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Impressed Current Laboratory Testing of Aluminum and Zinc Alloy Anodes

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ABSTRACT

Describes a quality assurance procedure for determining the potential and current capacity characteristics under laboratory conditions for aluminum and zinc alloy anodes used for cathodic protection. The procedure screens various heats or lots of anodes to determine performance consistency on a regular basis from lot to lot. One method for anode potential evaluation and two methods (mass loss and hydrogen evolution) for current capacity evaluations are described. Performance criteria and sampling frequency are left to the discretion of users of the standard.

KEYWORDS

anodes, cathodic protection, testing.

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Foreword

*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.*

This standard test method describes a quality assurance procedure for determining the potential and current capacity characteristics under laboratory conditions for aluminum and zinc alloy anodes used for cathodic protection (CP). Field performance of anodes should be evaluated to correspond to actual anode performance.

This standard is intended primarily for users, designers, and manufacturers involved with the application of CP in marine environments. This standard can be used by manufacturers and users of aluminum and zinc anodes for quality control verification. The most common usage is expected to be by manufacturers to meet quality control requirements requested by the purchasing user. This standard is based on experiences from the paper by J.F. Brown Jr., "Quality Control Testing of Aluminum Anodes: T-7L-2 Task Group Progress Report,"[1] and on ANSI/NACE SP0115/ISO 15589-2[2] and Military Specification MIL-DTL-18001.[3]

This standard was originally prepared in 1990 by NACE International Task Group T-7L-2 on Aluminum Anode Quality Control, a component of Unit Committee T-7L on Cathodic Protection, in conjunction with ASTM[(1)] Task Group G01-09-02 T-1. It was revised by Task Group T-7L-12 in 1998, reaffirmed by Specific Technology Group (STG) 30, "Oil and Gas Production: Cathodic Protection," in 2006, and revised in 2012 by Task Group (TG) 459, "Review and Revise as Necessary NACE Standard TM0190-2006." It was reaffirmed by STG 30 in 2017. It is issued by NACE under the auspices of STG 30. These committees are composed of industry representatives, including producers, consumers, and interested individuals.

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

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Figures

Tables

1.1 This standard test method describes a laboratory procedure for determining the potential and current capacity characteristics of aluminum and zinc alloy anodes used for CP. It provides a means for screening various heats or lots of anodes to determine performance consistency on a regular basis from lot to lot. Items such as sampling frequency and performance criteria (i.e., test values and intermediate times) are left to the discretion of the user of the test method.

1.2 One test method for anode potential evaluation and two test methods for anode current capacity evaluations are described.

1.3 The actual values obtained in these tests should not be used for design purposes because they represent laboratory testing.

1.4 This procedure can be validated by using zinc anode samples as a reference in the test to verify results of aluminum anodes tested. Zinc samples shall be as defined in ASTM B418[4] or Military Specification MIL-DTL-18001 for zinc anodes.

1.5 This procedure was evaluated by testing alloys of Al-Zn-Sn, Al-Zn-Hg, Al-Zn-In-Mg, and MIL-DTL-18001 zinc of the respective nominal alloy composition ranges shown in Table 1. The results of the test are reported in Paper No. 346 presented at CORROSION/84.[1]

1.6 The precision of the test has not been validated. The scatter in the test results is considered to result from heterogeneities in aluminum alloy anode materials in general, as tested, rather than the test method itself. Only anode materials exhibiting good, reproducible performance (in accordance with this test method) and meeting manufacturer or user specifications are acceptable.

1.6.1 Ranges of performance from those alloys tested are listed in Table 2.

Table 1
Nominal Alloy Composition Ranges for Anodes Tested (%)

	Al-Zn-Sn	Al-Zn-Hg	Al-Zn-In-Mg	Zinc (MIL-DTL-18001)
Zn	6.0 to 8.0	1.25 to 2.00	1.0 to 3.0	Remainder
Sn	0.10 to 0.20	—	—	—
Si	—	—	—	0.125 max.
Hg	—	0.030 to 0.08	—	—
Pb	—	—	—	0.006 max.
Mg	—	—	0.50 to 1.0	—
In	—	—	0.20	—
Fe	0.10 max.	0.10 max.	0.10 max.	0.005 max.
Cd	—	—	—	0.025 to 0.15
Cu	0.003 max.	0.003 max.	0.010 max.	0.005 max.
Al	Remainder	Remainder	Remainder	0.10 to 0.50

Table 2
Range of Evaluation Results

Alloy	Operating Potential (SCE[A]-mV)	Hydrogen Evolution (% Efficiency)	Impressed Current Capacity	
			A-h/kg	A-h/lb
Al-Zn-Sn	940 to 1,176	70 to 94	1,014 to 2,711	460 to 1,230
Al-Zn-Hg	830 to 1,114	96	2,623 to 2,949	1,190 to 1,338
Al-Zn-In-Mg	1,032 to 1,140	90	2,354 to 2,742	1,068 to 1,244
Zinc	969 to 1,051	98	754 to 804	342 to 365

[A] Saturated calomel electrode.