

# Special Specification 4038

## Zinc Cathodic Protection System



### 1. DESCRIPTION

Furnish, install, and energize a sacrificial zinc anode cathodic protection system to bent caps, tie beams, concrete walls and columns in accordance with the plans and the requirements of this Item.

The cathodic protection system consists of a thermal sprayed High Purity Zinc anode coating, connector plates, and water based inorganic zinc silicate top coat.

Follow the minimum requirements for connectivity of anode to steel, unless shown otherwise:

- Install a minimum of six anode connector plates per bent cap.
- Install a minimum of four anode connector plates per column bent or one anode connector plate per pile on trestle pile bents.
- Connect the anode system directly to the reinforcing steel and no provision for electrical isolation be made.
- When Zinc Cathodic Protection System is adjacent to sacrificial cathodic protection system jacket, extend additional electrical connectivity wire from jacket system to anode connector plate as directed.

### 2. REFERENCE SPECIFICATIONS

Observe the following standards:

- ASTM D1002 Strength Properties of Adhesives in Shear by Tension Loading
- ASTM D4285 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 Testing
- ASTM D4263 Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
- ICRI 03732 Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings and Polymer Overlays
- SSPC CS23 Guide for Thermal Spray Metallic Coating Systems

### 3. MATERIALS

All materials, fabrication and installations are subject to inspection and testing by the Department or its designated representative. Use only specified materials.

- 3.1. **Anode.** Provide anode grade 1/8 in., standard size zinc wire with minimum 99.9% purity and a maximum iron content of 14 ppm.

Provide a manufacturer's certification and laboratory test results for each lot of zinc including the purity of all zinc wire to be used on this project and listing the percentage of each impurity. Include the anode lot number and date of manufacture in the certification documentation.

- 3.2. **Anode Connector Plate.** Provide anode connector plate, 3 in. diameter, 1/8 in. thick, with 1/4 in. hole in center, fabricated from carbon steel and metalized with the same zinc alloy being used for the metalized zinc anode. Apply metalized coating on the plates to a thickness of 10 mils on both sides and edges. Prepare surfaces by grit blasting the steel to provide a sharp anchor tooth profile of approximately 3-4 mils. Apply metalized coating before any flash rusting or contamination of the prepared steel surfaces can occur. Metalize connector plates prior to delivering to the project site.

Provide inorganic zinc silicate coating material in accordance with DMS-8101, "Structural Steel Paints-Performance" for top coat over thermal spray zinc. Apply coating in accordance with manufacturer specifications.

Provide white epoxy paste to cover surface over anode connector plate after all other coatings applied.

#### 4. EQUIPMENT

Apply thermal spray zinc coating using electric-arc type spray equipment consisting of a spray gun, wire feed unit, power supply, and air supply unit. The zinc spray unit and air compressor must include a moisture/oil separator. Service the separators daily. Provide air supply unit capable of delivering a minimum of 250 cu. ft. of air per min. at 100 psi or pressure and having an adjustable pressure range of 70 to 125 psi. Compressed air used for spraying must be clean, oil-free and dry, per ASTM D 4285. Install airline filters and moisture separators upstream from the spraying equipment. Inspected daily for cleanliness and correct operation.

#### 5. QUALIFICATIONS

Submit in writing the qualifications for review and approval of the proposed personnel to perform the thermal spray work.

- 5.1. **Contractor.** Provide documentation verifying previous experience applying thermal spray to concrete. Optionally, provide a Cathodic Protection Specialist (CPS) to train and assist with the thermal spray work with the following qualifications:
- Cathodic protection practitioner with a minimum of 2 yrs. of experience in the field of thermally sprayed zinc and 5 yr. of verifiable experience in the field of corrosion control on marine structures.
  - licensed professional engineer competent in cathodic protection with similar training as for the NACE certified specialist.
- 5.2. **Thermal Spray Personnel.** The thermal spray personnel must have adequate technical training and field experience, to safely and proficiently apply the coatings on concrete structures in a marine environment. The thermal spray crew foreman must have a minimum of 2 yr. of previous experience of thermal spray work practice, in metalizing operations in the field, and have performed at least one similar project within the last five years. Submit for approval all proposed thermal spray applicators indicating their training and experience.

#### 6. CONSTRUCTION

Obtain approval of personnel and procedures prior to beginning thermal spray work.

