturer's instructions.

Protect installed anodes and associated wiring against contamination, electrical shorts, moisture intrusion, impact, and construction damage.

457-4.5.1 Embedded Discrete Anodes: Pre-wet anodes when required by the manufacturer. Install pre-wetted anodes in a saturated surface-dry condition. Install anodes at the spacing shown in the Plans along the perimeter of the repair area. Install at least one anode within repair areas having a perimeter of less than 12 inches.

Provide a minimum 1 inches of cover between the anode and finished concrete surface and a minimum 1 inch of repair material between the anode and the adjacent or underlying concrete surfaces at remaining sides so that the patch material surrounds the anode.

Secure each anode to clean reinforcing steel. Wrap and tighten the tie wires to prevent movement during placement of repair material while achieving minimum cover requirements.

Inspect each anode and verify continuity with the reinforcing steel before placing repair material. Correct deficient connections before patching the repair area.

457-4.5.2 Thermally Sprayed Anodes: Produce the mockup at the job site for measure the bond strength. Prepare four test sections with a minimum surface area of 4 square feet each. Do not locate test sections within designated repair areas unless approved by the Engineer. Prepare the surface and install the anode, binder, coating, or overlay using the materials, equipment, personnel, and procedures proposed for production work. Testing the bond strength in accordance with ASTM D7234 at 24 hour to meet minimum bond strength 100 psi.

Apply thermally sprayed anodes in accordance with American Welding Society (AWS) C2.23M/C2.23 and AMPP SSPC-CS 23.

Allow repair materials to be cured for at least 7 days before metallizing. Complete metallizing within 90 days after placement of repair material.

Obtain written certification from the Engineer for metallizing proposed more than 90 days after placement of repair material stating the area has a low probability of corrosion activity around the repair. Do not metalize more than 120 days after placement of repair material.

Do Not Use Without CO Spec Authorization

Install threaded rods before metallizing. Install anode connection plates after metallizing the concrete surface, as shown in the Plans.

Complete metallizing within 2 hours after final surface preparation. Air-blast prepared surfaces immediately before metallizing to remove surface-preparation residue. Use clean, moisture-free air at a minimum pressure of 50 psi. Test the air supply for moisture and pressure daily.

Apply the anode continuously within each repair area or CP zone. Do not permit cold overlaps. Mask surfaces not designated to receive metallizing and provide neat horizontal and vertical application limits.

Apply multiple passes to provide a coating thickness of 15 to 20 mils. Measure coating thickness using coupons or another method accepted by the Engineer.

For application areas smaller than 10 square feet, obtain at least three thickness measurements in each application area. For application areas larger than 10 square feet, obtain at least three measurements for each 10 square feet.

Use a spherical-anvil and spherical-spindle micrometer capable of measuring from 0 to 1 inch. Electronic thickness-measuring devices may be used when approved in writing by the Engineer and calibrated against the mechanical instrument.

Where coating thickness is less than 15 mils, remove the coating by blasting and remetallize the area. Complete additional metallizing within 2 hours after the initial application or remove and remetallize the entire affected area.

Perform two bond tests in application areas smaller than 10 square feet. For larger application areas, perform two bond tests for each 25 square feet. Where the application covers repaired and original concrete, perform one test on each substrate.

Perform bond testing from 2 to 72 hours after metallizing in accordance with ASTM D7234 using a fixed-alignment adhesion tester with a range of 0 to 500 psi. Provide bond-test results exceeding 90 percent of the accepted test-section value.

Provide a uniform finished surface free of cracks, burns, blisters, uncoated areas, and other visible defects. Remove and remetallize areas having visible defects, insufficient bond strength, or coating thickness less than 15 mils at no additional cost to the Department.

Install the anode connection plate over the threaded rods at the locations shown in the Plans. Metallize the connection plate, connect the system-ground wire to the threaded rod, and install the lock washer and nut. Apply epoxy over the connection as shown in the Plans.

Verify continuity between the ground wire and threaded stainless steel bolt before metallizing the connection plate and applying the epoxy coating.

Apply the approved zinc-silicate overcoat within 72 hours after metallizing. Apply the overcoat in accordance with the manufacturer’s instructions. Extend the overcoat at least 6 inches beyond the metallized area and provide a minimum thickness of 5 mils.

