Note to Specifier: This document is intended to provide assistance in developing a specification for the use of embedded powered galvanic anodes and should be modified as appropriate to accommodate project specific conditions and applications. For additional information, contact Vector Corrosion Technologies.

Galvashield® Fusion® T2 - Anode Type 2A, Class C – powered galvanic anodes embedded within drilled holes to extend the life of existing reinforced concrete structures.

SECTION 03700 – EMBEDDED ANODES

PART 1 GENERAL

1.1 Related Documents

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 Summary

A. This Section includes furnishing all labor, tools, materials, equipment and services necessary to properly install embedded anodes.

B. Powered galvanic anodes are designed to mitigate corrosion in chloride-contaminated or carbonated concrete. When placed in drilled holes at the appropriate spacing, the anodes will extend the service life of the concrete structure.

C. The two-stage anode system shall be installed by a concrete cathodic protection contractor with four years of experience in two-stage anode installation on similar projects. Training and technical oversight will be provided by a NACE-certified Cathodic Protection Technician (CPT), either supplied by the anode manufacturer working under the supervision of a NACE-certified Cathodic Protection Specialist (CPS).

1.3 References

A. ACI/ICRI Concrete Repair Manual

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

C. ACI Field to Concrete Repair Application Procedures (RAP Bulletin 8-22) – Installation of Embedded Galvanic Anodes

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

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

F. ASTM C 309 Curing Compounds for Concrete

G. ISO 12696:2022 - Cathodic protection of steel in concrete

H. NACE SP0290-2019 - Impressed Current Cathodic Protection of Reinforcing Steel in Atmospherically Exposed Concrete Structures

I. AMPP SP21520 Acceptance Criteria for Cathodic Protection of Steel in Concrete

Structures

J. ISO15257:2017 Cathodic Protection. Competence levels of cathodic protection persons. Basis for a certification scheme.

*Note to Specifier: Vector provides a standard limited warranty against defects in materials and workmanship of the manufactured product. This is included in the standard terms of sale and can be downloaded from the Vector website at* [*www.vector-corrosion.com/warranty.pdf*](http://www.vector-corrosion.com/warranty.pdf)*.*

*An extended limited project-specific warranty is also available that covers anode activity over a ten-year period. Eligible projects shall be professionally designed by a licensed architect or engineer and include manufacturer supplied site training.*

***If a project is to require an extended limited warranty, contact Vector’s Business Development Manager prior to final design and include the information in Section 1.4 and Section 3.5.***

1.4 Manufacturer Extended Limited Warranty

A. Contractor shall provide a Limited Warranty with a notarized signature from a corporate officer of the anode manufacturer.

B. The Limited Warranty shall state the following:

*Note to Specifier: The typical Galvashield Fusion T2 system has an estimated design life of 30 years however this can be adjusted as required. Enter the actual design life used in the system design in 1.4.B.1.*

1. The design guidelines for anode size and spacing are based on an estimated *[X]*-year anode service life.

2. The Stage 1 phase has sufficient capacity to passivate active corrosion based on typical design guidelines.

3. The Stage 2 galvanic phase will remain electrochemically active and produce galvanic current in relation to the environment in which it is installed for a minimum of 10 years from the date of anode installation.

4. The galvanic anode does not include intentionally added substances that will cause adverse effects to concrete or reinforcing steel and will not contribute to reinforcing steel corrosion damage over the life of the structure.

5. The anodes meet all building and repair code requirements.

PART 2 PRODUCTS

2.1 Embedded Anodes

1. Embedded anodes shall be GalvashieldFusion T2 *[-Standard, -Slim, -X],* a Type 2A anode with the following nominal dimensions: *[add anode dimensions, see below]* available from Vector Corrosion Technologies (www.vector-corrosion.com).

