



# Standard Test Method for Determining the Crevice Repassivation Potential of Corrosion-Resistant Alloys Using a Potentiodynamic-Galvanostatic-Potentiostatic Technique<sup>1</sup>

This standard is issued under the fixed designation G192; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method covers a procedure for conducting anodic polarization studies to determine the crevice repassivation potential for corrosion-resistant alloys. The concept of the repassivation potential is similar to that of the protection potential given in Reference Test Method **G5**.

1.2 The test method consists in applying successively potentiodynamic, galvanostatic, and potentiostatic treatments for the initial formation and afterward repassivation of crevice corrosion.

1.3 This test method is a complement to Test Method **G61**.

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:<sup>2</sup>

**B575** Specification for Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper, Low-Carbon Nickel-Chromium-Molybdenum-Tantalum, Low-Carbon Nickel-Chromium-Molybdenum-Tungsten, and Low-Carbon Nickel-Molybdenum-Chromium Alloy Plate, Sheet, and Strip

**D1193** Specification for Reagent Water

**E691** Practice for Conducting an Interlaboratory Study to

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee **G01** on Corrosion of Metals and is the direct responsibility of Subcommittee **G01.11** on Electrochemical Measurements in Corrosion Testing.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

### Determine the Precision of a Test Method

**G1** Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens

**G5** Reference Test Method for Making Potentiodynamic Anodic Polarization Measurements

**G15** Terminology Relating to Corrosion and Corrosion Testing (Withdrawn 2010)<sup>3</sup>

**G48** Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution

**G61** Test Method for Conducting Cyclic Potentiodynamic Polarization Measurements for Localized Corrosion Susceptibility of Iron-, Nickel-, or Cobalt-Based Alloys

**G78** Guide for Crevice Corrosion Testing of Iron-Base and Nickel-Base Stainless Alloys in Seawater and Other Chloride-Containing Aqueous Environments

## 3. Terminology

3.1 *Definitions*—For definitions of corrosion-related terms used in this test method, see Terminology **G15**.

## 4. Summary of Test Method

4.1 This anodic polarization test method combines techniques such as potentiodynamic, galvanostatic, and potentiostatic polarization methods. This test method is called the Tsujikawa-Hisamatsu Electrochemical (THE) test method to honor the two precursors of this technique (see **1** and **2**).<sup>4</sup> The new technique will be called the THE test method. This new THE test method is more time-consuming than the already well-established cyclic potentiodynamic polarization (CPP) described in Test Method **G61**.

4.2 The THE test method can be used with any corrosion-resistant alloy, but it was developed by studying Alloy 22 (UNS N06022). The composition and other properties of Alloy 22 are given in Specification **B575**. Alloy 22 is a nickel-based alloy containing approximately 22wt% Cr, 13wt% Mo, 3wt%

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>4</sup> The boldface numbers in parentheses refer to a list of references at the end of this standard.

W and 3wt% Fe. The THE test method is a complement to the cyclic potentiodynamic polarization (CPP) described in Test Method G61. CPP may be used as a first fast screening method and THE test method for fine-tuning the repassivation potential for crevice corrosion when the environment is not highly aggressive (3-6). The THE test method has also been applied to other highly corrosion-resistant alloys, such as Titanium grade 7 (Ref 7).

4.3 The THE test method can be used with any electrolyte solution. A standard 1 M NaCl solution at 90°C or lower temperature may be used to compare alloys of interest. The round robin described in Section 15 was carried out in 1 M NaCl solution at 90°C.

4.4 The test involves in polarizing the test electrode in three steps:

4.4.1 *Step 1*—The test electrode is polarized potentiodynamically at a rate of 0.168 mV/s (as in Test Method G61) starting at or slightly below the corrosion potential until a preset current (or current density) is reached (for example, 2  $\mu\text{A}/\text{cm}^2$ ). After this initial potentiodynamic polarization, the polarization control is changed to galvanostatic mode (Step 2).

4.4.2 *Step 2*—The preset current of 2  $\mu\text{A}/\text{cm}^2$  is kept constant for a 2-h period to develop and grow a crevice corroded area (if any develops). During the galvanostatic Step 2, the potential output is monitored.

4.4.3 *Step 3*—The polarization control is shifted to the potentiostatic mode. The potential at the end of the galvanostatic hold (Step 2) is read, and then 10 mV are subtracted. The resulting value of potential is applied for a 2-h period while the current output is monitored. Then successive potentiostatic treatments are applied, each time at 10 mV lower than the previous treatment. A total of 10-15 potentiostatic treatments are usually required to finish Step 3.