Install monitoring junction boxes where required by the Contract Documents. Route structure-ground, anode, and reference-cell wires to the junction boxes as shown in the Plans.

457-4.5.3 Zinc Mesh Anode: Produce the mockup at the job site for measure the bond strength. Prepare four test sections with a minimum surface area of 4 square feet each. Do not locate test sections within designated repair areas unless approved by the Engineer. Prepare the surface and install the anode, binder, coating, or overlay using the materials, equipment,

Do Not Use Without CO Spec Authorization

personnel, and procedures proposed for production work. Testing the bond strength in accordance with ASTM C1583 at 28 days to meet minimum bond strength 150 psi.
Allow repair materials within the installation area or CP zone to cure for at least 7 days before installing the zinc mesh system. Provide a saturated surface-dry concrete surface before applying the binder.

Drill holes for the mesh fasteners. Apply the initial binder coat uniformly at a rate of 1.0 to 1.2 pounds per square foot in accordance with the manufacturer's instructions. Install zinc mesh having flag connectors welded to the mesh and protected with epoxy. Compress the mesh into the binder until the binder penetrates the mesh openings, and secure it with rivets.

Connect anode wires to the flag connectors as shown in the Plans. Apply a second binder coat at a rate of 0.8 to 1.0 pound per square foot. Cover the mesh completely so that no mesh shadowing is visible.

Maintain the binder in a moist condition for 24 to 48 hours using temporary plastic sheeting or another approved method. Cure the binder for at least 7 days before applying the topcoat. Apply the topcoat in accordance with the coating manufacturer's instructions.

Apply binder materials only when the following conditions are met:

1. Substrate temperature is from 45 to 90°F.
2. Ambient temperature is from 40 to 95°F.
3. The concrete surface is saturated surface-dry.
4. Relative humidity is at least 30 percent.

Perform bond testing after 28 days of curing in accordance with ASTM C1583. Perform one bond test within each repair area. For full-surface applications, perform one test for each 25 square feet, with at least one test for application areas smaller than 25 square feet.

Provide a minimum bond strength of 150 psi. Repair test locations using the approved binder material. Remove and replace unacceptable work at no additional cost to the Department.

Install monitoring junction boxes where required by the Contract Documents. Route structure-ground wires, anode wires from the flag connectors, and reference-cell wires to the associated junction box. Complete connections as shown in the Plans.

457-4.5.4 Bulk Anode: Install bulk anodes as pile-mounted assemblies, mechanically fastened assemblies, or hanging assemblies, as shown in the Contract Documents. Use metallic anchors to secure bulk anodes to concrete surface without creating electrical shorts.

457-4.5.4.1 Pile-Mounted Bulk Anodes: Install factory-fabricated bulk anode assemblies on piles at the locations and elevations shown in the Plans.
Clamp the anode to the pile or jacket using two 2-inch hot-dip galvanized steel channels with the flanged side facing the pile or jacket. Use galvanized attachment hardware.
Position the anode at the angle and depth shown in the Contract Documents guaranteeing the entire length of the anode is in contact with the surface of the pile or jacket. Maintain the required contact with the pile or jacket where applicable. Route the anode wire as shown in the Plans.

Perform bulk anode installation prior to placement of the filling material for the CP jacket.

Do Not Use Without CO Spec Authorization

457-4.5.4.2 Mechanically Fastened Bulk Anodes: Mechanically fasten bulk anode assemblies to the concrete surface shown in the Plans. Use Type 316 stainless steel attachment hardware. Install the assembly without damaging the concrete or creating an unintended electrical connection with reinforcing steel.

457-4.5.4.3 Hanging Bulk Anode: Excavate the concrete and install the anode connection junction box and the eyebolt with the drop-in anchors at the locations shown in the Plans. Install the eyebolt with no more than 1/2 inch of its shank is exposed beyond the concrete surface.

Suspend the anode assembly from the eyebolt using wire rope and an approved split or U-bolt connector. Secure the assembly against loosening under the design load.

