



Designation: G108 – 23

Standard Test Methods for Electrochemical Reactivation (EPR) for Detecting Sensitization of AISI Type 304 and 304L Stainless Steels¹

This standard is issued under the fixed designation G108; 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 These test methods cover a laboratory procedure for conducting an electrochemical reactivation (EPR) test on AISI Type 304 and 304L (UNS No. S30400 and S30403, respectively) stainless steels. These test methods can provide a nondestructive means of quantifying the degree of sensitization in Type 304 stainless steels (**1, 2, 3**).² These EPR test methods have found wide acceptance in studies of the effects of sensitization on intergranular corrosion and intergranular stress corrosion cracking behavior (see Terminology **G193**). The EPR technique has been successfully used to evaluate other stainless steels and nickel base alloys (**4**), but the test conditions and evaluation criteria used were modified in each case from those cited in the current test methods. This standard test covers two tests, (1) Test Method A or Single Loop, and (2) Test Method B or Double Loop.

1.2 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.

1.3 *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.*

1.4 *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.*

¹ These test methods are under the jurisdiction of ASTM Committee **G01** on Corrosion of Metals and are the direct responsibility of Subcommittee **G01.11** on Electrochemical Measurements in Corrosion Testing.

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² The boldface numbers in parentheses refer to a list of references at the end of this standard.

2. Referenced Documents

2.1 *ASTM Standards*:³

- A262** Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
- D1193** Specification for Reagent Water
- E3** Guide for Preparation of Metallographic Specimens
- E7** Terminology Relating to Metallography
- E112** Test Methods for Determining Average Grain Size
- E691** Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
- G1** Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens
- G3** Practice for Conventions Applicable to Electrochemical Measurements in Corrosion Testing
- G5** Reference Test Method for Making Potentiodynamic Anodic Polarization Measurements
- G28** Test Methods for Detecting Susceptibility to Intergranular Corrosion in Wrought, Nickel-Rich, Chromium-Bearing Alloys
- G61** Test Method for Conducting Cyclic Potentiodynamic Polarization Measurements for Localized Corrosion Susceptibility of Iron-, Nickel-, or Cobalt-Based Alloys
- G193** Terminology and Acronyms Relating to Corrosion
- G215** Guide for Electrode Potential Measurement

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *integrated charge (Q)*, n —charge measured, in coulombs, during reactivation as given by the time integral of current below the reactivation peak of the curve.

3.1.2 *maximum anodic current density (i_p)*, n —current density measured at the peak of the anodic curve during reactivation.

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.

3.1.3 *normalized charge* (P_a), n —integrated current normalized to the specimen size and grain size. P_a represents the charge (in coulombs/cm²) of the grain-boundary area. The method for calculating P_a is given in 9.2.

3.1.4 *reactivation*, n —in the electrochemical reactivation (EPR) test, the potential sweep from the passivation potential returning to the corrosion potential.

3.1.5 *scan rate*, n —rate at which the electrical potential applied to a specimen in a polarization test is changed.

Test Method A—Single Loop

4. Summary of Test Method A—Single Loop

4.1 The EPR test is accomplished by a potentiodynamic sweep from the passive to the active regions of electrochemical potentials in a process referred to as reactivation. The EPR test measures the amount of charge associated with the corrosion of the chromium-depleted regions surrounding chromium carbide precipitated particles. Most of these particles in a sensitized microstructure are located at grain boundaries (see Terminology E7). Discrete particles located within the grain (referred to as intragranular precipitates) will also contribute to the total measured charge. Therefore, it is important to examine the alloy microstructure following an EPR test, to determine the relative proportion of corrosion site associated with intergranular versus intragranular precipitates.

4.2 The chromium-depleted zones around carbide precipitates in sensitized steels are particularly susceptible to corrosion in oxidizing acid solutions. Corrosion at chromium-depleted grain boundary sites causes a rapid rise in the current density when the electrochemical potential is changed from the passive to the active region.