4.5 The crevice repassivation potential (ER,CREV) is the highest potential in Step 3 for which current density does not increase as a function of time. It is understood that at a potential below ER,CREV the alloy will not develop crevice corrosion under the tested conditions.

## 5. Significance and Use

5.1 The THE test method is designed to provide highly reproducible crevice repassivation potentials for corrosion-resistant alloys (for example, Alloy 22) in a wide range of environments from non-aggressive to highly aggressive. In conditions of low environmental aggressiveness (such as low temperature or low chloride concentration), corrosion-resistant alloys such as Alloy 22 will resist crevice corrosion initiation and the cyclic potentiodynamic polarization test (Test Method G61) may fail to promote crevice corrosion mainly because it drives the alloy into transpassive dissolution instead of nucleating crevice corrosion. The THE test method provides a more controlled way of applying the electrical charge to the test electrode, which may induce crevice corrosion without moving it into transpassive potentials.

5.2 The more noble this crevice corrosion repassivation potential (ER,CREV) value, the more resistant the alloy is to crevice corrosion in the tested electrolyte. This is similar to

other test methods to measure localized corrosion resistance such as Test Method G61 and Test Methods G48. The results from this test method are not intended to correlate in a quantitative manner with the rate of propagation that one might observe in service when localized corrosion occurs.

5.3 This test method may be used to rank several alloys by using the same testing electrolyte and temperature. It can also be used to determine the response of a given alloy when the environmental conditions (such as electrolyte composition and temperature) change.

## 6. Apparatus

6.1 *Cell*—The polarization cell should be similar to the one described in Reference Test Method G5 and Test Method G61. Other polarization cells may be equally suitable. The cell should have a capacity of about 1 L and should have suitable necks or seals to permit the introduction of electrodes, gas inlet and outlet tubes, and a thermometer or thermocouple. The Luggin probe-salt bridge separates the bulk solution from the saturated calomel or saturated silver chloride reference electrode.

6.2 *Test Electrode (Specimen) Holder*—The test electrode holder and the mounting rod should be similar to the one described in Figure 5 in Reference Test Method G5 (reproduced in Fig. 1). A leakproof PTFE compression gasket, as described in subsection 4.6.1 in Reference Test Method G5, is also necessary.

6.3 *Potentiostat and Output Potential and Current Measuring Instruments*—The potentiostat and other instruments should be similar to the ones specified in Test Method G61. Most commercial potentiostat and related instruments meet the specific requirements for these types of measurements.

6.4 *Electrodes*—The standard recommended working or testing electrode is shown in Fig. 1, which is a prismatic measuring 0.75 by 0.75 by 0.375-in. thick (approximately 20 by 20 by 10 mm). It has a drilled and tapped hole on top for the connecting rod (as in Reference Test Method G5). The electrodes also have a 7-mm diameter hole in the center for mounting two crevice formers, one at each side using a bolt. The test electrode could be cut from any plate or extruded bar. It is recommended that the creviced faces of the test electrode correspond to the rolling or extruded direction. In certain tested conditions the test electrode may show end grain attack in the short transverse direction, but generally the crevice former provides a more active path for corrosion than the freely exposed surfaces.

6.5 *Crevice Former or Crevice Washer*—The crevice former is a multiple crevice assembly (MCA), and it is described in subsection 5.4 of Test Methods G48, in subsection 9.2.2 in Guide G78, and in Ref 8. This MCA crevice former should be fabricated using a hard non-conductive ceramic material such as alumina or mullite (Fig. 2). Before mounting on the test electrode (specimen), the crevice washers should be covered with a PTFE tape. This tape is 1.5-in. wide and 0.003-in. thick (standard military grade MIL-T-27730A). A corrosion-resistant fastener is used to secure the two MCA washers, one on each side of the test electrode. Crevice formers made of solid