*Note to Specifier:*

*Galvashield Fusion T2 anodes are available in 3 standard configurations (T2-Standard, T2-Slim, and T2-X). Custom sizes are also available for specific projects. Anode selection should be based on factors such as steel density and concrete thickness. Specify the required anode configuration in 2.1.*

*Anode Size Anode Dimensions Hole Dimensions*

*T2-Standard 46 x 105 mm (1 ¾ x 4 1/8 in.) 50 x 135 mm (2 x 5 5/16 in.)*

*T2-Slim 29 x 135 mm (1 1/8 x 5 3/8 in.) 35 x 165 mm (1 3/8 x 6 ½ in.)*

*T2-X 46 x 130 mm (1 ¾ x 5 1/8 in.) 40 x 160 mm (2 x 6 1/3 in.)*

*Type: Anode Type is a two-character code*

*The first character indicates where the anode is installed:*

*1 - Embedded in concrete repairs, or*

*2 - Embedded into sound concrete.*

*The second character denotes the type of zinc activation utilized:*

*A - Alkali-activated using high pH, or*

*H - Halide-activated using corrosive salts.*

1. The anode unit shall be a single, pre-manufactured unit, capable of providing 2-stage protection without the need for external power or manual switching. Stage 1 shall be characterized by a period of self-powered impressed current cathodic protection (ICCP). Stage 2 shall be delivered by an alkali-activated galvanic anode capable of providing Cathodic Prevention for the design life of the system.
2. Each anode shall operate independently in Stage 1 and be able to deliver a similar charge, irrespective of the variability in concrete resistance.

*Note to Specifier:*

*If Galvashield Fusion T2-Slim is specified, use 60 Days Stage 1 impressed current treatment in Section D. below.*

1. All steel within the treatment area shall receive a minimum charge of *[X]* kC/m2 of steel surface area during Stage 1.
2. During Stage 1 the galvanic element shall remain electrically isolated so that charge is not distributed from the zinc surface.
3. Each anode shall operate independently in Stage 1 and be able to deliver a total charge of 50kC, irrespective of the variability in concrete resistance.
4. The impressed current treatment shall last for a minimum period of 50 days to maximize the durability of the passive film.
5. The current provided by the galvanic anode shall meet or exceed the cathodic prevention requirements of ISO 12696 (0.2-2mA/m2) for the design life of the system.
6. The zinc core of the galvanic anode shall be in compliance with ASTM B418 Type II and be encased in an activating cementitious mortar with a pH of 14 or greater. The activating mortar shall contain no intentionally added chloride, bromide, sulphate or other constituents that are corrosive to reinforcing steel as per ACI document 222R.
7. Both stages of the treatment shall be conformant to the performance characteristics as outlined in NACE SP0290 and ISO 12696 for cathodic protection and cathodic prevention.
8. A maximum anode to steel connection ratio of 20:2 shall be used to maximize redundancy such that the failure of any one connection shall not impair the performance of the system.

*Note to Specifier:*

*Galvashield Fusion T2 Anodes have the capability to be installed such that Stage 1 can be repeated at a later time. This feature would need to be incorporated into the design. For more information, contact Vector.*

1. The anode unit shall have the capability to be installed so that Stage 1 can be repeated at a later time.

Approved equals shall be requested in writing two weeks before submission of project bids. The application shall include verification of the following:

1. A single, pre-manufactured anode capable of delivering 2-stage protection.
2. ICCP anode capable of delivering a steel charge density of between 75-300kC/m2 during Stage 1 without the need for external power.
3. Stage 2 shall be a solid zinc core (ASTM B418) surrounded by a highly alkaline cementitious shell with a pH of 14 or greater with a proven activation track record showing a minimum of 20 years of field performance.
4. Contain no intentionally added constituent’s corrosive to reinforcing steel or detrimental to concrete, e.g. chloride, bromide, sulphates, etc.
5. Cathodic Prevention anode capable of delivering a continuous current density of between 0.2-2mA/m2 for the design life of the system (Stage 2)
6. Autonomous switching between Stages 1 and 2 with single wire installation.
7. Provide warranty indicating galvanic stage will provide protective current for a minimum of 10 years from the date of anode installation independent of the level of chloride in the concrete.
8. Recommended anode spacing utilizing anode aging factor (half-life) calculated from field data to achievecurrent density of *[X]* mA/m2 of steel surface area after *[X]* years considering the existing risk of corrosion and environmental conditions including temperature.
9. Assured charge density per area of concrete.

