Designation: G162 – 99 (Reapproved 2010)

Standard Practice for
Conducting and Evaluating Laboratory Corrosion Tests in Soils[1]

This standard is issued under the fixed designation G162; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers procedures for conducting laboratory corrosion tests in soils to evaluate the corrosive attack on engineering materials.

1.2 This practice covers specimen selection and preparation, test environments, and evaluation of test results.

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:*[2]

D1193 Specification for Reagent Water

D1654 Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

D2570 Test Method for Simulated Service Corrosion Testing of Engine Coolants

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

G51 Test Method for Measuring pH of Soil for Use in Corrosion Testing

G57 Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

G71 Guide for Conducting and Evaluating Galvanic Corrosion Tests in Electrolytes

G102 Practice for Calculation of Corrosion Rates and Related Information from Electrochemical Measurements

3. Significance and Use

3.1 This practice provides a controlled corrosive environment that has been utilized to produce relative corrosion information.

3.2 The primary application of the data from this practice is to evaluate metallic materials for use in soil environments.

3.3 This practice may not duplicate all field conditions and variables such as stray currents, microbiologically influenced corrosion, non-homogeneous conditions, and long cell corrosion. The reproducibility of results in the practice is highly dependent on the type of specimen tested and the evaluation criteria selected as well as the control of the operating variables. In any testing program, sufficient replicates should be included to establish the variability of the results.

3.4 Structures and components may be made of several different metals; therefore, the practice may be used to evaluate galvanic corrosion effects in soils (see Guide G71).

3.5 Structures and components may be coated with sacrificial or noble metal coatings, which may be scratched or otherwise rendered discontinuous (for example, no coating on the edges of metal strips cut from a wide sheet). This test is useful to evaluate the effect of defective metallic coatings.

3.6 Structures and components may be coated or jacketed with organic materials (for example, paints and plastics), and these coatings and jackets may be rendered discontinuous. The test is useful to evaluate the effect of defective or incompletely covering coatings and jackets.

3.7 The corrosivity of soils strongly depends on soluble salt content (related parameters are soil resistivity, see Test Method

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[1] This practice is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.10 on Corrosion in Soils.

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[2] 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.

G57, and chemistry), acidity or alkalinity (measured by soil pH, see Test Method G51), and oxygen content (loose, for example, sand, or compact, for example, clay, soils are extreme examples). The manufacturer, supplier, or user, or combination thereof, should establish the nature of the expected soil environment(s) and select the test environment(s) accordingly. Multiple types of soil can be used to determine the effect of this variable.

4. Test Apparatus and Conditions

4.1 *Container*—The container for the soil shall be made from a material that is not affected by the soil environment and that does not affect the soil. Container materials, such as glass, plastic, or corrosion-resistant metal or alloy, can be used; however, electrically conductive containers must be electrochemically isolated from the specimens. The size of the container is determined by the volume of soil required for the test. A minimum of 40 cm^3 should be used for each 1 cm^2 of exposed metal surface area (see Fig. 1).

4.2 *Soil Environment*—The container is filled with a soil sample of choice. A soil sample from a specific outdoor location may be retrieved for the test, or a soil sample may be prepared with a specific property and chemistry. If necessary, physical and chemical characteristics of the soil may be determined.

4.2.1 A field soil sample may be utilized for purposes of conducting a soil corrosion test in a specific environment.

4.2.2 Laboratory soil samples may be prepared by using washed sand, (that is, No. 2 silica sand) clean clay (that is, bentonite) or other uniform known media.

4.2.3 *Soil Chemistry*—The field soil sample and the laboratory soil sample are saturated with a known electrolyte chosen for the test. Typically, the electrolyte is added to the soil of choice in the container. A typical electrolyte for use with washed sand is ASTM corrosive water (see Test Method D2570). With field soil samples, deionized or distilled water (see Test Method D2570) is commonly used. Periodically, deionized or distilled water (see Specification D1193) is added to maintain the soil in a saturated condition. A non-saturated condition can be maintained if desired.

4.2.4 *Temperature*—The test is conducted under laboratory ambient temperature unless the effect of temperature is being evaluated.

4.2.5 *Test Specimen*—The test specimen is buried in the soil within the container and is prepared as discussed in Section 5.