Route the anode wire to the connection junction box through an NPT cable gland. Connect the anode wire to the waterproof quick-disconnect fitting. Do not leave copper exposed. Route the wire from the connection junction box to the monitoring junction box through a trench or conduit.

Install the cable guard, after the Engineer inspect and approve the installation. Align the top of the cable guard with the top of the connection junction box and completely cover the anode assembly

457-4.5.5 Cathodic Protection Pile Jackets: Per the Contract Documents, CP pile jacket systems shall consist of embedded zinc anodes of expanded zinc mesh anodes pre-installed against the inside face of the fiberglass pile jacket forms. 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 prior to the installation of any jacket.

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. Before ordering jackets, complete the inspection and sound testing required by 457-4.3.2. Record and verify the dimensions of identified deficiencies and verify the proposed jacket limits encompass all major cracked, delaminated and spalled areas. (e.g., deteriorated or damaged concrete). Determine the Mean Low Water Level (MLWL) and Mean High Water Level (MHWL) for each pile. Install reinforcing steel, anodes, or jacket forms based on plan.

Perform visual inspection before placing the jacket. 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 of the surface preparation.

Provide a pile-mounted bulk anode with each CP pile jacket, unless otherwise shown in the Contract Documents or approved by the Engineer. Install the bulk anode in accordance with 457-3.5.4.1.

457-4.5.5.1 Location and Length: Install pile jacket cover area as shown in Contract Documents or as directed by the Engineer. In case of damage all the way to the cap, terminate the jacket 6 in. from the cap to allow for proper filling of the annular space and bevel placement. Obtain the Engineer's written 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

Do Not Use Without CO Spec Authorization

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 developmental specification.

457-4.5.5.2 Form Placement for Pile Jackets: Place the fiberglass form in position around the pile at the location and elevation shown in the Plans. Coordinate form placement with the wiring requirements of 457-4.7. Protect wires and connections from displacement or damage during form installation. Secure and seal interlocking joints. Install the compressible bottom seal and coat the seal using an APL-listed Type K 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.

457-4.5.6 Titanium Mesh Anodes: Allow repair materials within the installation area or CP zone to cure for at least 7 days before installing the mesh. Prepare the concrete surface to provide the bond required for the overlay. Maintain the prepared surface free of debris, oil, marine growth, oyster beds, salt deposits, and other contaminants until overlay placement. In addition, electrically isolate metallic items in accordance with 457-4.3.

Install continuous sections of titanium mesh within each CP zone at the locations and in the directions shown in the Plans. Do not splice or interrupt the mesh in the direction of installation unless permitted by the Contract Documents. Fasten the mesh flush against the concrete surface. Space adjacent fasteners no more than 4 feet apart. Install additional fasteners where necessary to maintain contact with the concrete surface. Wash the installed mesh using fresh water. Remove debris and salt deposits. Protect the mesh from contamination and marine exposure until placing the overlay.

Resistance-weld current distributor bars to the mesh at the locations shown in the Plans. Provide continuous distributor bars without splices, except where a distributor bar wraps back upon itself.

Spot-weld titanium connectors for titanium mesh systems to facilitate efficient current distribution. Use welding equipment approved or furnished by the titanium mesh manufacturer. The CP Technologist shall inspect and certify mesh and distributor-bar connections.

Place the concrete overlay as shown in the Plans. Continuously monitor electrical isolation between the anode mesh and structure ground during overlay placement. Stop placement when a short is detected and correct the short before continuing.

457-4.6 Surface Finishing and Infill Placement: Place patching and embedment materials in accordance with the applicable material specifications and manufacturer's instructions.

457-4.6.1 Patching and Embedment: Provide complete encapsulation of structure-ground connections, continuity bonds, reference cells, wire-routing trenches, and other components designated for embedment. Prevent voids, segregation, contamination, and displacement of installed CP components. Protect wires and connections during placement and consolidation.

457-4.6.2 Concrete Overlays: Prepare the receiving concrete surface and install overlays in accordance with the Contract Documents. Protect anodes, current distributor bars,

Do Not Use Without CO Spec Authorization

sensors, structure grounds, and associated wiring during overlay placement. Monitor for electrical shorts during overlay placement. Stop placement when a short is detected. Locate and correct the short before continuing. Consolidate and cure the overlay without damaging, displacing, or shorting CP system components.

