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Standard Guide for Conducting and Evaluating Galvanic Corrosion Tests in Electrolytes¹

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1. Scope

1.1 This guide covers conducting and evaluating galvanic corrosion tests to characterize the behavior of two dissimilar metals in electrical contact in an electrolyte under low-flow conditions. It can be adapted to wrought or cast metals and alloys.

1.2 This guide covers the selection of materials, specimen preparation, test environment, method of exposure, and method for evaluating the results to characterize the behavior of galvanic couples in an electrolyte.

NOTE 1—Additional information on galvanic corrosion testing and examples of the conduct and evaluation of galvanic corrosion tests in electrolytes are given in Refs (1)² through (7).

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:³

G1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens

G3 Practice for Conventions Applicable to Electrochemical Measurements in Corrosion Testing

G4 Guide for Conducting Corrosion Tests in Field Applications

G16 Guide for Applying Statistics to Analysis of Corrosion Data

G31 Practice for Laboratory Immersion Corrosion Testing of Metals

G46 Guide for Examination and Evaluation of Pitting Corrosion

3. Significance and Use

3.1 Use of this guide is intended to provide information on the galvanic corrosion of metals in electrical contact in an electrolyte that does not have a flow velocity sufficient to cause erosion-corrosion or cavitation.

3.2 This standard is presented as a guide for conducting galvanic corrosion tests in liquid electrolyte solutions, both in the laboratory and in service environments. Adherence to this guide will aid in avoiding some of the inherent difficulties in such testing.

4. Test Specimens

4.1 *Material*—Test specimens should be manufactured from the same material as those used in the service application being modeled. Minor compositional or processing differences between materials or between different heats can greatly affect the results in some cases.

4.2 *Size and Shape*:

4.2.1 The size and shape of the test specimens are dependent on restrictions imposed by the test location. When determining material behavior in the laboratory, it is advisable to use the largest specimens permissible within the constraints of the test equipment. In general, the ratio of surface area to metal volume should be large in order to favor maximum corrosion loss per weight. Sufficient thickness should be employed, however, to minimize the possibility of perforation of the specimens during the test exposure. When modeling large components, the size of the specimens should be as large as practical. When modeling smaller components, specimen size should be as close as possible to that of the application being modeled. Surface area ratio in the test should be identical to the application being modeled. This ratio is defined as the surface area of one member of the couple divided by the surface area of the other member of the couple. Only the area in contact with the electrolyte (wetted area) is used in this calculation. In

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² The boldface numbers in parentheses refer to a list of references at the end of this standard.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

low-resistivity electrolytes, maintaining proximity between the materials being coupled may be more important than maintaining the exact area ratio. Also, with some couples, such as copper coupled to aluminum, there may be effects of corrosion products washing from one electrode to another which may have to be considered in determining specimen placement.

4.2.2 Laboratory tests are normally performed on rectangular plates or on cylinders. When modeling service applications, the shapes of the couple members should approximate the shapes in the application. Frequently complex shapes are simplified for testing purposes. The shape of the specimen is more important in electrolytes of low conductivity, where voltage drop in the electrolyte is significant. In highly conductive electrolytes, the shapes of the couple members may therefore deviate somewhat from the shapes in the application.

4.3 Specimen Preparation:

4.3.1 The edges of the test specimens should be prepared so as to eliminate all sheared or cold-worked metal except that cold-working introduced by stamping for identification. Shearing will, in some cases, cause considerable attack. Therefore, specimens having sheared edges should not be used. The edges should be finished by machining or polishing. The slight amount of cold working resulting from machining will not introduce any serious error.

4.3.2 Specimens should be cleaned in accordance with Practice G1, or else the specimen surface condition should be similar to the application being modeled. The metallurgical condition of the specimens should be similar to the application being modeled. In all cases surface contamination, such as dirt, grease, oil, and thick oxides, should be removed prior to weighing and exposure to the test environment.

4.3.3 The specimen identification system must be one that will endure throughout the test period. Edge notches, drilled holes, stamped numbers, and tags are some of the methods used for identification. The identification system must not induce corrosion attack in any way.

4.4 Number of Specimens:

4.4.1 The number of galvanic couples to be tested will be determined by whether or not one or more periodic specimen removals are scheduled during the course of the test. As a minimum, duplicate and preferably triplicate specimens should be tested for any given test period to determine the variability in the galvanic corrosion behavior. The effect of the number of replications on the application of the results is set forth in Guide G16.

4.4.2 Control specimens should also be tested to provide corrosion rates of the individual metals and alloys without coupling for comparisons. These specimens should be of the same alloys, shapes, sizes, and metallurgical conditions as the materials in the couple.

5. Test Environment

5.1 Laboratory Tests:

5.1.1 In the laboratory, the test solution should closely approximate the service environment. The amount of test solution used depends on the size of the test specimens. A good rule of thumb is to use 40 cm³ of test solution for every 1 cm² of exposed surface area of both members of the couple. The

volume of test solution may be varied to closely approximate the service application.

5.1.2 Galvanic corrosion tests conducted for an extensive period of time may exhaust important constituents of the original solution. Some accumulated corrosion products may act as corrosion accelerators or inhibitors. These variables may greatly change the end results, and replenishment of the solution should be chosen to be representative of the service application. A test system using continuously replenished test electrolytes is often the only solution to this problem.

5.1.3 Periodic measurements of the test environment should be made when the test duration in a fixed volume solution is for periods of several days or longer. These observations may include temperature, pH, O₂, H₂S, CO₂, NH₃, conductivity, and pertinent metal ion content.

5.2 Field Tests—Field testing should be performed in an environment similar to the service environment. Periodic measurements of those environmental variables which could vary with time, such as temperature, dissolved O₂, and so forth, should be made.

6. Procedure

6.1 Laboratory Versus Field Testing:

6.1.1 Galvanic corrosion tests are conducted in the laboratory for several purposes: (1) inexpensive screening to reduce expensive field testing, (2) study of the effects of environmental variables, and (3) study of the corrosion accelerating or protective effects of various anode/cathode surface area ratios.

6.1.2 The materials proven in the laboratory to be the most promising should also be tested in the field, since it is frequently impossible to duplicate the actual service environment in the laboratory.

6.2 Test Procedure:

6.2.1 Specimens should be electrically joined before exposure. There are a number of methods for joining the specimens. Laboratory testing generally employs external electrical connection through wires such as to allow current measurement (see Fig. 1). Field tests frequently employ direct contact physical bonding by threaded rods as in Fig. 2, soldering, brazing, and so forth. Prime considerations are that the electrical bond to the specimen will not corrode, which could result in decoupling, that the method of joining will not in itself be a galvanic couple or introduce other corrosion mechanisms (crevice, and so forth), and that the resistance of the electrical path be small compared to the polarization resistance of the couple materials. Soldering or brazing will prevent the use of mass measurements for calculating corrosion rates. A coating may be applied to the electrical connections to prevent electrolyte access as in Fig. 2, provided the coating does not result in other corrosion phenomena, such as crevice attack, and is sufficiently resistant to the environment.

6.2.2 The physical relationship between the members of each couple should approximate that of the service situation being modeled. This is particularly important in electrolytes with low conductivity, since the effect of IR drops will be more noticeable. The specimens may be positioned by the use of nonconductive holders, provided that these do not result in