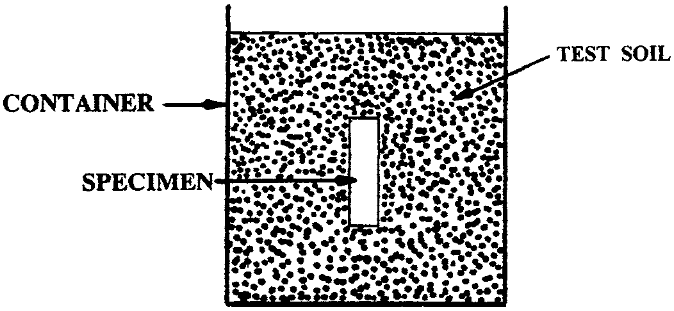

FIG. 1 Apparatus for Conducting Laboratory Corrosion Tests in Soils

5. Test Specimen

5.1 *Material*—Prepare the test specimens from the same material as that used in the structures or components being studied. Alternatively, use test specimens from the actual products.

5.2 *Size and Shape:*

5.2.1 The size and shape of test specimens are dependent on several factors and cannot be rigidly defined. When determining corrosion behavior of metals 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 obtain maximum corrosion loss per specimen weight. However, sufficient thickness should be employed to minimize the possibility of perforation of the specimen during the test exposure unless an evaluation of perforation susceptibility is of interest. When modeling large structures or components, the size of the specimens should be as large as practical. When modeling small components, the specimen size should be as close as possible to that of the component modeled. When the structure or component is made of two or more metals, the surface area ratio of the test specimen should be similar to the structure or component being modeled.

5.2.2 When modeling service applications, the shapes of the specimens should approximate the shapes in the application. Complex shapes are frequently simplified for testing purposes. For some tests, the specimen may be taken from the manufacturing line or cut from manufactured pieces (for example, short sections of pipes, wires, cables).

5.3 *Specimen Preparation:*

5.3.1 Prepare the edges of the test specimens so as to eliminate all sheared or cold worked metal, except for cold working introduced by stamping for identification. Shearing can, in some cases, introduce residual stress that may cause considerable attack. Therefore, do not use specimens with sheared edges unless this effect is being evaluated. Finish the edges by machining or polishing. The slight amount of cold work resulting from the machining process should not introduce serious error.

5.3.2 The specimen metallurgical and surface condition should be similar to the application being modeled. In all cases, remove surface contamination, such as dirt, grease, oil and thick oxides, prior to weighing and exposure to the test environment (see Practice G1).

5.3.3 The effect of damage areas on coated specimens may be of interest. In this circumstance, artificially introduce uniform damages, similar in size to the expected field damage. Some methods of applying standardized mechanical damage to coated specimens are presented in Test Method D1654.

5.3.4 Introduce a specimen identification system that will endure throughout the test period. Edged 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.

5.4 *Number of Specimens:*

5.4.1 The number of scheduled periodic specimen removals during the test should include duplicate and, preferably, triplicate specimens for any given test period to determine the variability in the corrosion behavior. The effect of the number of replications on the evaluation of the results is set forth in Practice G16.

5.4.2 If the test specimens are made of galvanically coupled dissimilar metals, control specimens should also be tested to provide corrosion rates of the individual metals and alloys (without coupling) for comparison. These specimens should be of the same alloys, shapes, sizes, surface, and metallurgical condition as the materials in the couple.

6. Test Procedure

6.1 *Test Assembly*—Introduce the test soil into the container no less than 2 cm from the top of the container. Bury the specimen (or specimens) within the soil. The specimen should not contact the container and should be completely buried unless the effect of partial burial is desired (see Fig. 1).

6.1.1 The corrosion behavior of metals in soil is influenced by the compaction of the soil around the metal and the effect of pore structure of the soil on the oxygen transport to the metal surface. Therefore, when simulating site conditions, the test soil shall be compacted appropriately.

6.1.2 Space the specimens (if more than one is buried within a container) such that a minimum of 40 cm^3 of test soil surrounds each square centimetre of exposed surface area.

6.1.3 The appropriate electrolyte is introduced to the container such that the soil is saturated and the level of liquid is at the same height as the level of the soil within the container. Deionized or distilled water (see Specification D1193) is added periodically to maintain saturation in the soil. The container may be loosely covered to minimize evaporation.

