SP-090096
(New)

Iowa Department of Transportation

SPECIAL PROVISIONS
FOR
APPLICATION OF GALVANIC ANODE COATING
FOR
REINFORCED CONCRETE PIERS

Polk County
FSSN-069-4(94)--3T-77

Effective Date:
January 19, 2011

THE STANDARD SPECIFICATIONS, SERIES 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

090096.01 DESCRIPTION.
This special provision pertains to the application of a Zinc or Aluminum-Zinc-Indium (Al-Zn-In) galvanic anode coating on the surface of concrete at designated piers using the thermal spray process, hereinafter referred to as the System. The purpose of the anode coating is to stop corrosion of the embedded steel by galvanic cathodic protection. When electrically shorted to the reinforcing steel in the concrete, a small direct current will flow from the sacrificial anode to the steel; thereby providing cathodic protection current to the embedded reinforcement.

The electrically shorted System shall consist of a Zn anode coating plus activation coating containing humectant, or an Al-Zn-In anode coating, and connector plates. In addition, a non-shorted test system shall also be installed for the purpose of evaluating system performance. The non-shorted system shall be installed in a small isolated area, such as a 10 square foot test window, and shall consist of the anode coating, anode connector plates, embedded reference electrodes, system grounds, and all necessary wiring.

The System furnished shall include all materials identified in these specifications and on the drawings.

The Contractor shall demonstrate that they are capable of spraying the sacrificial alloy prior to installation at the job site. The thermal spray operator shall have adequate technical training and field experience, to safely and proficiently apply the anode coating on concrete structures, with a minimum of 5 years experience in cathodic protection of a similar nature. The operator shall demonstrate the ability to set up and operate the thermal spray equipment. The Contractor shall submit valid records showing operator qualifications, along with the manufacturer's equipment specifications and recommended operations procedures, and a certificate verifying purity of the anode wire, for review by the Engineer.

The current edition of following standards shall be observed:

ASTM B 6	Standard Specification for Zinc
ASTM B 833-01A	Specification for Zinc Wire
ASTM D1002	Strength Properties of Adhesives in Shear by Tension Loading
ASTM D 4285.	Standard Test Method for Indicating Oil or Water in Compressed Air ASTM D4541 Standard Test Method for Pull-off Strength of Coatings Using Portable Adhesion Testers
NACE	National Association of Corrosion Engineers
AWS C2.20	Specification for Thermal Spraying Zinc Anodes on Steel Reinforced Concrete
SSPC CS 23.00	Guide for Thermal Spray Metallic Coating Systems
ACI 222R	Protection of Metals in Concrete Against Corrosion

090096.02 MATERIALS AND EQUIPMENT.
As a minimum, the Contractor shall supply the following:

A. Abrasion of Concrete Surface.
The abrasive blasting equipment shall be a conventional, air pressure-type blaster. A maximum of 80 psi shall be maintained at the blast nozzle.

The abrasive material shall be clean and dry non-metallic grit with no mineral constituents, which tend to break down and remain on the surface in visible quantity. The abrasive size shall be selected from 20-40 mesh, and shall be hard and angular in shape. Abrasives that have been previously used to remove oil and/or grease shall not be allowed.

Compressed air used for abrasive blasting shall be clean, oil-free, and dry per ASTM D 4285. Air line filters and moisture separators shall be installed upstream from the blasting equipment. These shall be inspected daily for cleanliness and correct operation.

B. Application Equipment.
The coating shall be applied using electric-arc spray equipment. The arc spray equipment shall consist of a spray gun, wire feed unit, power supply, and air compressor. To readily spray the coiled anode wire, a straightening device may be necessary. The Contractor shall be responsible for making any necessary modifications and adjustments to the thermal spray equipment, so that the alloy wire can be sprayed properly. The manufacturer's equipment specifications and recommended operational procedures shall be submitted to the Engineer at least two weeks prior to commencement of work. Such equipment shall include, but is not limited to:

- Spray Equipment.
- Air Compressors.
- Adhesion Gages for Coatings.
- Thickness Gages for Coatings.
- Voltmeter.