The plans for the cathodic protection system are diagrammatic and are not intended to be scaled for exact locations unless scales are explicitly stated on the drawing. Field conditions and non-interference with structural features determine exact locations.

- 6.1. **Work Plan.** Submit a detailed Work Plan for all phases of work and a description of proposed materials to be used in this project to the Engineer for approval prior to beginning work. Work plan must be reviewed and endorsed by the CPS. Independent validation tests may be conducted by the Engineer, or his appointed representative, apart from the quality control testing required to be performed by the CPS.
- Coordinate installation of the system components with all other construction operations.
- 6.2. **Demonstration.** Perform demonstration of zinc spraying operation (metalizing) to Engineer prior to commencing production work. Test spray, area not less than 10 sq. ft. per location, a prestressed concrete piling and the overhead and vertical faces of a reinforced concrete pile cap near either end of the bridge, as

directed. Perform bond testing on the test sections after a minimum of 24 hr. after application per ASTM D4541-02. A minimum bond strength of 150 psi is required for the average of three (3) tests per location.

6.3. **Access.** Provide safe access for workers, supervisors and inspectors to all areas where work is being performed.

6.4. **Installation.** Provide safe access for workers, supervisors and inspectors to all areas where work is being performed.

Do not perform thermal spray operations when raining, choppy waters are wetting the intended spray surface, or when wind conditions are such that the spray operations are being negatively effected, as determined by the Engineer.

Perform metalizing operations continuously on a single member. Cold overlaps of zinc spray is not permitted, unless approved by CPS and the Engineer.

6.4.1. **Anode Connector Plates.** The anode connector plates provide a direct electrical connection between the sacrificial anode and the reinforcing steel. For each anode connector plate, a 1/4 in. 20 threaded galvanized steel rod (stud) must be attached to the reinforcing steel to facilitate attachment of the anode connector plate, as shown on the detail drawing and in accordance with the following:

- Use an electronic concrete cover meter or pachometer, to locate the reinforcing steel at the location where the shorted-system anode connector plated is to be installed.
- Drill a 1 in. diameter hole into the concrete to expose the reinforcing steel.
- Attach a 1/4 in. diameter galvanized steel 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. Secure the rod in the hole by backfilling with an epoxy adhesive. Take care not to drip epoxy on the surrounding concrete surface. Make sure that the epoxy is flush with the surface, but does not overlap onto the concrete. The threaded rod must extend a minimum of 1 in. beyond the outer concrete surface to facilitate attachment of the anode connector plate.
- Place duct tape over the exposed rod and proceed with the abrasive blasting and metalizing process. Do not over apply the zinc coating in the anode connection plate area.
- After the metalizing process is complete, remove the duct tape and install the anode connector plate over the stud. Secure with a galvanized steel washer and nut. After the anode plates are installed and tightened any excess length of the threaded rod must be sheared off to prevent damage caused by fishing lines or vessels tying off to the rod.
- Clean surface and proceed with a final coat of zinc over the connector plate and surrounding concrete. Ensure good contact between the coating and connector plate by measuring the resistance and voltage drop between surrounding coating and steel stud.

6.4.2. **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 zinc anode may be obtained.

Do not abrasive blast surfaces for coating before concrete repairs are completed and patch materials are allowed to cure as required.

Provide the following equipment and material meeting the requirements included:

6.4.2.1. **Abrasive Blasting Equipment.** Abrasive conventional, air pressure-type blasting equipment able to maintain a minimum pressure of 80 psi at the blast nozzle.

6.4.2.2. **Abrasives.** Provide clean dry silica sand as the abrasive material. The blast material must be plant packaged and maintained in a clean and dry condition at all times. Do not use material stored in the sand blaster pot overnight.

6.4.2.3. **Compressed Air.** Compressed air used for abrasive blasting must be clean, oil free, and dry, per ASTM D 4285. Air line filters and moisture separators must be installed upstream from the blasting equipment. These must be inspected daily for cleanliness and correct operation. Any indication of malfunctioning equipment must be corrected immediately.

6.4.3. **Application of Zinc Anode Coating.** Install anode connector plates before application of the anode coating as follows:

- Allow concrete repairs to cure for a minimum 14 day before abrasive blasting and metallizing. Do not metalize if the enclosure temperature and surfaces to be sprayed are 5°F or less above the dew point.
- Thoroughly vacuum or blow clean surfaces within 15 min. before thermal spray application is started. Remove any oil, grease, soil, water, or other foreign matter that may have deposited on the surface after the surface preparation has been completed before spray application. Only proceed with coating application when the concrete surface is clean and dry. Tests moisture in concrete prior to metallizing in accordance with ASTM D 4263-88 or use a surface moisture meter for concrete, such as the Tramax Concrete Encounter Meter. If significant moisture is present, which adversely affects bonding of zinc alloy coating, a portable propane powered weed burner may be used to achieve adequate low concrete moisture levels.

