Designation: G123 – 00 (Reapproved 2022)ε1

Standard Test Method for Evaluating Stress-Corrosion Cracking of Stainless Alloys with Different Nickel Content in Boiling Acidified Sodium Chloride Solution[1]

This standard is issued under the fixed designation G123; 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—Replaced Terminology G15 with Terminology G193 and other editorial changes made throughout in Oct. 2022.

1. Scope

1.1 This test method covers a procedure for conducting stress-corrosion cracking tests in an acidified boiling sodium chloride solution. This test method is performed in 25 % (by *mass*) sodium chloride acidified to pH 1.5 with phosphoric acid. This test method is concerned primarily with the test solution and glassware, although a specific style of U-bend test specimen is suggested.

1.2 This test method is designed to provide better correlation with chemical process industry experience for stainless steels than the more severe boiling magnesium chloride test of Practice G36. Some stainless steels which have provided satisfactory service in many environments readily crack in Practice G36, but have not cracked during interlaboratory testing (see Section 12) using this sodium chloride test method.

1.3 This boiling sodium chloride test method was used in an interlaboratory test program to evaluate wrought stainless steels, including duplex (ferrite-austenite) stainless and an alloy with up to about 33 % nickel. It may also be employed to evaluate these types of materials in the cast or welded conditions.

1.4 This test method detects major effects of composition, heat treatment, microstructure, and stress on the susceptibility of materials to chloride stress-corrosion cracking. Small differences between samples such as heat-to-heat variations of the same grade are not likely to be detected.

1.5 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.6 *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.* For specific hazard statements, see Section 8.

1.7 *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:*[2]

D1193 Specification for Reagent Water

E8 Test Methods for Tension Testing of Metallic Materials [Metric] E0008_E0008M

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

G16 Guide for Applying Statistics to Analysis of Corrosion Data

G30 Practice for Making and Using U-Bend Stress-Corrosion Test Specimens

G36 Practice for Evaluating Stress-Corrosion-Cracking Resistance of Metals and Alloys in a Boiling Magnesium Chloride Solution

G49 Practice for Preparation and Use of Direct Tension Stress-Corrosion Test Specimens

G107 Guide for Formats for Collection and Compilation of Corrosion Data for Metals for Computerized Database Input

G193 Terminology and Acronyms Relating to Corrosion

3. Terminology

3.1 *Definitions*—For definitions of corrosion-related terms used in this test method, see Terminology G193.

[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.

Current edition approved Oct. 1, 2022. Published October 2022. Originally approved in 1994. Last previous edition approved in 2015 as G123–00(2015). DOI: 10.1520/G0123-00R22E01.

[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.

4. Summary of Test Method

4.1 A solution of 25 % sodium chloride (by *mass*) in reagent water is mixed, and the pH is adjusted to 1.5 with phosphoric acid. The solution is boiled and U-bends (or other stressed specimens) are exposed in fresh solution for successive one-week periods.

4.2 The test may be continued for as many weeks as necessary, but six weeks (about 1000 h) or less are expected to be sufficient to crack susceptible materials. Longer exposures provide greater assurance of resistance for those materials which do not crack.

4.3 It is recommended that samples of a susceptible material, for example, UNS S30400 or S31600 (Type 304 or Type 316 stainless, respectively), be included as a control when more resistant materials are evaluated.

5. Significance and Use

5.1 This test method is designed to compare alloys and may be used as one method of screening materials prior to service. In general, this test method is more useful for stainless steels than the boiling magnesium chloride test of Practice G36. The boiling magnesium chloride test cracks materials with the nickel levels found in relatively resistant austenitic and duplex stainless steels, thus making comparisons and evaluations for many service environments difficult.

5.2 This test method is intended to simulate cracking in water, especially cooling waters that contain chloride. It is not intended to simulate cracking that occurs at high temperatures (greater than 200 °C or 390 °F) with chloride or hydroxide.

NOTE 1—The degree of cracking resistance found in full-immersion tests may not be indicative of that for some service conditions comprising exposure to the water-line or in the vapor phase where chlorides may concentrate.

5.3 Correlation with service experience should be obtained when possible. Different chloride environments may rank materials in a different order.