4.3 A sensitized steel produces a curve similar to the active portion of the polarization curve during the reactivation from the passive region back to the rest potential (E_{corr}) as shown in Fig. 1. A nonsensitized (solution annealed) steel polarized under the conditions given in this test method will produce a curve with lower current densities than a sensitized steel.

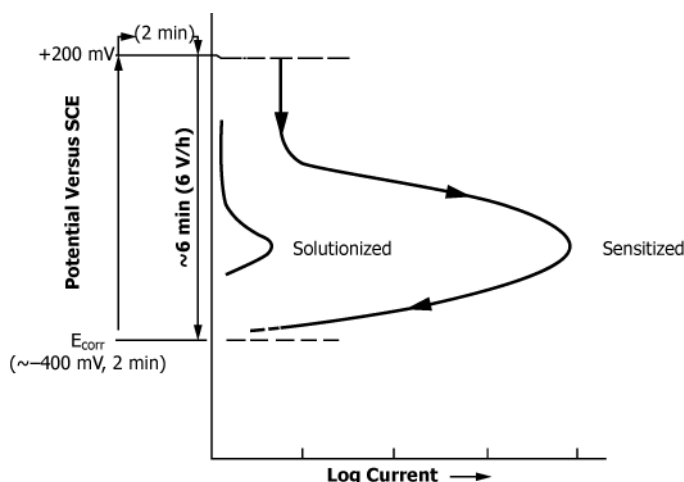


FIG. 1 Schematic EPR Curves for Sensitized and Solutionized AISI Type 304 Stainless Steel for Method A—Single Loop

4.4 The EPR test results are readily reproducible, as long as the electrolyte temperature, electrolyte composition, and scan rate are carefully controlled. The EPR test is significantly affected by the composition, thermomechanical condition and surface finish of the specimen as well as the presence of non-metallic inclusions, that result in pitting of the etched microstructure.

NOTE 1—Various cutting and grinding operations can promote sensitization of Type 304 (5). Superficial carbide precipitation can occur during cutting and grinding or during subsequent low temperature heat treatments, such as 24 h at 500 °C.

4.5 The criteria used to distinguish between sensitized and solution annealed samples are the activation charge, Q (given by the time integral of current density below the reactivation peak of the curve), or the maximum anodic current density, i_r , in the active state. Sensitized steels are easily activated and show higher Q and i_r values than solution annealed steels, that are not susceptible to intergranular corrosion. The value Q is normalized for both specimen size and grain size. The value normalized in this fashion is called P_a and represents the charge (in units of coulombs) per unit grain-boundary area. This normalization permits direct comparisons of different heats of material that exhibit different Q values solely as a result of differences in grain size.

5. Significance and Use for Test Method A—Single Loop

5.1 This test method describes an EPR test method for quantitatively determining the relative degree of sensitization in AISI Type 304 and 304L stainless steels. The EPR test has found wide use as a means to provide a numerical level of sensitization in studies of the effects of sensitization on intergranular corrosion and intergranular stress corrosion cracking behavior. The results of this test method correlate with other test methods (for example, Practices A262 and Test Methods G28) that are commonly used to assess sensitization in stainless steels.

5.2 The EPR test can also be used for product acceptance, service evaluation, regulatory statutes, and manufacturing controls providing that both the supplier and user have agreed upon appropriate acceptance criteria and a sensitizing treatment. The test is not intended for design purposes since the test conditions accelerate corrosion in a manner that does not simulate any actual service environment.

5.3 The EPR test involves the measurement of the amount of charge resulting from the corrosion of the chromium-depleted regions surrounding the precipitated chromium carbide particles. Most of these particles in a sensitized microstructure are located at the grain boundaries. However, discrete particles located within grains (referred to as intragranular precipitates) will also contribute to the total measured charge. (See Fig. 2.) Therefore, it is important to examine the alloy microstructure following an EPR test to determine the relative proportion of corrosion sites associated with intergranular versus intragranular precipitates. Sites of intergranular attack will appear similar to grain boundary ditching as defined in Practice A of Practices A262.