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# Standard Practice for Evaluating Stress-Corrosion Cracking Resistance of Low Copper 7XXX Series Al-Zn-Mg-Cu Alloys in Boiling 6 % Sodium Chloride Solution[1]

This standard is issued under the fixed designation G103; 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.

ε[1] NOTE—Ref (9) was updated editorially, and other editorial changes were made throughout in January 2023.

## INTRODUCTION

Continuous immersion in boiling 6 % sodium chloride solution historically was considered to be an effective accelerated SCC testing medium for all Al-Zn-Mg-Cu alloys (**1**, **2**),[2] but in more recent years, alternate immersion in 3.5 % sodium chloride solution (Practice G44) has become the favored test medium for the high copper (1.2 % to 2.6 % Cu) 7XXX series alloys (**3**, **4**). Evidence to date shows, however, that the boiling 6 % sodium chloride medium correlates better with outdoor atmospheric exposure than Practice G44 for the 7XXX series alloys containing little or no copper (**5**, **6**, **7**, **8**).



## 1. Scope

1.1 This practice primarily covers the test medium which may be used with a variety of test specimens and methods of applying stress. Exposure times, criteria of failure, and so on, are variable and not specified.

1.2 This stress-corrosion testing practice is intended for statically loaded smooth non-welded or welded specimens of 7XXX series Al-Zn-Mg-Cu alloys containing less than 0.26 % copper.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* See Section 8 for additional precautions.

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]

B580 Specification for Anodic Oxide Coatings on Aluminum
D1193 Specification for Reagent Water
G30 Practice for Making and Using U-Bend Stress-Corrosion Test Specimens
G38 Practice for Making and Using C-Ring Stress-Corrosion Test Specimens
G39 Practice for Preparation and Use of Bent-Beam Stress-Corrosion Test Specimens
G44 Practice for Exposure of Metals and Alloys by Alternate Immersion in Neutral 3.5 % Sodium Chloride Solution
G49 Practice for Preparation and Use of Direct Tension Stress-Corrosion Test Specimens
G58 Practice for Preparation of Stress-Corrosion Test Specimens for Weldments

[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] The boldface numbers in parentheses refer to the 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.

## 3. Summary of Practice

3.1 Stressed specimens are totally and continuously immersed in boiling 6 % sodium chloride solution for up to 168 h. Various types of smooth test specimens and methods of stressing may be used. Performance is based on time to visual cracking.

## 4. Significance and Use

4.1 This practice is normally used for stress-corrosion screening for the development of Al-Zn-Mg-Cu alloys containing less than 0.26 % copper. Effects on stress-corrosion resistance due to variables such as composition, thermo-mechanical processing, other fabrication variables, and magnitude of applied stress may be compared.

4.2 For a given mechanical method of stressing, the relative stress-corrosion resistance of the low copper Al-Zn-Mg-Cu alloys in atmospheric exposure correlates better with performance in boiling 6 % sodium chloride solution than with other accelerated testing media (**7-9**). In addition, this practice is relatively rapid.

4.3 This practice is not applicable to 2XXX (Al-Cu), 5XXX (Al-Mg), 6XXX (Al-Mg-Si), and the 7XXX (Al-Zn-Mg-Cu) series alloys containing more than 1.2 % copper.

4.3.1 For 7XXX series alloys containing between 0.26 % and 1.2 % copper, there is no general agreement as to whether this practice or Practice G44 correlates better with stress-corrosion resistance in service (**5-8**, **10**).