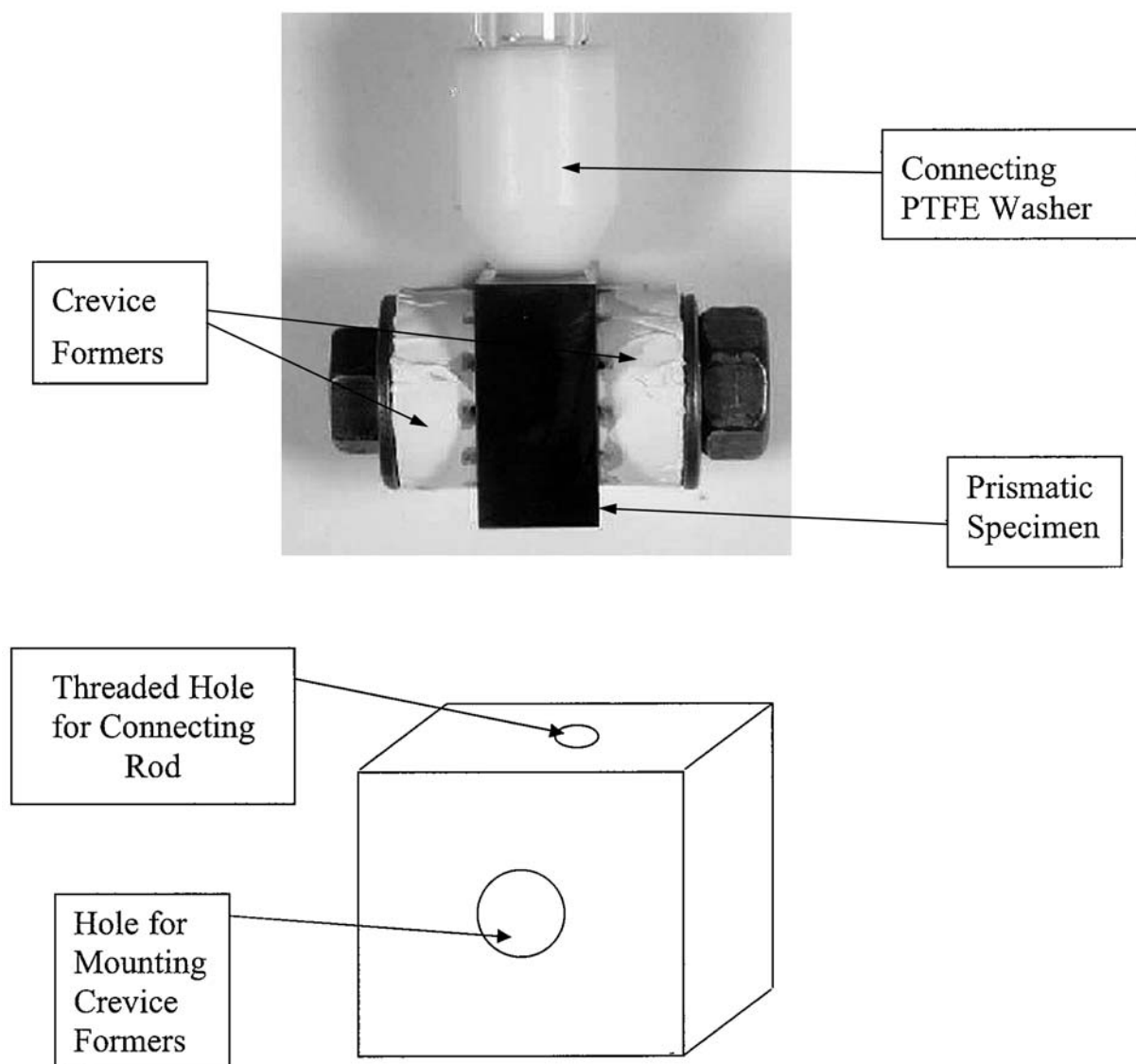


FIG. 1 Prismatic Test Electrode (0.75 by 0.75 by 0.375 in. or approximately 20 by 20 by 10 mm)

PTFE such as in Test Methods G48 or Guide G78 are not as effective, since they do not form a crevice gap tight enough for certain high end corrosion-resistant materials. This may result in higher and poorly reproducible repassivation potential values. Two standard metal washers are used as well (Figs. 1 and 2). The standard pressure on the MCA crevice formers may vary (depending of the study underway) but a minimum of 30-in.-lb (3.4-N-m) torque may be needed to form a tight crevice. Use a calibrated torque wrench to apply the torque. Electrical contact between the bolt and the test electrode should be avoided. Effective insulation may be provided by the use of nonmetallic sleeves or by wrapping the assembly bolt with PTFE tape.

6.6 *Counter Electrode*—The counter electrodes may be prepared as in Reference Test Method G5 or may be prepared from high-purity platinum flat stock and wire. Counter electrodes could be easily fabricated by spot welding platinum wire

to a platinum foil, which could be curved to adapt to the cell geometry. It is recommended that the area of the platinum counter electrode be twice as large as the one of the working electrode (test electrode or specimen).

6.7 *Reference Electrode*—Reference electrodes could be commercially available saturated calomel or silver-silver chloride. These electrodes are durable and reliable; however, they should be maintained in the proper conditions. The potential of the reference electrodes should be checked at periodic intervals to ensure their accuracy.

## 7. Reagents and Materials

7.1 *Purity of Reagents*—Reagent grade chemicals should be used in all tests.

7.2 *Purity of Water*—The water should be distilled or deionized conforming to the requirements of Specification D1193, Type IV reagent water.