C. Anode Systems.
The following Systems are approved for application of galvanic anode coating. For the selected System, certifications with physical properties of all materials proposed for use shall be submitted to the Engineer for review at least two weeks prior to commencement of work.

1. The CORRSPRAY™ system as supplied by Corrpro Companies, Inc., 1055 West Smith Road, Medina, Ohio 44256; or its agents and subsidiaries. The material shall have the following material specifications:

Nominal Chemical Composition:	Al-20Zn-0.2In
Wire Diameter:	1/8 inch
Type:	Cored Wire

Density:	202 pcf
Open Circuit Potential in Simulated Concrete Pore Solution w/pH = 12-13:	>-1.6 V (CSE)

The anode connector plate shall consist of a perforated aluminum sheet 4inches by 4inches, galvanized steel stud, nut and washers. The connector plate shall have a minimum of 5 holes drilled in the corners and center of the plate for attachment. Each hole shall be 3/4 inch in diameter. The anode wire and anode connector plates shall be kept clean, dry and free from oxides at all times.

The epoxy for the anode connector plates shall be Concresive AEX 1419 as manufactured by Adhesive Engineering Co., DP-420 by 3M Co., or approved equal.

2. Galvanode ASZ + humectant-activated zinc metalizing as supplied by Vector Corrosion Technologies, 14452 Bruce B. Downs Blvd., Tampa, FL 33613; or its agents and subsidiaries.

The zinc for the zinc anode shall be zinc wire of minimum 99.99% purity with impurities not to exceed limits established in ASTM B833-01A-2001, Specification of Zinc Wire. The nominal thickness of the zinc applied to the concrete shall be 20 mils. The applied zinc shall have a minimum bond strength of 150 psi when tested in conformance with ASTM D4541.

The anode connector plate shall be a flattened expanded zinc mesh plate 6 inches by 6 inches with galvanized steel threaded stud, nut and washers. The connector plate shall have a minimum of 5 holes drilled in the corners and center for attachment.

The zinc activation coating shall contain a humectant with documented field performance.

090096.03 CONSTRUCTION.

The Contractor shall field verify all dimensions. The Contractor shall coordinate installation of the system components with all other construction operations.

Installation shall proceed in accordance with the following sequence.

A. Preparation of the Concrete Surface.

Work performed under this section consists of cleaning the concrete surface and providing an anchor profile by abrasive blasting, so that an adequate bond between the concrete and thermally sprayed anode can be obtained. The main purpose is to remove dust, grit, chalk marks, paints, curing compounds, and other substances, which might inhibit bonding of the anode to the concrete.

Abrasive blasting shall not commence before concrete repairs (as detailed on the plans) are completed and patch materials are allowed to cure properly. Abrasive blasting shall not take place on surfaces that will be wet or damp following blasting. Exposed System wiring shall be covered with a shielding material to prevent damage to the insulation from the blasting operations. No abrasive blasting or metalizing shall be performed until the Engineer has approved the concrete removal.

The anode wire shall be kept clean and dry at all times.

B. Steel Continuity.

The purpose of the steel continuity check is to ensure that all of the embedded steel is electrically continuous. If the embedded steel is discontinuous, it will not receive cathodic protection current. The reinforcing steel shall be checked for electrical continuity at a minimum of 5 locations per 1,000 square feet and between all exposed rebars during the delamination repair stage, and other metallic members by using the DC millivolt technique. Testing shall be conducted during the

delamination repair stage, so as to alleviate unwanted excavation. Test equipment for this procedure shall consist of a standard digital DC voltmeter, test leads and wire reel. The millivolt drop between the steel is measured. Readings greater than 1.0 millivolt indicate electrical discontinuity and the discontinuous steel must be bonded back into the steel network.

All reinforcing steel which is found to be discontinuous must be electrically bonded to the continuous steel with one No. 10 AWG wire with HMWPE insulation using the thermite welding procedure, or by brazing a steel wire between the bars.

C. Installation of Reference Electrodes and Ground Wires (For Test Area).
All instrumentation shall be installed as detailed on the drawings and at the locations shown.