## 5. Apparatus

5.1 Fig. 1 illustrates one type of apparatus that has been used.

5.2 *Materials of Construction:*

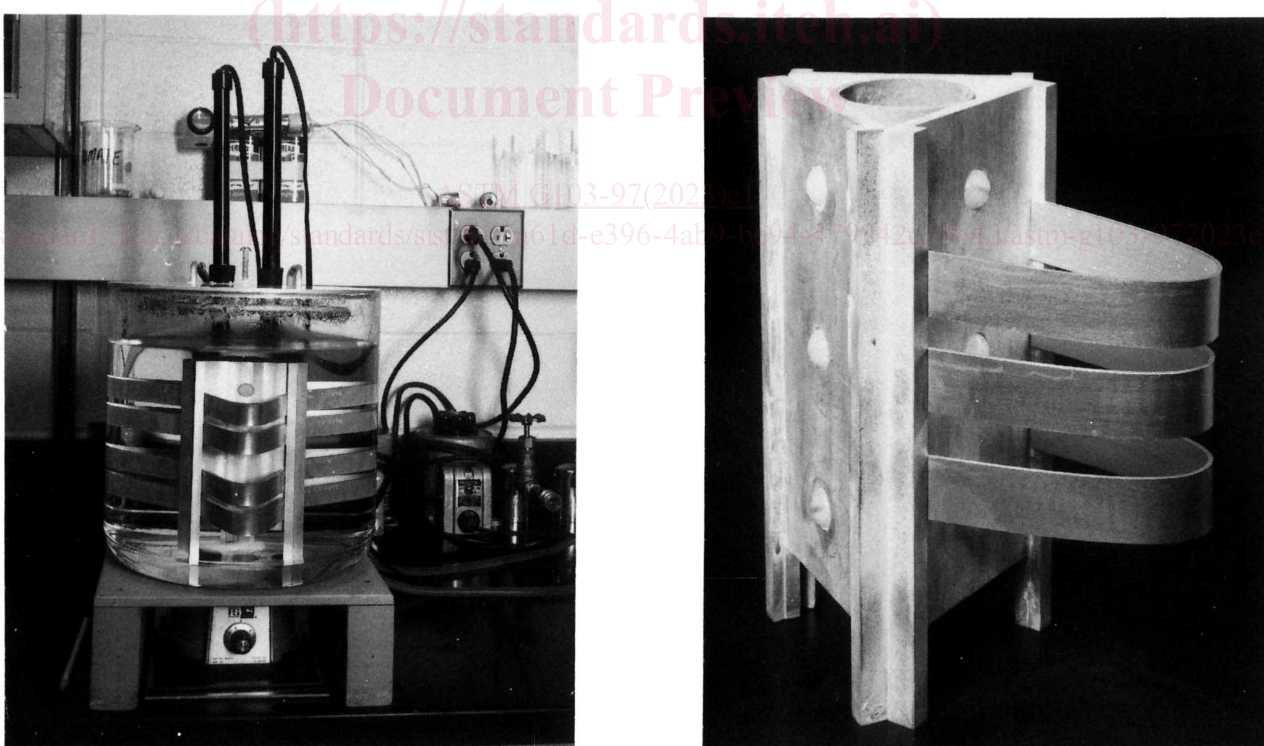
5.2.1 Materials of construction that come in contact with the boiling salt solution shall be such that they are not affected by the corrodent to an extent that they can cause contamination of the solution and change its corrosiveness.

5.2.2 Use of glass or aluminum containers and condensers is recommended.

5.2.3 Metallic materials of construction should be limited to copper free aluminum alloys, which may be anodized to provide electrical contact resistance.

5.3 *Specimen Holders*—The specimen holders should be designed to electrically insulate the specimens from each other and from other bare metal. An anodized aluminum holder has been found to be appropriate. (Satisfactory anodic coating may





U bend specimens (Practice G39) stressed in an anodized aluminum fixture (right photo) are placed in a pyrex battery jar (left photo), which is placed over a magnetic stirrer. The 6 % salt solution is heated to boiling by means of two quartz immersion heaters. A powerstat controls the heat output of the quartz heaters. A cold water circulating aluminum condenser tube is placed just below the aluminum cover to prevent evaporation losses. Stressed specimens are placed in the jar after the solution comes to a boil. Specimens are examined in place for visual evidence of cracking.

**FIG. 1 Boiling 6 % NaCl—Stress-Corrosion Testing Practice**

be Type A or B, Specification B580.) Periodic ohmeter checks may be made to confirm electrical isolation of specimen and anodized holder.

5.4 *Heater for Solution:*

5.4.1 Heaters must be of sufficient capacity that boiling temperature can be maintained and solution can be brought back up to a boil within 10 min after the introduction of test specimens.

