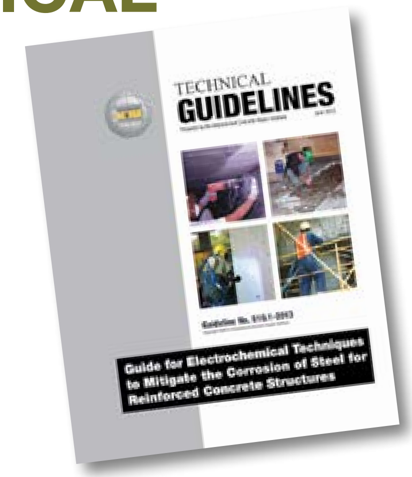
INTRODUCTION TO ICRI TECHNICAL GUIDELINE NO. 510.1-2013,

GUIDE FOR ELECTROCHEMICAL TECHNIQUES TO MITIGATE THE CORROSION OF STEEL FOR REINFORCED CONCRETE STRUCTURES



BY DAVID WHITMORE

Rust Never Sleeps. This phrase, made famous by Winnipeg native Neil Young as the title of his award-winning 1979 album, has a special connotation to those of us in the concrete repair industry. Every day of our lives, we experience the negative effects of corrosion. Entering a parking structure with spalling concrete, avoiding the scaffolding at a condo rehabilitation, sitting in slowed traffic caused by a bridge repair…these are minor inconveniences compared to a structural failure that can impact public safety.

Advancements in the understanding of the mechanisms of corrosion, concrete technology, and concrete design have provided many tools for structural engineers to meet demanding service life requirements for new construction. Unfortunately, we are still repairing structures that are only 10 to 20 years old. This not only has major economic impact (cost of corrosion is estimated at 3 to 4% of Gross National Product in studies conducted in the United States, UK, and Japan) but also an environmental impact, especially when structures are replaced.

Fig. 1: Impressed current cathodic protection

Today, we can be proud of the increase in awareness and implementation of corrosion management plans led by many in the concrete repair industry. However, there is much more to do. For that reason, ICRI has published Technical Guideline No. 510.1-2013, “Guide for Electrochemical Techniques to Mitigate the Corrosion of Steel for Reinforced Concrete Structures.” This document is the culmination of over 10 years of effort by experienced engineers, contractors, and technology suppliers who are active on ICRI Committee 510, Corrosion.

The primary purpose of the Guideline is to provide information on electrochemical techniques that are used to mitigate corrosion in reinforced concrete structures. The term “electrochemical” may be a little unfamiliar to some but essentially corrosion is both an electrical and chemical process. These techniques are similar in that they employ electrochemical processes to mitigate corrosion.

The starting point in any corrosion repair project is to investigate the structure to determine the magnitude and extent of the corrosion problem. Condition surveys that include scientific techniques such as chloride profiling, depth of carbonation, depth of cover, half-cell corrosion potentials to determine the probability of corrosion and, in some cases, corrosion rate testing, can be conducted by experienced engineers and technicians. This information is an extremely useful addition to more common evaluation tests such as sounding, compressive strength, and petrographic testing when developing an economical corrosion management strategy that meets the owner’s project objectives.

The electrochemical techniques covered by the Guideline can be grouped into three categories:

1. Impressed current cathodic protection (ICCP);
2. Galvanic cathodic protection (GCP); and
3. Electrochemical treatments including chloride extraction (ECE) and realkalization (ERA).

ICCP was one of the earliest electrochemical corrosion mitigation techniques used for reinforced concrete with early systems dating back to the late 1950s. ICCP systems are powered by an outside DC power source such as a transformer/rectifier, solar cells, or batteries. A well-designed, monitored, and maintained ICCP system will provide a lifetime of active corrosion protection.

Like any technical development, ICCP anode systems have evolved over time. Recent installations commonly use long-life anodes such as mixed-metal oxide (MMO) coated titanium anodes in ribbon or expanded mesh forms that are placed into saw-cut slots or overlaid with concrete, or discrete anodes such as MMO-coated titanium or conductive ceramic tubes that are grouted into drill holes. Other anode types include conductive coatings and conductive overlay systems. ICCP systems are used when long service life and a high level of system control are desired.

The development and use of GCP systems for concrete structures was significantly advanced in the mid-to-late 1990s. Galvanic systems use metals, such as zinc, that are more electronegative than the steel in concrete. External power supply is not necessary, as the galvanic cell causes DC current to flow naturally, like a common alkaline battery. GCP is also referred to as "sacrificial protection," as the anodic metal corrodes over time. These systems are used when simplicity is desired, as the effort required for monitoring and maintenance is minimal.

Galvanic anodes for localized protection are usually zinc-based and encased in a mortar shell that contains a chemical activator to ensure long-term activity of the anode surface. Anodes can be directly attached to reinforcement at the perimeter of concrete repair areas to mitigate the negative effects of ring (incipient) anode formation at the interface between new and existing concrete. These types of anodes can also be used in sound concrete to target "hot spots" identified in corrosion potential surveys by grouting them into drilled holes.

Distributed GCP systems constitute a broad array of galvanic technologies. These systems use the same concept of dissimilar metals, but the anodes are distributed over large areas to provide widespread or global protection. Distributed galvanic systems are available in the following forms:

1. Zinc-based anodes inside protective jackets for piles in a marine environment;
2. Anodes that are spray-applied to concrete surfaces;
3. Strips that are embedded in concrete encasements and overlays; and
4. Self-adherent sheets.

Introduced in the late 1980s, electrochemical treatments such as ECE and ERA use a short-term application of current by placing a temporary anode

Fig. 2: Installation of galvanic anodes in repair area

Fig. 3: Humectant-activated arc spray zinc

Fig. 4: Electrochemical chloride extraction

on the surface of the structure to move ionic species (for example, chloride, hydroxide, and alkali) within the concrete, thus changing the chemistry of the concrete surrounding the reinforcing steel. When the treatment process is complete, the system is removed and the structure is left in a noncorroding, passive condition.

The ECE process, also called desalination, increases the concrete alkalinity and reduces the amount of chloride in the concrete surrounding the reinforcing steel. Under the influence of the electric field, alkali is generated at the steel by hydrolysis and soluble chloride ions move away from the steel and toward the temporary external anode. The ERA treatment process is used specifically to increase the pH of carbonated structures. While similar in function to the ECE process, the ERA process draws an externally applied alkaline electrolyte toward the steel, thus passivating carbonation-induced corrosion. Electrochemical treatments are ideal when long-term protection is required without the desire for long-term maintenance of electrical components.

The new ICRI Guideline presents a comprehensive summary of electrochemical technologies that are available to extend the life of corrosion-damaged concrete structures. Engineers, contractors, and asset owners with an interest in repair and rehabilitation of concrete structures will benefit from the detail in the new Electrochemical Techniques Guideline. On behalf of ICRI Committee 510, Corrosion, we encourage you to use this information as a tool in your ongoing fight against corrosion as, without it, Rust Never Sleeps. Rest comfortably knowing ICRI Committee 510 is on your side.

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