CATHODIC PROTECTION OF STEEL IN CONCRETE
(DEV 05-19-2026)

The following new Section is added:

SECTION 457
CATHODIC PROTECTION OF STEEL IN CONCRETE

457-1 Description.

Furnish, fabricate, and install 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	Section 632 or 939
Conduit	Section 630 or 939
Junction Boxes	Section 635 or 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 as directed by the Engineer.

457-3 Construction.

457-3.1 Submittal: Provide installation schedule and shop drawings and obtain the Engineer's approval prior to installation. Provide shop drawings that delineate the type of CP system, precise locations of all components, installation methodologies, and procedures for concrete placement and waste containment.

The submittal shall include detailed construction calculations, components, and material specifications. For structures containing prestressing steel, include a specific assessment for hydrogen embrittlement risks.

457-3.2 Surface Preparation: Clean all concrete surfaces intended to receive cathodic protection to ensure a non-friable substrate and achieve the required bond strength. Remove any items that will cause a short-circuit between the anode and reinforcement. Use cementitious repair materials free of metallic fibers. Repair spalled concrete areas in accordance with Developmental Specifications 401 and 930. Notify the Engineer at least 48 hours prior to placing any concrete.

457-3.2.1 Pile Jackets: 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. Before ordering jackets, the dimensions of all deficiencies (e.g., deteriorated or damaged concrete) shall be recorded and verified.

Provide surface preparation by hydro demolition (unless prohibited in the Plans) 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, if existing reinforcing steel is exposed, sound concrete will require removal to obtain the 3/4 in. to 1 in. behind the existing reinforcing steel to achieve a mechanical bond. Use a 15-lb. chipping hammer (maximum size) to remove the spalled and behind bars concrete. 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 in. to 1/8 in. in depth with a new fractured aggregate surface. Sandblast exposed steel to a near white condition per the current 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. 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 underwater 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 areas 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, 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 of the surface preparation.

457-3.3 Anode Installation: Install the anode to encompass the zones receiving cathodic protection as indicated in the Contract Documents to ensure uniform current distribution. Utilize non-metallic connections to secure anode materials to the concrete surface or reinforcement to prevent electrical short-circuits. Use metallic anchors to secure bulk anodes to concrete surface without creating electrical shorts. Spot-weld titanium connectors for titanium mesh systems to facilitate efficient current distribution.

457-3.3.1 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. The Engineer or CP technologist 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, 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 prior to the installation of any jacket.

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-in. 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-in. 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-in. diameter by an 8-in. 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 the 1.25-in. diameter PVC pipe to a 3/4-in. PVC pipe. Extend the 3/4-in. pipe approximately 2 in. 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 directed by Engineer.

457-3.3.1.1 Location and Length: Install pile jacket to cover a minimum of 2 feet above and 2 feet below the major deficient area on the pile. 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 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.

457-3.4 Connections: Implement a connection strategy that ensures a low-impedance electrical path throughout the entire CP zone. Provide each CP zone with a minimum of two redundant negative cable connections to the reinforcement and 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 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.

457-3.4.1 Pile Jackets: 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. 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-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 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 within Quality Control(QC) plan.

457-3.5 Electrical Installation: Cathodic protection electrical work shall comply with ISO 12696 and NEC NFPA70. Direct current (DC) cables shall be color-coded and identified using permanent tags within junction boxes and power supplies. All signal cables for monitoring sensors shall be shielded twisted pairs to mitigate electromagnetic interference. All other electrical work shall comply with NCE Standards.

457-3.6 Testing During Installation: Conduct testing throughout the installation phase, including polarity checks for all circuits and continuity verification to ensure individual circuit resistances confirm isolation or continuity as required for the individual components. For impressed current systems, perform continuity checks to demonstrate electrical isolation between DC positive and negative circuits.

457-3.6.1 Pile Jackets: 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 as directed by CP technologist or CP Technician.

The CP technologist or CP Technician 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 CP technologist or CP Technician, 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 least 3 days.

