



Designation: G217 – 16 (Reapproved 2022)

Standard Guide for Corrosion Monitoring in Laboratories and Plants with Coupled Multielectrode Array Sensor Method¹

This standard is issued under the fixed designation G217; 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 guide outlines the procedure for conducting corrosion monitoring in laboratories and plants by use of the coupled multielectrode array sensor (CMAS) technique.

1.2 For plant applications, this technique can be used to assess the instantaneous non-uniform corrosion rate, including localized corrosion rate, on a continuous basis, without removal of the monitoring probes, from the plant.

1.3 For laboratory applications, this technique can be used to study the effects of various testing conditions and inhibitors on non-uniform corrosion, including pitting corrosion and crevice corrosion.

1.4 *Units*—The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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

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

¹ This guide 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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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.

G4 Guide for Conducting Corrosion Tests in Field Applications

G16 Guide for Applying Statistics to Analysis of Corrosion Data

G46 Guide for Examination and Evaluation of Pitting Corrosion

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

G96 Guide for Online Monitoring of Corrosion in Plant Equipment (Electrical and Electrochemical Methods)

G102 Practice for Calculation of Corrosion Rates and Related Information from Electrochemical Measurements

G193 Terminology and Acronyms Relating to Corrosion

G199 Guide for Electrochemical Noise Measurement

3. Terminology

3.1 *Definitions*—The terminology used herein, if not specifically defined otherwise, shall be in accordance with Terminology **G193**. Definitions provided herein and not given in Terminology **G193** are limited only to this guide.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *coupled multielectrode array sensor, CMAS, n*—device with multiple working electrodes that are coupled through an external circuit such that all the electrodes operate at the same electrode potential to simulate the electrochemical behavior of a single-piece metal.

3.2.2 *non-uniform corrosion, n*—corrosion that occurs at various rates across the metal surface, with some locations exhibiting higher anodic rates while others have higher cathodic rates, thereby requiring that the electron transfer occurs between these sites within the metal.

3.2.2.1 *Discussion*—Non-uniform corrosion includes both localized corrosion and uneven general corrosion (**1**).³ Non-uniform corrosion also includes the type of general corrosion that produces even surfaces at the end of a large time interval, but uneven surfaces during small time intervals.

3.2.3 *uneven general corrosion, n*—corrosion that occurs over the whole exposed surface or a large area at different rates.

³ The boldface numbers in parentheses refer to a list of references at the end of this standard.

3.2.3.1 *Discussion*—In this guide, general corrosion is further divided into even general corrosion, or uniform corrosion, which is defined as the corrosion that proceeds at exactly the same rate over the surface of a material (see Terminology G193) and uneven general corrosion. Uneven general corrosion is defined as the general corrosion that produces uneven surface or wave-like surface on a metal that has an even surface before the corrosion (2, 3).

3.2.4 *zero-voltage ammeter, ZVA, n*—device that imposes a negligibly low voltage drop when inserted into a circuit for measurement of current.

3.2.4.1 *Discussion*—The ZVA defined in this guide also meets the definition of the zero-resistance ammeter (ZRA) in Guide G199. A typical ZRA is built with inverting operational amplifiers to limit the voltage drop in the current-measuring circuit to a low value. Both ZRA and a simple device formed with a shunt resistor and a voltmeter can be used as a ZVA as long as they do not impose a significant voltage drop (<1 mV) in the current-measuring circuit (see Annex A2 for more information).

4. Significance and Use

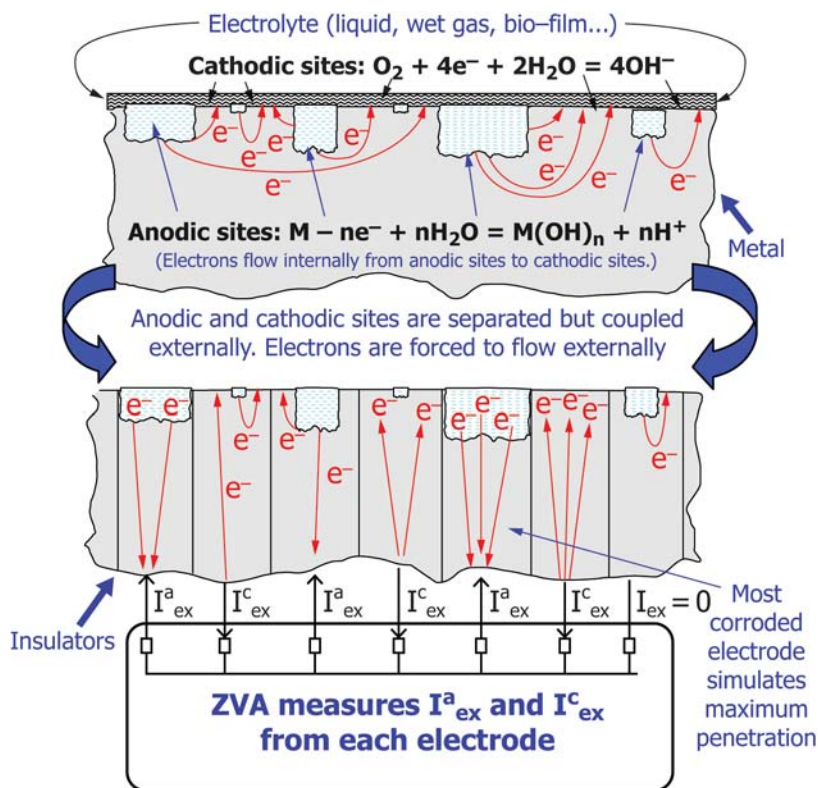
4.1 Guide G96 describes a linear-polarization method and an electrical resistance method for online monitoring of corrosion in plant equipment without the need to enter the system physically to withdraw coupons. These two online monitoring techniques are useful in systems in which process upsets or other problems can create corrosive conditions. An early

warning of corrosive attack can permit remedial action before significant damage occurs to process equipment. The two methods described in Guide G96 are suitable for uniform corrosion, but may not be sensitive enough for non-uniform corrosion, especially localized corrosion. This guide describes a new method for monitoring non-uniform corrosion, especially localized corrosion.

4.2 The CMAS technique measures the net anodic current or net cathodic current from each of the individual electrodes (I_{ex}^a or I_{ex}^c in Fig. 1), which is the characteristic of non-uniform corrosion such as localized corrosion and uneven general corrosion. Therefore, the CMAS technique can be used to estimate the rate of uneven general corrosion and localized corrosion (see Section 5).

4.3 Unlike uniform corrosion, the rate of non-uniform corrosion, especially localized corrosion, can vary significantly from one area to another area of the same metal exposed to the same environment. Allowance shall be made for such variations when the measured non-uniform corrosion rate is used to estimate the penetration of the actual metal structure or the actual wall of process equipment. This variability is less critical when relative changes in corrosion rate are to be detected, for example, to track the effectiveness of corrosion inhibitors in an inhibited system.

4.4 The same as the method described in Guide G96, the CMAS technique described in this guide provides a technique for determining corrosion rates without the need to enter the



NOTE 1—The upper section shows the electron flows from the corroding area to the less corroding areas inside a metal when localized corrosion takes place; the lower section shows the electron flows after the anodic and cathodic areas are separated into individual small electrodes and coupled through an external circuit that measures the anodic current (I_{ex}^a) and cathodic current (I_{ex}^c) through each of the individual electrodes (4).

FIG. 1 Principle of CMAS Probe