Designation: G139 – 05 (Reapproved 2022)

Standard Test Method for Determining Stress-Corrosion Cracking Resistance of Heat-Treatable Aluminum Alloy Products Using Breaking Load Method[1]

This standard is issued under the fixed designation G139; 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 test method covers procedures for evaluation of stress corrosion cracking (SCC) resistance by the breaking load test method, a concept which uses residual strength as the measure of damage evolution (in this case environmentally assisted cracking).

1.2 This test method covers specimen type and replication, test environment, stress levels, exposure periods, final strength determination, and statistical analysis of the raw residual strength data.

1.3 The test method was developed for use with heat-treatable aluminum alloys, that is, 2XXX alloys and 7XXX with 1.2 to 3.0 % Cu, and test specimens oriented in the short-transverse direction relative to grain structure (**1**, **2**).[2] However, the residual strength measurements and the statistics used to analyze the data are not specific to heat-treatable aluminum alloys and can be used for other specimen orientations and different types of materials.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

E8/E8M Test Methods for Tension Testing of Metallic Materials
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
G44 Practice for Exposure of Metals and Alloys by Alternate Immersion in Neutral 3.5 % Sodium Chloride Solution
G47 Test Method for Determining Susceptibility to Stress-Corrosion Cracking of 2XXX and 7XXX Aluminum Alloy Products
G49 Practice for Preparation and Use of Direct Tension Stress-Corrosion Test Specimens
G64 Classification of Resistance to Stress-Corrosion Cracking of Heat-Treatable Aluminum Alloys

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *censor*—a statistical term indicating that the value from an individual observation may fall outside of the range that can be measured because of test procedures or conditions.

3.1.2 *sample*—the nominally uniform, bulk material from which individual stress-corrosion cracking specimens are obtained.

4. Summary of Test Method

4.1 This test method describes a procedure for using residual strength after exposure to a corrosive environment to evaluate stress corrosion cracking susceptibility in heat treatable aluminum alloy product forms such as sheet, plate, extrusions, forgings, and bar. These products generally are most susceptible to SCC in the long transverse direction of sheet, the short transverse direction of plate, extrusions and

[1] This test method 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] The boldface numbers in parentheses refer to the list of references at the end of the 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.

forgings, and the transverse direction of rod and bar stock. In this test, tensile bars or direct tension sheet specimens, prepared according to Practice G49, are exposed to 3.5 weight % aqueous sodium chloride solution (Practice G44), are removed before they fail and are tension tested to determine the amount of corrosion damage that has occurred. The average retained strength is then calculated and the Box-Cox Transformation can be used for statistical analysis of the results.

4.2 The procedure calls for exposure of unstressed specimens which are used to factor out the effects of pitting, intergranular, and general corrosion. These phenomena degrade residual strength but do not require applied stress for their occurrence.

5. Significance and Use

5.1 The test method was developed for use with high strength aluminum alloys (2XXX and Cu containing 7XXX) that are normally tested in 3.5 weight % NaCl by alternate immersion. However, the concept which uses residual strength as a measure of damage evolution (in this case environmentally assisted cracking) can, in principle, be applied to any alloy and environmental system.

5.2 This test method has been developed for research studies of alloys and tempers with improved resistance to SCC. The test results permit different material variants to be compared with a high degree of confidence and with much more precision than the results of pass/fail tests. Thus, it is particularly useful for comparing materials with similar levels of resistance to stress-corrosion cracking. The procedure could be modified for use as a quality assurance tool but this has not been a primary purpose during its development.

5.3 The exposure periods and conditions that are described in this test method apply specifically to high strength aluminum alloys, but the statistical techniques should be valid for other alloy systems with different exposure conditions.

5.4 Although this particular procedure was primarily intended for testing products in the short-transverse stressing direction, it is useful for other stressing directions, particularly the long-transverse direction in sheet and thin plate products.

5.5 Determination of the actual serviceability of a material requires stress-corrosion testing performed in the intended service environment, under conditions relating to the end use, including protective measures such as coatings and inhibitors and is outside the scope of this test method.

5.5.1 There is no good way to compare test environments to actual service because most service environments have large inherent variability with respect to a single structure that may experience many different environments or with respect to two identical structures that serve in different locations. Unless a sample can be tested in the actual service environment for the expected life of the component, no conclusive determination can be made about the suitability of a particular material for a particular application. Designers must therefore make judgments on the suitability of particular materials for applications based on knowledge of the material and of the service environment. To avoid service failures, the environment used for preliminary evaluations is often chosen based on a worst case scenario leading to intentional overestimations of corrosion damage.

6. Interferences

6.1 The breaking load test factors out pitting corrosion that occurs in environments such as the 3.5 % NaCl solution used in alternate immersion testing per Practice G44. The primary concern in using the breaking load test is choice of appropriate exposure stress. If the exposure stress is too low no damage will accumulate. On the other hand, if the applied stress is too high many of the specimens will fail before the end of their scheduled exposure periods. The statistical procedures included in this test method can accommodate small numbers of failed specimens but not large numbers.

6.2 The breaking load test is applicable to specimens that have been exposed in natural and service environments. However, conditions in these environments may not be constant so consideration must be given to the period and timing of exposure to avoid biasing results. For example, environmental conditions that vary seasonally such as temperature, moisture, and pollutant concentration may affect the corrosivity of outdoor exposure stations. Direct material comparisons should be made using identical environmental conditions.

6.3 Some care is required when comparison samples have different original (uncorroded) tensile strength and fracture toughness values. Large variations in initial properties can either reduce or increase the apparent differences in SCC performance of the samples. To avoid bias due to tensile properties, the statistical procedures incorporated in this test method are based on percentages of original strength. However, to examine the effect of fracture toughness, which affects residual strength, a flaw size calculation must be done using fracture mechanics techniques (**3**).

7. Test Specimens

7.1 The breaking load procedure may be conducted using any specimen that can be axially stressed in a fixture that will sustain an applied displacement. However, results obtained using different specimen geometries or stressing methods can not be directly compared. While the relative susceptibilities of the samples will not be changed, the absolute numbers can be quite different.

7.2 Whenever the geometry of the metal sample permits, the test should be conducted using smooth, round tension specimens prepared in accordance with Practice G49. In the case of sheet and other products that may be too thin to yield tensile bars, sheet tensile specimens may be used. The test sensitivity increases with the ratio of surface area to volume in the specimen gage section; however tests made using round tensile specimens have shown that the same relative rankings can be achieved with different size specimens (**1**).

8. Exposure Procedure

8.1 *Stressing Procedure and Exposure Conditions*—The specimens shall be stressed by axially loading in constant deflection-type fixtures as in Figure 1 of Practice G49 and