The reference electrodes shall be silver-silver chloride designed for permanent installation in concrete structures. The electrodes shall be supplied with a No. 10 AWG stranded copper lead wire with HMWPE blue insulation. The lead wire to reference electrode connection shall be completely sealed to prevent moisture penetration into the connection.

The epoxy for the anode connector plates shall be Concresive AEX 1419 as manufactured by Adhesive Engineering Co., DP-420 by 3M Co., or approved equal.

The reference electrodes shall be located according to the layout plans. After locating the reinforcing steel in the concrete at each location with a pachometer, the Contractor shall excavate an area approximately 4 inches by 8 inches to the depth of the reinforcing steel or prestressing steel. Care shall be taken not to expose the steel in the excavation.

A ground wire shall be connected to the reinforcing steel at each reference electrode location. The ground wire connection shall be at least 18 inches from the reference electrode in a separate excavation.

D. Wire Connections to Embedded Steel.
The system ground and reference cell ground wires shall be No. 10 AWG copper wires with black HMWPE insulation. The connection of each ground wire to the reinforcing steel shall be made using the thermite brazing or welding process, in accordance with appropriate manufacturers' instructions. The connection of any exposed copper stranded wires in the excavated area shall be completely coated with a 100% solid epoxy. After properly installing the reference electrode and ground wires, the excavated areas shall be filled with an air-entrained portland cement concrete patching material. Each ground wire shall then be routed through a PVC conduit to a nearby PVC junction box, as shown on the drawings.

E. Installation of Anode Connector Plates for Non-Shorted Test System.
The purpose of the anode connector plate for the non-shorted test system is so that the anode can be disconnected from the steel to help facilitate testing of the System. The anode connector plates shall be installed at each location designated in the layout plans, using the following procedures:

1. Using a concrete cover meter or pachometer, locate the position the reinforcing steel bars in the area where the anode connector plates are to be installed for the non-shorted test area. Mark a spot on the concrete between the bars.

2. At the spot, drill a 3/4 inch diameter by 1 1/4 inch deep hole into the concrete, making sure that no steel is exposed (see attached illustration).

3. Chip an area, of approximately 4 inches in diameter and to a minimum depth of 1 inch, in the concrete surrounding this drilled hole where the anode connector plate is to be installed. The chipped area shall be filled with a cementitious grout. Prior to hardening of the grout, press

the connector plate against the grout so that the disk is recessed into the grout surface, as shown in the illustration.

4. Insert a 1/4 inch diameter galvanized, threaded rod (stud) into the drilled hole, and secure the rod in the hole by backfilling with an epoxy adhesive. The threaded rod must extend to the outer concrete surface to facilitate attachment of the anode connector plate.

5. Secure the galvanized steel washer and nut over the anode connector plate.

F. Installation of Anode Connector Plate for Shorted System.

The anode connector plates in the shorted system provide a direct electrical connection between the sacrificial anode and the reinforcing steel. For each anode connector plate, a threaded galvanized rod (stud) shall be attached to the reinforcing steel to facilitate attachment of the anode connector plate. The following procedure shall be followed:

1. Using a concrete cover meter or pachometer, locate the reinforcing steel at the location where a shorted-system anode connector plated is to be installed.

2. Drill a 1 inch diameter hole into the concrete to expose the reinforcing steel (see illustration).

3. Chip an area, of approximately 4 inches in diameter and to a minimum depth of 1 inch, in the concrete surrounding this drilled hole where the anode connector plate is to be installed. The chipped area shall be filled with an approved cementitious grout. Prior to hardening of the grout, press the connector plate against the grout so that the disk is recessed into the grout surface, as shown in the illustration.

4. Attach a 1/4 inch diameter galvanized, threaded rod (stud) to the exposed steel, using the tapping method. The threaded rod must extend to the outer concrete surface to facilitate attachment of the anode connector plate.

5. Secure the galvanized steel nut over the anode connector plate.

G. Application of Galvanic Anode Coating.

Anode connector plates shall be installed before application of the anode coating. The Contractor shall furnish all necessary labor, materials and equipment for installation of the anode system, in accordance with the following procedure.