457-4.6.3 Pile Jacket Filler: Place pile-jacket filler in accordance with the Contract Documents after visual inspection is complete and continuity is confirmed, backfill area for buried elements or place concrete filler for embedded elements.

Monitor embedded wiring, anodes, structure grounds, and reinforcement during filler placement. Stop placement when a component is displaced, damaged, or electrically shorted. Correct the condition before continuing.

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.

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. Do not drop filler material into forms higher than 5 ft. or forms containing water. Prevent contamination of the filler during placement and provide vibration to ensure proper consolidation. Fill the jacket to approximately 1 in. from the top during the pumping process. Prior to the fill material fully hardening, apply a 45-deg. 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.

After removal of temporary supports around the jacket, core drill 1.5-in. diameter access holes through the jacket to the depth of the original pile surface on one face of the pile at an elevation of 6 inches above the Mean High Water Elevation Level (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 monitoring ports with an approved PVC screw-on cap.

457-4.7 Electrical Installation: Cathodic protection electrical work shall in accordance with ISO 12696 and NEC NFPA70. All signal cables for monitoring sensors shall be shielded twisted pairs to mitigate electromagnetic interference. All other electrical work shall comply with NCE Standards. Provide each CP zone with at least one dedicated, non-current-carrying test connection.

All connections shall provide a low-impedance path. Electric connections to the reinforcement using exothermic welding are preferred. Use mechanical connections only if indicated in the Contract Documents. The voltage drop across a connection interface shall not

Do Not Use Without CO Spec Authorization

exceed 1 mV. Provide positive connections to the anode system with redundancy to ensure that the loss of any single connection does not compromise the continuity or functional performance of the local anode zone. Use shielded twisted-pair signal cables for monitoring sensors. Use insulated cable specifically designed for DC cathodic protection service for anode and structure-ground connections embedded in concrete or fully submerged in water.

Route wires not embedded in concrete or fully submerged in water through conduit as shown in the Plans. Provide junction boxes sized to accommodate the required wiring, terminals, connectors, and maintenance access. Locate junction boxes to reduce the potential for submergence, vandalism, impact, and environmental damage at locations shown in the Plans. Make connections mechanically secure, electrically stable, waterproof, alkali-resistant, and suitable for the anticipated exposure environment.

For pile jacket, 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 FDOT Standard Specification 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 in. 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. 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. Fabricate the terminal box to accept 1/4-in. 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 1 ft. above the 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 within QC plan.

457-4.8 Pre-Commissioning Testing: Conduct testing throughout the installation phase, including polarity checks for all circuits, continuity verification to ensure individual circuit resistances confirm isolation or continuity as required for the individual components, component installation and absence of electrical shorts. For impressed current systems, perform continuity checks to demonstrate electrical isolation between DC positive and negative circuits.

Do Not Use Without CO Spec Authorization

Test structure grounds, anode connections, reference-cell connections, sensors, monitoring components, cables, and wires before covering, embedding, backfilling, or placing concrete.

Monitor for electrical shorts during placement of concrete, repair material, overlay, binder, and jacket filler. Stop placement when a short is detected. Locate and correct the short before continuing. Record the test location, equipment, calibration information, test procedure, measured values, acceptance criteria, corrective action, and final testing result.

457-4.9 Visual Inspection: Perform visual inspection of the CP system and its components to confirm correct installation, alignment, position, labeling, connections, coatings, and protection from environmental or mechanical damage. For buried or embedded elements, complete and document this inspection before backfilling or concrete placement.

457-4.10 Energizing: Energize each CP zone after the completion of construction and once the repair and anode embedment materials have achieved final curing. Initial energization shall begin at a low level. Include the energizing and commissioning procedure in the QC Plan. Record the following for each CP zone a minimum of 4 hours after the CP systems are initially activated, as applicable:

1. System resistance.
2. Native anode potential.
3. Voltage drop between the anode and structure.
4. Native reinforcing-steel potential.
5. On and instant-off reinforcing-steel potentials.
6. System current.
7. Power-source input voltage.
8. Rectifier output voltage.
9. Reference-cell readings.
10. Remote-monitoring readings.

