BDA 412-04 | SEPTEMBER, 2020

EMBEDDED GALVANIC ANODES

Reference: IDM 412-3.05(01) Cathodic Protection

Note: Example calculations for embedded galvanic anode spacing is provided in a sample spreadsheet. A presentation titled "Deck Problems After Patching" was given at the 2016 INDOT Bridge Design Conference, which covered the use of embedded galvanic anodes.

Embedded galvanic anodes can delay corrosion of reinforcing bars by redirecting the corrosion process to the anode, rather than the reinforcing steel. The anodes contain zinc, which is more willing to give up its electrons than the iron in the reinforcing steel. When zinc corrodes it has minimal expansion that will not cause spalling as long as there is at least one inch of clear cover over the anode. The amount of zinc required to protect the existing reinforcing steel is a function of the surface area of the reinforcing steel near the anode. All uncoated reinforcing steel bars that are electrically connected to each other will draw from the embedded galvanic anodes. Therefore, the larger the surface area of the reinforcing bars to be protected, the higher the required zinc per repair area. The galvanic anodes must be connected to the reinforcing steel with a resistance of less than one Ohm. Therefore, the Designer will need to develop project-specific criteria to use embedded galvanic anodes to protect epoxy coated reinforcing steel, and the construction costs will be higher than typical.

Chlorides that are present in existing concrete are the primary driver of corrosion. Therefore, zinc anodes are most effective when placed along the interface of new and existing concrete, such as around the perimeter of a patch. Current will be drawn from the anode both inside and outside the patch, thus the steel reinforcing on both sides of the patch edge should be considered in the steel density calculation. In situations where chloride laden concrete is suspected to exist at the bottom of a partial depth patch, anodes may be placed within the area of the patch in addition to the anodes places around the perimeter.

In repairs that include two layers of reinforcing within 12 inches of each other, both layers of reinforcing should be included in the steel density calculations, even if only one layer is anticipated to be exposed. The anodes required by this calculation can be placed entirely on the reinforcing layer closest to the surface that has been exposed to chlorides.

The density of the reinforcing steel to be protected is calculated as the ratio of surface area of the reinforcing bars to the surface area of the patch.

$$\text{Steel Density (per reinforcing layer)} = [\text{diameter of bar}] \times \pi \div [\text{spacing of bar}]$$

All of the reinforcing layers to be protected by the anodes should be included in the total steel density calculation. Variables such as chloride content and desired service life will influence the amount of zinc required, and Designers are encouraged to consider project specific conditions when determining anode spacing. For a typical rehabilitation project, the amount of zinc required, in grams per inch, can be determined by the following equation, which was developed based on the recommendations of several manufacturers.

$$\text{Zinc Required (grams per inch)} = 1.7 \times [\text{Total Steel Density}] + 4 \text{ grams/in}$$

The spacing of the embedded anodes can then be determined by assuming 100 gram anodes, with a maximum allowable spacing of 28 inches.

Anode Spacing = 100 grams ÷ [Zinc Required, grams/in] ≤ 28 in.

The contract plans should show the required anode spacing and should indicate the size and spacing of the existing reinforcing steel to be protected.