1. Surfaces shall be thoroughly vacuumed or blown clean within 15 minutes before thermal spraying of the area is started. Any oil, grease, soil, water, or other foreign matter that may have deposited on the surface after the surface preparation has been completed shall be removed before spray application. Coating application shall only be performed when the concrete surface is clean and dry.

2. All metallic components or appurtenances such as drain pipes, conduit, or bearing steel plates shall be isolated from the anode and temporarily covered with suitable masking materials, which shall extend, from the objects, by at least 1 inch on the concrete surfaces.

3. The installation areas shall be enclosed during spraying for dust containment. The enclosure shall consist of tarps, panels, or other methods to prevent dust from escaping the immediate area such that it would constitute a health hazard. Personnel conducting spraying operations within the enclosure shall be provided with a hood with external air supply for respiration in accordance with OSHA 19-10-134.

4. Concrete surfaces shall not be sprayed when the temperature is less than 41°F.

5. During application, the thermal spray nozzle shall be maintained at a travel speed and a distance from the work surface such that the anode deposit efficiency and bond strength are maximized. Travel speed shall be approximately 16 inches per second, unless equipment supplier requires a different speed. The distance from the nozzle to the surface should be approximately 6 inches.

6. This step differs for the non-shorted test area and the shorted systems. Therefore, the Contractor shall follow the appropriate steps outlined below, according to the designation of an area (see layout plans):
   a. For Non-shorted Test System: The spray application of the sacrificial anode shall begin by metallizing the area(s) in which the anode connector plates are installed. To detect electrical short circuits between the anode and the reinforcing steel, connect a DC voltmeter between the threaded rod and a system ground. Begin by spraying the anode over the connector plate and then proceed toward the surrounding concrete. To facilitate short circuit detection, monitor the potential on the voltmeter for any sudden drop (i.e., at or close to 0 millivolt). A sudden drop in potential is indicative of a short circuit. When a short circuit is detected, all installation work shall stop until the short is identified and eliminated.
   b. For Shorted System: The spray application of the sacrificial anode shall begin by metallizing the area(s) in which the anode connector plates were installed. Begin by spraying the anode coating over the connector plate and then proceed toward the surrounding concrete.

7. The coating should be applied in multiple passes and should overlap on each pass in a crosshatch pattern, before the first layer of material has cools down. Uniform gun movement should be used to ensure a consistent thickness. Sufficient anode material shall be sprayed to achieve a minimum thickness of 20 mils.

   The thickness of the coating shall be measured at a minimum of 5 locations per 100 square feet using a metallic coating thickness gage, such as a DeFelsko Positector. The detector shall calibrated for the alloy being tested.

8. Compressed air used for spraying shall be clean, oil-free and dry, per ASTM D 4285. Air line filters and moisture separators shall be installed upstream from the spraying equipment. These shall be inspected daily for cleanliness and correct operation. Any indication of malfunction in the equipment, indicated by oil or water in the filter or traps, shall be corrected immediately.

9. The anode coating shall not contain any lumps, blisters, coarse texture, or loosely adhering particles, nor shall it contain any cracks, pinholes, or chips, which expose the concrete substrate. Unacceptable areas shall be repaired. Repair work shall be conducted as follows:
   a. Remove all degraded anode coating by scraping, strip blasting or both. During this process, light blasting shall be applied to the areas without exposing large aggregates.
   b. Re-apply sacrificial anode coating.
   c. Inspect the sprayed anode for proper thickness, as described above.

10. For the Zinc System, after the zinc spraying is completed and accepted in each area, a zinc activation coating containing humectant shall be applied to the surface of the zinc spray according to the manufacturer's recommendations. Each coat shall be applied and allowed to dry prior to the application of subsequent coats. Coats shall be applied until the total quantity of activator applied is 0.14 pounds per square yard (dry basis).

11. The following shall be submitted to the Engineer, to document metal anode usage:
   a. A record of the mass of the wire coil at the beginning and the end of the application of metal anode each day.

b. A record of the total quantity of metal anode applied upon the completion of arc spraying of each zone.