Use temporary reference cells when permanent reference cells are not installed.

For prestressed and post-tensioned concrete elements, do not permit the polarized reinforcing-steel potential to become more negative than minus 1,100 MV relative to a copper-copper sulfate reference electrode unless otherwise shown in the Contract Documents

457-4.10.1 Galvanic Systems: Verify anode-to-reinforcement continuity, system polarity, anode current output, reinforcing-steel potentials, and absence of electrical shorts. Compare the system performance with the acceptance criteria shown in the Contract Documents. Correct deficient connections, damaged anodes, electrical shorts, and other conditions preventing satisfactory operation.

For galvanic CP pile jacket systems shall provide CP per AMPP SP0216 and SP0408 as determined by potentials measured with a portable Copper Sulfate Electrode (CSE) reference electrode placed in the water at the monitoring ports above the MHWEL.

457-4.10.2 Impressed Current Systems: Begin energization at a current density of 2 mA per square foot of concrete surface area unless otherwise shown in the Contract Documents.

Operate the system in constant-current or constant-voltage mode as required by the Plans. At least 30 days after initial energization, perform depolarization testing. Adjust the system to achieve 100 mV of polarization or depolarization unless another criterion is shown in the Contract Documents. Repeat depolarization testing following adjustment.

Do Not Use Without CO Spec Authorization

457-4.10.3 Hybrid Systems: Energize, operate, disconnect, and monitor hybrid systems in accordance with the Contract Documents and manufacturer's written procedures.

Document the impressed-current activation period, current supplied, operating voltage, disconnection procedure, and galvanic operation following disconnection. Verify system performance using the acceptance criteria shown in the Contract Documents.

457-4.10.4 Remote Monitoring and Communication: Verify remote-monitoring measurements by comparison with field measurements performed by the Engineer.

The manufacturer or authorized representative shall certify that rectifiers, remote monitoring units, and communication systems operate as designed.

Diagnose and correct deficient equipment, unreliable data, and communication failures before acceptance. CP zones without functional and reliable remote monitoring and communication equipment will not be accepted when such equipment is required by the Contract Documents.

457-4.11 Finishing: Upon completion of commissioning, prepare final system documentation. This includes the installation and initial performance verification report and the operation and maintenance manual, detailing procedures for routine performance assessments and data interpretation in accordance with the selected protection criteria.

457-4.12 Incidental Work and Others: Perform all incidental work necessary to provide a complete and functional CP system as delineated in the approved shop drawings and design documents.

457-5 Quality Assurance.

The Engineer shall conduct the following QA tasks as a minimum:

1. Review all CP-related submittals before they are submitted to the Department for approval. Inspect all CP system materials and personally supervise every phase of the installation of the CP systems.

2. 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.

3. Perform or direct electrical continuity testing and certify the continuity results.

4. Inspect and test continuity corrections and verify that electrical continuity has been established.

5. Inspect and test structure-ground, reference-cell, anode, sensor, cable, and wire connections.

6. Verify anodes, junction boxes, power supplies, monitoring equipment, and communication equipment are installed in accordance with the Contract Documents.

7. Test for electrical shorts during placement of repair materials, overlays, binders, jacket filler, and other cementitious materials where an anode-to-reinforcement short may occur.

8. Train Contractor personnel authorized to perform QC testing.

9. Energize and commission the CP system and document the results.

10. Troubleshoot and resolve installation and operational deficiencies that affect CP system performance.

11. Prepare and submit the CP Report.

457-6 Acceptance.

457-6.1 Documentation Review: Submit all installation records to the Engineer for approval. Submitted records must include a pre-installation baseline potential survey and

Do Not Use Without CO Spec Authorization

comprehensive performance data, including static (native) potentials, instant-off potentials, and polarization data. Installation records shall also include circuits resistance and reinforcement continuity correction data.

457-6.2 Inspection: Provide the Engineer with the opportunity to inspect or perform system testing at any phase of construction to ensure the quality of the CP system. This includes visual, mechanical, and electrical testing.

