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# Standard Practice for Exposure of Metals and Alloys by Alternate Immersion in Neutral 3.5 % Sodium Chloride Solution[1]

This standard is issued under the fixed designation G44; 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.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope

1.1 This practice covers procedures for making alternate immersion stress corrosion tests in 3.5 % sodium chloride (NaCl) (Note 1). It is primarily for tests of aluminum alloys (Test Method G47) and ferrous alloys, but may be used for other metals exhibiting susceptibility to chloride ions. It sets forth the environmental conditions of the test and the means for controlling them.

NOTE 1—Alternate immersion stress corrosion exposures are sometimes made in substitute ocean water (without heavy metals) prepared in accordance with Specification D1141. The general requirements of this present practice are also applicable to such exposures except that the reagents used, the solution concentration, and the solution pH should be as specified in Specification D1141.

1.2 This practice can be used for both stressed and unstressed corrosion specimens. Historically, it has been used for stress-corrosion cracking testing, but is often used for other forms of corrosion, such as uniform, pitting, intergranular, and galvanic.

1.3 This practice is intended for alloy development and for applications where the alternate immersion test is to serve as a control test on the quality of successive lots of the same material. Therefore, strict test conditions are stipulated for maximum assurance that variations in results are attributable to variations in the material being tested.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *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]

D1141 Practice for the Preparation of Substitute Ocean Water
D1193 Specification for Reagent Water
E3 Guide for Preparation of Metallographic Specimens
G1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens
G16 Guide for Applying Statistics to Analysis of Corrosion Data
G47 Test Method for Determining Susceptibility to Stress-Corrosion Cracking of 2XXX and 7XXX Aluminum Alloy Products

## 3. Summary of Practice

3.1 The alternate immersion test utilizes a 1-h cycle that includes a 10-min period in an aqueous solution of 3.5 % sodium chloride (NaCl) followed by a 50-min period out of the solution, during which the specimens are allowed to dry. This 1-h cycle is continued 24 h/day for the total number of days recommended for the particular alloy being tested. Typically, aluminum and ferrous alloys are exposed from 20 to 90 days or longer, depending upon the resistance of the alloy to corrosion by saltwater.

## 4. Significance and Use

4.1 The 3.5 % NaCl alternate immersion procedure is a general, all-purpose procedure that produces valid comparisons for most metals, particularly when specimens are exposed at high levels of applied stress or stress intensity.

4.2 While the alternate immersion test is an accelerated test and is considered to be representative of certain natural conditions, it is not intended to predict performance in specialized chemical environments in which a different mode of cracking may be operative. For example, it does not predict the performance of aluminum alloys in highly acidic environments

[1] This practice is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.06 on Environmentally Assisted Cracking.

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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.

such as heated inhibited red fuming nitric acid (IRFNA). For such cases, the results of the alternate immersion test are of doubtful significance until a relationship has been established between it and anticipated service environments.

4.3 While this practice is applicable in some degree to all metals, it is not equally discriminative of all alloys, even within the same metal system. Consequently, information should be established to allow comparisons of performances of the alloy of interest in the alternate immersion test and in natural environments.

NOTE 2—The alternate immersion concept can be useful for exposure of corrosion specimens in other solutions because the procedure and apparatus provide a controlled set of conditions. Details of this are beyond the scope of this practice.

## 5. Interferences

5.1 A disadvantage of the 3.5 % NaCl alternate immersion test for stres-corrosion cracking tests of certain high-strength aluminum alloys is the severe pitting that develops in the specimens. Such pitting can interfere with the initiation of stress-corrosion cracks and may cause mechanical failures that complicate the interpretation of the stress-corrosion test results. This is particularly a problem with copper-bearing aluminum alloys when tested with specimens of small cross section. Thorough metallographic examination of the specimens is necessary for proper diagnosis of the cause of failure and separation of stress corrosion failures from those caused by mechanical overload.

5.2 An advantage of the substitute ocean water (Note 1) is that it causes less pitting corrosion of aluminum alloys than the 3.5 % NaCl solution.

## 6. Apparatus

6.1 *Method of Cycling*—Any suitable mechanism may be used to accomplish the immersion portion of the cycle provided that: *(1)* it achieves the specified rate of immersion and removal, and *(2)* the apparatus is constructed of suitable inert materials. The usual methods of immersion are:

6.1.1 Specimens placed on a movable rack that is periodically lowered into a stationary tank containing the solution.

6.1.2 Specimens placed on a hexagonal Ferris wheel arrangement which rotates every 10 min through 60° and, thereby, passes the specimens through a stationary tank of solution. Use of a Ferris wheel continuously rotating at a rate of 1 revolution per hour is not recommended for very large specimens for which the rate of immersion would be slower than that specified in 6.2.

6.1.3 Specimens placed in a stationary tray open to the atmosphere and having the solution moved by air pressure, nonmetallic pump, or gravity drain from a reservoir to the tray.

6.2 *Rate of Immersion*—The rate of immersion and removal of the specimens from the solution should be as rapid as possible without jarring them. For purposes of standardization, an arbitrary limit shall be adopted such that no more than 2 min elapse from the time the first portion of any specimen is covered (or uncovered) until it is fully covered (or uncovered) by solution.

6.3 *Materials of Construction:*

6.3.1 Materials of construction that come in contact with the salt solution shall be such that they are not affected by the corrodent to an extent that they can cause contamination of the solution and change its corrosiveness.

6.3.2 Use of inert plastics or glass is recommended where feasible.

6.3.3 Metallic materials of construction should be selected from alloys that are recommended for marine use and of the same general type as the metals being tested. Preferably, all metal parts should be protected with a suitable corrosion-resistant coating that also satisfies paragraph 6.3.1.

6.4 *Specimen Holders:*

6.4.1 Specimen holders should be designed to electrically insulate the specimens from each other and from any other bare metal. When this is not possible, as in the case of certain stressing bolts or jigs, the bare metal contacting the specimen should be isolated from the corrodent by a suitable coating. Protective coatings should be of a type that will not leach inhibiting or accelerating ions or protective oils over the noncoated portions of the specimen. Coatings containing chromates are to be particularly avoided.

NOTE 3—Coatings that have been satisfactorily used by several laboratories are described in Appendix X1.

6.4.2 The shape and form of specimen supports and holders should be such that:

6.4.2.1 They avoid, as much as possible, any interference of free contact of the specimen with the salt solution;

6.4.2.2 They do not obstruct air flow over the specimen, thereby retarding the drying rate;

6.4.2.3 They do not retain a pool of solution in contact with the specimen after the immersion period; and

6.4.2.4 Drainage from one specimen does not directly contact any other specimen.



## 7. Reagents

7.1 Reagent grade sodium chloride (NaCl) shall be used conforming to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are applicable (see Note 1).[3]

7.2 The solution shall be prepared using distilled or deionized water conforming to the purity requirements of Specification D1193, Type IV reagent water except that for this practice the values for chloride and sodium shall be disregarded.

## 8. Solution Conditions

8.1 *Concentration*—The salt solution shall be prepared by dissolving 3.5 ± 0.1 parts by weight of NaCl in 96.5 parts of water.

[3] *Reagent Chemicals, American Chemical Society Specifications,* American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals,* BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary,* U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.