Designation: G61 – 86 (Reapproved 2014)

Standard Test Method for
Conducting Cyclic Potentiodynamic Polarization Measurements for Localized Corrosion Susceptibility of Iron-, Nickel-, or Cobalt-Based Alloys[1]

This standard is issued under the fixed designation G61; 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 a procedure for conducting cyclic potentiodynamic polarization measurements to determine relative susceptibility to localized corrosion (pitting and crevice corrosion) for iron-, nickel-, or cobalt-based alloys in a chloride environment. This test method also describes an experimental procedure which can be used to check one's experimental technique and instrumentation.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]
D1193 Specification for Reagent Water
G3 Practice for Conventions Applicable to Electrochemical Measurements in Corrosion Testing
G5 Reference Test Method for Making Potentiodynamic Anodic Polarization Measurements
2.2 *ASTM Adjuncts:*
Standard Samples (set of two)[3]

3. Significance and Use

3.1 An indication of the susceptibility to initiation of localized corrosion in this test method is given by the potential at which the anodic current increases rapidly. The more noble this potential, obtained at a fixed scan rate in this test, the less susceptible is the alloy to initiation of localized corrosion. The results of this test are not intended to correlate in a quantitative manner with the rate of propagation that one might observe in service when localized corrosion occurs.

3.2 In general, once initiated, localized corrosion can propagate at some potential more electropositive than that at which the hysteresis loop is completed. In this test method, the potential at which the hysteresis loop is completed is determined at a fixed scan rate. In these cases, the more electropositive the potential at which the hysteresis loop is completed the less likely it is that localized corrosion will occur.

3.3 If followed, this test method will provide cyclic potentiodynamic anodic polarization measurements that will reproduce data developed at other times in other laboratories using this test method for the two specified alloys discussed in 3.4. The procedure is used for iron-, nickel-, or cobalt-based alloys in a chloride environment.

3.4 A standard potentiodynamic polarization plot is included. These reference data are based on the results from five different laboratories that followed the standard procedure, using specific alloys of Type 304 stainless steel, UNS S30400 and Alloy C-276, UNS N10276.[3] Curves are included which have been constructed using statistical analysis to indicate the acceptable range of polarization curves.

3.5 The availability of a standard test method, standard material, and standard plots should make it easy for an investigator to check his techniques to evaluate susceptibility to localized corrosion.

4. Apparatus

4.1 The polarization cell should be similar to the one described in Reference Test Method G5. Other polarization cells may be equally suitable.

4.1.1 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. The Luggin probe-salt bridge separates the bulk solution from the saturated calomel reference electrode. The probe tip should
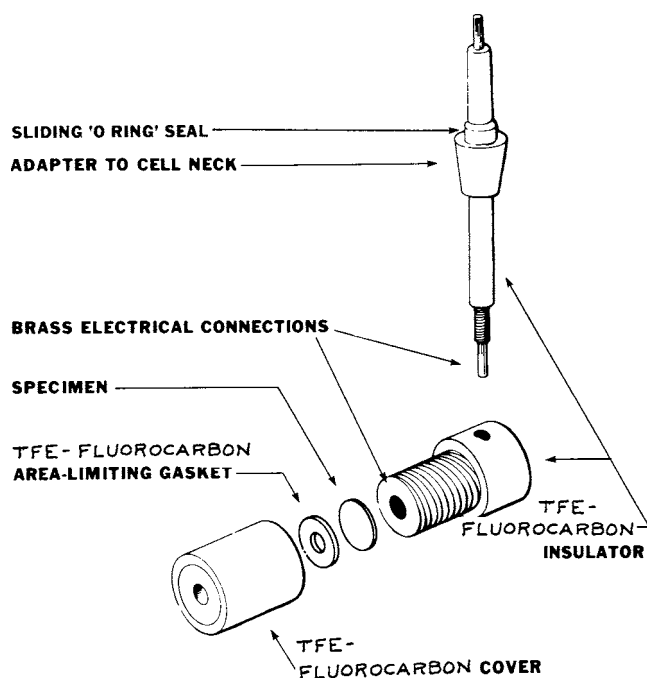

FIG. 1 Schematic Diagram of Specimen Holder (see Footnotes 3 and 4)

be adjustable so that it can be brought into close proximity with the working electrode.

