Electrochemical Realkalization and Chloride Extraction for Reinforced Concrete

This NACE International (NACE) standard represents a consensus of those individual members who have reviewed this document, its scope, and provisions. Its acceptance does not in any respect preclude anyone, whether he or she has adopted the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not in conformance with this standard. Nothing contained in this NACE standard is to be construed as granting any right, by implication or otherwise, to manufacture, sell, or use in connection with any method, apparatus, or product covered by letters patent, or as indemnifying or protecting anyone against liability for infringement of letters patent. This standard represents minimum requirements and should in no way be interpreted as a restriction on the use of better procedures or materials. Neither is this standard intended to apply in all cases relating to the subject. Unpredictable circumstances may negate the usefulness of this standard in specific instances. NACE assumes no responsibility for the interpretation or use of this standard by other parties and accepts responsibility for only those official NACE interpretations issued by NACE in accordance with its governing procedures and policies which preclude the issuance of interpretations by individual volunteers.

Users of this NACE standard are responsible for reviewing appropriate health, safety, environmental, and regulatory documents and for determining their applicability in relation to this standard prior to its use. This NACE standard may not necessarily address all potential health and safety problems or environmental hazards associated with the use of materials, equipment, and/or operations detailed or referred to within this standard. Users of this NACE standard are also responsible for establishing appropriate health, safety, and environmental protection practices, in consultation with appropriate regulatory authorities if necessary, to achieve compliance with any existing applicable regulatory requirements prior to the use of this standard.

CAUTIONARY NOTICE: NACE standards are subject to periodic review, and may be revised or withdrawn at any time in accordance with NACE technical committee procedures. NACE requires that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of initial publication and subsequently from the date of each reaffirmation or revision. The user is cautioned to obtain the latest edition. Purchasers of NACE standards may receive current information on all standards and other NACE publications by contacting the NACE FirstService Department, 15835 Park Ten Place, Houston, TX 77084-5145 (telephone +1 281-228-6200).

ABSTRACT
This standard addresses corrosion of reinforcing steel in concrete, a serious problem throughout the world in parking structures, bridges and roadways, buildings, sanitary and water facilities, marine structures, concrete pipe, storage facilities, and other structures. This corrosion is directly attributable to the presence of significant amounts of aggressive substances at the steel surface. This standard provides procedures to control corrosion of conventional reinforcing steel in Portland cement concrete structures through the application of chloride extraction or realkalization. These electrochemical techniques are related to the use of impressed current cathodic protection of steel in concrete, as described in NACE SP0290.

KEYWORDS
reinforcing steel, reinforced concrete, realkalization, chloride extraction, corrosion, rebar, cathodic protection.
Foreword

This NACE standard practice presents the requirements for electrochemical chloride extraction and electrochemical realkalization of reinforcing steel in atmospherically exposed concrete structures. The standard provides the design engineer and contractor with the requirements for control of corrosion of conventional reinforcing steel in Portland cement concrete structures through the application of chloride extraction or realkalization. This standard is intended for use by owners, engineers, architects, contractors, and all those concerned with rehabilitation of corrosion-damaged reinforced concrete structures.

These electrochemical techniques are related to the use of impressed current cathodic protection of steel in concrete as described in NACE SP0290.\textsuperscript{1} State-of-the-art reports on the techniques were previously published by the task group and are available from NACE.\textsuperscript{2,3} For more information on design, maintenance, and rehabilitation of reinforcing steel in concrete, refer to NACE SP0187\textsuperscript{4} and NACE SP0390.\textsuperscript{5}

To provide the necessary expertise on all aspects of the subject and to provide input from all interested parties, Task Group (TG) 054 is composed of corrosion consultants, consulting engineers, architect engineers, cathodic protection engineers, researchers, structure owners, and representatives from both industry and government.

The provisions of this standard should be applied under the direction of a registered Professional Engineer or a person certified by NACE International as a Corrosion Specialist or Cathodic Protection Specialist. His or her professional experience should include suitable experience in corrosion control of reinforced concrete structures.

This standard was prepared in 2007 and revised in 2017 by TG 054 on Reinforced Concrete: Electrochemical Chloride Removal and Realkalization, which is administered by Specific Technology Group (STG) 01 on Reinforced Concrete and sponsored by STG 41 on Electric Utility Generation, Transmission, and Distribution. It is published by NACE under the auspices of STG 01.
NACE International Standard Practice (SP0107-2017)

Electrochemical Realkalization and Chloride Extraction for Reinforced Concrete

1. General .................................................................................................................4
2. Electrochemical Chloride Extraction ..................................................................5
3. Electrochemical Realkalization ........................................................................13
   References ...........................................................................................................21
   Bibliography ......................................................................................................21

This is a preview of "NACE SP0107-2017". Click here to purchase the full version from the ANSI store.
Section 1: General

1.1 Background

1.1.1 Following this General section, this standard is divided into two stand-alone sections, the first on electrochemical chloride extraction and the second on electrochemical realkalization. This will help the user by ensuring that all the relevant provisions are in one place.

1.1.2 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 formation of a highly alkaline passive oxide film on the surface of the reinforcement by Portland cement contained in the concrete. This passive oxide film may be compromised by (1) excessive amounts of chloride or other aggressive ions and gases such as carbon dioxide, or (2) the concrete not fully encasing the steel.

1.1.3 Corrosion of the steel 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 electrons flow; and an electrolyte (concrete), where the ions flow. The anodic and cathodic areas occur as a result of coupling of dissimilar metals (e.g., reinforcing steel to copper, brass or galvanized fittings or aluminum window frames), exposure to differential environmental conditions, or both. If any one of the four elements of the electrochemical cell is eliminated, corrosion can be prevented.

1.1.4 Corrosion of reinforcing steel in concrete is a serious problem in certain environments throughout the world. This corrosion is directly attributable to the presence of significant amounts of aggressive substances and/or conditions at the steel surface. Parking structures, bridges and roadways, buildings, sanitary and water facilities, marine structures, concrete pipe, storage facilities, and other reinforced concrete structures are being damaged by corrosion. Industry published information indicates that refurbishment and replacement of concrete structures with corroded reinforcement and/or cracking and spalling damage of the concrete costs billions of dollars each year. These losses can be reduced if proper corrosion control factors are considered and addressed during rehabilitation and maintenance repair of reinforced concrete structures.

1.1.5 Carbonation of concrete is a major factor that leads to reinforcing steel corrosion. Carbonation is a process by which atmospheric carbon dioxide reacts with the alkalis in the pore water of the concrete, reducing the pH to near neutral. A carbonation front proceeds through the cover concrete to the reinforcement, where it leads to the breakdown of the passive oxide layer, allowing corrosion to proceed. Electrochemical realkalization can be used to reverse this process and restore the alkaline environment to the reinforcement, preventing further corrosion.

1.1.6 Chloride contamination of the concrete is another major factor that leads to reinforcing steel corrosion. Depending on the environment, it has been shown that chloride ion content as low as approximately 0.2 percent by weight of cement (or approximately 0.6 kg/m² [1 lb/yd²] of concrete, depending on the cement content of the mix) at the steel depth can initiate the corrosion process. Electrochemical chloride extraction (ECE) can be used to move chloride ions away from the steel surface and reestablish the protective passive oxide layer.