5.4 In interlaboratory testing, this test method cracked annealed UNS S30400 and S31600 but not more resistant materials, such as annealed duplex stainless steels or higher nickel alloys, for example, UNS N08020 (for example 20Cb-3[3] stainless). These more resistant materials are expected to crack when exposed to Practice G36 as U-bends. Materials which withstand this sodium chloride test for a longer period than UNS S30400 or S31600 may be candidates for more severe service applications.

5.5 The repeatability and reproducibility data from Section 12 and Appendix X1 must be considered prior to use. Interlaboratory variation in results may be expected as occurs with many corrosion tests. Acceptance criteria are not part of this test method and if needed are to be negotiated by the user and the producer.

[3] 20Cb-3 is a registered trademark of Carpenter Technology Corp., Reading, PA.

6. Apparatus

6.1 The glassware used for this test method is shown in Fig. 1 and is as follows:

6.1.1 *Flask*—1000 mL Erlenmeyer flask with a 45/50 ground-glass joint.

6.1.2 *Condenser,* a four-bulb Allihn condenser with a 45/50 ground-glass joint (water-cooled joint suggested), a water jacket at least 20 cm (8 in.) long and a 1 cm to 2.5 cm (0.4 in. to 0.95 in.) long drip tip is used. (Modified Allihn condensers with no drip tip and condensers with longer drip tips may produce different results. These alternate Allihn condenser designs may be used if control samples of susceptible (for example, UNS S31600) and resistant (for example, UNS N08020) materials are included in the study.)

6.1.3 *Hot Plate,* capable of maintaining the solution at its boiling point.

7. Reagents

7.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that

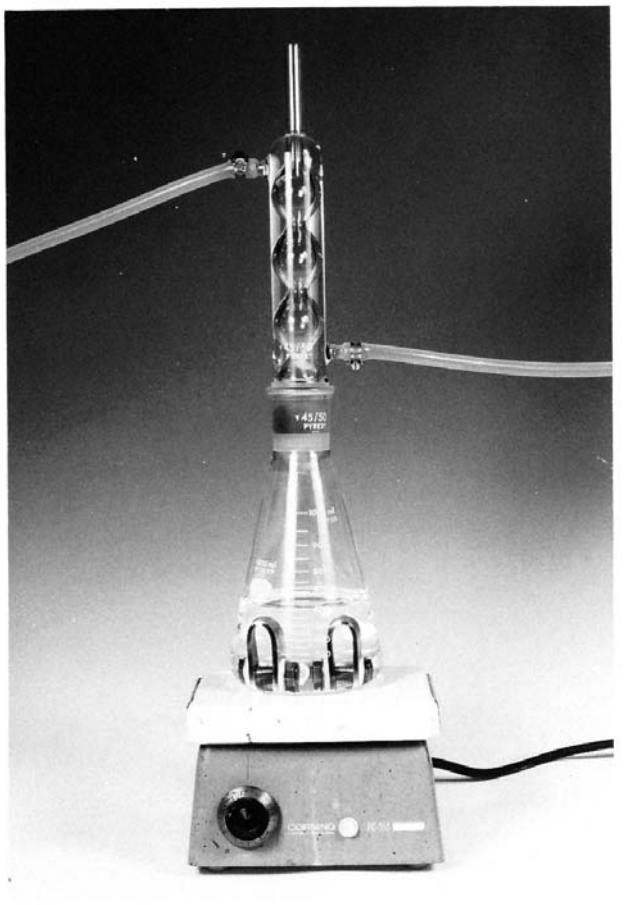

FIG. 1 Apparatus Used for Stress-Corrosion Cracking Test

all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[4] Other grades may be used provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without affecting results.

7.2 *Purity of Water*—Solutions shall be made with water of purity conforming to at least Type IV reagent water as specified in Specification D1193 (except that for this method limits for chlorides and sodium may be ignored).