457-6.3 Commissioning: Submit a comprehensive continuity log covering all reinforcing steel and metallic elements in the concrete components. The appropriate reference electrode must be selected based on the exposure environment: a silver/silver chloride (Ag/AgCl) reference electrode shall be used for all measurements conducted underwater or in saturated splash zones, while a CSE reference electrode shall be used for measurements on dry concrete surfaces. Use silver/silver chloride (Ag/AgCl) reference electrode for all permanent electrodes embedded in the concrete. All field logs must clearly identify the electrode type used for each measurement. For final reporting and Department acceptance, all potentials shall be converted and referenced to CSE, with the specific conversion factors and temperature corrections documented in the report.

During system energization and initial startup of the system, the system must comply with Overprotection Limits: for plain reinforcing steel, the instantaneous-off potential shall not be more negative than -1,100 mV to prevent hydrogen embrittlement. For structures containing prestressing steel, the safe potential limit shall not exceed that shown in the Contract Documents to ensure structural integrity. Electrical short-circuit monitoring between the anode and reinforcement shall be maintained throughout construction, installation, and concrete placement to ensure immediate detection and correction of any shorts or misalignments. All testing instrumentation shall have valid calibration certificates, and digital voltmeters must have a minimum input impedance of 10 MΩ with an accuracy of ± 5 mV or better.

457-6.4 Report: Submit an original final construction report produced by the CP technologist 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 4 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.

457-7 Method of Measurement.

Measurement encompasses all components necessary to provide a fully operational system as per the specific technology deployed.

457-7.1 CP Integral Pile Jacket: The quantities to be paid for will be the length, in feet, of the structure, as measured between the lower and upper limits of the forms.

457-7.2 CP Testing Pile Jacket: The quantities to be paid for will be the length, in feet, of the structure, as measured between the lower and upper limits of the forms.

457-7.3 CP Electrical Work: Electrical work completed and accepted, including but not limited to, labor, equipment, conduit, materials, wiring, instrumentation, AC power, DC power and other related electrical work will be paid lump sum.

Do Not Use Without CO Spec Authorization

457-7.4 CP Embedded Discrete Anodes: The quantities to be paid for will be the number of point anodes.

457-7.5 CP Thermally Sprayed Anodes: The quantity to be paid for will be the area, in square feet, as measured along the finished surface.

457-7.6 CP Zinc Mesh Anodes: The quantity to be paid for will be the area, in square feet, as measured along the finished surface.

457-7.7 CP Bulk Anodes: The quantity to be paid for will be the number of bulk anode.

457-7.8 CP Titanium Mesh Anodes: The quantity to be paid for will be the area, in square feet, as measured along the finished surface.

457-8 Basis of Payment.

Price and payment will be full compensation for furnishing materials and completing all work described herein or shown in the Plans including, but not limited to, Cathodic Protection Technologist work, energization, QA/QC Plan, grounding plan, performance monitoring, and As-Installed drawings, regardless of the specific CP technology or materials utilized. No separate payment will be made for reinforcing steel, filler material, anode materials, wiring, or specialized coatings. Repair any connection that tests discontinuous or is otherwise found deficient at no additional cost to the Department. CP system failing to function as specified in the Contract Documents shall be removed and replaced at no additional cost to the Department.

Payment will be made under:

Item No. 457-2 - Cathodic Protection Integral Pile Jacket, - per foot.
Item No. 457-3 - Cathodic Protection Testing Pile Jacket, - per foot.
Item No. 457-4 - Cathodic Protection, Electrical Work - lump sum.
Item No. 457-5 – Cathodic Protection Anodes
Embedded Discrete Anodes - each.
Thermally Sprayed Anodes - per square foot.
Zinc Mesh Anodes - per square foot.
Bulk Anodes - each.
Titanium Mesh Anodes - per square foot.

Do Not Use Without CO Spec Authorization

CATHODIC PROTECTION SYSTEM MATERIALS
(REV 10-26-2026)

The following new Section is added:

SECTION 939
CATHODIC PROTECTION SYSTEM MATERIALS

939-1 Description.

This section specifies the general material requirements for Cathodic Protection (CP) in structural concrete. Anode type, location, and intended use are project specific and shall comply with the project Contract Documents.

939-1.1 Limitations: This specification does not cover incidental or alternate materials. Such materials shall be submitted on a project-by-project basis as authorized by the Engineer.