When using the weed burner, keep the burner moving slowly at an even pace, heating the concrete surface to a maximum temperature of 300°F.

- Isolate all metallic components or appurtenances such as drainpipes, conduit, or bearing steel plates from the anode and temporarily covered with suitable masking materials.
- Do not thermal spray surfaces when surface temperature is less than 5°C (41°F), unless the concrete surface is preheated with a torch prior to the thermal spray application.
- During application, the thermal spray nozzle must be maintained at a travel speed and a distance from the work surface such that the anode deposit efficiency and bond strength are maximized. The distance from the nozzle to the surface should be approximately 6 in.
- Begin the spray application of the sacrificial anode by metallizing the concrete area where the anode connector plates are to be installed. Install the connector plate and then continue spraying the anode coating over the connector plate and then proceed toward the surrounding concrete.
- Apply the coating in multiple passes and overlap on each pass in a crosshatch pattern, before the first layer of material has cooled down.

Uniform gun movement should be used to ensure a consistent thickness. Sufficient anode material must be sprayed to achieve uniform deposition of material to an average thickness of 375 microns (15 mils). This should correspond to a deposition rate of approximately 0.645 lbs. of anode material per square foot of treated surface. Material usage logs must be used to document installation of the proper anode quantity. For confirmation of the material usage, the thickness of the coating must be measured at a minimum of 5 locations per 100 ft., two using a reverse eddy current thickness gage, such as the DeFelsko PosiTector 6000. Calibrate the test instrument for the zinc alloy being tested. The average of the 5 readings must be a minimum of 375 microns (15-mils). If the average is less than 375 microns (15-mils), the areas of low thickness must be identified and repaired as follows:

- Clean existing anode by lightly blasting the areas without exposing large aggregates.
- Re-apply sacrificial anode coating using the procedures outlined in this specification.
- Inspect the sprayed anode for proper thickness and adhesion to the existing coating.
- Apply anode coating continuous, without lumps or blisters, with a smooth texture. The coating must be free from loosely adhering particles, nor contain any cracks, pinholes, or chips, which expose the concrete substrate. It must have a uniform homogeneous appearance. Repair unacceptable areas as follows:
  - Remove all degraded anode coating by scraping, strip blasting or both. During this process, light blasting must be applied to the areas without exposing large aggregates.
  - Re-apply sacrificial anode coating.

- Inspect the sprayed anode for proper thickness, as described above.
- Apply top coat consisting of one coat of a water based inorganic zinc silicate over the metalized areas of the structure after the zinc coating has been approved by the Engineer. Perform top coating within 72 hr. after the metalizing.  
Extend the coating application 6 in. beyond the metalized areas in each direction. Properly mask areas not to be coated to protect them from over spraying or over-run.
- Apply neat epoxy paste over anode connector plate.

6.4.4. **Adhesion Strength Testing.** Measure adhesion strength between anode and concrete substrate with a calibrated Proceq-Model DYNA Z5, or approved equal. Use the procedure and test equipment provided by the manufacturer for calibration. Use 2 in. diameter dolly size. Dollies may be left in place.

If they are removed, clean the area of epoxy and the reapply sacrificial coating. Perform a minimum of one adhesion test be performed per 540 sq. ft. of concrete surface, or bent cap as directed. The adhesion strength of the sacrificial anode coating must be greater than 150 psi. Perform testing in the presence of the TXDOT representative.

Remove the anode coating from areas where the adhesion strength is less than the established target value and re-apply the anode coating in accordance with these specifications.

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## 7. MEASUREMENT

This Item will be measured by the square foot.

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## 8. PAYMENT

The work performed and the materials furnished in accordance with this Item and provided under "Measurement" will be paid for at the unit price bid "Zinc Cathodic Protection System." This price is full compensation for all materials, access platforms, anode connector plates, surface preparation, equipment, tools, testing, testing equipment, repair of defective area, labor-including services provided by cathodic protection specialist (if necessary), transportation and all other incidentals necessary to make the cathodic protection system operate as designed.