NACE SP0104-2020
Item No. SP0104-2020
Revised 2020-08-14
Reaffirmed 2014-04-07
Approved 2004-12-03

Techniques for Monitoring and Measuring Corrosion and Related Parameters in Field Applications

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ABSTRACT

Cathodic protection (CP) coupons have been used since the 1930s by pioneers of the corrosion control industry, both in North America and in Europe. They have been shown to be a practical tool for determining the level of polarization of a structure and to confirm the IR drop in a potential measurement.

The purpose of this standard is to provide a method for evaluating the effectiveness of a CP system using coupons. It is intended for use by people who design and maintain CP systems for buried or submerged pipelines, underground storage tanks (USTs), on-grade storage tank bottoms, reinforcing steel in concrete, water storage tanks, and various other structures in buried or aqueous environments.

The body of the standard primarily addresses applications for coupons attached to buried pipelines. Appendixes cover the use of coupons for other applications, including USTs, aboveground storage tanks, internal surfaces of water tanks, and reinforced concrete structures.

This revision adds new appendixes on the use of coupons on cased pipelines and the use of coupons to measure alternating current interference data.

KEYWORDS

Cathodic protection, coupon, pipeline, underground storage tank, aboveground storage tank, water tank, reinforced concrete,TG 210.

ISBN 1-57590-196-X

Foreword

Coupons are used to determine the level of corrosion protection provided by a cathodic protection (CP) system to a variety of structures, such as buried or submerged pipelines, underground storage tanks (USTs), aboveground (on-grade) storage tank bottoms, cased crossings and steel in reinforced concrete structures.

Structure-to-electrolyte potential measurements have long been used as the basis for assessing CP levels and compliance with CP criteria. It is well known that a voltage drop exists in the soil and across the coating, and that this voltage drop produces an error in the structure-to-electrolyte potential measurement. This voltage drop can be a function of reference electrode placement, soil resistivity, burial depth of the structure, coating condition, stray currents, local or long-line corrosion cells, and the amount of CP current applied.

CP coupons have been used since the 1930s by several pioneers of the corrosion-control industry, both in North America and in Europe. CP coupons have been shown to be a practical tool for determining the level of polarization of a structure and to confirm the voltage drop in a potential measurement. Research sponsored by the pipeline industry has explored the use of CP coupons and has helped validate the use of this technology. The purpose of this standard recommended practice is to provide a method for evaluating the effectiveness of a CP system using coupons. It is intended for use by people who design and maintain CP systems for buried or submerged pipelines, USTs, on-grade storage tank bottoms, reinforcing steel in concrete, water storage tanks, and various other structures in buried or aqueous environments.

The body of the standard primarily addresses applications for coupons attached to buried pipelines. Appendixes cover the use of coupons for other applications, including USTs, aboveground storage tanks (ASTs), internal surfaces of water tanks, and reinforced concrete structures.

This standard was originally published in 2004 by Task Group (TG) 210, "Cathodic Protection Coupon Technology." It was reaffirmed in 2014 by Specific Technology Group (STG) 35, "Pipelines, Tanks, and Well Casings" and revised in 2020 by TG 210. TG 210 is administered by STG 05, "Cathodic/Anodic Protection," and sponsored by STG 35. This standard is issued by NACE under the auspices of STG 05.

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.

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Tables and Figures

Section 1: General

1.1 A CP coupon may be used to determine the level of CP of a buried or submerged metallic structure. CP coupons are installed in the electrolyte near the structure and are then connected to it through a test station. This allows the CP coupon to be connected to the CP system on the structure, thus simulating a similar-sized bare area of the structure's surface, such as at a holiday in the coating. The CP coupon may be disconnected from the circuit during periodic testing, and its instant-disconnect potential measured. The potential of the CP coupon may then continue to be monitored and the depolarization calculated. These measurements represent the polarized and depolarized potentials of the structure in the vicinity of the CP coupon. They also allow the voltage drop in the electrolyte to be calculated for use in conventional potential measurements made from grade level. A second, freely corroding (native) coupon may be installed at the same location as the CP coupon to measure the free-corrosion potential of the structure in open-circuit conditions.

1.2 NACE SP0169[1] includes criteria for determining the CP status of a buried or submerged structure. For voltage measurements that are made when CP current is applied, voltage drops other than those across the structure-to-electrolyte boundary must be considered. NACE SP0169 includes several ways this may be done and NACE Standard TM0497[2] includes a number of test methods used for these criteria. CP coupons may also be used to evaluate compliance with CP criteria, including considering the voltage drop. The practices described in this standard must be followed with careful evaluation of the specific situation in which the coupons are to be used.

1.3 CP coupons have several advantages. Structure-to-electrolyte potentials that have an IR considerably reduced or eliminated may be obtained without interrupting multiple CP sources. CP coupons may also be used on buried structures with direct-connected galvanic anodes, which either cannot or may not be practical to interrupt. Using CP coupons, depolarization testing may be performed in most cases without de-energizing the CP system. An additional advantage is the ability to record accurate structure-to-electrolyte potentials on structures affected by stray currents.

1.4 When CP coupons are used, there may be differences between polarized potentials of the CP coupon and the structure. This is because the polarized structure-to-electrolyte potential measured at grade is usually the combined potential of the structure over a rather large area, including holidays in the coating and locations where the electrolyte or other conditions that affect the potential of a structure may vary. Errors caused by these variations are included in a potential measured at any given point along a structure and may be significant. These errors generally do not occur with coupons because of their small size and uniform conditions. Coupons located in areas where these variables are different can provide a good representation of the CP effectiveness on a structure.

1.5 A typical problem in measuring a structure-to-electrolyte potential is the effect of voltage drops from uninterruptible current sources. By design, CP coupons may be disconnected from the structure and CP system, thereby eliminating the voltage drop attributable to these current sources. Even when all current sources have been interrupted, long-line currents can still affect the structure-to-electrolyte potential readings measured at grade on a pipeline. Because the effective reference point of a CP coupon is very close to the CP coupon surface, voltage drops caused by long-line currents are minimized.

Section 2: Definitions

The definitions of many of the corrosion-related terms used in this standard may be found in NACE/ASTM(1) G193.[3] Other terms not included therein that have been used in this standard are defined as follows:

Automated Coupon Reader: A portable electronic instrument capable of taking several types of measurements at multiple coupon test stations and storing these values to be later uploaded to a computer.

Buried Stationary Reference Electrode: A reference electrode, usually copper-copper sulfate (Cu/CuSO4 or CSE), designed to last for many years permanently installed in a buried position.

Cathodic Protection (CP) Coupon: A coupon that is connected to the external surface of, and immersed in the electrolyte adjacent to, the structure being protected by cathodic protection.

Concentric CP Coupon and Reference Electrode: A device containing a CP coupon and a reference electrode that have the same geometric center point.

Corrosion Rate Probe: A probe that measures the rate at which corrosion proceeds.

Coupon-to-Electrolyte Potential: The potential difference between the surface of a buried or submerged coupon and the electrolyte that is measured with reference to an electrode in contact with the electrolyte.

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