H. Completion of Anode Connector Plate Installation.

This step differs for the non-shorted test system and the shorted system. Therefore, the Contractor shall follow the appropriate steps, outlined below for each system:

1. Non-shorted Test System: Securely attach a red No.10 AWG HMWPE copper lead wire between the anode connector plate and the galvanized steel washer and nut, making sure that the nut is firmly tightened. Enclose the connection with a PVC junction box, and provide a connection (through a precision 0.1 ohm fixed resistor) to the system ground wire.

2. For Shorted System: Check to make sure that the galvanized washer and nut are tightly secured over the anode connector plate using the galvanized steel threaded rod. Then cover the washer-and-nut assembly with epoxy adhesive.

Adhesion strength between the anode coating and concrete substrate shall be measured with a Proceq Model DYNA Z 5, or equal. A minimum of one adhesion test shall be performed per 300 square feet of concrete surface. The target adhesion strength of the sacrificial anode coating shall be greater than 150 psi. The Contractor shall remove the anode coating from areas where the adhesion strength is less than 50 psi, and re-apply the anode coating in accordance with these specifications.

I. Installation of Junction Boxes and Conduit.

1. The Contractor shall install Schedule 40 PVC conduit and PVC junction boxes for the System.

2. All conduit joints, fittings, couplings and adapters shall be jointed by means of a solvent cement or as recommended by the conduit manufacturer.

3. The junction boxes and the conduit shall be secured on the concrete surface using stainless steel (grade 304 or 316) bolts with a vinylester adhesive resin.

4. The conduit shall be secured on the concrete surface using non-metallic clamps or hangers in accordance with National Electric Code.

5. Any conduit sections to be bent must be heated evenly over the entire length of the curve. Only electrical heaters designed specifically for the size and purpose of bending non- metallic conduit shall be used. Conduit bending shall be performed according to conduit manufacturer's recommendations. For "blind" bends or for compound turns in a conduit run, the heated conduit may be solvent cemented in place while still flexible. The use of torches or other flame-type devices shall not be permitted. PVC conduit sections that were exposed to excessive heating, as evident by brown discoloration shall be discarded.

J. Installation of Electrical Wiring.

1. Wiring for the System shall be installed in accordance to the plans and material specifications.

2. All wiring shall be installed or routed into PVC conduit.

3. All cathodic protection wires shall be identified in the junction boxes, and at the test station using durable identification tags. Each wire shall be clearly marked as to its function. Care shall be taken to identify each wire correctly in accordance with the legend shown in any schematic-wiring diagram.

4. All connections and wire splices shall be housed in junction boxes, which are encapsulated to prevent any moisture intrusion, and to provide electrical insulation from other nearby connections or wires. A weep hole shall be provided in the base of each junction box.

K. Energizing and Testing of the System.

In the designated junction boxes, connect each red anode lead wire to a nearby system ground, through a 0.1 ohm shunt. Always properly seal all connections in the junction boxes with waterproof materials to prevent future moisture intrusion. Likewise, route all lead wires from the embedded reference electrodes and their grounds all the way, without splices, to the junction box. Properly mark each wire and its function with durable identification tags.

In each Non-shorted Test Zone, measure and record the AC resistance and DC voltage between the anode and steel, the DC millivolt drop across each shunt, the AC resistance between each reference electrode and the steel, and the native potential of the steel using the embedded reference electrodes. Conduct minimum 4 hour depolarization tests using the embedded reference electrodes. The System Technical Representative shall conduct these tests. The results of the testing shall be submitted in writing.

090096.04 METHOD OF MEASUREMENT.

The quantity of Galvanic Anode Coating for which payment will be made will be the quantity shown in the contract documents. The surface area in square feet will be computed by the Engineer from dimensions shown on the plans of the existing bridge, copies of which may be obtained from the Contracting Authority.

090096.05 BASIS OF PAYMENT.

Payment for Galvanic Anode Coating will be at the contract unit price per square foot, and shall include all materials, scaffolding, enclosures, equipment, tools, and labor incidental for the completion of this item, including surface preparation and installation of non-shorted test system. Payment for concrete repairs to the substrates, prior to surface preparation, will be made separately.