Prior to installing the jackets, the CP technologist or CP Technician 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 CP technologist. The CP technologist or CP Technician 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 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 CP technologist 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. 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. 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 discontinuous 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.

457-3.7 Visual Inspection: Perform visual inspection of the CP system and its components to confirm correct installation, position, labeling, and protection from environmental or mechanical damage. For buried or embedded elements, complete and document this inspection before backfilling or concrete placement.

457-3.8 Backfilling or Concrete Placement: After visual inspection is complete and continuity is confirmed, backfill area for buried elements or place concrete filler for embedded elements.

457-3.8.1 Form Placement for Pile Jackets: 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 CP technologist 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 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.

457-3.8.2 Concrete Placement for Pile Jackets: 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.

457-3.8.3 Monitoring Port: 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 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.

457-3.9 Energizing: Energize the system only 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. Record native and energized potentials at all permanent reference electrodes to verify a negative potential shift, confirming correct system polarity. Record current and anode to cathode resistance for all cathodic protection circuits.

457-3.9.1 Pile Jackets: 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 4 hours after the CP systems are initially activated. Galvanic CP 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.

457-3.10 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. Complete spalled area repairs in accordance with Section 401.

457-3.11 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. This includes, but is not limited to, the installation of shielding to prevent interference with non-protected metallic fixtures, the provision of insulating spacers to prevent short-circuits during concrete vibration, and any structural adjustments required to accommodate monitoring sensors or cable management systems. All incidental activities shall be coordinated with the Engineer to ensure the structural integrity and the long-term effectiveness of the corrosion control measures are maintained throughout the project duration.

457-3.11.1 Pile Jacket: Excavation at the mud line may be necessary to install the jacket systems and is considered incidental work, thus its cost is included within the Pay Item contained in this Section. 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.

Removal and disposal of existing debris is considered incidental work, thus its cost is included within the Pay Item contained in this Section. Avoid debris falling into the water.

Collect any debris that falls into the water and dispose of it in accordance with all local, state, and federal requirements.

Pollution control and monitoring plan required per FDOT Standard Specifications is considered incidental work, thus its cost is included within the Pay Item contained in this Section.

457-4 Quality Control and Quality Assurance.

457-4.1 Quality Control Plan: Develop a 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 methodology and frequency of QC testing, procedures for locating existing reinforcing steel, detailed protocols for electrical continuity testing of the reinforcement, anode installation verification, and alternating current (AC) resistance measurements. 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 Quality Control 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.

457-4.2 Quality Control Personnel:

457-4.2.1 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.

457-4.2.2 Cathodic Protection Technologist: Provide CP technologist to oversee installation the CP system, including commissioning, visual inspection, energizing, finishing and reporting, The CP technologist shall be an 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.

457-4.3 Performance Criteria: The installed CP system shall demonstrate effectiveness through electrochemical measurements as specified in the Contract Documents.

457-4.4 Quality Assurance: The CP technologist 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. 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.

457-4.4.1 Pile Jackets: 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 4 hours after the CP systems are initially activated).

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.

457-5 Acceptance.

457-5.1 Documentation Review: Submit all installation records to the Engineer for approval. Submitted records must include a pre-installation baseline potential survey and 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.

457-5.2 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.

457-5.3 Testing and Commissioning: Perform all electrical continuity testing and submit a comprehensive continuity log covering all reinforcing steel and metallic elements in the concrete components. The acceptance criterion for such testing shall be a measured resistance of less than 1.0 Ω. Ensure all reference electrodes are calibrated against a certified laboratory reference electrode to ensure that the potential difference remains within ±5 mV of the values stated on their calibration certificates. 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.

457-5.4 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.

457-6 Method of Measurement.

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

457-6.1 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.

457-6.2 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.

457-6.3 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.

457-7 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.

CATHODIC PROTECTION SYSTEM MATERIALS
(DEV 05-19-2026)

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

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.

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.

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.

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 alternating current (AC) input to a rectifier or 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 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.