7.3 *Sodium Chloride (NaCl)*—A solution of 25 % NaCl (by mass) acidified to pH 1.5 with phosphoric acid (H_3PO_4) is used. The solution may be prepared by adding 750 g H_2O (750 mL) to 250 g NaCl, and adjusting to pH 1.5 with H_3PO_4. Varying quantities of solution may be prepared and larger amounts may be stored indefinitely in appropriate glassware. The pH must be determined prior to each use.

8. Hazards

8.1 Normal precautions for handling boiling liquid should be observed.

8.2 All heating or boiling of the NaCl solution should be done in an area where personnel are not likely to accidentally bump the flask. A hooded area is preferred.

8.3 Minimum personal protective equipment for handling boiling sodium chloride should include safety glasses or goggles, face shield, laboratory coat, and rubber gloves. (**Warning—**U-bends (and other highly stressed test specimens) may be susceptible to high rates of crack propagation and a specimen containing more than one crack may splinter into two or more pieces. This may also occur due to a cracked restraining bolt. Due to the highly stressed condition in a U-bend specimen, these pieces may leave the specimen at high velocity and can be dangerous.)

9. Test Specimens

9.1 U-bends are preferred but other stress corrosion cracking specimens may be used with this test solution. The specimen style chosen should provide sufficient stress to crack less resistant materials (for example, UNS S30400 or S31600) in 1000 h or less). (See Annex A1.) Regardless of the specimen style, it is recommended that UNS S30400 or UNS S31600, or both, be included as controls.

9.2 The test specimen must be thick enough so that the applied stress does not cause mechanical rupture of less resistant materials if the cross section is reduced by pitting or general corrosion.

9.3 The size of alternate specimens (other than those in Annex A1) must allow a solution volume to specimen surface area ratio of at least 5:1 mL/cm^2 (33 mL/in.^{2}).

9.4 A minimum of four replicates (two per flask) is required because of the variability typical in stress-corrosion testing.

9.5 Methods of fabricating U-bend specimens are provided in Annex A1. These procedures are based on Practice G30, but in addition provide a specimen that fits through a 45/50 ground-glass joint. Assurance that the legs are stressed sufficiently by the bolt is also provided.

9.5.1 Other methods of producing U-bends described in Practice G30 may be used; however, during exposure the U-bends must be (*1*) in the plastic range and (*2*) stressed to the maximum applied tensile load experienced during fabrication. The same method must be used to fabricate all the U-bends in a given study.

9.5.2 The bolt, nut, and flat washer must be made of a material resistant to general corrosion, pitting, and stress corrosion cracking in the environment. UNS N10276 (Alloy C-276) is recommended because some other materials (for example, titanium or UNS N06600 [Alloy 600]) may be attacked resulting in an increase in solution pH.

9.5.3 The metallic fastener must be electrically isolated from the specimen by a rigid shoulder washer (that is, zirconia or another material that will not be compressed during the test).

9.5.4 The extended end of the bolt may require cutting to fit into the test vessel.

10. Procedure

10.1 Stress the specimens, examine at 20×, and replace any specimens with cracks or other defects.

NOTE 2—The direction and intensity of the incident light may affect crack detection during the 20× examination.

10.2 Degrease in a halogen-free solvent or laboratory detergent, rinse as necessary, and dry. It is best practice to stress the specimens immediately before the beginning of the test. Any storage of the specimens should be in a clean enclosure. A desiccant such as silica gel may be used. The specific level of relative humidity is not important for the alloys of interest.

10.3 Place duplicate specimens in each 1000 mL Erlenmeyer flask. Duplicate flasks (four specimens) are necessary to evaluate a given sample of the specific material, material condition, etc. (The specimens may be placed in the flasks after the solution has been added, if convenient.)

10.4 The specimens in each flask must be kept separate and completely submerged. Tight crevices between the stressed (bend) area and any means of specimen support should be avoided. The stressed area should be free from direct contact with heated surfaces. Specimens may be supported on glass rods or tubes or by glass fixtures.

10.5 Drop boiling chips[5] into the flasks.

10.6 Add 600 mL of 25 % NaCl solution, pH 1.5, to each flask. When each flask contains two U-bends as described in

[4] *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.

[5] The sole source of supply of amphoteric alundum granules known to the committee at this time is Hengar Co., Philadelphia, PA. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.