6.1.4 To simulate conditions in which soil is not water saturated, the distilled or deionized water is added periodically to maintain a water level below the test specimen.

6.2 *Test Duration:*

6.2.1 The duration of the exposure to the test environment should be sufficient to allow prediction of the corrosion behavior for the entire service duration. Measure corrosion data as a function of time until a curve is developed that one can extrapolate to the service duration, provided that steady-state conditions have been reached and that no transient environmental conditions are expected in service to affect this steady state.

6.2.2 If the exposure time is extensive, some of the important constituents of the test medium may be depleted. Therefore, the test environment may be altered and provide results that are not representative.

6.2.3 Remove test specimens based on a preplanned schedule.

7. Evaluation of Test Specimens

7.1 *Measurements During Exposure*—Data recorded during exposure may include potential measurements of the test specimens and galvanic current measurements in galvanic couples. Measure the potentials against a suitable reference half-cell as recommended in Practice G3. Current data can be converted into corrosion rate based on Faraday's law when all of the current is due to the corrosion reaction (see Practice G102).

7.2 *Measurements After Removal:*

7.2.1 After removal, take samples of corrosion products for chemical and physical analysis. Record visual observations after taking color photographs of each specimen. Clean the specimens in accordance with Practice G1, and weigh the specimens to determine the corrosion mass loss, which can be converted to corrosion rate as set forth in Practice G31. Additional recommendations for specimen cleaning are in Guide G4 and Practice G31.

7.2.2 Some examples in which mass loss measurements are not always possible or meaningful are *(1)* specimens with organic coating and jacketing, *(2)* specimens made of soldered assemblies, and *(3)* specimens subject only to localized corrosion (for example, pitting or cracking). In these cases, base the corrosion evaluation on visual assessment, loss of tensile strength, loss of thickness, or on other measurement techniques. Analyze localized corrosion, such as pitting, using the methods described in Guide G46. Analyze specimens undergoing crevice corrosion with depth of attack measurements and with detailed description, including changes taking place at the edges as well as on the surfaces. In addition, measure changes in physical properties, such as tensile strength and loss of ductility. In some cases, metallographic examination of specimen cross sections can be used to determine the depth of corrosion.

7.2.3 Compare the behavior of galvanic test specimens to that of exposed uncoupled controls of the individual anode and cathode materials. Subtracting the results found on the control samples from the values of the coupled specimens yields the corrosion behavior of anode and cathode materials due to coupling.

7.2.4 Where replicate specimens are exposed, apply statistical analysis of the data, as set forth in Practice G16, to generate confidence intervals for predictive purposes.

8. Report

8.1 *Report the Following Information:*

8.1.1 A detailed description of the exposed specimen, including alloy and temper, metallurgical history, chemical composition, processing parameters for formed parts, coating chemistry, weight and thickness, and specific details of products, such as jacketed cables or wire.

8.1.2 Physical dimensions, surface preparation, and cleaning.

8.1.3 Details of exposure conditions, including period of exposure, soil sample type, and electrolyte chemistry.

8.1.4 Details of retrieval, including after exposure cleaning methods.

8.1.5 Express the results of the test as corrosion rate in penetration per unit time (for example, millimetres per year) or loss in thickness or mass during the exposure period. When the test specimens are galvanic couples, report the corrosion rates for both controls (uncoupled) and coupled specimens with the change in corrosion rate due to the coupling. Report this information either as the difference between control and coupled specimens or as the coupled rate divided by the control rate (acceleration factor).

8.1.6 When perforation by corrosion is of concern, report the evaluation of perforation corrosion by number of perforations per unit area or percent of surface perforated per unit area.

8.1.7 When the corrosion is in the form of pitting or crevice corrosion, report the pitting factor in accordance with Practice G46. Report also the depths of pitting. For galvanic couples, use pitting factors or depth of penetration to determine the change in corrosion due to coupling.

8.1.8 If any physical property of the specimens is measured before and after the exposure, report the change in that property in the same manner as corrosion rates or pitting factors.

8.1.9 Report changes in the physical appearance of the specimens during the exposure period.

9. Keywords

9.1 corrosion test; corrosivity; electrolyte; localized corrosion; galvanic corrosion; soil burial; soil corrosion; underground

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