

**CATHODIC PROTECTION OF STEEL IN CONCRETE
(DEV 04-01-2026)**

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.

Complete spalled area repairs in accordance with Section 401.

457-2 Materials.

Portland Cement Concrete-Class IV*	Section 346
Reinforcement.....	Section 415
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

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, 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.

457-3.3 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.

457-3.4 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. Electrical 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.

457-3.5 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.

457-3.7 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 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 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.

457-3.10 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.

457-4 Quality Control.

457-4.1 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 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.

457-5 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 copper-copper sulfate (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 M Ω with an accuracy of \pm 5 mV or better.

457-6 Method of Measurement.

The quantities to be paid for will be lump sum for the complete and functional CP system, accepted for all work including, but not limited to: Cathodic Protection Technologist work, energization, QA/QC Plan, grounding plan, performance monitoring, and As-Installed drawings. This measurement encompasses all components necessary to provide a fully operational system as per the specific technology deployed.

457-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, 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.

Payment will be made under:

Item No. 457-1- Standard Integral Pile Jacket - per foot.

Item No. 457-2- Cathodic Protection Integral Pile Jacket - per foot.

Item No. 457-3- Cathodic Protection System – lump sum.

**CATHODIC PROTECTION SYSTEM MATERIALS
(DEV 04-01-2026)**

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 M Ω . 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 the interior of the forms with a rough surface texture and ensure a bond with the filler material. 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.