2.2 Grout

 Grouting material shall be Vector Galvashield Embedding Mortar from Vector Corrosion Technologies, no approved equals will be permitted.

2.3 Anode Connections

A. For individual anode connections, use a Vector Rebar Connection Kit and Vector Setting Tool from Vector Corrosion Technologies or approved equal.

B. To connect anodes in series (daisy chain), use Vector Anode Connection Kit or Rivet Connection Kit from Vector Corrosion Technologies or approved equal.

2.4 Storage

Deliver, store, and handle all materials in accordance with manufacturer’s instructions. Anode units shall be stored in dry conditions in the original unopened containers in a manner to avoid exposure to extremes of temperature and humidity.

PART 3 EXECUTION

3.1 Anode and Rebar Connection Layout

1. Using a suitable rebar locator or ground penetrating radar, locate and mark out the reinforcing grid in areas where anodes are to be installed.

*Note to Specifier: Specify maximum grid dimensions in 3.1.B. Contact Vector for design assistance if required.*

1. Mark out locations for anode installation. The anodes shall be installed in a grid pattern with a maximum spacing of *[enter maximum grid dimension]* on center, in each direction. Wherever possible, anodes shall be installed in the center of the reinforcing grid.
2. Mark out location of rebar connections. If the anodes are to be individually connected, one rebar connection per anode is required. If the anodes are to be installed to a common header wire, two rebar connections per string of anodes are required with a maximum of 20 anodes per string.

3.2 Drill Holes and Saw Cuts

1. Rebar Connection – Electrical connections shall be established using a Vector Rebar Connection Kit or Rivet Connection Kit.
	1. If using Vector Rebar Connection Kit, at the location of the rebar connections, drill ½ inch (12 mm) diameter holes from the concrete surface until contact is established with the top surface of the rebar. Let the drill bit spin on top of the bar to provide a clean contact area.
	2. If using the Rivet Connection Kit, break out concrete and install using supplied bit and rivets.

*Note to Specifier: Refer to Galvashield Fusion T2 product data sheet for appropriate anode hole dimensions and specify on 3.2.B appropriate for the selected anode.*

B. Anode Location - Drill a hole *[enter the minimum anode hole dimensions, see above]* at the marked out location to accommodate the anode. Do not damage rebar when drilling holes.

C. Saw cuts – All saw cuts into the concrete surface between the anode installation holes and the rebar connection holes shall be approximately ¼ inch (6 mm) wide by ½ inch (12.5 mm) deep.

1. If anodes are to be individually connected, saw cut grooves between the anode installation hole and the rebar connection hole for each anode location.

2. If anodes are to be installed in series, saw cut a single continuous groove between the anode installation holes and the rebar connection holes.

1. All holes and saw cuts shall be cleaned of debris and concrete dust.

3.3 Rebar Connections

A. Option 1 - Vector Rebar Connection Kit

1. Using one Vector Rebar Connector per rebar connection hole, place the weighted end of the connector into the drilled hole until the steel coil contacts the top of the steel.
2. Feed the steel connector wire through the Vector Setting Tool and set into place by striking with a hammer.
3. Option 2 - Rivet Connection Kit
	1. A 2 in. (50 mm) diameter holes shall be made to expose the rebar taking care to avoid cutting steel.
	2. Electrical connection to the steel can shall be established by drilling a 5-7mm deep hole using the 3.5mm drill bit provided.
	3. 3.2mm stainless steel pop rivets are used to connect the anode connecting wire to the steel.
	4. The connection shall be insulated by a neutral cure sealant or epoxy.
4. Proper connection and rebar continuity for each rebar connection shall be verified between two installed rebar connectors using a multi-meter. Maximum resistance between the two locations shall be less than 1 ohm.

3.4 Electrical Continuity of Reinforcing Steel

Proper connection and rebar continuity for each rebar connection shall be verified between two installed rebar connectors using a multi-meter. Maximum resistance between the two locations shall be less than 1 ohm.

