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Impressed Current Cathodic Protection of Reinforcing Steel in Atmospherically Exposed Concrete Structures

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ABSTRACT

Presents guidelines for cathodic protection of reinforcing steel in concrete structures. The guidelines are limited to impressed current cathodic protection systems for new or existing atmospherically exposed reinforced concrete and are not intended for application to prestressed concrete. Criteria described include 100 mV polarization development/decay, statistical distribution analysis, and E-log I analysis. This standard includes sections that address criteria for achieving cathodic protection, design of ICCP systems, installation practices, energizing and system adjustment, operation and maintenance of ICCP systems, and records.

KEYWORDS

Impressed current cathodic protection, ICCP, reinforced concrete, reinforcing steel, 100 mV polarization criterion, TG 044

Foreword

The purpose of this NACE standard practice is to present guidelines for impressed current cathodic protection of reinforcing steel in atmospherically exposed concrete structures. This standard is aimed at owners, engineers, architects, contractors, and all those concerned with rehabilitation of corrosion-damaged reinforced concrete structures.

For more information on design, maintenance, and rehabilitation of reinforcing steel in concrete, refer to NACE SP0187¹ and NACE SP0390.² For a state-of-the-art overview regarding the use of reference electrodes for atmospherically exposed reinforced concrete structures, refer to NACE Publication 11100.³ For a state-of-the-art overview on criteria for cathodic protection of prestressed concrete structures, refer to NACE Publication 01102.⁴

This standard was originally prepared in 1990 by NACE Task Group (TG) T-3K-2, a component of Unit Committee T-3K on Corrosion and Other Deterioration Phenomena Associated with Concrete. It was revised by Work Group T-11-1a in 2000 and reaffirmed by Specific Technology Group (STG) 01, "Reinforced Concrete," in 2007. It was revised in 2019 by TG 044, "ICCP of Reinforcing Steel in Atmospherically Exposed Concrete Structures." TG 044 is administered by STG 01 and sponsored by STG 05 on "Cathodic/Anodic Protection." This standard is published by NACE under the auspices of STG 01.

In NACE standards, the terms **shall**, **must**, **should**, and **may** are used in accordance with the definitions of these terms in the NACE Publications Style Manual. The terms **shall** and **must** are used to state a requirement, and are considered mandatory. The term **should** is used to state something good and is recommended, but is not considered mandatory. The term **may** is used to state something considered optional.

NACE International Standard Practice (SP0290-2019)

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Section 1: General

1.1 Background

- 1.1.1** Reinforcing steel is compatible with concrete because of similar coefficients of thermal expansion and because concrete normally provides the steel with excellent corrosion protection. The corrosion protection is the result of the highly alkaline Portland cement that allows a stable, corrosion-mitigating passive oxide film to form and be maintained on the surface of the encased steel. If the film does not form, or is weakened or destroyed so that it does not protect the steel, corrosion can occur. The protective oxide film does not form or is destroyed if (1) excessive amounts of chloride or other aggressive ions are present, (2) alkalinity is lost by reaction with corrosive liquids or gases, or (3) the concrete does not fully encase the steel.
- 1.1.2** Corrosion occurs as a result of the formation of an electrochemical cell. An electrochemical cell consists of four components: an anode, where oxidation occurs; a cathode, where reduction occurs; a metallic path, where the electric current is electron flow; and an electrolyte (concrete), where the electric current is ion flow in an aqueous medium. The anodic and cathodic areas occur as a result of coupling dissimilar metals or exposure to differential environmental conditions. If any one of the four elements of the electrochemical cell is eliminated, corrosion can be prevented.

1.2 Cathodic Protection

- 1.2.1** The basic principles of corrosion can be used to understand the theory of cathodic protection. Cathodic protection is defined as a technique to reduce the corrosion of a metal surface by making that surface the cathode of an electrochemical cell.
- 1.2.2** Cathodic protection is a proven technique for controlling corrosion of steel in existing chloride-contaminated concrete structures. However, cathodic protection will neither replace lost steel nor return corroded reinforcement to its original cross-sectional area and strength. There may be areas of the reinforced concrete structure that appear sound by traditional inspection techniques that are, in fact, corroding and experiencing corrosion-related tensile stress near the rupture levels. Such distressed areas may crack, spall, or delaminate subsequent to the application of cathodic protection.
- 1.2.3** Galvanic corrosion of steel reinforcement that could result from intentional contact with other metals, such as during grounding for safety and stray current mitigation measures, or unintentional contact such as reinforcement touching galvanized window frames, shall be carefully considered.

1.3 Scope and Limitations

- 1.3.1** The provisions of this standard shall be applied by or under the direction of a Subject Matter Expert (SME) in Cathodic Protection. The SME shall be certified to NACE CP 4 or have equivalent national or international qualification and experience. The SME shall have a minimum of 4 years verifiable experience in cathodic protection of reinforced concrete structures.

NOTE: Under certain circumstances, a cathodic protection system may either become a structural component or significantly affect the serviceability and structural performance of a reinforced concrete structure; therefore, review of such impact by the cathodic protection system should be made by a qualified registered Structural Engineer or the equivalent.

- 1.3.2** The guidelines presented here are limited to impressed current cathodic protection systems for new or existing atmospherically exposed reinforced concrete operating at ambient temperature and are not applicable to pre-stressed concrete.

Section 2: Definitions

The definitions of many of the corrosion-related terms used in this standard can be found in NACE/ASTM⁽¹⁾ G193.⁵ Other terms not included therein that have been used in this standard are defined as follows:

Design Specifications: A set of documents that, in aggregate, form the nucleus for well-founded, understandable, and equitable contract documents. These documents include written specifications and drawings.

Drying Effect: Migration of water molecules away from the anode as a result of current flow.

⁽¹⁾ ASTM International (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.