5.4.1.1 Quartz immersion heaters may be used.

5.4.1.2 Hot plate resistance heaters may be used.

## 6. Reagents and Solution Conditions

6.1 Reagent grade sodium chloride (NaCl) shall be used. It shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are applicable.

6.2 The 6 % NaCl solution shall be prepared using distilled or deionized water conforming to the purity requirements of Specification D1193, Type IV reagent water, except that values for chloride and sodium shall be disregarded.

6.3 *Concentration*—The salt solutions shall be prepared by dissolving 6.0 ± 0.1 parts by weight of NaCl in 94.0 parts of water.

6.4 *Solution pH,* shall be between 6.4 and 7.2. The pH may be adjusted by the addition of dilute reagent grade HCl or NaOH solutions. (See Practice G44.)

6.5 *Minimum Volume*—The volume of solution should be large enough to avoid any appreciable change in its corrosiveness through exhaustion of corrosive constituents, or the accumulation of corrosion products or other constituents that might significantly affect further corrosion. A minimum ratio between the volume of solution and total exposed area of specimens of 20 mL/in.$^2$ (3 mL/cm$^2$) is recommended.

6.6 Reflux condensers are required in order to prevent evaporation losses. Condenser material can be glass or copper-free aluminum alloy.

6.7 Solution should be boiling throughout the exposure, except for the first few minutes after specimens are immersed.

6.8 *Replacement of Solution*—New solution should be used for each new set of specimens. Solution should not be changed during exposure.

## 7. Test Specimens

7.1 *Type and Size*—No single configuration of test specimen is applicable for the many complex shapes and sizes of products that can be evaluated. Bent beams (G39) and U bends (G30) are useful for thin products while C-rings (G38) or tension specimens (G49) are more suitable for thicker products and for short transverse testing. Guidance for selection of appropriate specimens for evaluating weldments is given in Practice G58.

7.2 *Stressing Direction and Magnitude of Stress*—Any of the three primary grain directions may be used. The magnitude of stress can be either within the elastic range or beyond. The method of stressing the specimens should be reproducible and in accordance to standard procedures for the type of specimen selected.

7.3 *Surface Preparation*—The specimen surface should be free of oil, grease, and dirt. This usually entails cleaning with organic solvents such as alcohol or acetone.

7.4 There is no need to provide compensation for thermal expansion effects on applied stress.

## 8. Safety Precautions

8.1 Care should be taken in order to avoid burns from hot surfaces.

8.2 Appropriate eye protection equipment should be used.

## 9. Procedure

9.1 Allow solution to boil for a minimum of 10 min before specimens are immersed.

9.2 Immerse specimens as soon as possible after stressing (delays between stressing and testing should be avoided unless the stressed specimens are kept in a desiccator at a relative humidity less than 5 %).

9.3 *Inspection Method and Frequency*—Specimen surfaces should be examined for visual evidence of cracking or the initiation of gas evolution from the surface in areas of highest stress. (Usually gassing is noted before cracking becomes visible.) It is preferred that these inspections be done in situ, which can be accomplished with glass reaction vessels. If the specimens have to be removed from the boiling salt solution, then the time out of solution should be kept to a minimum, no more than 5 min.

9.4 Time to first gassing and the first visual evidence of cracking shall be recorded.

9.5 *Duration of Exposure*—The duration of exposure shall be determined by the inherent resistance to corrosion of the alloy, the configuration and size of the test specimen, and the purpose of the test. Common practice is a maximum of 168 h.

9.6 *Final Examination*—Give all specimens a final inspection for evidence of cracking at the termination of the exposure.

## 10. Report

10.1 Report the following information:

10.1.1 Details of all exposures, including type and size of specimen, orientation of specimen and number of replicates, solution volume to surface area ratio, stress level, and time of exposure, and time to failure.

10.1.2 Identification of alloy, temper, product form, thickness of materials exposed and reference to applicable specifications.

10.1.3 Any deviation from the procedures outlined above.

## 11. Keywords

11.1 accelerated test environment; aluminum-zinc-magnesium-copper alloys; boiling sodium chloride solution; continuous immersion