939-2 Product Acceptance.

All products shall be items listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of products for inclusion on the APL shall submit an application in accordance with Section 6 and include the documentation shown on Table 939-1.

Table 939-1

Documentation	Requirements
Type of Product	Indicate if Reference Electrode, Power Supply, Data Logger, Anodes, etc.
Assembly and Installation Instructions	Include any surface preparations, assembly/installation instructions, operation manual, troubleshooting guides, and repair procedures.
Anode Class and Application	Specify if Galvanic, Impressed Current, Hybrid Anode– For Piles, Footings, Beams, Deck, etc.
Technical Data Sheet	Product meets requirements below and the system manufacturer expected service life.
Product Drawings	Installation drawings; materials, system and equipment specifications; method of installation; testing, energizing, commissioning and operation procedures.
Product Label Photo	Labeling shows the manufacturer's name, trademark, and product model number/name.
Product Photo	Displays the significant features of the product as required in this section.

A separate application must be submitted for each product to be evaluated, showing that the component meets the applicable requirements.

939-3 Components of System.

Do Not Use Without CO Spec Authorization

939-3.1 Anodes: All anodes shall provide the manufacturer specified maximum current output without deterioration. For anodes embedded into or applied to the surface of the concrete structure, the current density shall conform to the design specifications.

939-3.1.1 Atmospherically Exposed Concrete Structures: For concrete structures that are atmospherically exposed, such as bridge decks, beams, columns, and building elements, the anode system is intended to distribute uniform cathodic protection current to the embedded steel. The anodes are typically installed directly on or embedded within the concrete surface to provide a uniformly distributed current.

939-3.1.1.1 Galvanic Anode Materials: Use Thermally Sprayed Zinc (Zn), Al-Zn / Al-Zn-In Alloys, Embedded Zinc Anodes, Zinc Mesh, Adhesive Zinc Sheet, or other anode materials meeting the Contract Documents requirements as authorized by the Engineer.

939-3.1.1.2 Impressed Current Anode Materials: Use Mixed Metal-Oxide-Coated Titanium (MMO/Ti), Conductive Carbon-Based Coatings, Thermally Sprayed Metallic Coatings (Zn/Ti), Conductive Cementitious Materials, Conductive Ceramics, or other anode materials meeting the Contract Documents requirements as authorized by the Engineer.

939-3.1.2 Immersed Concrete Structures: For concrete structures that are immersed, the anodes do not have to be in direct physical contact with the concrete. The anodes can be located away from the structure but are immersed in the same electrolyte in which the reinforced concrete structure is immersed.

939-3.1.2.1 Galvanic Anode Materials: Use Aluminum-Zinc-Indium Alloys, Zinc Alloys, Magnesium Alloys or other anode materials meeting the Contract Documents requirements as authorized by the Engineer.

939-3.1.2.2 Impressed Current Anode Materials: Use High-Silicon Iron, Mixed Metal-Oxide-Coated Titanium, Platinized Titanium, Platinized Niobium or anode other materials as approved meeting the Contract Documents requirements by the Engineer.

939-3.1.3 Buried Concrete Structures: For concrete structures buried in soil, the anodes do not have to be in direct physical contact with the concrete. The anodes are typically located buried a short distance from the structure and may be placed in a suitable conductive or chemical backfill to optimize performance.

939-3.1.3.1 Galvanic Anode Materials: Use Zinc Alloys, Magnesium Alloys, or other anode materials meeting the Contract Documents requirements as authorized by the Engineer.

939-3.1.3.2 Impressed Current Anode Materials: Use High-Silicon Iron, Mixed Metal-Oxide-Coated Titanium, Platinized Titanium, Platinized Niobium, Graphite, and other anode materials meeting the Contract Documents requirements as authorized by the Engineer.

939-3.2 Hybrid Anodes: All anode materials intended for use as Hybrid Anodes shall be provided to the State Materials Office (SMO) for technical review and approval.

939-3.3 Embedded Reference Electrodes: Use embedded permanent Silver/Silver Chloride reference electrodes specifically designed for use in concrete. 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 meeting the Contract Documents requirements as authorized by the Engineer.

