*Note to Specifier: This document is intended to provide assistance in developing a specification for the use of the Galvashield® DAS distributed anode system and should be modified as appropriate to accommodate project specific conditions and applications. Anode selection including weight and length are determined on a project-by-project basis. For additional information, contact Vector Corrosion Technologies.*

DISTRIBUTED ANODE SYSTEM FOR GALVANIC

PROTECTION OF CONCRETE STRUCTURES

SECTION 03770 – DISTRIBUTED GALVANIC CORROSION PROTECTION

PART 1 GENERAL

* 1. DESCRIPTION

A. The work under this section consists of supplying, installing, and energizing a zinc-based galvanic corrosion protection system, including required electrical connections, materials, testing, and ensuring continuity of the reinforcing steel to all elements as outlined in the construction drawings.

B. Distributed embedded galvanic anodes are designed to provide galvanic corrosion protection. The anodes are connected to reinforcing steel and embedded in concrete to mitigate corrosion.

* 1. REFERENCES

A. ACI Guideline No. 222 – Corrosion of Metals in Concrete

B. ICRI Guideline 310.1R-2008 Guide for Surface Preparation for the Repair of Deteriorated Concrete resulting from Reinforcing Steel Corrosion

C. ASTM B418 – Standard Specification for Cast and Wrought Galvanic Zinc Anodes

1.3 BID QUANTITY

Base bids on the quantity, dimensions, length, weight and information in this specification and shown on the drawings.

1.4 SUBMITTALS

Shop drawings showing typical galvanic corrosion protection system installation details, such as distributed anode installation locations steel connections, and inter-anode connections shall be prepared by the Contractor and submitted for approval prior to any field installations.

PART 2 PRODUCTS

2.1 DISTRIBUTED ANODE SYSTEM

*Note to Specifier:*

*Typical Galvashield® DAS Sizes and Weights As of March 31, 2023*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *Lengths:*  *Typical 39 in. (100 cm) but can be customized to project requirements.*   |  |  |  | | --- | --- | --- | | **Corrosion Risk Category** | **Chloride Level\*** | **Minimum Current Density at end of life\*\*** | | Low to Moderate | <0.8% | 0.6mA/m2 (0.06mA/ft2) | | High | 0.8%-1.5% | 1.2mA/m2 (0.11mA/ft2) | | Extremely High | 1.5% | 2.4mA/m2 (0.22mA/ft2) |   *\*Chloride content is based on percent by weight of cement.*  *\*\*designer to specify end of life minimum current.* | *Nominal Dimensions\*:*  ***DAS****:*  *0.6 lb./ft. (0.89 kg/m)  1.1” x 1.5” (28mm x 38mm)*  ***DAS-X****:*  *1.65 lb./ft. (2.45 kg/m)  1.25” x 2” (32mm x 50mm)*  *\*typically, +/- 1/8” (3mm)*  *Design based on aging term of 12.5 years and an efficiency/utilization of 75%.* |
| *Note: In environments with average annual temperatures higher than 15°C (60°F), use Galvashield® DAS-X. Find your annual average temperature at https://en.climate-data.org/. For marine / submerged applications, use Galvashield® DAS Marine Type M or Type W anodes.* | |

The distributed galvanic anode units shall be alkali-activated with a pH greater than 14 and shall not contain intentionally added constituents that are corrosive to reinforcing steel as per ACI 222R such as chlorides, bromides, or other halides. The anode core shall be manufactured with zinc in compliance with ASTM B418 Type II (Z13000) with iron content less than 15 ppm and that is evenly distributed around a steel core which is continuous along the length of the unit. Unless otherwise specified, the anode unit shall be supplied with a pair of uncoated steel tie wires with optional loop ties to make connections to the reinforcing steel.

Individual anode units shall be approximately *[enter nominal dimensions from table above]*. The length of individual anode units shall be *[enter length of each anode] [as shown on the drawings]*. Anode units shall be supplied with uncoated, steel tie wires for *[direct connection to the steel or connection to an inter-anode connecting header wire as per the design].* Distributed galvanic anodes shall be *[GalvashieldDAS] [GalvashieldDAS-X]* available from Vector Corrosion Technologies (www.vector-corrosion.com) USA (813) 830-7566, Canada (204) 489-9611, UK (44) 1384 671 400 or approved equal.

The spacing of the distributed galvanic anode units will be *[enter spacing here]* as per the design. The basis of design is as follows:

Anode: [*Galvashield DAS] [Galvashield DAS-X]*

Service Life: 20 years minimum

Efficiency\*Utilization Factor: 75%

Minimum current density delivered over the anode service life

*[select one from table above:*

* *Low to Moderate Risk – 0.6 mA/m2 of steel surface area*
* *High Corrosion Risk – 1.2 mA/m2*
* *Extremely High Risk – 2.4 mA/m2]*

Anode aging factor: 12.5 years (approximate half-life, the time when anode current drops by 50%)]

Application for approved equals shall be requested in writing two weeks before submission of project bids. Application for galvanic anode approved equals shall include verification of the following information:

1. Type of activation mechanism must be stated and demonstrated.
2. The distributed anode contains no intentionally added constituents corrosive to reinforcing steel or detrimental to concrete, e.g. chloride, bromide, sulfate, etc.
3. Initial startup current per anode per area at specified average annual temperature of structure.
4. Aging term - This is the number of years over which the electric current produced by the installed anode drops to half of the initial measured current.
5. Submittal of monitored performance data for two examples of satisfactory field performance where said aging term has been achieved.
6. Efficiency and utilization determined from site performance data of no less than seven years.
7. Anode spacing to achieve specified current density at 20 years
8. Initial mass of zinc and projected consumption over the life of the anode.
9. Anode units contains zinc around uncoated, (non-galvanized) steel tie wires.
10. Third party product evaluation, such as from Concrete Innovations Appraisal Service, BBA, etc.
11. Using the information above, model how the alternative design will meet the minimum current density at the end of life of [enter service life here].

