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Standard
Test Method

Testing of Embeddable Impressed Current Anodes for Use in Cathodic Protection of Atmospherically Exposed Steel-Reinforced Concrete

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Foreword

This NACE International standard has been prepared to provide users and manufacturers of embeddable anodes with a test method for evaluating the anode material to an expected lifetime criterion. It is applicable to embeddable anode materials, such as titanium mesh, commonly used for cathodic protection of atmospherically exposed steel-reinforced concrete. The test method is intended to evaluate whether an embeddable anode material complies with minimum required specifications of design life expectancy at rated current output. This test method is not applicable to surface-mounted anodes or conductive coating materials.

This NACE International test method was originally prepared in 1994 by Task Group (TG) T-3K-6 on Test Procedure for Anodes Used in Concrete, a component of Unit Committee T-3K on Corrosion and Other Deterioration Phenomena Associated with Concrete. It was reviewed by TG 045 on Anodes Test Procedures and reaffirmed in 2001 by Specific Technology Group (STG) 01 on Concrete and Rebar. It was revised by TG 045 in 2007. TG 045 is administered by STG 01 and sponsored by STG 05 on Cathodic/Anodic Protection. This standard is issued by NACE International under the auspices of STG 01, now called Reinforced Concrete.

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*, 4th ed., Paragraph 7.4.1.9. *Shall* and *must* are used to state mandatory requirements. The term *should* is used to state something good and is recommended but is not mandatory. The term *may* is used to state something considered optional.

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Contents

Section 1: General

1.1 Accelerated testing of anodes for use in concrete is intended to provide an indication of an anode's ability to perform satisfactorily for a specific number of years. Unfortunately, accelerated life testing cannot be conducted in concrete because testing at high current levels results in premature failure of the concrete as the test electrolyte. Accelerated life testing must therefore be conducted in an aqueous solution.

1.1.1 When using accelerated life tests, anodes shall be demonstrated to survive a minimum total charge density of 38,500 A-h/m^2 (3,580 A-h/ft^2) of actual anode surface area. This is the amount of total charge density an anode is subjected to if operated at a current density of 108 mA/m^2 (10 mA/ft^2) of anode surface for 40 years. If an anode is designed to operate at any other current density, the test should be modified to reflect the charge density equivalent to 40 years of operating life.

1.1.2 Under certain circumstances, the user may require a greater total charge density than 38,500 A-h/m^2 (3,580 A-h/ft^2) of anode surface, because of a longer life requirement than 40 years, or because of a higher operating current density. In these cases, the test may be extended or the charge density increased until the desired charge is met.

1.2 It is possible that a cathodic protection (CP) anode may be incorrectly powered cathodically during the initial system energization. This condition may not be noticed by merely observing the rectifier meters and can remain undetected until the depolarization test is performed after several days of operation. It is also possible that an anode may be exposed to current reversal caused by an electrical short between the anode and the steel. In this case, the anode is subjected to cathodic current until the system is energized and tested, sometimes several months later. In view of these possibilities and the serious implications of damage to the anode, the ability of the anode to survive a brief current reversal must be ensured.

1.2.1 Assuming the anode is operated at a reversed current density of 108 mA/m^2 (10 mA/ft^2) of anode surface for one month, the anode experiences approximately 71 A-h/m^2 (6.6 A-h/ft^2) of cathodic charge density. It shall be tested to endure such a current reversal and then continue to provide an equivalent of at least 40 years, or 38,500 A-h/m^2 (3,580 A-h/ft^2) of anode surface, of protection.

1.3 The anodic portion of life testing shall be conducted over a period of at least 180 days.

1.4 Life testing shall be conducted using a constant current, filtered direct current (DC) power supply having a maximum ripple of 5%.

1.5 Accelerated life testing shall be conducted in duplicate in the following aqueous solutions:

1.5.1 30 g/L of sodium chloride in distilled or deionized water

1.5.1.1 Cathodic protection anodes are often used to protect bridge piers and pilings in seawater and therefore are exposed to this chloride environment. This solution tests the ability of anodes to tolerate the chlorine evolution reaction.

1.5.2 40 g/L of sodium hydroxide in distilled or deionized water

1.5.2.1 This solution, though at a higher pH than concrete, is conductive enough to nullify effects of solution changes. The solution also tests the ability of the anode to tolerate oxygen evolution, a reaction more favored at low current density and the low chloride contamination level experienced with fresh overlays.

1.5.3 Simulated pore water in sand

1.5.3.1 The electrolyte available to the anode in a cured concrete structure is pore water. This solution tests the ability of the anode to tolerate the actual concentrations of the pore water components and any possible synergistic effects imposed by these components. The use of fine sand to encompass the electrode, eliminating convective mixing, tests the ability of the anode to tolerate the situation most closely simulating its operation in cured concrete. The composition by mass of simulated pore water used shall be as follows:

0.20% $Ca(OH)_2$
3.20% KCl
1.00% KOH
2.45% NaOH
93.15% distilled or deionized water

1.6 Failure of the anode shall be determined by loss of the electrochemical activity as evidenced by an increase in anode potential as discussed in Paragraph 6.2.