3.5 Anode Installation

1. Prewet the holes, sawcuts and anodes to a saturated-surface dry condition prior to anode placement. Do not let the anodes soak for longer than 20 minutes in a shallow water bath.
2. Mix one 44 lb. (20 kg) bag of embedding mortar with 3.2 to 3.7 liters of potable water using a slow speed drill and paddle 3 minutes until a smooth consistency is achieved.
3. After removing any excess water from the presoaked holes, fill each anode installation hole approximately 2/3 full with mixed embedding mortar.
4. Insert an anode into each hole, forcing the embedding mortar to fill the annular space from the bottom up.
5. Clean out excess mortar from the top of the anode leaving the wire fully exposed.
6. Complete wiring between the anodes and the rebar connections.

1. If anodes are to be connected individually, insert the end of the rebar connection wire though the open side of the button-type wire connectors and the steel anode wire into the terminated side. Crimp the button connector until it is flush with its casing and cut off the excess rebar connection wire. (Test connection as per 2.b.)

2. If anodes are to be installed in series,

a. Insert the interconnecting coated wire though the open side of the button-type wire connectors supplied in the Vector Anode Connection Kit and the coated anode wire into the terminated side. With the anode alongside of the installation hole, crimp the button connector to cut through the wire coating until the connector is flush with its casing.

b. After all anodes along the string are connected to the interconnecting header wire, verify connection with a multi-meter and a portable copper/copper sulfate reference electrode. Connect the DC Volt port of the multi-meter to the exposed header wire and the portable reference cell to the COM port. With the reference cell on top of each anode within the string record the individual readings at each anode. A reading more negative than -2.5V indicates a positive connection.

1. Top off the anode hole with embedding mortar and strike off excess flush with the concrete surface. Minimum cover over the top of the anode shall be 1 in. (25 mm).
2. Bury all wiring into the saw cuts and drilled holes and fill with embedding mortar or other material approved by the owner and strike off flush with the concrete surface.

*Note to Specifier: It is important that the Galvashield Fusion T2 anodes be grouted into place with the specially formulated Galvashield Embedding Mortar. Saw cuts and rebar connection holes can be backfilled with the Galvashield Embedding Mortar or other cementitious or polymer-based materials.*

1. Wet cure cement-based mortar or cure with two coats of a membrane-forming concrete curing compound meeting the requirements of ASTM C309.
2. Protect area from traffic for 24 hours.

*Note to Specifier: If the project designer or owner requires that the anode manufacturer provides an experienced corrosion technician for on-site contractor training, or if an extended warranty will be required (per Section 1.4) include the language in Section 3.5.*

3.5 Manufacturer Corrosion Technician

A. The contractor will enlist and pay for a technical representative provided by the two-stage anode manufacturer to provide pre-project contractor training and support and on-site technical assistance during the initial installation of the powered galvanic anodes. The technical representative shall be a NACE-certified Cathodic Protection Technician (CP2) or higher or a Cathodic Protection Technician (Level II) certified to ISO 15257:2017.

B. The qualified corrosion technician shall have a minimum of 1 year of verifiable experience in the installation and testing of galvanic protection systems for atmospherically exposed reinforced concrete structures.

1. The contractor shall coordinate its work with the designated corrosion technician to allow for site support during project startup and initial anode installation. The corrosion technician shall provide contractor training and support for development of application procedures, verification of electrical continuity, site procedures for quality control, and other project documentation.

3.6 Quality Control Documentation

1. The contractor shall submit documentation indicating acceptable installation of the two-stage anode system.
2. The quality control documentation shall include at a minimum:
	1. A numbering system for individual anodes and anode zones.
	2. The measured depth of anode installation at each location.
	3. The actual anode spacing and notation of exceptions approved by the CPS.
	4. Confirmation of electrical continuity between reinforcing steel locations.
	5. Calibration data for any stationary reference electrode.
	6. Calibration certificate and reference of multimeter.
	7. Anode-to-steel voltage reading for each anode using calibrated reference electrode.
	8. Step by step photo documentation for typical installation method.
	9. Date of training and other field visits by cathodic protection specialist.

END OF SECTION