Do Not Use Without CO Spec Authorization

Submit documentation and technical data sheets to the State Materials Office (SMO) for technical review and approval for buried or submerged permanent reference electrodes.

939-3.4 Monitoring Instrumentation: Use digital voltmeters for measuring sensors and power supplies with a minimum resolution of 1 mV, an accuracy of ±5 mV, and an input impedance of at least 10 MΩ. Incorporate data loggers that operate under a real date-time clock, and provide a multi-channel input or multiplexers to record all selected channels.

939-3.5 Data Management System: The system shall maintain records of anode-zone layouts, sensor types and locations, DC power unit ratings, and all initial pre-commissioning and commissioning data. The system shall record sensor data and DC power supply output at designated intervals. The system shall be capable of identifying data points that fall outside of pre-set, user-definable limits upon request and maintaining a complete event record, including inspection dates and changes in system operation.

939-3.6 Cables: Cables shall be sized to carry the design current without excessive voltage drop and must be clearly and permanently identified at each termination and junction. The conductor shall be copper, with insulation and sheathing materials selected for resistance to moisture, high alkalinity, and the chemical products of anodic reactions. All connections to anodes, reinforcement, and sensors shall be mechanically secure, electrically stable, and fully encapsulated with an approved waterproof electrical insulator, alkali-resistant material to prevent moisture ingress.

939-3.7 Conduit: Conduit shall be PVC schedule 80 (min) rated to provide appropriate protection against the environment, taking into account the specific types of connections made within the designed Cathodic Protection System. All hardware for the junction boxes shall be stainless steel grade 316.

939-3.8 Junction Boxes: Boxes shall be rated to provide appropriate protection against the environment, taking into account the specific types of connections made within the box and the extremely aggressive environmental and mechanical exposure to which the box is to be subjected. All hardware for the junction boxes shall be stainless steel grade 316. Box cover screws shall be Type 316 Stainless Steel. Use Schedule 80, sunlight-resistant PVC, for all PVC components as applicable.

939-3.9 Power Supply System: Where utility electrical power is available, the direct current (DC) power supply shall be provided by a transformer-rectifier or switch-mode rectifier unit. Solar systems may be used to provide Direct Current (DC) input to a solar controller to generate controlled DC output directly. Renewable systems may include battery storage and rectification as required to supply DC current to controllers.

939-3.10 Transformer Rectifiers: Transformer-Rectifiers shall be continuously rated, self-contained, and suitable for the intended service environment. The incoming alternating current (AC) supply shall be terminated in accordance with the power supplier's requirements and Contract Documents. Transformer rectifiers shall be capable of maintaining the required current outputs to each zone independently.

939-3.11 Stay-In-Place Forms for Pile Jackets: 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 in. and a minimum thickness at the corners of 1/4 in. extending a minimum of 2 in. 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

Do Not Use Without CO Spec Authorization

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. Provide the interior of the forms with 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 by the Engineer or Engineer's representative prior to placement. Remove from the project any jacket form that has been rejected. The forms shall meet the following physical property requirements of Table 939- 2. The thickness and dimension shall meet the Project Contract Documents requirements.

Table 939-2
Physical Requirements of Stay-In-Place Forms

Property	Test Method	Requirement
Water Absorption*	ASTM D 570	≤1%
Ultimate Tensile Strength*	ASTM D 638	≥9,000 psi
Flexural Strength*	ASTM D 790)	≥16,000 psi
Modulus of Elasticity*	ASTM D 790)	≥700,000 psi
IZOD Impact	ASTM D 256	≥15 pounds/inch
Barcol Hardness	ASTM D 2583	≥45
Color	AMS Standard Color Chart Number 595A	AMS-STD 36373 AMS-STD 36440 AMS-STD 36463 AMS-STD 36473 AMS-STD 36492 AMS-STD 36495 AMS-STD 36559 AMS-STD 36595 AMS-STD 36622 AMS-STD 36628 The color must be integral in the form gel coat.

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

939-3.11.1 Test Results: Submit certified test results per lot of the stay-in-place forms to the State Materials Office (SMO) for technical review and final approval. No test report for tests made more than two years prior to shipment will be accepted for the stay-in-place jacket forms.

Do Not Use Without CO Spec Authorization