2.2 CONCRETE

Concrete mixture shall be of sufficient consistency to encapsulate the anodes without voids or segregation. Concrete shall have an electrical resistivity of less than 50,000 ohm-cm. Concrete mixtures that contain elevated levels of pozzolanic materials such as silica fume, ground-granulated blast-furnace slag, or fly ash will reduce the electrical conductivity of the concrete and may not be suitable for use. If higher resistance concrete is used, or the resistivity is unknown, use Galvashield Embedding Mortar to create a conductive bridge to the substrate prior to concrete installation.

PART 3 – EXECUTION

3.0 GENERAL DESCRIPTION

The galvanic corrosion protection system shall consist of alkali-activated distributed galvanic anodes placed *[evenly across the concrete surface] [in a single line]*. The anode units are connected to the reinforcing steel to be protected and encased in concrete with a minimum of 1 ½ in. (38mm) of clear concrete cover over the anode units. After the anode units are installed and encased in concrete, the system provides galvanic protection to the embedded reinforcing steel.

3.1 MANUFACTURER TECHNICAL ASSISTANCE

A. The contractor will enlist and pay for the services of a NACE-qualified cathodic protection technician (CP2 or greater) supplied by the galvanic anode manufacturer. The qualified corrosion technician shall have verifiable experience in the installation and testing of embedded galvanic protection systems for reinforced concrete structures.

B. The technician shall provide contractor training and support for development of application procedures, shop drawings for submittals, anode and concrete installation, reinforcing steel connection procedures, and verification of electrical continuity of embedded steel. The contractor shall coordinate its work with the designated technician to allow for site support during project startup and initial anode installation.

3.2 CONCRETE REMOVAL

Remove loose or delaminated concrete. Use the smallest practical size chipping hammer to minimize damage to sound concrete. *[Undercut all exposed reinforcing steel by removing concrete from the full circumference of the steel as per ICRI R310.1R. The minimum clearance between the concrete substrate and reinforcing steel shall be ¾ inch (19 mm) or ¼ inch (6 mm) larger than the top size aggregate in the repair material, whichever is greater. Concrete removal shall continue along the reinforcing steel until no further delamination, cracking, or significant rebar corrosion exists and the reinforcing steel is well bonded to the surrounding concrete as per ICRI R310.1R.]*

3.3 CLEANING AND REPAIR OF REINFORCING STEEL

Clean exposed reinforcing steel of rust, mortar, etc. to provide sufficient electrical connection and mechanical bond. If significant reduction in the cross section of the reinforcing steel has occurred, replace or install supplemental reinforcement as directed by the engineer of record. Secure loose reinforcing steel by tying tightly to other bars with steel tie wire. Verify electrical continuity of all reinforcing steel, including supplemental steel, as per Section 3.5.

3.4 CONCRETE PREPARATION

Concrete repairs shall be square or rectangular in shape with squared corners per ICRI Guideline 310.1R-2008. Saw cut the repair boundary ½ inch (13 mm) deep or less if required to avoid cutting reinforcing steel. Create a clean, sound substrate to receive the repair *[overlay]* material by removing bond-inhibiting materials from the concrete substrate by high pressure water blasting or abrasive blasting.

3.5 ELECTRICAL CONTINUITY OF STEEL AND ANODES

Reinforcing steel shall be tested for electrical continuity by procedures as directed by the cathodic protection technician. Electrical connection is acceptable if the DC resistance measured with the multi-meter is 1 W or less or the DC potential is 1 mV or less. Reinforcing steel found to be discontinuous shall be bonded to continuous reinforcement by steel tie wire.

Any new steel added to the structure, such as supplemental reinforcing, wire mesh or rebar shall be electrically continuous. The new steel shall be connected to the anode grid or bonded to existing reinforcing steel. After the distributed galvanic anodes are installed, the continuity of the connection between anode tie wire and reinforcing steel is verified using the same procedures prior to concrete placement.

3.6 DISTRIBUTED ANODE PLACEMENT

Distributed anodes shall be placed in locations as per the design and indicated on the drawings. Secure anodes to prevent movement during concrete placements. Do not allow the anodes to soak in water greater than 20 minutes prior to concrete placement.

3.7 REINFORCING STEEL CONNECTIONS

Distributed anode system must be connected to the reinforcing steel to be protected. The anodes are directly tied to cleaned exposed steel or can be interconnected to header wires to create a distributed anode grid. The anode grid shall be connected to reinforcing steel with a minimum of two connections per 500 ft2 (46 m2) of concrete area.

If no exposed steel exists after preparation of the substrate, a small area of concrete shall be removed to expose reinforcing steel for anode connection. Electrical connections to the reinforcing steel shall be established by tying the header wire to the exposed steel or by alternate methods. Proposed electrical connection details shall be approved by the anode manufacturer and shall be detailed on the shop drawing submittal for approval by the engineer.

3.8 CONCRETE PLACEMENT

After the distributed galvanic anodes have been installed. Place approved concrete taking care to avoid damage to the anodes, connections, and wiring. Consolidate concrete around anodes assuring no voids exist. [*For vertical and overhead repairs like columns and beams, use the following “Minimum concrete cover depth over the anodes shall be ¾ in. (20mm).” For horizontal applications like bridge deck overlays and joint replacements, use the following “Minimum concrete cover depth over the anodes shall be 1.5 in. (39 mm).]*

\*\*\*END OF SPECIFICATION\*\*\*