

Acceptance Criteria for Cathodic Protection of Steel in Concrete Structures

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Foreword

Historically, NACE SP0290, NACE SP0216, and NACE SP0408 included sets of criteria that needed to be satisfied to indicate that a cathodic protection (CP) system is delivering adequate current to passivate the reinforcing steel or reduce its corrosion current to low and non-destructive levels. These criteria were mostly the same, so the aim of this standard is to set out the essential criteria that each one of the above standards must satisfy in a single document. This allows each of the above standards, which deal with different applications of cathodic protection, to concentrate and expand on aspects that are specific for each application. This standard further suggests techniques that can be employed to estimate the level of protection achieved by a non-compliant cathodic protection method.

Scope

This document defines the cathodic protection criteria required to protect reinforcing steel in concrete.

Rationale

Historically, NACE SP0290, NACE SP0216, and NACE SP0408 included sets of criteria that needed to be satisfied to indicate that a cathodic protection (CP) system is delivering adequate current to passivate the reinforcing steel or reduce its corrosion current to low and non-destructive levels. These criteria were mostly the same, so the aim of this standard is to set out the essential criteria that each one of the above standards must satisfy in a single document. This allows each of the above standards, which deal with different applications of cathodic protection, to concentrate and expand on aspects that are specific for each application. This standard further suggests techniques that can be employed to estimate the level of protection achieved by a non-compliant cathodic protection method.

Referenced Standards and Other Consensus Documents

The latest edition, revision, or amendment of the referenced standards in effect shall govern unless otherwise dated.

AMPP/NACE/SSPC, www.ampp.org:

NACE SP0290	Impressed Current Cathodic Protection of Reinforcing Steel in Atmospherically Exposed Concrete Structures
NACE SP0216	Sacrificial Cathodic Protection of Reinforcing Steel in Atmospherically Exposed Concrete Structures
NACE SP0408	Cathodic Protection of Reinforcing Steel in Buried or Submerged Concrete Structures
NACE/ASTM G193	Standard Terminology and Acronyms Relating to Corrosion
NACE Publication 35108	One Hundred Millivolt (mV) Cathodic Polarization Criterion

American Society for Quality (ASQ), www.asq.org:

ANSI/ASQ Z1.47	Sampling Procedures and Tables for Inspection by Attributes
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ASTM International (ASTM), www.astm.org:

ASTM C876	Standard Test Method for Corrosion Potentials of Uncoated Reinforcing Steel in Concrete
ASTM G3	Standard Practice for Conventions Applicable to Electrochemical Measurements in Corrosion Testing
ASTM E105	Standard Guide for Probability Sampling of Materials

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Documents

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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 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, which allows electrons to move between the anode and the cathode; and an electrolyte (concrete), where ions can move between the anode and the cathode 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 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 may be experiencing corrosion-related stress and micro-cracking. Such distressed areas may crack, spall, or delaminate subsequent to the application of cathodic protection.
- 1.2.3** Galvanic corrosion can result from contact between different metals. Examples include contact between steel reinforcement and copper grounding systems or steel reinforcement and aluminum conduits. Situations which may result in undesired deterioration and damage should be avoided.

1.3 Scope and Limitations

- 1.3.1** This standard outlines the criteria required to verify the cathodic protection of steel in concrete as well as describing some methods which may be considered. It does not describe the design,

materials, installation or operation considerations for any cathodic protection system. Please refer to the AMPP standard relevant to the type of cathodic protection system which is used.

Section 2: Definitions

The definitions of many of the corrosion-related terms used in this standard may be found in NACE/ASTM G193.

Section 3: Criteria

- 3.1** The criteria in this section serve as a guide for achieving cathodic protection and providing corrosion control for uncoated reinforcing steel embedded in buried, submerged or atmospherically exposed concrete. Compliance with these criteria is dependent on analysis of representative potential data in each situation. The number and locations of potential measurements made during data collection should be commensurate with the complexity of the structure being protected.

Potentials of reinforcing steel or other steel embedments measured against portable reference electrodes shall be obtained in accordance with the techniques described in ASTM C876.

Sign conventions for potential and current density as well as conventions for graphical presentation of data should be in accordance with ASTM G3.

- 3.2** Monitoring points should be in accordance with ASTM E105. Sample size should be determined in accordance with ANSI/ASQ Z1.47 with the unit of product typically being 1.0 m² (1.00 yd² or 9.0 ft²) of protected metal surface area. Situations in which physical conditions effectively preclude full implementation of sampling programs derived from ASTM E105 and ANSI/ASQ Z1.47 may exist. Examples of these cases include asphalt or other nonconductive overlays, and situations in which access to the cathodically protected surface is difficult and limited. For structures in which cathodic protection systems are divided into discrete zones, testing inspection lots should be defined. Acceptable quality and confidence levels should also be defined.
- 3.3** Impressed current cathodic protection (ICCP) systems utilize a power supply and control systems which generally allow interrogation of embedded reference electrodes, typically from a central unit.
- 3.4** Sacrificial anodes are directly or indirectly electrically connected to the reinforcing steel. Therefore, measurements should be taken where testing can be conducted.
- 3.5** Potentials shall be measured to determine compliance with criteria for cathodic protection. Measurements obtained using a portable reference electrode shall be obtained using techniques described in ASTM C876. Potentials of reinforcing steel or other steel embedded metals can be measured using an external/portable or internal/embedded reference electrode.
- 3.6** The following criteria were developed through empirical evaluation of data obtained from successfully operated ICCP systems and from results in numerous research publications.

NOTE: While a combination of criteria may be used for different zones (location) in a single structure, only a single criterion shall be required to be met in any particular zone (location). It is not intended that persons responsible for corrosion control be limited to these criteria if it can be demonstrated by other means that corrosion control has been achieved. Persons using this standard should review data made available after this standard's publication to determine whether more effective criteria have been established.

3.6.1 100 mV Polarization Development/Decay Criterion

- 3.6.1.1** A minimum of 100 mV of polarization should be achieved at the most anodic location in each area or zone, or at artificially constructed anodic sites, provided its