4.2 *Specimen Holder:*

4.2.1 Specimens should be mounted in a suitable holder designed for flat strip, exposing 1 cm^2 to the test solution (Fig. 1). Such specimen holders have been described in the literature.[4] It is important that the circular TFE-fluorocarbon gasket be drilled and machined flat in order to minimize crevices.

4.3 *Potentiostat* (Note 1)—A potentiostat that will maintain an electrode potential within 1 mV of a preset value over a wide range of applied currents should be used. For the type and size of standard specimen supplied, the potentiostat should have a potential range of −1.0 to +1.6 V and an anodic current output range of 1.0 to 10^5 μA. Most commercial potentiostats meet the specific requirements for these types of measurements.

Note 1—These instrumental requirements are based upon values typical of the instruments in the five laboratories that have provided the data used in determining the standard polarization plot.

4.4 *Potential-Measuring Instruments* (Note 1)—The potential-measuring circuit should have a high input impedance on the order of 10^{11} to 10^{14} Ω to minimize current drawn from the system during measurements. Instruments should have sufficient sensitivity and accuracy to detect a change in potential of ±1 mV, usually included in commercial potentiostats. An output as a voltage is preferred for recording purposes.

TABLE 1 Chemical Composition of Alloys Used in the Round Robin, Weight %

Element	Alloy C-276 (UNS N10276)	Type 304 Stainless Steel (UNS S30400)
Carbon	0.003	0.060
Chromium	15.29	18.46
Cobalt	2.05	...
Columbium	...	0.11
Copper	...	0.17
Iron	5.78	balance
Manganese	0.48	1.43
Molybdenum	16.03	0.17
Nickel	balance	8.74
Phosphorus	0.018	0.029
Silicon	0.05	0.60
Sulfur	0.006	0.014
Vanadium	0.20	...
Tungsten	3.62	...

4.5 *Current-Measuring Instruments* (Note 1)—An instrument that is capable of measuring a current accurately to within 1 % of the absolute value over a current range between 1.0 and 10^5 μA should be used. Many commercial units have a build-in instrument with an output as a voltage, which is preferred for recording purposes. For the purpose of the present test a logarithmic output is desirable.

4.6 *Anodic Polarization Circuit*—A scanning potentiostat is used for potentiodynamic measurements. Potential and current are plotted continuously using an *X-Y* recorder and a logarithmic converter (contained in the potentiostat or incorporated into the circuit) for the current. Commercially available units are suitable.

4.7 *Electrodes:*

4.7.1 The standard Type 304 stainless steel (UNS S30400) and Alloy C-276 (UNS N10276) should be machined into flat 0.625-in. (14-mm) diameter disks. The chemical compositions of the alloys used in the round robin are listed in Table 1.

4.7.2 *Counter Electrodes*—The counter electrodes may be prepared as described in Reference Test Method G5 or may be prepared from high-purity platinum flat stock and wire. A suitable method would be to seal the platinum wire in glass tubing and introduce the platinum electrode assembly through a sliding seal. Counter electrodes should have an area at least twice as large as the test electrode.

4.7.3 *Reference Electrode*[5]—A saturated calomel electrode with a controlled rate of leakage (about 3 μL/h) is recommended. This type of electrode is durable, reliable, and commercially available. Precautions should be taken to ensure that it is maintained in the proper condition. The potential of the calomel electrode should be checked at periodic intervals to ensure the accuracy of the electrode.

5. Reagents and Materials

5.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society,

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[4] France, W. D., Jr., *Journal of the Electrochemical Society*, Vol 114, 1967, p. 818; and Myers, J. R., Gruewlar, F. G., and Smulezenski, L. A., *Corrosion*, Vol 24, 1968, p. 352.

[5] Ives, D. J., and Janz, G. J., *Reference Electrodes, Theory and Practice*, Academic Press, New York, NY, 1961.